NBER WORKING PAPER SERIES

THE EFFECTS OF FOREIGN MULTINATIONALS ON WORKERS AND FIRMS IN THE UNITED STATES

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Working Paper 26149
http://www.nber.org/papers/w26149

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
August 2019

The opinions expressed in this paper are those of the authors alone and do not reflect the views of the Internal Revenue Service, the U.S. Treasury Department, or the National Bureau of Economic Research. We thank our discussant at the NBER summer institute, Emanuele Colonnelli, as well as Pol Antras, David Atkin, Nick Bloom, Victor Couture, Ben Faber, Aaron Flaaen, Rick Hornbeck, Erik Hurst, Mina Kim, Jim Tybout, Danny Yagan, and Stephen Yeaple for useful comments that have substantially improved the paper. Setzler gratefully acknowledges the financial support of the Washington Center for Equitable Growth. Tintelnot gratefully acknowledges the financial support of the Becker Friedman Institute for Economics at the University of Chicago.

The Effects of Foreign Multinationals on Workers and Firms in the United States
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NBER Working Paper No. 26149
August 2019
JEL No. F23,J3,R1

ABSTRACT

Governments go to great lengths to attract foreign multinational enterprises because these enterprises are thought to raise the wages paid to their employees (direct effects) and to improve outcomes at incumbent local firms (indirect effects). We construct the first U.S. employer-employee dataset with foreign ownership information from tax records to measure these direct and indirect effects. We find the average direct effect of a foreign multinational firm on its U.S. workers is a 7 percent increase in wages. This premium is larger for higher skilled workers and for the employees of firms from high GDP per capita countries. We leverage the past spatial clustering of foreign-owned firms by country of ownership to identify the indirect effects. An expansion in the foreign multinational share of commuting zone employment substantially increases the employment, value added, and—for higher earning workers—wages at local domestic-owned firms. Per job created by a foreign multinational, our estimates suggest annual gains of 16,000 USD to the aggregate wages of local incumbents, of which about two-thirds is due to indirect effects. We compare our findings to the value of subsidy deals received by foreign multinationals.

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1 Introduction

Foreign multinational enterprises account for a sizable fraction of value added, exports, and R&D in the U.S. (BEA, 2017). These firms are affected by regulations on foreign investment, trade policies, and local subsidy competition.[1] It is widely believed that attracting a foreign multinational to a location will have transformative effects on the outcomes of local workers and producers. The hard evidence on this has been limited by data unavailability and the challenge of identifying causal effects. The key questions for policy makers and local stakeholders center around the direct and indirect effects of a job created by a foreign multinational. How much more does a worker earn when she is hired by a foreign multinational? How are domestic firms and their workers in nearby locations affected by foreign firms?

This paper makes four main contributions to understanding the effects of foreign multinationals. First, we use tax records to construct a panel data set for the U.S. that links the population of workers and firms with foreign ownership information of the firms. Second, we develop a model which provides the theoretical underpinnings to study the direct effects that foreign multinationals have on their own workers and the indirect effects that they have on domestic-owned firms and their workers in the local labor market. Third, we leverage the movers between firms to identify the foreign firm premium, i.e., the wage gain for the same worker when moving from a domestic to a foreign firm. Fourth, we document and exploit the spatial clustering of foreign firms to construct an instrument for foreign investment in the local labor market, allowing us to identify the indirect effects of foreign multinationals on the output, employment, and wages paid at domestic firms.

Our data is created by merging the population of annual U.S. corporate tax filings with the population of annual W-2 tax filings on the wage payments made by employers to workers during 1999-2017.[2] Then, we identify foreign multinationals in these data from a filing requirement for each 25 percent or more foreign-owned U.S. corporation. This information also includes the country of foreign ownership. To our knowledge, this is the first paper to combine linked employer-employee panel data with foreign ownership information in the U.S.[3] These panel data provide a unique opportunity to investigate the direct and indirect

[1]OECD (2019) ranks the U.S. slightly above the OECD average in terms of foreign direct investment restrictiveness. Prominent examples of subsidy deals offered to foreign multinationals include the BMW plant in Spartanburg, South Carolina (1992); the Toyota plant in Blue Springs, Mississippi (2007); and the Foxconn plant in Mount Pleasant, Wisconsin (announced 2017).

[2]Findings from the matched firm-worker tax records have been reported in studies by Yagan (2018), Kline, Petkova, Williams, and Zidar (2019), Lamadon, Mogstad, and Setzler (2019), and Smith, Yagan, Zidar, and Zwick (2019).

[3]Prior studies on foreign multinationals in the U.S. rely on firm-level data without worker-level information. Several studies combine the Bureau of Econonomic Analysis (BEA) survey of foreign direct investment in the U.S. and the Census of Manufactures data. Boehm, Flaaen, and Pandalai-Nayar (2019) merge ownership information from LexisNexis Directory of Corporate Affiliations into the Longitudinal Business Database at the Census Bureau. Saha, Firkri, and Marchio (2014) document regional patterns of FDI based on NETS

effects of foreign multinationals in the U.S. labor market.

Regarding direct effects, we find in our data that foreign firms pay 25 percent higher average wages than domestic firms, after controlling for industry and location. To understand the direct effects of foreign multinationals on the earnings of their workers, the key empirical challenge is to distinguish between foreign firms paying higher wages because they disproportionately employ high-skilled workers and foreign firms paying higher wages to a worker of a given skill level. In order to disentangle worker composition from the foreign firm premium, we leverage the panel data to follow workers who move between foreign and domestic firms. We find that the typical worker earns 7 percent more at the average foreign firm relative to the average domestic firm, indicating that most of the foreign firm wage differential is due to worker composition, but also indicating a substantial foreign firm premium. Quantitatively, the wage premium paid by foreign multinationals is quite large in the aggregate—accounting for 34 billion USD annually in wages (about 0.6 percent of the entire private sector wage bill).

We document four important properties of the direct effects. First, we find that the wage premium is larger for higher-skilled workers and absent for the lowest decile of worker skill. Second, we disaggregate the foreign firm premium by country of origin, finding larger premiums in origin countries with greater GDP per capita. Third, we find that the foreign wage premium is not explained by size differences between foreign and domestic firms, as the foreign wage premium is greatest when comparing small foreign firms and small domestic firms. Fourth, domestic-owned multinationals have nearly identical firm premiums to foreign multinationals on average. Our model rationalizes the existence of the wage premium and greater wage premiums for high-skilled workers with a skill-biased productivity advantage of foreign firms. While these productivity differences may in part be attributable to fixed costs of market entry and selection (Helpman, Melitz, and Yeaple, 2004), the greater premiums for higher-GDP-per-capita countries, greater premiums than (non-multinational) domestic firms of the same size, and similar premiums for domestic-owned multinationals together suggest that tangible and intangible foreign inputs could be behind the higher productivity of these firms.

Regarding the indirect effects of job creation at foreign firms on local domestic firms and their workers, the key identification challenge is that foreign multinationals may increase investment in a location due to other factors that also cause contemporaneous growth at local domestic firms. In order to overcome this endogeneity, we document in our data that foreign firms cluster into locations by country of ownership, then exploit this clustering to construct an instrumental variable for local foreign investment. Our identification strategy is

data. The closest data set is the one described by Bureau of Labor Statistics, U.S. Department of Labor (2019), which has employer-employee links and country of ownership. However, it is for the 2012 cross-section only, and the questions we address in this paper require a panel in order to observe changes over time.

analogous to the immigration literature that uses spatial clustering of immigrants to identify the effects of immigrants on native workers' wages (see Card 2001). Due to the large size of our data, we are able to include a rich set of fixed effects as controls in the empirical analysis, such as granular industry-year fixed effects and a commuting-zone-specific time trend. These controls ameliorate identification concerns arising from the fact that ownership-country-specific shocks can be correlated with confounding factors, such as industry-specific shocks.

Equipped with this identification strategy, we find that an increase in employment at foreign-owned firms significantly raises value added, employment, and wage bill at domestic-owned firms in the same commuting zone. The effects are larger in the tradable than in the non-tradable sector and largest among domestic firms with more than 100 employees. In terms of wage effects for continuing workers at domestic firms, we only find positive effects for higher-earning workers but not for lower-earning workers. Our estimates imply that, for every 1 job created by a foreign multinational, approximately 0.42 jobs and 91,000 USD in value added are generated by domestic firms in the same local labor market. Our model rationalizes these indirect effects in terms of knowledge spillovers or input/output linkages. In an extension, we construct analogous instrumental variables for foreign employment growth at horizontal, upstream, and downstream industries in the same location. We find that the indirect effects on domestic firms are greatest when investment occurs at upstream foreign multinationals, suggesting that a greater supply of inputs locally sourced by domestic firms from foreign-owned firms is an important driver of the indirect effects. We also find no evidence of negative effects on horizontal firms, suggesting that the costs of competition do not outweigh the agglomeration benefits even when the domestic and foreign firms are in the same industry.

In terms of policy implications, our estimates of the direct wage premium by foreign firms highlight sizable benefits of trade and investment policies that promote foreign firms to invest in the U.S. Furthermore, our estimates imply incentives for local policy makers to compete for investments by foreign multinationals, since in addition to direct wage benefits, we find positive and sizable local indirect effects on domestic firms and their workers—in particular the higher earning ones. Together, the direct and indirect wage effects imply that one additional job created by a foreign multinational generates, on average, annual aggregate wage gains for incumbent workers in the commuting zone of approximately 16,000 USD, two-thirds of which is due to the indirect effects. Outside data suggests that, in the aggregate, foreign multinationals in the U.S. receive about 3 to 6.5 billion USD in economic development subsidies per year.[4] Abstracting from any indirect effects, the value of these subsidies is

[4]According to data retrieved from the policy group *Good Jobs First*'s subsidy tracker database, the foreign firm share in total annual economic development subsidies in the U.S. between 2012 and 2017 ranges between 10 and 35 percent. The so called *mega-deals* (with subsidies larger than 50 million USD) play an

much below the aggregate foreign wage premium of 34 billion USD per year. However, when focusing on the *mega-deals* for the establishment and expansion of large plants, the subsidies per job can be quite large. Specifically, when comparing our estimates to the analysis by Slattery (2018), it appears that foreign multinationals are able to extract a sizable fraction of the surplus from such investments in the bargaining with local governments for mega-deals. We note that while there may be local benefits to competing for foreign multinational investments with subsidies, this does not imply that such subsidies are beneficial from a national welfare perspective.

Our paper contributes to several literatures. Regarding the direct effects of foreign multinationals, numerous studies have found that foreign multinationals pay higher wages than domestic firms. For the U.S., Doms and Jensen (1998), Feliciano and Lipsey (1999), and others find that at the firm-level the average wage at foreign-owned firms is higher than at domestic-owned firms. We contribute to this literature by—for the first time for the U.S.— separating worker-skill composition from foreign firm wage premiums. We show that the average wage difference shrinks substantially, but is still positive, when accounting for worker composition. Several studies outside the U.S. have found that the foreign wage premium shrinks and sometimes disappears when accounting for worker composition (Heyman, Sjöholm, and Tingvall 2007; Balsvik 2011; and Hijzen, Martins, Schank, and Upward 2013). One possible explanation for a significant wage gain for workers at foreign multinationals even after controlling for worker types is that the U.S. is relatively remote from its major sources of foreign firms (e.g., Europe and Asia), and therefore the selected firms that establish affiliates in the U.S. are especially productive. Another possibility is that firms anchor their wages to headquarter levels as suggested by Hjort, Li, and Sarsons (2019).

The existing studies on the effects of foreign multinationals on domestic firms in host countries outside the U.S. have found diverse effects. Aitken and Harrison (1999) and Lu, Tao, and Zhu (2017) find negative effects from foreign multinationals on revenue productivity of domestic firms in the same industry in Venezuela and China, respectively.[5] Other papers find positive effects on productivity at domestic-owned firms, which are sometimes associated with buyer-supplier linkages (Smarzynska Javorcik 2004; Haskel, Pereira, and Slaughter 2007; Alfaro and Chen 2018; Jiang, Keller, Qiu, and Ridley 2018; Kee 2015; and Alfaro-Urena, Manelici, and Vasquez 2018). Poole (2012) finds positive effects on wages at domestic firms from a greater share of co-workers with experience at foreign firms in Brazil.

The closest antecedents of our research on the indirect effects of foreign multinationals

important role for the overall volume of foreign firm subsidies—accounting for about half of all subsidies to foreign firms.

[5]Consistent with competition effects, Atkin, Faber, and Gonzalez-Navarro (2018) document a decline in Mexican grocery store prices in response to entry by foreign retailers. See Gorg (2004) for a survey of the empirical literature on FDI spillovers. A method to separate technology spillover from competition effects is provided by Bloom, Schankerman, and Van Reenen (2013).

on domestic U.S. firms are Head, Ries, and Swenson (1995), Figlio and Blonigen (2000), and Keller and Yeaple (2009).[6] Head et al. (1995) document the local clustering of Japanese affiliates in the U.S. Such clustering by country of origin forms the basis of our identification strategy. Figlio and Blonigen (2000) use between-county variation in foreign investment in South Carolina and find that foreign multinationals raise local real wages.[7] Keller and Yeaple (2009) use firm-level data from Compustat and variation in foreign-firm activity across industries. They find that spillovers from foreign multinationals can account for 14 percent of productivity growth in U.S. firms between 1987 and 1996. We contribute to this literature by providing a novel identification strategy for the indirect effects of foreign firms and an improved measurement of outcomes for both workers and firms. We also contribute to this literature by providing a local labor market perspective and investigating indirect effects on horizontal, upstream, and downstream industries within local labor markets.

While our identification strategy for the indirect effects of foreign multinationals on domestic firms is distinct from the prior literature on FDI spillovers, it is more closely related to prior work in urban economics. Going back to Bartik (1991), many studies have used a shift-share research design to measure local agglomeration benefits.[8] Our identification approach for measuring the indirect effects of foreign firms on domestic firms exploits past spatial clustering of firms by country of ownership and is analogous to the large empirical literature on immigration that exploits past spatial clustering by immigrants' country of origin (Card, 2001). Moretti (2010) uses a shift-share instrument to measure spillovers from the tradable sector on the non-tradable sector. Our identification strategy for the indirect effects of foreign firms on domestic firms complements the study on the spillover effects from new plant openings by Greenstone, Hornbeck, and Moretti (2010), particularly whenever data on runner-up locations is unavailable. Aside from providing an alternative identification strategy on the effects of plant expansions, the activities by foreign firms are of particular policy interest for both the local and national level.

Our paper is also related to the literature on local labor market benefits of various place-based policies in spatial equilibrium. In addition to the work by Slattery (2018), most closely related are the papers by Gaubert (2018) and Ossa (2015), who model local policymakers using subsidies to compete for firms in spatial equilibrium with agglomeration. Other related studies include business relocation responses to state-level corporate tax changes (Suarez Serrato and Zidar, 2016), agglomeration effects of infrastructure investment Kline and Moretti

[6]Other related work on the indirect effects of foreign multinationals in the U.S. includes Aitken, Harrison, and Lipsey (1996), Branstetter (2001) and Blonigen and Slaughter (2001).

[7]As their data does not distinguish between wages at domestic and foreign firms, this estimate combines both direct and indirect effects.

[8]An evolving literature discusses the econometric properties of this approach including Goldsmith-Pinkham, Sorkin, and Swift (2018), Adao, Kolesar, and Morales (2018), and Borusyak, Hull, and Jaravel (2018).

(2013), and indirect effects of employment tax credits (Busso, Gregory, and Kline, 2013). As in our discussion of policy implications, this literature distinguishes between the value of the indirect effects from the perspective of a local policymaker versus a national policymaker, where the local policymaker does not discount the stealing of business from other locations and the national policymaker does; see also the discussion by Glaeser and Gottlieb (2009).

2 Data and Descriptive Evidence

2.1 Data

We construct a matched worker-firm panel data set from the population of annual U.S. Treasury tax filings from 1999 to 2017. For each worker-firm-year, W-2 tax forms provide information on earnings, the firm's employer identification number (EIN, which is masked to us), and the worker's residential ZIP code.[9] Earnings are defined as all remuneration for labor services deemed taxable by the IRS, including wages and salaries, bonuses, and exercised stock options. We obtain year of birth and sex information from SSA birth records for each worker. Following Lamadon et al. (2019), the analysis sample focuses on workers aged between 25 and 60 at the highest-paying employment relationship in each worker-year with earnings above the full-time equivalence (FTE) threshold, which we approximate using the minimum wage.

For each firm-year, forms 1120 (C-corporations), 1120S (S-corporations), and 1065 (partnerships) provide information on value added and the NAICS industry code, where value added equals sales minus cost of goods sold.[10] We refer to the 3-digit NAICS code as the firm's industry. Foreign-ownership is indicated by the filing of form 5472, which is the information return for a 25 percent or more foreign-owned U.S. corporation and includes the country of foreign ownership. We link worker data to firm data using the EIN. We keep only those firms that have at least one FTE worker. We use the terms "foreign" and "foreign-owned" interchangeably throughout this draft.[11] Due to difficulties in interpreting value added, we omit the finance, insurance, and real estate (FIRE) industries from all analysis.

[9] In the event that the ZIP code is missing or invalid in year t but not in year s with $|t-s| \leq 2$, and the worker receives a W-2 from the same EIN in t and s, we impute it in t using the value from s.

[10] In the manufacturing and mining sectors, the cost of goods sold contains production wages (labor compensation to workers directly involved in the production process). We construct a measure of production wages to add back into value added for these sectors (the difference between total wages associated with the firm through worker tax forms and non-production wages reported by the firm).

[11] Similarly, we refer to "domestic" and "domestic-owned" firms interchangeably. We note that even a domestic-owned firm could be in the hands of many small foreign owners, in particular when the company is publicly listed. While we do not have hard data on this, we think these cases are likely to be rare and not necessarily associated with the same effects. In the event that the employer fails to file form 5472 in year t but files as foreign owned with ownership country c in one of $(t-2, t-1)$ as well as one of $(t+1, t+2)$, we impute foreign ownership in year t as c.

To our knowledge, ours is the first panel data set for the U.S. that links the population of workers and firms with foreign ownership information of the firms. However, there are two challenges in working with this data. First, since corporate tax filings provide the foreign ownership information while the W-2s provide the information on employment and wages, we can only classify the foreign status of a worker's firm for those workers whose EIN on the W-2 is also an EIN associated with a corporate tax filing. As emphasized by Yagan (2018), many workers cannot be linked to a corporate tax filing, often because the employer is not required to file (especially because the employer is a government or non-profit organization) or because the employer is a subsidiary and only the parent corporation files while the subsidiary uses its distinct EIN to issue W-2s. To overcome this challenge, we combine two sources of information on subsidiary linkages. The first source is Schedule K, Line 3b, which provides the EIN of the parent corporation in the years in which the subsidiary is a filer, from which we learn the EIN of the parent corporation in future years in which the subsidiary is a non-filer. The second source is the Affiliations Schedule from form 851, which defines a subsidiary as 80 percent owned by another corporation. However, we only observe a running list of parent-subsidiary relationships taken from the Affiliations Schedules through 2016, so changes over time due to extensive margin changes in subsidiary relationships may be mismeasured when using the second source. For this reason, we only utilize the second source for subsidiary linkages that are not covered by the first source, i.e., subsidiaries that are missing Schedule K filings.

The second challenge is that our analysis requires a firm's activity to be associated with *each* commuting zone in which it is active. This differs from using the address of the firm's headquarters to define its location, as the headquarters may be chosen to obtain favorable state-level tax rates rather than to represent the firm's actual location of activity, and the firm may be active in many locations. Since specific establishments of multi-establishment firms are not observable in U.S. tax data, we follow Yagan (2018) by inferring firms' commuting zone-level operations from workers' residential locations. We aggregate number of workers and wages within the commuting zone of the worker's address on the W-2 to define the firms' local employment and wage bill. However, we do not observe value added at the firm-commuting zone level directly because it is reported only on firm-level tax forms. To overcome this challenge, we use the share of wage bill paid in the commuting zone of each firm to allocate value added to commuting zones. For example, if 75 percent of a firm's wage bill is paid in the first commuting zone and 25 percent in the second commuting zone, we allocate 75 percent of value added to the first and 25 percent to the second.

2.2 Observed Differences between Domestic and Foreign Firms

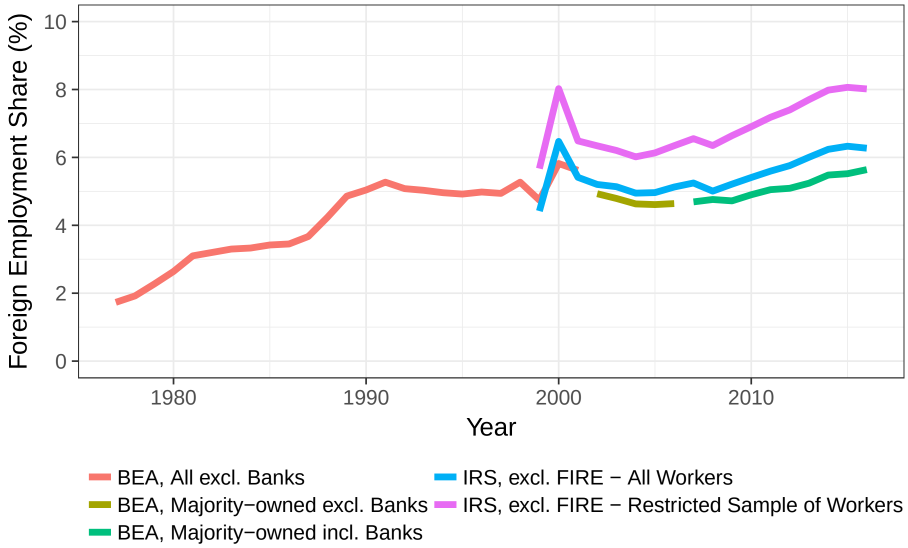
This subsection documents statistical patterns of FDI observed in our data and compares them to the existing literature on FDI in the U.S. (e.g., Flaaen 2014). While we do not consider any of the findings in this subsection to be novel, they serve the purpose of demonstrating that our data matches well established empirical findings from the literature—ensuring that it is representative before we use it to provide novel estimates in the remainder of our paper. Of particular relevance, we find that between 5 and 6 percent of American workers are employed at foreign firms and the average worker at a foreign firm earns 25 percent more than the average worker at a domestic firm, which match the statistics from Bureau of Labor Statistics, U.S. Department of Labor (2019).

First, we validate that the data is representative of the share of workers employed by foreign firms. Figure 1 visualizes the share of American workers employed at foreign firms between 1977 and 2017. It compares three series available from BEA to the series we construct from tax data. Each series follows different sample selection rules, yet during the years of overlap, the series are generally consistent. It shows that the share of employees at foreign-owned firms rose rapidly from 2 percent to 5 percent during the late 1970s and 1980s, remained around 5 percent during the 1990s, and jumped to 6 percent in 2000. It then returned to 5 percent through much of the 2000s, before rising again to 6 percent in the 2010s. By plotting separately the foreign employment share for all workers in the U.S. and those for workers in our restricted sample, we see that foreign firms hire relatively more prime-aged FTE workers.

Second, we examine the number and size of firms. Cross-sectional statistics on the number of foreign firms and the number of firm-location pairs are presented in Appendix Table A1 for the year 2015. We find that 1.1 percent of firms and 4.6 percent of firm-location pairs are foreign. As implied by the share of workers at foreign firms being greater than the share of firms that are foreign, the average foreign firm is much larger than the average domestic firm, with about 28 workers per domestic firm and 172 workers per foreign firm. The fact that foreign firms are larger is consistent with theories of foreign direct investment that emphasize selection of only the most productive firms able to overcome the entry hurdles of establishing a foreign affiliate (see Helpman et al. (2004)). However, foreign firms may be larger simply because they select into industries or regions in which more workers per firm are greater also among domestic firms.

To disentangle industry and region selection from foreign ownership, Figure 2 visualizes the distribution of foreign firm concentration by size after controlling for industry and commuting zone effects. The horizontal axis displays residual firm size—the log of the number of FTE workers per firm-year residuals from a regression on industry-year and commuting zone-year indicators, which has mean zero. The vertical axis displays the fraction of firms

Figure 1: Employment at Foreign-owned Firms

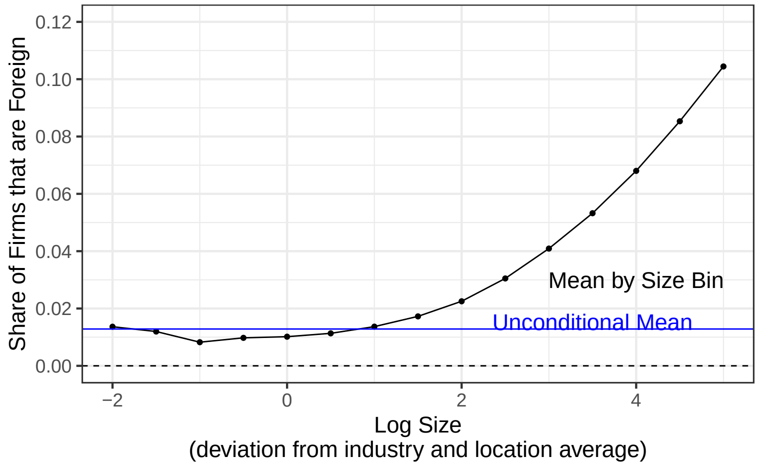


Notes: This figure displays the share of American private sector employees at foreign-owned firms between 1977 and 2017. It compares three series available from BEA to the analysis sample of firms we construct from tax data, both for all workers and for only the workers that satisfy our FTE and other restrictions. Each of the series use different sample selection rules.

within each size bin that are foreign. We plot the share of foreign firms within each log size residual bin (black line), as well as the unconditional share (blue line). Firms are equally weighted when estimating averages within log size bins. When comparing within each size bin, we see that foreign firms comprise less than 2 percent of firms in the distribution when firm size is less than 2 log points above the mean. However, foreign firms comprise more than 10 percent of all firms, conditional on firm size being 5 log points above the mean. This indicates vast over-representation of foreign firms among the largest firms within an industry and region.

Third, we examine differences in wages and value added at foreign and domestic firms. Appendix Table A1 shows that, in 2015, value added per worker was 82,700 USD at domestic firms and 153,100 USD at foreign firms, indicating nearly twice as much value added per worker at foreign firms. When restricting to the analysis sample of workers (i.e., prime-aged FTE workers), which are relatively more concentrated at foreign firms, value added per worker is about 44 percent higher at foreign firms. Furthermore, the average worker in the restricted sample earns 60,700 USD at domestic firms and 75,700 USD at foreign firms, indicating 25 percent higher wages at foreign firms. The findings on larger value added and wages at foreign firms are consistent with evidence presented for the U.S. in much earlier work by Doms and Jensen (1998), Feliciano and Lipsey (1999), and Moran and Oldenski

Figure 2: Share of Firms that are Foreign-owned by Firm Size



Notes: In this figure, the x-axis indicates bins constructed from the log of the number of prime-aged FTE workers per firm-year (log size). The blue line indicates the unconditional fraction of firms that are foreign owned, while the black line indicates the fraction of foreign-owned firms within each log size bin, both presenting equally weighted averages across firms. Log size is residualized on indicators for CZ-year and industry-year, and the x-axis omits the bottom and top 1 percentile tails of the residual log size distribution.

(2013) based on matched BEA FDI survey and the Census of Manufactures data.[12]

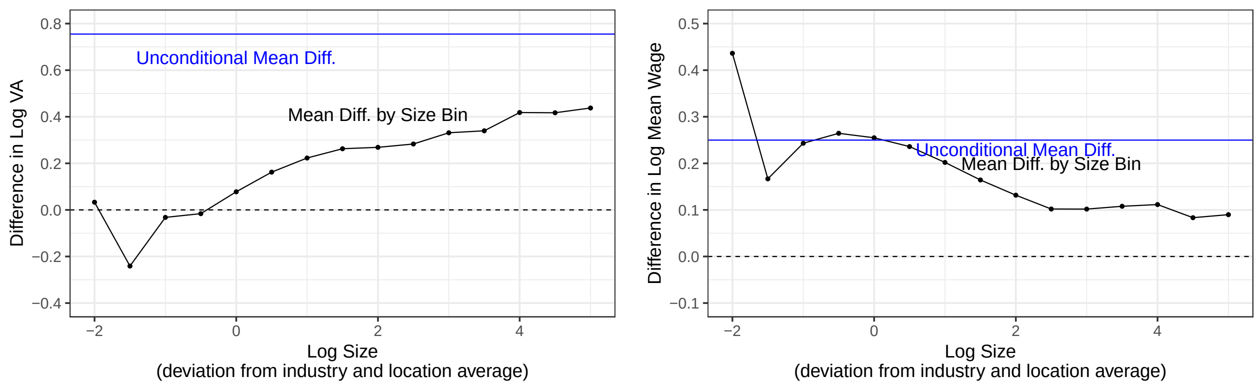
A natural question is whether or not foreign firms produce more value added and pay greater wages than other firms of the same size in the same industry and location. Figure 3 compares log size residuals to log value added residuals (subfigure a) and log mean wage residuals (subfigure b), where residuals are again taken from a regression on industry-year and commuting zone-year indicators. It plots the conditional mean difference within each log size residual bin (black lines), as well as the unconditional mean difference (blue lines). In Figure 3(a), the blue line indicates that value added is 76 percent higher in foreign-owned firms, controlling for industry-year and commuting zone-year, while the black line indicates that this difference for firms *of the same size* ranges from around zero among smaller firms up to around 40 percent among larger firms.[13] In Figure 3(b), the blue line indicates that the mean wage is 26 percent higher in foreign-owned firms, controlling for industry-year and

[12]Weber, Kim, and Mason (2011) find that also U.S.-owned multinational firms pay higher wages in the U.S. than non-multinationals.

[13]While it may at first blush appear counter-intuitive that the unconditional mean difference is greater than any of the conditional mean differences for log value added, this is explained by differences in the share of foreign and domestic firms across the size bins. This phenomenon is known as Simpson's Paradox. To illustrate this with a simple numerical example, suppose that there are two size bins (small and large). Suppose that 10 percent of foreign firms are small while 90 percent of domestic firms are small. Suppose the mean log wage for foreign firms is 12 if small and 11 if large, while the mean log wage for domestic firms is 11 if small and 10 if large. The conditional mean difference at small firms is 1.0 and the conditional mean difference at large firms is 1.0. The unconditional mean difference is (0.9*11 + 0.1*10) - (0.1*10 + 0.9*9) = 1.8. Thus, the average of conditional mean differences is 1.0 while the unconditional mean difference is 1.8.

Figure 3: Differences between Foreign and Domestic Firms

(a) Difference in Mean Log Value Added (b) Difference in Mean Log Earnings



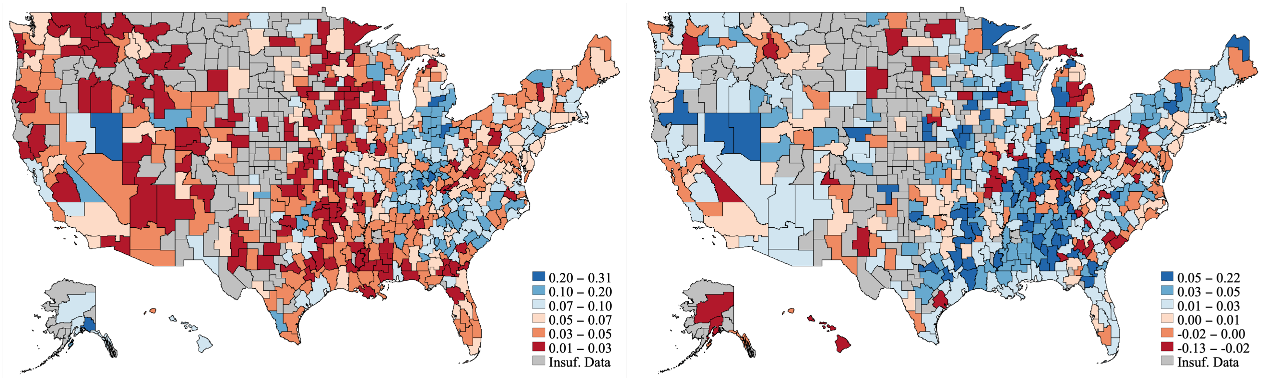
Notes: In this figure, the x-axis indicates bins constructed from the log of the number of prime-aged FTE workers per firm-year (log size). Subfigures (a) and (b) plot the mean differences in log value added and log mean earnings per firm, where firms are equally weighted when estimating averages within log size bins. The blue line indicates the unconditional mean across all firms in the analysis sample. Log size, log value added, and the log mean wage are residualized on indicators for CZ-year and industry-year, and the x-axis omits the bottom and top 1 percentile tails of the residual log size distribution.

commuting zone-year, while the black line indicates that this difference for firms *of the same size* is greater than 10 percent throughout the distribution and above 25 percent around the mean residual firm size. It is interesting that even conditional on size—an endogenous outcome that itself may already reflect higher firm productivity (see Helpman et al. (2004) and Yeaple (2009))—foreign firms have higher value added (except at the smallest firms, where foreign ownership is rare) and earnings per worker. One possible explanation for this finding is that firms obtain valuable inputs from their foreign headquarters. Hence, conditional on their employment size in the U.S., foreign firms are more productive than a domestic firm without the same headquarter input. Another possible explanation is that foreign firms simply hire better workers, which we investigate in Section 4 below.

2.3 The Geographic Concentration of Foreign Employment

Lastly, we discuss an important feature of the data: the spatial concentration of FDI. Our records on the residential addresses of workers employed by foreign firms allow us to pinpoint the geographic locations of the economic activity of foreign multinationals. In this subsection, we will examine two aspects of the spatial distribution. First, we compare the FDI distribution near the beginning of our sample to the FDI distribution near the end of our sample, revealing that FDI was initially concentrated along the East Coast and the Rust Belt, but the growth has been especially concentrated in southern states. Second, we examine the share of FDI within each location that is owned in Asia, Canada, or Europe, revealing that

Figure 4: The Spatial Distribution of Employment at Foreign Firms



(a) Share of employment at foreign firms by commuting zone in 2001

(b) Change in share of employment at foreign firms by commuting zone from 2001 to 2015.

Notes: The two figures display spatial variation in employment at foreign-owned firms observed in the tax data for the workers sample of interest. In the first figure, the share of workers employed at foreign-owned firms is plotted in 2001 for each commuting zone. In the second figure, changes from 2001 to 2015 in the share of employment at foreign-owned firms are plotted by commuting zone.

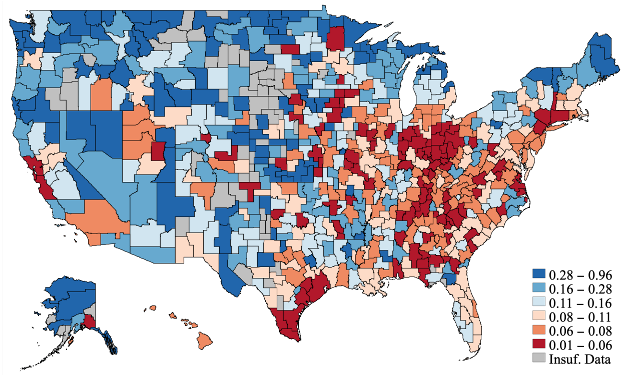
Asian employment is disproportionately concentrated on the West Coast, Canadian employment is disproportionately concentrated on the northern border, and European employment is disproportionately concentrated on the East Coast. While it is not a novel finding that distance to the country of origin of the foreign investor plays a role in the location decision, it is reassuring to confirm this feature in our data. In Section 5, we will leverage both the spatial distribution of FDI growth and the variation in relative concentration by ownership country in order to identify the indirect effects of FDI on local markets.

Figure 4 presents spatial variation in employment at foreign firms observed in the tax data for the analysis sample of prime-aged FTE workers. In Figure 4a, the share of workers employed at foreign firms is plotted in 2001 for each commuting zone. It shows particularly high levels of employment at foreign firms along the East Coast and in Rust Belt cities in Indiana, Michigan, and Ohio, but especially low levels in the South. In Figure 4b, changes from 2001 to 2015 in the share of employment at foreign firms are plotted by commuting zone. There have been substantial changes across the U.S., with Gulf Coast states like Alabama, Louisiana, and Mississippi experiencing especially rapid growth, while parts of the East Coast and the Rust Belt have experienced sharp declines in FDI concentration.

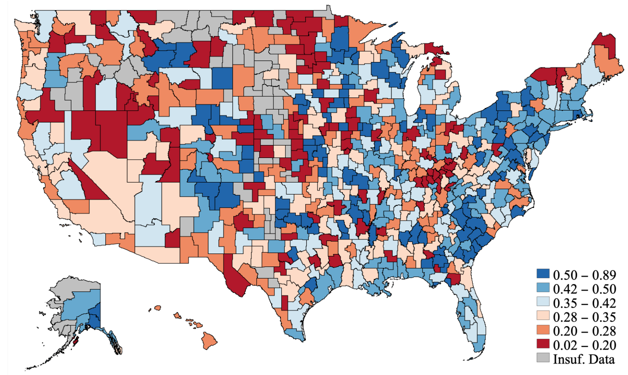
In Figures 5a, 5b, and 5c we display the share of employment at Canadian, Western European, and East Asian firms as a share of total employment at foreign-owned firms by commuting zone, averaging across all of our sample years. A clear visual pattern emerges from the three figures: Canadian firms are more likely to be near the Canadian border, European firms are primarily engaged on the eastern part of the U.S., and Asian firms

Figure 5: Geographic Clustering of Foreign Firms by Country of Origin

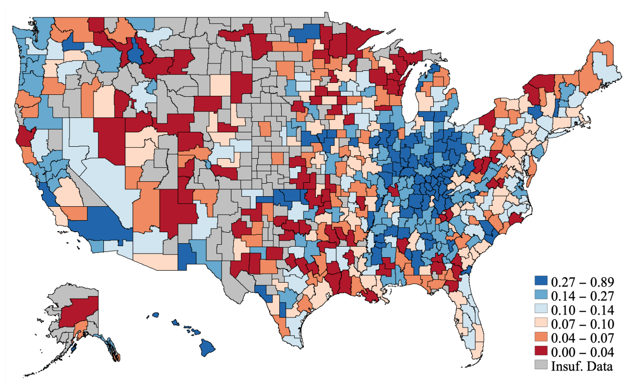
(a) Share of workers at foreign firms that are owned in Canada



(b) Share of workers at foreign firms that are owned in Western Europe



(c) Share of workers at foreign firms that are owned in East Asian



Notes: The figures display spatial variation in the concentration of foreign employment that is at firms owned in particular groups of owner countries.

account for a large share of foreign-owned firms near the West Coast as well as in the Midwest. The maps suggest that distance to the country of origin of the foreign investor plays a role in the location decision. We conclude this section by discussing a number of plausible reasons why firms cluster by nationality and distance to home country matters.

First, the cost of shipping intermediate goods from the home country or the costs of communication between headquarter and subsidiary are positively correlated with distance (Keller and Yeaple, 2013). Communication costs may be reduced by the availability of airline routes to the home country, and places across the U.S. differ with respect to the availability of air travel to the foreign headquarters (Giroud 2013 and Campante and Yanagizawa-Drott 2017). Second, it is well known that foreign firms are more likely to employ employees (in particular, managers) from their country of origin that already had business experience at the firm's headquarters. These employees may prefer to live near other employees of the same country of origin for the same reasons that immigrants cluster by nationality. Relatedly, Burchardi, Chaney, and Hassan (2016) document for the U.S. that foreign investment follows past ancestors' regional choices. Fourth, foreign firms of a particular country of origin may share information, for example, by using similar plant site selection firms that already have business and political contacts in certain regions. Fifth, it is well known that foreign firms from particular countries are specialized in certain industries and that firms cluster by industry (Head et al., 1995). While the first four reasons for clustering by nationality appear to be rather idiosyncratic and reasonably exogenous, the fifth reason for clustering by nationality implies that the instrument could be correlated with other shocks at the industry level. We will come back to this concern when discussing the empirical strategy below.

3 Theory

Before diving into the empirical analysis, we develop a simple model that characterizes direct and indirect effects of foreign multinationals on domestic firms and workers. Following recent work by Card, Cardoso, Heining, and Kline (2018), Lamadon et al. (2019), Berger, Herkenhoff, and Mongey (2019), and others, we assume that workers have idiosyncratic tastes for firms, which gives firms market power in their wage setting. We allow for the possibility of local technology spillovers from foreign to domestic firms and illustrate how spillovers affect the predictions for domestic firm outcomes as the employment at foreign-owned firms in a location rises. We assume there is a large set of locations in the U.S. and focus on the outcomes in one particular location. For simplicity, all regions are trading friction-less within the U.S. Furthermore, workers are assumed to be immobile across locations. There are two types of firms—domestic and foreign—and two types of workers—skilled and unskilled.

Suppose there are M_D domestic firms and M_F foreign firms in a particular location. To simplify notation, we omit the locations subscript and focus on the outcomes at one location. We denote by L_D and L_F the number of workers working at domestic and foreign firms, respectively. The number of workers working at each type of firm will be equilibrium objects. We allow domestic and foreign firms to differ in productivity.

The production function of a firm with nationality $N \in \{D, F\}$ is linear in skilled and unskilled labor:

$$Q(N, l_u, l_s) = \phi_N \left(l_u + \bar{\phi}_{Ns} l_s \right) \tag{1}$$

The nationality of a firm is either domestic, D, or foreign, F. We assume that the production function of foreign firms is more strongly skill-augmenting, i.e., $\bar{\phi}_{Fs} > \bar{\phi}_{Ds} > 1$. Furthermore, foreign firms are, by assumption, more productive than domestic firms, $\phi_F \geq \phi_D$. See Helpman et al. (2004) for a micro-foundation of this pattern resulting from selection combined with larger fixed cost of establishing a foreign rather than a domestic plant. While we take as given the productivity of foreign firms, $\phi_F > 1$, we allow for spillovers of productivity from foreign to domestic firms. The productivity of a domestic firm is given by $\phi_D = 1 + \tau \frac{L_F}{L_D + L_F}(\phi_F - 1)$. The parameter τ, with $0 \leq \tau \leq 1$, governs the degree of spillovers from workers at foreign to domestic firms. The spillovers to domestic firms rise in the fraction of workers in this location that are employed at foreign firms.

3.1 Labor supply

Each region is equipped with a number of potential skilled workers $\bar{L}_s$ and unskilled workers $\bar{L}_u$ that is taken as exogenous. A worker of skill type h has idiosyncratic preferences for which firm to work for and an outside option of home production. Let j denote a firm and i denote a worker with skill type $h(i)$:

$$V_{ij} = \log w_{jh(i)} + \epsilon_{ij}, \tag{2}$$

where human capital type h is either skilled, s, or unskilled, u. We denote the wage of the outside option of not-working at any firm by w_0. Assuming that ϵ_{ij} is distributed i.i.d. type 1 extreme value with dispersion parameter $1/\eta$, the labor supply for firm j is a function of its own wage w_{jh} for worker type h and a composite term that includes the wage offerings of everyone else in the market:

$$L_{jh} = w_{jh}^{\eta} \frac{\bar{L}_h}{W_h}, \quad h \in \{u, s\} \tag{3}$$

with $W_h = \sum_{k=0}^{M_D+M_F} w_{kh}^{\eta}$.

3.2 Labor demand

Each firm produces a homogeneous good that is freely traded. We normalize the price of the output good to 1. We assume the firm exploits the idiosyncratic worker tastes in its labor demand decision. While the firm does not know the tastes of each worker, the firm knows the distribution of tastes and can offer different wages for skilled and unskilled workers. We further assume that there are many firms of its type in its region, so each firm acts monopsonistically competitive, meaning it does not take the effect of its own choice of w_j or l_j on W into account. Given the production function in equation (1) and the labor supply function in (3) a firm with nationality N offers the following wage for workers of each skill type:

$$w_{Nh} = \frac{\eta}{\eta+1}\phi_N\bar{\phi}_{Nh} \quad N \in \{D, F\} \tag{4}$$

where we normalize $\bar{\phi}_{Nh} = 1$ for $h = u$.

3.3 Direct wage effect on workers employed at foreign firms

According to equation (4), a firm sets the wage equal to a constant mark-down of the marginal product of labor at the firm. As skilled workers are more productive, they earn higher wages. As productivity is higher at foreign firms, foreign firms pay higher wages. The *direct effect* of foreign firms on its workers is that they earn higher wages than at a domestic firm. Furthermore, more productive workers will earn dis-proportionally more at foreign firms.

3.4 Indirect effects of an expansion of foreign firms

We next describe the model's predictions for increases in the number of foreign firms, M_F. Here, we focus on the indirect effects, i.e., the outcomes at domestic owned firms. We show in the Appendix that if the initial employment share at foreign owned firms is small and employment is roughly constant during the counterfactual, the model suggests that the following equation approximates the wage effect at domestic owned firms:

$$\log(w_{Dh}^{'}) - \log(w_{Dh}) \approx \tau(\phi_F - 1)\frac{L_F^{'} - L_F}{L_D + L_F} \tag{5}$$

The equation suggests that the wage at domestic firms depends on the change in the employment share at foreign firms, $\frac{L_F^{'} - L_F}{L_D + L_F}$. With technology spillovers (i.e., $\tau > 0$), an increase in the number of foreign firms, M_F, raises L_F and thereby also w_{Du} and w_{Ds}. In the absence of productivity spillovers (i.e., $\tau = 0$), there is no wage increase at domestic firms when the number of foreign firms increases.

A change in foreign firm activity also affects other outcomes at domestic firms. Due to labor market competition effects, the model *without* productivity spillovers implies a *decline* in the output at domestic firms as the activity by foreign firms in a location increases. The effect on output at domestic-owned firms can be positive or negative—depending on other parameters—in the model *with* technology spillovers. While the labor market competition effect from foreign firms lowers output at domestic firms, the technology spillover effect raises output at domestic firms. We derive these model predictions in Appendix B. Overall, the model suggests that the indirect effect of foreign firms on domestic firms can be either positive or negative. The sign of the indirect effect depends, among other parameters, on the technology spillovers parameter, τ.

3.5 Model limitations

Before proceeding to the empirics, we note several limitations of the model. Clearly, the model is highly stylized with only two types of workers and two types of firms. By assuming firms' output is freely tradable, the model abstracts away from product market competition effects associated with foreign firm entry in a commuting zone (see Bloom et al. (2013) for a method of separating product market competition effects from technology spillover effects). Furthermore, the simple model abstracts away from input-output linkages between firms. An improvement in the technology of an upstream sector, however, to the extent that it affects firms locally, would essentially operate analogous to a technology spillover.[14] Finally, the technology spillover is assumed to affect the technology of domestic firms in a factor-neutral way. In the empirical application in the next section, we will relax some of these assumptions.

4 Direct Effects of Foreign Multinationals

We next empirically examine the direct effects of foreign multinationals on workers in the U.S. Our primary goal is to disentangle the extent to which higher wages at foreign owned firms are due to worker quality differences as opposed to foreign firm premiums.

4.1 Foreign Ownership, Firm Premiums, and Worker Quality

In order to empirically distinguish average worker quality in the firm from the firm premium when comparing foreign to domestic firms, we estimate the two-way fixed effects wage regression originally proposed by Abowd, Kramarz, and Margolis (1999):

$$\log w_{i,t} = \psi_{j(i,t)} + x_i + \chi_{i,t}'\beta + \epsilon_{i,t}, \tag{6}$$

where $j(i,t)$ denotes the firm j that employs worker i in year t, ψ denotes the firm premium, x denotes worker quality, and χ denotes a vector of observable determinants of earnings.[15]

Equation (6) is a generalization of the equilibrium wage setting presented in equation (4) to allow for each firm and each worker to have its own productivity. However, it is less general in that it imposes skill-neutrality. To see this, note that in the model, $\log w_{i,t} = \log \frac{\eta}{\eta+1} + \log \phi_{N(j)} + \log \bar{\phi}_{N(j)h(i)}$, where $h(i)$ is the skill level of individual i. This can be

[14]To see this, suppose the production function is $Q^*(N, l_u, l_s, I) = Q(N, l_u, l_s)^\gamma I^{1-\gamma}$, where $Q(N, l_u, l_s)$ is a value added production function as in (1) and I denotes an intermediate input. Then a quality improvement or a cost reduction in the intermediate good, I, affects output and the marginal product of labor analogous to an improvement in productivity, ϕ_N.

[15]Song, Price, Guvenen, Bloom, and von Wachter (2018) and Lamadon et al. (2019) also estimate (6) on the U.S. tax data, but do not examine foreign ownership.

generalized by replacing $\phi_{N(j)}$ with ψ_j so that each firm has its own productivity, by replacing $\log \bar{\phi}_{N(j)h(i)}$ with ϱ_{ij} so that each worker-firm pair has its own productivity, and by adding worker-specific observable wage determinants $\chi'_{i,t}\beta$ and unobservable determinants $\epsilon_{i,t}$ to the log wage equation. Equation (6) imposes $\varrho_{ij} = x_i$, which can be interpreted in our model as imposing that the technology is skill-neutral, i.e., $\bar{\phi}_{N(j)h(i)}$ does not vary with $h(i)$. We relax the skill-neutrality assumption in the next subsection. Identification of this regression requires that workers do not select into firms based on the idiosyncratic time-varying error term $\epsilon_{i,t}$ (see the discussions by Card et al. 2018 and Lamadon et al. 2019). Selection based on the workers effects, firm effects, or observable controls does not violate identification.

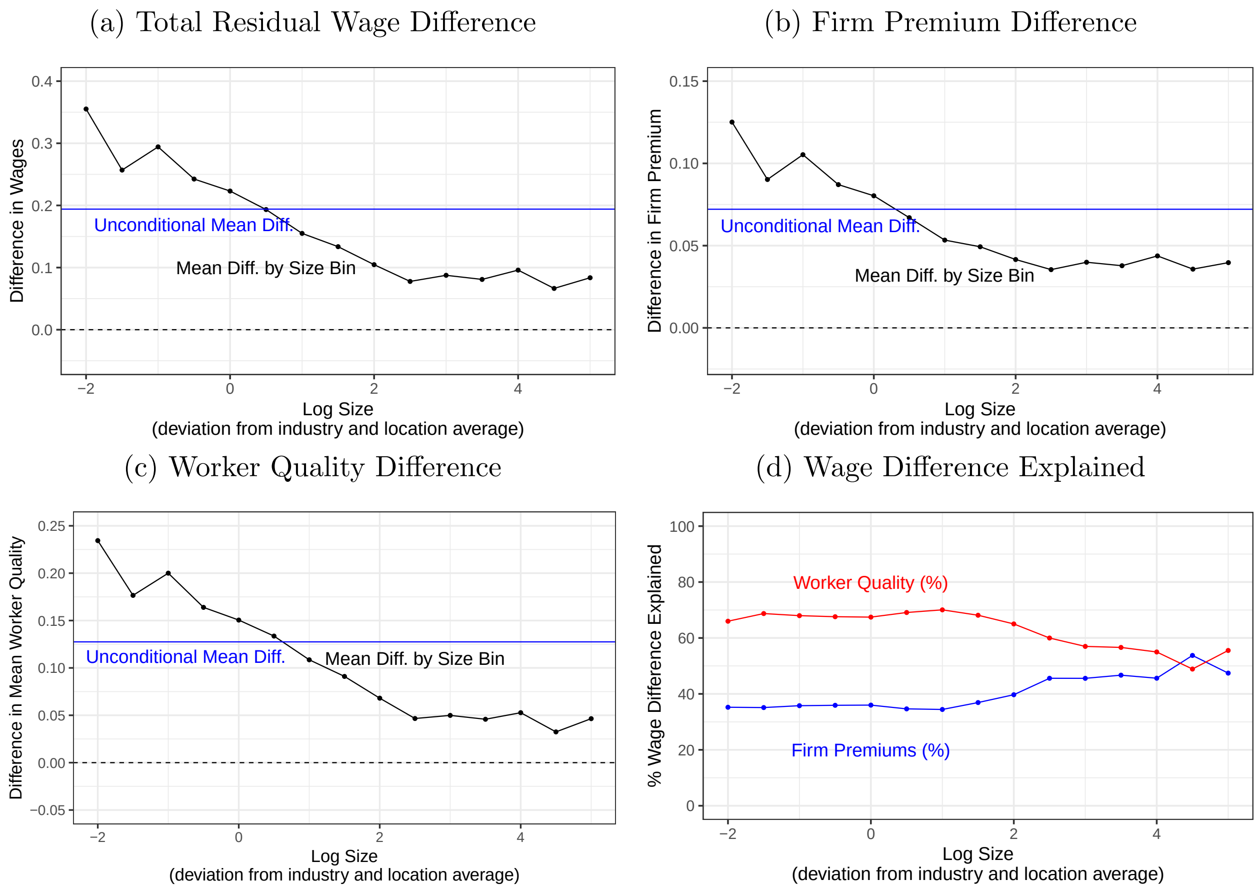
Before estimating the wage equation, we note that *limited mobility* makes it challenging to precisely estimate firm premiums and worker effects (Andrews, Gill, Schank, and Upward, 2008). The earnings changes for workers who are observed at multiple firms ("movers") provides the identifying content on firm premiums, and the bias in those firm premium estimates declines as the number of movers per firm grows. However, the modal firm in the U.S. has *a single mover*, providing the opportunity for massive limited mobility bias in our context. To address this, we follow the approach of Bonhomme, Lamadon, and Manresa (2019) (hereafter, BLM) and estimate a set of grouped-fixed effect models. Instead of obtaining a fixed effect for each firm, we allocate all firms in our data to $k = 10$ clusters ($k = 20$ in a robustness check) with similar wage structures using k-means cluster analysis.[16] These clusters preserve the wage structure while reducing the number of fixed effects that must be estimated. Indeed, we find that 86 (90) percent of all between firm wage variance is captured by only these 10 (20) clusters. Since there is much more mobility between these clusters than between the millions of unique firms, any bias should be mitigated.

In Figure 6, we provide the first estimates of firm premiums and worker quality by foreign ownership for firms in the U.S. The results allow us to distinguish the direct effect of foreign ownership—that is, the difference in the mean firm premium between foreign and domestic firms—from the worker quality composition. Our main specification uses the bias-correction procedure of BLM for 2010-2015 on the largest connected set of firms, with robustness checks presented below.[17] Figure 6(a) presents the total residual wage differential between foreign and domestic firms. It plots the conditional mean within each log size residual bin (black line), as well as the unconditional mean across the population of firms (blue line). We find

[16] Lamadon et al. (2019) are the first to provide bias-corrected estimates of firm premiums and sorting for the U.S. Using the BLM bias correction with $k = 10$ clusters, they document that the variance of firm premiums is inflated by a factor of about three when ignoring limited mobility bias, while the correlation between worker quality and firm premiums is deflated by a factor of about four. They find that the results are nearly identical when considering $k = 20, 30, 40, 50$ clusters. They find similar results when using the bias-correction procedure of Kline, Saggio, and Sølvsten (2018).

[17] Equation (6) is typically estimated on short time intervals, as fixed effects are a worse approximation to the wage structure over a longer period of time (see the discussion by Lamadon et al. 2019).

Figure 6: Foreign Ownership, Firm Premiums, and Worker Quality



Notes: This figure presents estimates of equation (6) from the BLM bias-correction procedure with $k = 10$ clusters during 2010-2015. The observable determinants of earnings are a cubic polynomial in worker's age and indicators for CZ-year and industry-year, so firm premiums and worker quality do not reflect differences due to location or industry selection.

that the foreign residual wage differential is about 19 percent on average when controlling for location-year, industry-year, and worker covariates, and the differential is declining in size, so that large foreign and domestic firms are more similar in mean wages than small foreign and domestic firms.

Figure 6(b) presents the main estimates of firm premium differences across the firm size distribution. The blue line indicates that the mean firm premium is 7.2 percent greater at foreign than domestic firms, while the black line indicates that this difference for firms *of the same size* is more than 12 percent at smaller firms and as low as 4 percent at larger firms. To put these estimates in context, Lamadon et al. (2019) find that the standard deviation of firm premiums in the national population is about 12 percent. By contrast, Appendix Figure A.2 demonstrates that we would find a *negative* foreign firm premium if we did not correct for limited mobility bias when estimating the wage model, indicating that limited mobility bias is an empirically important consideration when measuring the direct effects of foreign firms.

Figure 6(c) presents the estimates of worker quality differences. We find that foreign firms on average employ workers of 12.7 percent greater quality. The differences are more pronounced among smaller firms than larger firms, though average worker quality is higher at foreign than domestic firms throughout the distribution. Finally, Figure 6(d) quantifies the relative contribution of firm premiums and worker quality composition in explaining the total wage differential between foreign and domestic firms. While we find little variation across the size distribution, with around 60 percent due to worker quality and 40 percent due to firm premiums, firm premiums explain a greater share of the wage differential in larger firms, in which the wage differential is smaller.

4.2 Evidence on Skill-augmenting Technology at Foreign Firms

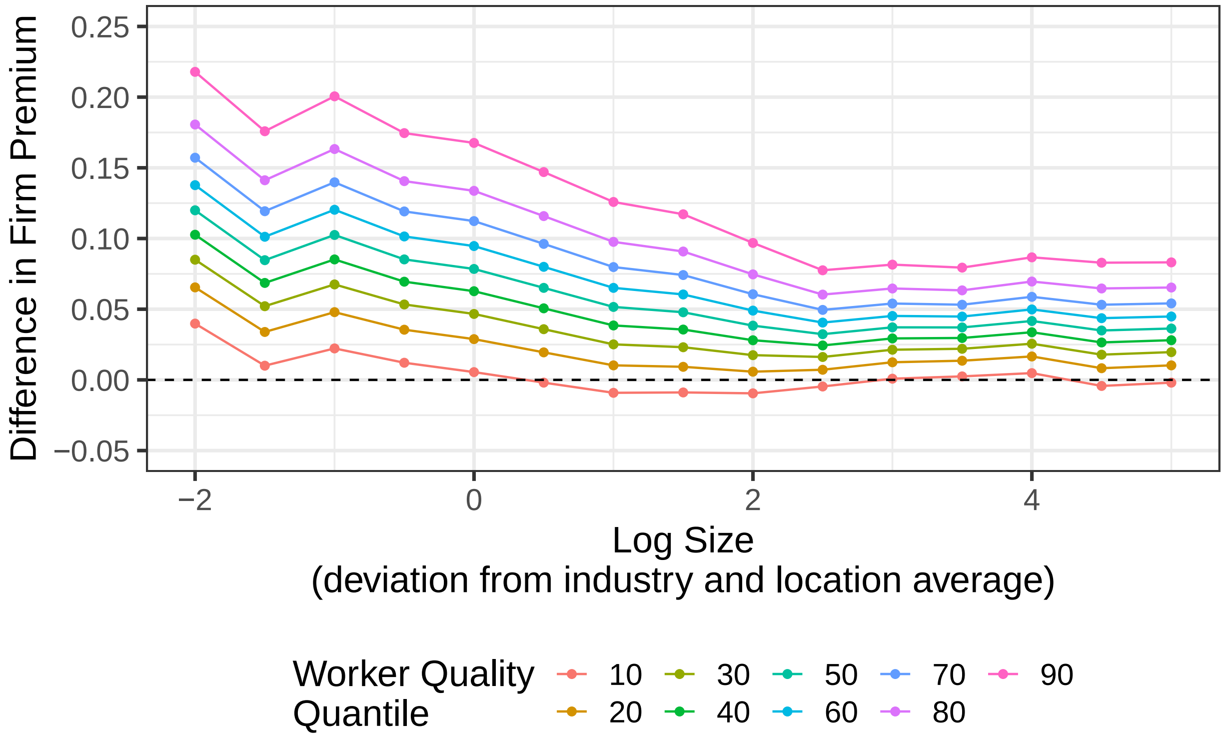
We now consider relaxing the skill-neutrality assumption implicitly made earlier in equation (6). BLM suggest and provide a bias-correction procedure for the following wage model:

$$\log w_{i,t} = \psi_{j(i,t)} + \theta_j x_i + \chi'_{i,t}\beta + \epsilon_{i,t}, \tag{7}$$

where θ_j may be correlated with ψ_j and x_i. This replaces the term $\log \bar{\phi}_{N(j)h(i)}$ from the wage setting model (4) with $\varrho_{ij} = \theta_j x_i$. It yields (6) as a special case when $\theta_j = 1$. If the technology is skill-augmenting, with the strength of skill augmentation varying across firms as in our model of foreign and domestic firms, then the equation (6) estimates of firm premiums and worker quality may be biased by not accounting for the correlated unobservable θ_j. In Appendix Figure A.3, we provide estimates from equation (7) of firm premiums for a worker of average quality as well as mean worker quality differences by foreign ownership when accounting for skill-augmenting technology. We find nearly identical estimates to those from equation (6), so it seems this equation provides a good approximation on average.

Figure 7 presents the mean difference in firm premiums between foreign and domestic firms for workers who have above average and below average quality using the estimated parameters from equation (7), finding substantial differences. For a worker at the 10th percentile of the skill distribution, the wage gain when moving from the average domestic firm to the average foreign firm is less than 5 percent if the firms are small and about 0 percent if the firms are large. By contrast, a worker at the 90th percentile of the skill distribution experiences about a 20 percent wage gain when moving from the average domestic to the average foreign firm if the firms are small and a 8 percent wage gain if the firms are large. We conclude that there is little to no direct effect of foreign employment on low-skilled workers but large positive effects on high-skilled workers. This evidence is consistent with

Figure 7: Firm Premiums with Firm-Worker Interactions



Notes: This figure presents estimates of the model in equation (7) from the BLM bias-correction procedure with $k = 10$ clusters during 2010-2015 when allowing for firm-worker interactions. The observable determinants of earnings are a cubic polynomial in worker's age and indicators for CZ-year and industry-year, so firm premiums and worker quality do not reflect differences due to location or industry selection.

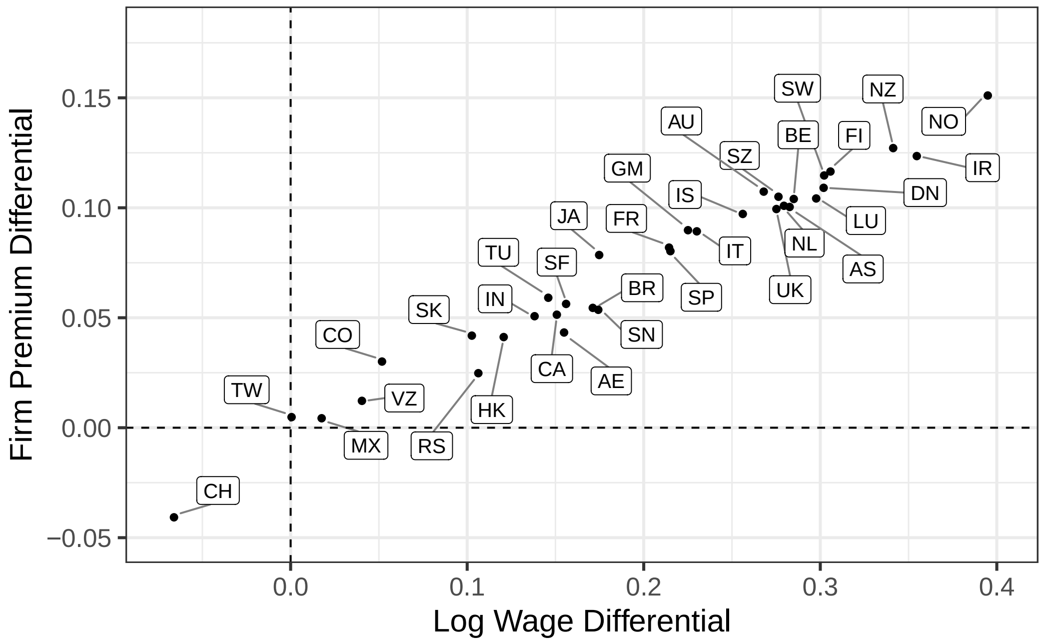
our model, in which we assumed that foreign firms have stronger skill-augmentation than domestic firms. To our knowledge, we are the first to estimate differences in skill-augmenting technology between foreign and domestic firms in the U.S.

4.3 Heterogeneity by Country of Ownership

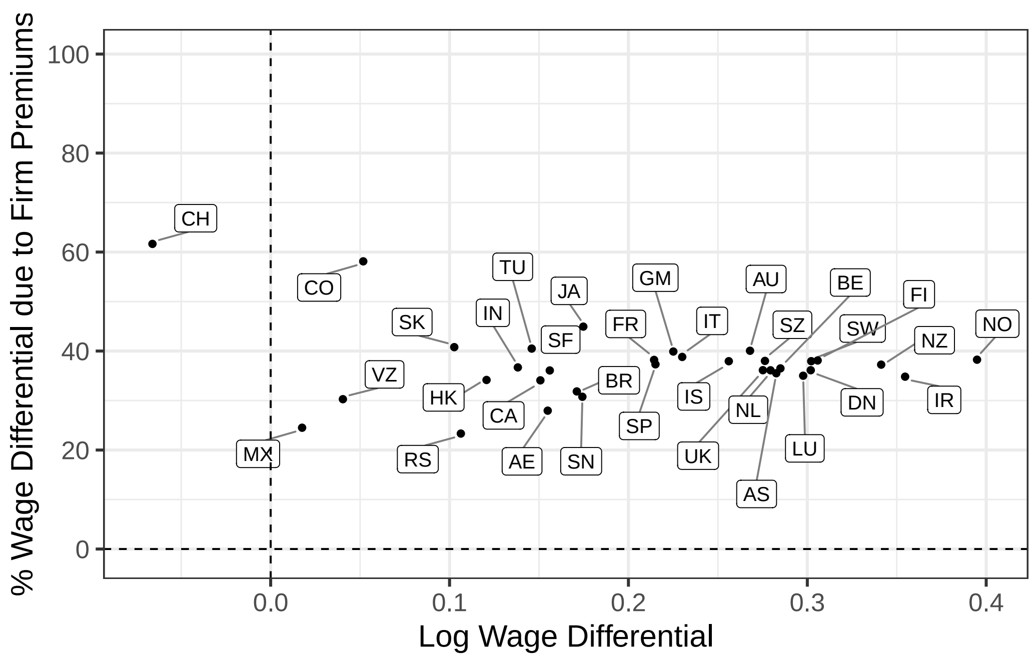
Up to this point, we have grouped together all countries of ownership, but one may wonder how firms from different ownership countries differ in their direct effects on workers and skill-intensities of employment. Using our estimates, we now document wage differentials, firm premiums, and worker quality differences by country of foreign ownership. The results are presented in Figure 8, where the x-axis is the total wage differential, the y-axis in subfigure 8a is the average firm premium differential, and the y-axis in subfigure 8b is the share of the wage differential explained by the firm premium differential. It presents estimates for the 40 countries with the most firms represented in the 2010-2015 connected set, omitting the 6 large tax havens (e.g., Cayman Islands), as it is difficult to interpret direct effects of tax

Figure 8: Country-specific Wage Differentials and Firm Premiums

(a) Firm Premiums



(b) Share of Wage Differential Explained by Firm Premiums



Notes: This figure presents estimates of equation (6) from the BLM bias-correction procedure with 10 clusters during 2010-2015. The observable determinants of earnings are a cubic polynomial in worker's age and indicators for CZ-year and industry-year, so firm premiums and worker quality do not reflect differences due to location or industry selection.

shelter ownership on workers. Recall that the estimates are residualized on industry-year and location-year fixed effects, so the differentials are not due to the concentration of certain country's economic activity in specific industries or regions.

We find substantial heterogeneity across countries. The Northern European countries of Norway, Finland, Sweden, and Denmark, as well as Ireland, and New Zealand have large firm premiums, above 11 percent for the average firm. Western and Southern European countries such as Austria, France, Germany, Italy, Spain, Switzerland, and the U.K. are joined by Australia, Israel, and Japan with firm premiums above 7 percent (approximately the overall average) but less than 11 percent. Countries with below average firm premiums, but still above 3 percent, include Brazil, Canada, Hong Kong, India, South Africa, South Korea, and Turkey. Small positive firm premiums are estimated for Colombia, Mexico, Russia, Taiwan, and Venezuela, while a *negative* 4 percent premium is estimated for China. The share of the wage differential explained by firm premiums is approximately the same across all countries at almost 40 percent.

There are many possible reasons for average firm premiums to vary by country. As the cost of entry increases, we expect the average firm premium of firms that enter to increase (see Helpman et al. 2004). This may explain why many of the countries in the Americas, such as Mexico and Canada, have relatively low premiums. Egger, Jahn, and Kreickemeier (2018) find a pattern of foreign firm wage premia that increase in distance to the headquarter country in Germany. Another possibility is that firms anchor their wages to headquarter levels as suggested by Hjort et al. (2019), which may explain the large firm wage premium estimated for Norwegian firms in the U.S. Finally, it could be that countries with access to greater technology have more productive firms, which could explain why firms from higher-GDP-per-capita countries tend to also have higher firm premiums. Indeed, regressing the firm premium on log distance from the U.S. and log GDP per capita yields a statistically insignificant coefficient of 0.009 on log distance and a highly statistically significant coefficient of 0.031 on log GDP per capita ($R^2 = 0.49$), suggesting that GDP per capita is more important than distance in explaining heterogeneity in the firm premium by country of ownership.

4.4 Robustness of the Direct Effect Estimates

We conduct five robustness checks to our foreign firm wage premium estimates. The first, discussed above, was to allow for firm-worker interactions. We find nearly identical average estimates to baseline when accounting for interactions. Second, the BLM bias correction procedure we used in estimating equation (6) requires one to specify the number of clusters in which to group firms using the k-means algorithm in the first stage of the estimation. Appendix Figure A.4 demonstrates that the results are nearly identical when allowing for

$k = 20$ clusters rather than $k = 10$. Third, we find that the results are robust to controlling for a third-order polynomial in log firm size, with a mean foreign firm premium estimate of 6.3 percent. Fourth, Appendix Figure A.5 demonstrates that the results are nearly the same when performing the estimation for the 2001-2006 sample rather than the 2010-2015 sample considered above. Fifth, below we use an event study design for measuring the foreign firm wage premium.

4.4.1 Event Study Estimates of the Average Firm Premium

As an alternate to the model in equation (6), we examine wage growth of workers depending on whether they stay at the same type of firm or switch, controlling for location-year and industry-year effects of both the initial firm and the new firm. Here, we allow for asymmetric wage changes between workers that move from domestic and foreign firms and those that move the other way. However, as in the theory, domestic and foreign are the only firm types. By looking at within-worker differences in wages, we remove the worker-specific time-invariant wage level. To implement this design, we define the following indicator variables:

$M_{i,t,DF}$: worker i moving from a domestic firm in $t-1$ to a foreign firm in t;
$M_{i,t,FD}$: worker i moving from a foreign firm in $t-1$ to a domestic firm in t;
$M_{i,t,DD}$: worker i moving from a domestic firm in $t-1$ to a domestic firm in t;
$M_{i,t,FF}$: worker i moving from a foreign firm in $t-1$ to a foreign firm in t;
$S_{i,t,F}$: worker i staying at the same foreign firm in $t-1$ and t.

Equipped with these indicator variables summarizing the workers job transition status, we estimate the following regression model:

$$\begin{aligned}\log w_{i,t} - \log w_{i,t-1} = {} & \beta_{FF} M_{i,t,FF} + \beta_{FD} M_{i,t,FD} + \beta_{DF} M_{i,t,DF} + \beta_{DD} M_{i,t,DD} \\ & + \beta_{SF} S_{i,t,F} + \mu_{cz(i),t} + \nu_{ind(i),t} + \tilde{\mu}_{cz(i),t-1} + \tilde{\nu}_{ind(i),t-1} + \epsilon_{i,t}. \quad (8)\end{aligned}$$

The controls consist of the industry-year fixed effects (both for the industry in year t and in year $t-1$), commuting-zone-year fixed effects (both for the commuting zone in year t and in year $t-1$), and a polynomial in age (to remove age-related wage growth). All of the parameters affecting wage growth are defined relative to staying at a domestic firm.

The results are displayed in Table 1. In the regression analysis, we first examine the immediate impact on wages by treating the outcome as the difference between the log wage at t (for movers, the first year at the new firm) and $t-1$ (for movers, the final year at the previous firm). We find that moving from a domestic to a foreign firm is associated with about a 5 percent increase in wages (relative to wage growth for workers who stay at the

Table 1: Robustness of Average Firm Premium Estimate: Event Study Approach

Outcome:		Shorter-term Wage Growth $\log(w_t) - \log(w_{t-1})$	Longer-term Wage Growth $\log(w_{t+1}) - \log(w_{t-2})$
Domestic to Foreign Moves:	**N =364,732**	**0.045*****	**0.073*****
		(0.002)	(0.003)
Foreign to Domestic Moves:	**N =265,566**	**-0.042*****	**-0.035*****
		(0.002)	(0.002)
Domestic to Domestic Moves:	N =12,485,029	0.005***	0.012***
		(0.001)	(0.001)
Foreign to Foreign Moves:	N =275,301	0.014***	0.031***
		(0.004)	(0.003)
Stayers at Foreign Firms:	N =4,661,673	-0.001	0.000
		(0.001)	(0.001)
Stayers at Domestic Firms:	N =58,780,343	(Omitted Category)	(Omitted Category)

Notes: Standard errors in parentheses. The controls consist of the industry-year fixed effects (both for the industry in year t and in year $t-1$), CZ-year fixed effects (both for the commuting zone in year t and in year $t-1$), and a polynomial in age (to remove age-related wage growth). All standard errors are clustered at the CZ-year level. The sample includes all worker spells of 4 consecutive years of FTE employment in which the worker does not change jobs in the first or last year of the spell. N refers to the number of unique worker spells.

same domestic firm), while 4 percent decrease in wages is associated with moving from a foreign to a domestic firm (either could be interpreted as an estimate of the average foreign firm premium).[18] Appendix Figure A.6 provides suggestive visual evidence that the effects are not driven by pre-trends for those moving to or from foreign firms.

Next, we note that for movers, the end date of previous employment and start date of new employment is not observed, which is likely to create noise when measuring wage changes so close to the move (e.g., some workers may experience periods of unemployment between jobs). To avoid measuring wages during the transition period, we also present estimates for the wage change when comparing wages in the second year of the new job, $t+1$, to wages in the next to final year of the old job, $t-2$. We see that moving from a domestic to a foreign firm is associated with about a 7 percent increase in wages, and moving from a foreign to a domestic firm is associated with about a 4 percent decrease in wages. Together, the evidence from the movers event study suggests average foreign firm premiums are between 4 and 7 percent depending on which type of move is considered, which is not too different from our baseline estimate of 7 percent when accounting for firm heterogeneity.

[18]Similar results for job movers are found by Martins and Esteves (2008) in Brazil.

4.5 Understanding the Mechanisms behind the Foreign Firm Premium

4.5.1 Productivity or Other Sources of Compensation Differences?

Our theoretical model suggests that workers at foreign firms earn higher wages because foreign firms are more productive. We conclude this section with a brief discussion of three alternative explanations for a foreign wage premium. First, it could be that workers at foreign firms simply work longer hours. While the tax data does not include information about hourly wages, according to survey data by Bureau of Labor Statistics, U.S. Department of Labor (2019), foreign firms pay 20 percent more than domestic firms even for workers in production occupations for which the reported wages should be primarily at the hourly wage instead of the annual salary level.[19] We therefore think it is unlikely that hours worked are the main driver of the foreign firm wage premium. Second, foreign firms may be perceived as more risky employers, as existing research has found (domestic) multinationals to be at greater risk of shutting down plants than non-multinational firms of similar size (Bernard and Jensen 2007). However, plant shutdowns account only for a small fraction of overall job separations. We find that the probability of staying at the same employer next year is actually higher for workers at foreign firms than for workers at domestic firms. Therefore, the risk of job separation appears to be lower at foreign firms. Finally, it could be that foreign firms have lower amenities than domestic firms. We have not been able to find systematic data on this claim. Plenty of anecdotes, however, suggest that foreign firms tend to be attractive employers overall. Examining the 20 employers ranked as having the "Top 20 Employee Benefits and Perks for 2017" in the U.S. by Glassdoor, we see that 5 (25 percent) are foreign-owned.[20]

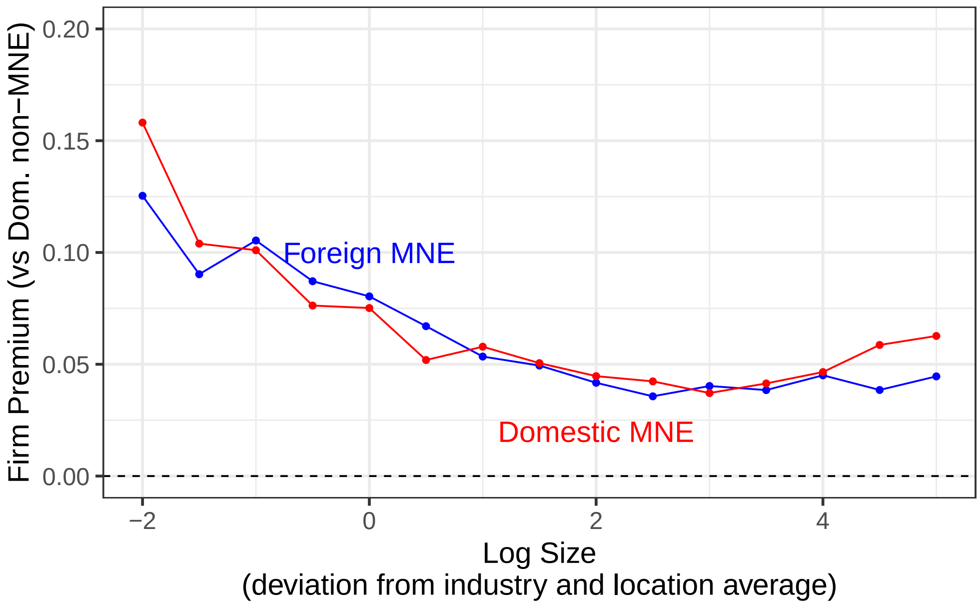
4.5.2 Foreign Ownership or Multinational Status?

Our evidence is consistent with foreign firms having greater productivity, which drives greater firm premiums. We now ask, is the mean foreign firm premium explained by foreign ownership status or belonging to a multinational network? In order to answer this question, we define a domestic firm as multinational if it pays a non-zero foreign business tax, then compare the mean firm premiums for foreign multinationals, domestic multinationals, and domestic non-multinationals. The results are displayed in Figure 9. We find that the mean firm premium differential for foreign and domestic multinationals of the same size is nearly

[19]According to the Current Population Survey, 80 percent of workers in production occupations receive hourly wages as opposed to a fixed annual salary. The instructions for the Occupational Employment Report ask to report part-time worker wages on an hourly basis and for salaried workers, who do not work a standard 2080 hours per year (40 hours per week), to also report wages on an hourly basis.

[20]Https://www.glassdoor.com/blog/top-20-employee-benefits-perks-for-2017/ (accessed July 12, 2019).

Figure 9: Firm Premiums for Foreign and Domestic Multinationals



Notes: This figure presents estimates of the model in equation (6) from the BLM bias-correction procedure with k = 10 clusters during 2010-2015. We define a domestic firm as multinational if it pays a non-zero foreign business tax. The estimates displayed are mean differences relative to domestic non-multinationals for foreign multinationals (blue) and domestic multinationals (red).

identical, where the differential is defined relative to the mean firm premium of domestic non-multinationals. This suggests that it is belonging to a multinational network rather than being owned in a foreign country *per se* that is associated with greater productivity. It also suggests a nuanced interpretation of the estimated heterogeneity by country of ownership in Subsection 4.3: belonging to a multinational network that includes high GDP countries, rather than being owned in a high GDP country *per se*, may explain why high GDP per capita country of ownership is associated with a greater foreign firm premium. However, our data does not indicate the country of foreign business activity associated with the foreign tax, so we cannot examine heterogeneity by countries in the network of domestic multinationals.

5 Indirect Effects of Foreign Multinationals

As discussed in theory section, in addition to directly affecting the wages of their workers, foreign multinationals may also affect domestic firms indirectly. The theory suggests that these effects can be positive or negative.

5.1 Empirical Strategy to Estimate Indirect Effects

In this section, we seek to measure the indirect effects of employment growth at foreign-owned firms on outcomes at domestic firms. Using a similar functional form as in equation (5), we consider the following regression equation:

$$\log y_{j,t} - \log y_{j,t-1} = \beta m_{cz(j),t} + \gamma' K_{j,t} + \epsilon_{j,t}, \tag{9}$$

where j is the firm; y is its outcome on a measure such as value added or wage bill; $cz(j)$ is its commuting zone; $m_{cz,t}$ denotes the *growth* in the employment share by foreign-owned firms in that commuting zone; and $K_{j,t}$ is a vector of controls such as industry-year indicators, CZ indicators, and a polynomial in $t-1$ firm size. The parameter of interest is β, which is the *indirect effect*.

Identifying β is challenging for at least two reasons. First, there is a classic selection issue with foreign-owned firm activity by commuting zone. Foreign-owned firms may choose to hire in regions in which wages are already set to grow. For example, the foreign-owned firm may be aware of new regional investments in production infrastructure or education and increase hiring in this region to benefit from the infrastructure or workforce improvements. Then, a naive regression of earnings growth on employment growth at foreign-owned firms would overstate the impact of foreign-owned firm activity. Conversely, foreign-owned firms may choose to hire in regions in which wages are already set to decline. For example, the foreign-owned firm may be aware that wages or intermediate goods prices are set to decline in this region, possibly because a large existing employer plans to layoff its workforce, so the foreign-owned firm may increase activity to take advantage of falling prices. This case is further confounded by the importance of local tax incentives, which are estimated to be large in the U.S. and may be targeted especially towards attracting foreign-owned firms into declining regions (see the discussion by Greenstone et al. 2010). Then, a naive regression of earnings growth on employment growth at foreign-owned firms would understate the impact of foreign-owned firm activity.

Second, we may be mismeasuring growth in the employment share of foreign firms in the commuting zone, $m_{cz,t}$. As discussed in the data section, we expect there to be some measurement error in the linkages between the parent and its subsidiaries and how these change over time.

In order to overcome these identification challenges, we adapt the identification strategy common in the literature about the effects of immigration on non-immigrants in the same region (Card, 2001). This literature uses the fact that immigrants cluster into regions in the U.S. based on country of origin. To adapt this instrument to identify the effects of foreign-owned firm activity on workers, we first notice that employment at foreign-owned firms tends to be clustered by region and country of origin (see Sec 2.3). For example, German-owned firms disproportionately employ workers in South Carolina in 2010 if they do so in 2005. This is analogous to the clustering of immigrants into regions.

We construct the instrument as the predicted change in employment at, for example, German-owned firms in South Carolina between 2009 and 2010 using only information about (i) the share of workers at German-owned firms in South Carolina in 2005 and (ii) the change in aggregate employment by German-owned firms in *any other* region in the US between 2009 and 2010. Since this instrument is not formed using information about the change in employment by German-owned firms in South Carolina between 2009 and 2010, it does not depend directly on changes in South Carolina's business climate between 2009 and 2010. In particular, it does not depend directly on infrastructure investments, improved educational opportunities, or changes in the generosity of tax incentives in South Carolina between 2009 and 2010, so it does not depend directly on the confounding factors discussed above.

To formalize the approach, relative foreign-owned firm employment growth in the commuting zone, $m_{cz,t}$, is defined by,

$$m_{cz,t} \equiv \frac{L^F_{cz,t} - L^F_{cz,t-1}}{L^F_{cz,t-1} + L^D_{cz,t-1}} \tag{10}$$

where $L^F_{cz,t}$ and $L^D_{cz,t}$ are the number of employees at foreign- and domestic-owned firms in commuting zone cz and year t, respectively. The parameter of interest is the effect of a change in the regional share of employment at foreign-owned firms, $X_{cz,t}$, on the change in an outcome, such as the earnings growth of a worker at a domestic firm in the region.

In order to form the instrument, we use the tax data on the firm's country of foreign ownership to construct the share $S^o_{cz,t}$ of all employment in commuting zone cz at firms whose owners are located in origin country o, defined by,

$$S^o_{cz,t} \equiv \frac{L^{F_o}_{cz,t}}{\sum_{cz'} L^{F_o}_{cz',t}} \tag{11}$$

Analogous to Card (2001) and the subsequent immigration literature, we then construct the instrumental variable $Z_{cz,t}$ as,

$$Z_{cz,t} = \frac{\sum_o (\sum_{cz' \neq cz} L^{F_o}_{cz',t} - L^{F_o}_{cz',t-1}) S^o_{cz,t-5}}{L^F_{cz,t-5} + L^D_{cz,t-5}} \tag{12}$$

This is interpreted as the prediction of $m_{cz,t}$, formed only from the share of employment by firms from country o in cz dated at $t-5$ and the change in aggregate employment by o in the US from $t-1$ to t. Note that we modify the approach from the immigration literature slightly by leaving out own-commuting-zone employment when constructing the aggregate change from $t-1$ to t, which helps to rule out confounding factors. The denominator is the total number of FTE workers in the commuting zone 5 years ago. Because $Z_{cz,t}$ is not a function of cz-specific changes between $t-1$ and t, it should satisfy that $Z_{cz,t}$ and the unexplained component of wage growth are orthogonal (conditional on observed covariates that explain wage growth). However, we see three major threats to identification, which we discuss below.

First, the instrument includes the past share of employment at foreign-owned firms from various origin countries, as well as the contemporaneous change in the employment at such firms in other regions. This raises the concern that there may be regional shocks that are correlated with our instrument. For example, regions near the Canadian border may be affected also by trade shocks originating in Canada that are correlated with the instrument. To deal with this concern, we include Census Division-year fixed effects in the regressions, which absorb all contemporaneous effects at the regional level.

Second, recent work by Jaeger, Ruist, and Stuhler (2018) suggests that, in the context of immigration, the past share of immigrants could have a direct effect on contemporaneous outcomes if the adjustment to former immigrant waves is delayed. The analogous concern in our setting is that adjustment to past investment by foreign-owned firms is ongoing. Since our instrument leverages variation in the country of origin of foreign-owned firm investment across commuting zones, we can include as a control variable the share of past employment at foreign-owned firms (not separated by country of origin) in the commuting zone. We provide robustness results to our main regressions when also including the share of employment at foreign-owned firms in $t-5$ as a control variable. We find that our main results are quantitatively robust to adding this control.

The third threat to identification is that industry shocks may be correlated with the instrument. For example, German- or Japanese-owned firms may be more likely to be in the car industry and select commuting zones that are also abundant with other car industry firms. To deal with this concern, we also include fine industry-year fixed effects that absorb any contemporaneous nation-wide growth trends by industry.

Before proceeding to the results, note that by including CZ-fixed effects in our differenced specification, we control for a CZ-specific linear time trend in the outcome variable. By including a polynomial in size in the differenced specification, we allow for trends based on number of employees at the firm.

5.2 Estimates of Indirect Effects on Local Labor Markets

We next discuss our estimates of indirect effects. The instrument and endogenous variable are constructed from information on both foreign and domestic firms, while the sample in the regression includes only continuing domestic firms. We focus on wage bill, value-added, and employment effects at domestic firms, and the sample size may vary across outcomes. (For example, value added can be negative, in which case log value added is not defined.) All standard errors are clustered at the CZ-year level, which is also the level at which our instrument varies. All observations in the firm-level regressions are weighted by the number of FTE workers in $t-1$.

The full sample results are presented in the first column of Table 2. The first-stage coefficient is 0.60 with F-statistic close to 300. This implies that the origin-country-specific initial shares of foreign employment in the region interacted with contemporaneous growth in aggregate employment by origin country provides a strong predictor of contemporaneous relative FDI growth in the region.

Using the instrument, we estimate that a 1 percentage point increase in the share of employment at foreign firms in the region increases the value added, employment, and wage bill at domestic firms by 0.64 percent, 0.45 percent, and 0.47 percent, respectively. These estimates are statistically significant. Appendix Table A2 compares these estimates to what we would obtain using OLS, with and without our rich set of controls. We see that OLS is downward-biased, though the downward bias is not as strong when including the controls. As we discussed in the previous section, one reason for the IV estimate to be larger than the OLS estimate is measurement error in $X_{cz,t}$; another reason is the selection of foreign investment into declining regions induced, for example, by tax incentives or declining prices.

Next, we consider heterogeneity in the effects across firm types using the same empirical specification but applied to various subsamples. Columns 2-4 of Table 2 explore heterogeneity in the indirect estimates for three size groups, using the number of FTE workers measured at time $t-1$. Columns 5-6 consider heterogeneity in the effect on tradable versus nontradable industries, using the classification of Mian and Sufi (2014). We then repeat the regression in 9 for each of these groups of firms. We find statistically significant indirect effects on value added for firms in the 10-99 and 100+ FTE workers size groups and in the tradable sector. The effects are much larger among large firms and firms in the tradable sector. We estimate that a 1 percentage point increase in the share of employment at foreign firms in the region increases value added by 1.7 at firms with at least 100 workers and 3.4 percent at firms in the tradable sector. By contrast, the point estimate is small and insignificant for firms with fewer than 10 workers and firms in the non-tradable sector. The patterns are similar for FTE employment and wage bill.[21]

Next, we examine indirect effects on wages. To do so, we perform a worker-level regression for continuing workers in the same domestic firm and commuting zone. We use a within-worker differenced specification to remove both worker fixed effects and firm fixed effects.

[21]Iacovone, Javorcik, Keller, and Tybout (2015) find qualitatively similar differences of the effects of FDI growth on domestic firms by firm size. They find negative effects from Walmart's entry into Mexico on small Mexican suppliers of retailers and positive effects on large suppliers.

Table 2: Indirect Effect Estimates: Results by Firm Type

	Full Sample	By Firm Size			By Sector	
		Size 1-9	Size 10-99	Size 100+	Tradables	Non-tradables
Panel A.	**Outcome: Log Value Added**					
2SLS Indirect Effect	**0.64****	**0.11**	**0.42*****	**1.66***	**3.37***	**0.31**
	(0.27)	(0.08)	(0.15)	(0.99)	(1.98)	(0.19)
First Stage Coefficient	0.60***	0.63***	0.59***	0.53***	0.56***	0.52***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
First Stage F-statistic	299	431	292	147	169	197
Firm Observations (Millions)	41.7	34.9	6.3	0.5	3.9	5.9
Panel B.	**Outcome: Log Full-time Workers**					
2SLS Indirect Effect	**0.45*****	**0.08**	**0.39*****	**1.23*****	**0.89****	**0.54*****
	(0.12)	(0.06)	(0.14)	(0.43)	(0.38)	(0.20)
First Stage Coefficient	0.60***	0.63***	0.58***	0.53***	0.56***	0.52***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
First Stage F-statistic	297	434	292	151	171	192
Firm Observations (Millions)	45.9	38.3	7.0	0.5	4.2	6.2
Panel C.	**Outcome: Log Wage Bill**					
2SLS Indirect Effect	**0.47*****	**0.03**	**0.37****	**1.15*****	**0.89****	**0.90*****
	(0.14)	(0.09)	(0.16)	(0.42)	(0.41)	(0.28)
First Stage Coefficient	0.60***	0.63***	0.58***	0.53***	0.56***	0.52***
	(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)
First Stage F-statistic	297	434	292	151	171	192
Firm Observations (Millions)	45.9	38.3	7.0	0.5	4.2	6.2

Notes: Controls are industry-year fixed effects, Census Divison-year fixed effects, CZ fixed effects, and a polynomial in $t-1$ log firm size. Recall that firm fixed effects are removed through the first-differenced specification. Standard errors are clustered at the CZ-year level. Observations are weighted by lagged firm size. The sample only includes continuing domestic firms.

The regression specification is the same as above, except for individuals instead of firms as the observations, and a polynomial in age is included to control for heterogeneous age profiles in wage growth. To investigate inequality in the wage effects, we split the sample into equally sized quintile bins by ranking lagged wages within the commuting-zone-year.

The results are presented in Table 3 for about 370 million worker-year observations. The full sample estimate indicates a positive but statistically insignificant effect on the average worker's wage growth. This is somewhat larger than suggested by the first column of Table 2, as the log wage bill effect minus the log number of employees effect yields the effect on log mean wages, which is 0.02 in Table 2 for all workers and 0.07 in Table 3 for continuing

Table 3: Indirect Effect Estimates: Results by Worker Wage Quintile

		By Income Quintile Group				
	Full Sample	**Quintile 1**	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**
	Outcome: Log Wage (continuing workers)					
2SLS Indirect Effect	**0.061**	**-0.098**	**-0.044**	**0.017**	**0.194****	**0.295*****
	(0.065)	(0.076)	(0.064)	(0.068)	(0.083)	(0.094)
First Stage Coefficient	0.582***	0.583***	0.582***	0.582***	0.580***	0.578***
	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)	(0.036)
First Stage F-statistic	263	263	263	263	263	264
Worker Observations (Millions)	369.6	73.9	73.9	73.9	73.9	73.9

Notes: The sample includes only workers employed by the same domestic firm in the same CZ during t and $t-1$. Controls are industry-year fixed effects, Census Division-year fixed effects, CZ fixed effects, a polynomial in $t-1$ log firm size, and a polynomial in worker age. Recall that worker and firm fixed effects are removed through the first-differenced specification. Standard errors are clustered at the CZ-year level. The sample only includes continuing workers at domestic firms. We divide workers into five wage groups within each CZ-year based on the ordering of their lagged wages.

workers only. While the wage bill growth associated with FDI indirect effects is nearly all through the margin of hiring more workers rather than paying greater wages per worker, there is some evidence that continuing workers capture more wage growth than new workers.

In columns 2-6 of Table 3, we examine wage growth effects for continuing workers at different lagged wage quintile bins. For the lowest three quintile bins, we find statistically insignificant estimates near zero. For the top two quintile bins, we find statistically significant estimates of about 0.2 and 0.3. This indicates that a one percentage point increase in the share of employment at foreign firms in the region results in 0.3 percent wage growth for high-paid continuing workers at domestic firms in the region, while low-paid workers experience little to no wage growth. This suggests that FDI indirect effects primarily benefit high-skilled workers at domestic firms, as predicted by an extension to our model in which the technology spillover is skill-biased (see Section 4).

5.3 Robustness of the Main Indirect Effect Estimates

To validate our empirical specification, Table 4 demonstrates that the main estimates are robust to alternative empirical specifications motivated by identification issues discussed in the previous section. First, motivated by the possibility that fine nation-wide industry shocks are correlated with regional growth due to the concentration of fine industries in regions, we show that the results are robust to replacing the 3-digit industry-year fixed effects with 6-digit industry-year fixed effects. Second, motivated by the concern that regions growing faster may also be regions that are more (or less) open to foreign investment, we control for the share of *total* foreign employment in the commuting zone at $t - 5$. We find that the coefficient of interest is invariant to adding this control. Third, excluding domestic multinationals somewhat weakens the estimation effects, while the qualitative results remain the same, which is consistent with smaller firms experiencing weaker indirect effects than larger firms. Fourth, motivated by the possibility that growth shocks in nearby commuting zones are driving both foreign investment and wages in a given commuting zone, we leave out foreign investment made within a 250 mile radius of the commuting zone when constructing the instrument, which results in stronger indirect effect estimates. Fifth, we exclude from the FDI measures any country with a non-positive firm premium estimate in Section 4 to investigate whether only high-premium firms yield indirect effects. Instead, we find that excluding these countries somewhat attenuates the estimates, suggesting that even foreign firms from countries with low average premiums have positive indirect effects. Finally, we exclude tax havens (e.g., Cayman Islands) from the sample when constructing the instrument and FDI measures, as these firms could be thought of as misclassified domestic-owned firms. The estimated indirect effects become stronger when omitting tax havens.

5.4 Understanding the Mechanisms behind the Indirect Effects

We conclude this section by discussing a number mechanisms that could explain the positive indirect effects estimates. In our model in Section 3, positive indirect effects arise from knowledge spillovers or increased efficiency of local suppliers (see footnote 14). We first note that knowledge spillovers could come in the form of technology or improved management practices. Bloom, Brynjolfsson, Foster, Jarmin, Patnaik, Saporta-Eksten, and Van Reenen (2019) find evidence for local spillovers in management practices associated with large plant openings using the "Million Dollar Plants" research design. In fact, most million dollar plants in their study belong to multinational corporations. Outside the scope of our model, increased competitive pressure may lead to higher efficiency at domestic firms (see Bloom, Draca, and Van Reenen 2015). However, competitive pressure also would predict that these firms become smaller in the short-run, contrary to our results. Yet another channel for positive indirect effects on local domestic firms is an increase in consumer demand for non-tradables (see Moretti 2010). While we do find evidence for a sizable increase in the wage bill for this sector, the effects tend to be similarly positive or even larger in the tradable sector—suggesting consumer demand cannot be the only channel behind the indirect effects. Another source of a change in local product demand is through the firms' input-output network (see Aitken and Harrison 1999 and Smarzynska Javorcik 2004). To explore this further, we next investigate whether the local indirect effects are more strongly associated with growth in employment at foreign multinationals in the same sector (i.e., horizontal) or

Table 4: Indirect Effects Estimates: Robustness Checks

	Baseline	**6-digit NAICS Fixed Effects**	**Lagged FDI as a Control**	**Exclude Dom. Multinationals**	**Exclude 250m Radius from Z**	**Exclude Tax Havens**
Panel A.	**Outcome: Log Value Added**					
2SLS Indirect Effect	**0.644****	**0.712*****	**0.629****	**0.579*****	**0.610****	**0.670****
	(0.266)	(0.220)	(0.268)	(0.221)	(0.286)	(0.295)
First Stage Coefficient	0.598***	0.596***	0.591***	0.612***	0.647***	0.574***
	(0.035)	(0.034)	(0.035)	(0.034)	(0.046)	(0.035)
First Stage F-statistic	299	300	291	333	196	268
Firm Observations (Millions)	41.7	41.7	41.7	40.4	41.7	41.7
Panel B.	**Outcome: Log Full-time Workers**					
2SLS Indirect Effect	**0.446*****	**0.434*****	**0.441*****	**0.410*****	**0.449*****	**0.457*****
	(0.125)	(0.120)	(0.125)	(0.120)	(0.134)	(0.138)
First Stage Coefficient	0.598***	0.597***	0.592***	0.609***	0.648***	0.574***
	(0.035)	(0.035)	(0.035)	(0.034)	(0.046)	(0.035)
First Stage F-statistic	297	298	289	325	195	264
Firm Observations (Millions)	45.9	45.9	45.9	44.5	45.9	45.9
Panel C.	**Outcome: Log Wage Bill**					
2SLS Indirect Effect	**0.466*****	**0.457*****	**0.453*****	**0.455*****	**0.477*****	**0.487*****
	(0.138)	(0.137)	(0.138)	(0.140)	(0.151)	(0.152)
First Stage Coefficient	0.598***	0.597***	0.592***	0.609***	0.648***	0.574***
	(0.035)	(0.035)	(0.035)	(0.034)	(0.046)	(0.035)
First Stage F-statistic	297	298	289	325	195	264
Firm Observations (Millions)	45.9	45.9	45.9	44.5	45.9	45.9

Notes: Unless otherwise specified in the column header, controls are 3-digit-industry-year fixed effects, Census Divison-year fixed effects, CZ fixed effects, and a polynomial in $t-1$ firm size. Recall that firm fixed effects are removed through the first-differenced specification. Standard errors are clustered at the CZ-year level. Observations are weighted by lagged firm size. The sample only includes continuing domestic firms.

upstream or downstream sectors.

5.4.1 Indirect Effects in the Input-Output Network

We extend our framework to allow for distinct indirect effects of foreign employment growth on horizontal, upstream, and downstream industries. To do so, we define employment growth at foreign-owned firms in cz in industry ι as,

$$m^{\text{Horizontal}}_{cz,\iota,t} \equiv \frac{L^F_{cz,\iota,t} - L^F_{cz,\iota,t-1}}{L^F_{cz,\iota,t-1} + L^D_{cz,\iota,t-1}} \tag{13}$$

Using this term, we then define downstream employment growth at foreign-owned firms in cz in industry ι (assuming time-invariant IO coefficients):[22]

$$m_{cz,\iota,t}^{\text{Downstream}} = \sum_{\kappa \neq \iota} \sigma_{\iota\kappa} m_{cz,\kappa,t}^{\text{Horizontal}} \tag{14}$$

where $\sigma_{\iota\kappa}$ is the fraction of output of industry ι that is sold to industry κ according to IO tables. We use the BEA input-output table for 2002, and an industry corresponds to a NAICS 3-digit sector. Analogously, we define upstream employment growth as,

$$m_{cz,\iota,t}^{\text{Upstream}} = \sum_{\kappa \neq \iota} \alpha_{\kappa\iota} m_{cz,\kappa,t}^{\text{Horizontal}} \tag{15}$$

where $\alpha_{\kappa\iota}$ is the fraction of intermediate inputs of industry ι that is coming from industry κ out of total sector ι intermediate input purchases.

Using these definitions, we specify the change in an outcome at domestic firm j in commuting zone cz as,

$$\begin{aligned} \log y_{j,t} - \log y_{j,t-1} = &\beta_h m_{cz(j),\iota(j),t}^{\text{Horizontal}} + \beta_d m_{cz(j),\iota(j),t}^{\text{Downstream}} + \beta_u m_{cz(j),\iota(j),t}^{\text{Upstream}} \\ &+ \gamma^{\text{ind}} K_{j,t} + \epsilon_{j,t}^{\text{ind}}, \end{aligned} \tag{16}$$

In order to instrument for the three endogenous variables in this equation, we require three instruments. The instrumental variables are defined similarly to the main instrument, but one is based on horizontal growth and $t-5$ country-of-ownership-industry-commuting-zone shares, another is based on downstream growth and lagged shares, and the last one is based on upstream growth and the corresponding lagged shares. The equations for constructing these instruments using the input/output weights $\sigma_{\iota\kappa}$ and $\alpha_{\kappa\iota}$ are analogous to those used to construct the endogenous variables and are presented in Appendix C.

Table 5 displays the results from this regression. We find clear evidence of employment growth at foreign firms upstream to positively affect domestic firms. The effects of employment growth at foreign firms in the same sector (i.e., horizontal) are precisely measured to be nearly zero or slightly positive. We lack the statistical precision to draw inference on the effects of local employment growth at foreign firms downstream from the domestic firms. The substantial upstream effects point to a clear channel of how these indirect effects transmit to domestic firms. While our analysis focuses on local indirect effects, Smarzynska Javorcik

[22] In the data, we find that a large share of foreign-owned firms are concentrated in NAICS sector 55, "management of other companies," while very few domestic firms belong to this sector. Because sector 55 does not correspond to any particular product market, it is difficult to define its upstream or downstream industries. To avoid losing much of the sample of foreign-owned firms in the input/output network regression, we use the NAICS code of the largest subsidiary for these foreign-owned firms.

Table 5: Input/Output IV Regression

	Outcome: Log Value Added		
Endogenous Regressor:	Horizontal FDI Growth	Downstream FDI Growth	Upstream FDI Growth
2SLS Indirect Effect	**0.133**	**-0.574**	**0.410**
	(0.118)	(0.417)	(0.326)
First Stage F-statistic (3 IVs)	108	13	21
Firm Observations (Millions)		37.0	

	Outcome: Log Full-time Workers		
Endogenous Regressor:	Horizontal FDI Growth	Downstream FDI Growth	Upstream FDI Growth
2SLS Indirect Effect	**0.038**	**0.235**	**0.389****
	(0.063)	(0.218)	(0.172)
First Stage F-statistic (3 IVs)	109	13	23
Firm Observations (Millions)		40.0	

	Outcome: Log Wage Bill		
Endogenous Regressor:	Horizontal FDI Growth	Downstream FDI Growth	Upstream FDI Growth
2SLS Indirect Effect	**0.061**	**-0.060**	**0.352***
	(0.076)	(0.306)	(0.205)
First Stage F-statistic (3 IVs)	109	13	23
Firm Observations (Millions)		40.0	

Notes: This table displays estimates from the regression with three endogenous variables and three instrumental variables. The endogenous variables are growth in foreign employment in the commuting zone at the same ("horizontal") industry, a weighted average of downstream industries, and a weighted average of upstream industries. The instrumental variables are defined analogously and using the same weights. See Appendix C for details.

(2004) investigated spillovers at the national level in Lithuania and found primarily positive effects from employment growth at foreign firms downstream. Similarly, Alfaro-Urena et al. (2018) find positive productivity effects for domestic firms selling to multinational firms in Costa Rica. One explanation why we find strong upstream effects and inconclusive effects downstream could be that multinationals do not procure their inputs primarily within the same commuting zone (see Flaaen 2014 for a description of the import behavior of foreign multinationals in the U.S.).

6 Local and Aggregate Implications

In this section, we use our estimates from Sections 4 and 5 to take a look at the local and aggregate implications of foreign multinationals. We emphasize that the numbers calculated below are not meant to summarize the overall welfare effect of foreign multinationals. We abstract, for example, from any worker-firm-specific preference heterogeneity in the calculations below. The calculations below are based on aggregate outcomes in 2015.

6.1 Aggregate Wage Gain due to Foreign Firm Premiums

We start by conducting the following thought experiment: Suppose one replaces all foreign multinationals with domestic firms—each equipped with the average productivity of domestic firms. How much would this lower the aggregate wages in the U.S.? We abstract away from any indirect effects (e.g., local spillovers). This is because our indirect effect estimates were obtained comparing commuting zones with smaller and larger changes in employment at foreign firms. By comparing one commuting zone with another, we can estimate the local indirect effects of foreign firms but not the national indirect effects, which are differenced out. For simplicity, we abstract from worker heterogeneity in the foreign firm premiums in the calculations below.

In Section 4, we estimate an average foreign firm wage premium of 7 percent—after removing the effect of worker-quality differences from the larger raw wage differences between foreign and domestic firms. The theory suggests that this wage premium arises because of larger productivity of foreign firms. Given an aggregate wage bill at foreign multinationals in the U.S. in 2012 of 515 billion USD, this suggests an aggregate national wage premium due to foreign multinationals in the ballpark of 36 billion USD annually.[23] These figures suggest large aggregate gains for workers in the U.S. due to foreign multinationals. We emphasize that measuring the foreign firm wage premium stripped of worker-quality differences is a key ingredient for calculating the overall wage premium in the U.S. due to foreign multinationals. These calculations depend critically on our data contribution—combining for the first time worker-firm-level panel data and foreign ownership information in the U.S.—enabling us for the first time to measure the foreign firm wage premiums in the U.S..

6.2 Local Effects of a New Foreign Plant

Beyond the aggregate wage effects of foreign firms, policy makers are often confronted with the question of the local economic benefit of a foreign firm. To be concrete, consider the establishment or expansion of a foreign firm that would create 1,000 new jobs in a commuting zone. Unlike in the previous subsection, we do not compare to a domestic firm expansion of similar size. The reason is that here we are interested in the direct as well as the local indirect effects, and our identification strategy delivers the indirect effects of foreign firms but not of domestic firms. Hence, the thought experiment is having a new foreign plant with 1,000 jobs over not having a new plant. Below, we describe some of the expected direct and indirect local effects. We focus on a commuting zone with an initial employment share at

[23]We calculate the aggregate wage bill at foreign multinationals from the average wage of a full-time employee at foreign-owned firms (Table A1) and the number of workers at foreign multinationals from the BEA (6.8 million). While we use per-worker estimates from tax data, we use BEA aggregate estimates because it is not possible to link all workers to firms in the tax data, as discussed in Section 2.

domestic firms of 94 percent, which corresponds to the national average.

6.2.1 Increase in wages for incumbents

We first focus on the wages for incumbent workers in a commuting zone. From the employer-employee panel data, we calculate that on average close to 90 percent of new workers at a foreign multinationals were working at a domestic-owned firm from the same commuting zone in the previous period.[24] Therefore, the calculations below assume that around 900 of the 1,000 positions are occupied by incumbent workers in the commuting zone previously working at a domestic firm. Based on these assumptions and our foreign firm wage premium estimate, we calculate direct wage gains of 4.8 million USD for incumbent workers at a commuting zone that find a job at the foreign firm.[25] In addition, the local effects for incumbent workers include the wage gain that arises indirectly at domestic firms. Recall that we estimate a wage increase of 0.2 and 0.3 percent for workers in the 4th and 5th wage quintile, respectively, due to a 1 percentage point increase of the share of employment at foreign firms in Table 3. We assume the indirect wage effect is zero for workers below the 4th wage quintile group. Again leveraging the worker-firm linked data, we calculate that a full-time worker, who is in the top quintile (2nd highest quintile) of the income distribution in a commuting zone and employed at a domestic firm, has an average wage of 156,700 USD (63,200 USD).

Combining these figures suggests an indirect wage effect on incumbent workers at domestic firms of 11.2 million USD.[26] Therefore, in total we calculate a 16 million USD wage gain for incumbent workers in a typical commuting zone due to a 1,000 employee foreign-owned plant. This suggests aggregate annual wage gains for incumbent workers at the commuting zone of about 16,000 USD per created job at a foreign-owned firm—of which about two-thirds is due to the indirect effects. Interestingly, at a "per-job-at-the-foreign-owned-firm" basis, the results are independent of the magnitude of the increase in employment at foreign owned firms and independent of commuting zone size. The effects get slightly larger with a smaller fraction of initial employment at foreign-owned firms in the commuting zone. Furthermore, we note that these statistics reflect annual figures. The net present value is naturally bigger and depends on the discount rate that is applied to these annual figures.

[24] Specifically, we calculate that among the 250,000 FTE workers that worked at a domestic firm in 2014 and became FTE workers at a foreign firm in 2015, 87.1 percent remained in the same commuting zone. Arguably the fraction of locally hired workers may be lower for very large plant expansions.

[25] Specifically, 900 workers $\times$ 75,700 USD per worker $\times$ 7 percent = 4.8 million USD.

[26] Specifically, let ζ denote the comuting zone size. The top quintile earners at domestic firms, which consist of 20 percent of 94 percent of ζ workers, experience a $0.3 \times \frac{1{,}000}{\zeta} \times 156{,}700$ USD wage gain, resulting in an indirect gain of 8.8 million USD for this group of workers. Similar calculations suggest a wage gain of 2.4 million USD for the second highest earning quintile of workers at domestic firms.

6.2.2 Increase in local economic activity

Beyond affecting the wages for incumbents, foreign multinationals also affect the overall size of economic activity in a location. While the theory suggests that the indirect effects on output at domestic owned firms can be positive or negative, the empirical analysis in Section 5 suggests the local indirect effects are positive on average. We calculate that 1,000 positions at a foreign-owned plant on average raise the value added in the commuting zone by 289 million USD per year.[27] Furthermore, employment increases by around 1,420 positions (i.e., an indirect effect of 420 more jobs at domestic firms), and the total wage bill increases by 93.4 million USD on average.[28] Our estimates of the total local job multiplier of about 1.42 (0.42 indirect jobs for 1 job created) are comparable to the estimates from the urban economics literature discussed by Bartik and Sotherland (2019), which often range from 1.5 to 2.5. While we lack a directly comparable estimate from the literature on the indirect number of jobs created by foreign multinationals, Moretti (2010) finds for each job in the tradable sector, 1.6 jobs are created in the non-tradable sector, resulting in a total job multiplier of 2.6.

6.2.3 Comparison to local subsidies given per direct job for mega-deals

While, as discussed above, our estimates do not shed light on the national indirect effects of foreign firms, they shed light on the local indirect effects. These figures are still policy-relevant, as local governments actively engage in subsidy competition to attract firms (see Gaubert 2018 and Ossa 2015). Extending data collected by the policy group *Good Jobs First*, Slattery (2018) analyzes 485 large subsidy deals given by state and local governments in the U.S.. In these data, the average firm promises to create 1,700 direct jobs and receives a subsidy worth 156 million USD. About a quarter of these large subsidy deals go to foreign multinationals. The median subsidy per direct job given to a foreign parent is 109,000 USD.[29] The estimate of 16,000 USD annual wage benefits to incumbent workers in a commuting zone above is a conservative estimate for the total benefits as it omits other non-wage benefits to

[27]The value added per worker at a foreign MNE is 220,100 USD and 154,300 USD at a domestic firm on average. In addition to a direct increase in value added in the commuting zone by 220 million USD, the estimates in Table 2 suggest an indirect increase in value added by 92.8 million USD (calculated as $\frac{1{,}000}{\zeta} \times 0.64 \times 0.94 \times \zeta \times$ 154,300 USD).

[28]The estimates in Panel B of 2 suggest an indirect increase in employment of about 420 workers (calculated as $\frac{1{,}000}{\zeta} \times 0.45 \times 0.94 \times \zeta$). If the foreign employment share is zero, the predicted indirect increase rises to 450 workers. The foreign plant would lead, on average, to a direct increase of wage the wage bill at foreign owned firms of 75.7 million USD. Using the estimates in Panel C of 2, we compute an indirect increase in the wage bill at domestic owned firms of 27.7 million USD (calculated as $\frac{1{,}000}{\zeta} \times 0.47 \times 0.94 \times \zeta \times$ 62,600 USD). The increase in the total wage bill is substantially larger than the increase in the wage premium for incumbents calculated in Section 6.2.1 above, as it includes wages paid to individuals that were previously working outside the commuting zone or were non-employed.

[29]We are grateful to Cailin Slattery for providing these statistics.

the commuting zone (e.g., increased tax revenues, increased variety of employment options). At a discount rate of 0.15, the average wage benefits per direct job at a foreign firm equal the typical subsidy payment. At a discount rate of 0.10, the net present value of the average wage benefits exceeds the typical subsidy by 51,000 USD per job. Since foreign multinationals are mobile in their location choices for large plant openings or expansions, it is intuitive that in the bargaining with local authorities over mega-deals they typically extract a large fraction of the overall local benefits via subsidy payments.

7 Conclusion

In this paper we use employer-employee panel data from 1999 to 2017 to conduct a comprehensive analysis of the effects of foreign multinationals in the U.S.. We find that these firms pay a wage premium of about 7 percent on average, meaning the same worker earns 7 percent more at a foreign-owned firm. The wage premium is larger for higher quality workers and absent for the lowest decile of worker quality. Our theory rationalizes these findings with a (skill-biased) productivity advantage of foreign firms. Empirically, we document that this foreign firm premium is correlated with GDP per capita of the origin country. Furthermore, on average, the firm premium is about the same for domestic multinational firms, suggesting that the multinational status itself is associated with higher wages for the same worker. One explanation is that tangible and intangible foreign inputs raise the productivity of these firms. We also find that the wage premium cannot simply be explained by the domestic size of the firm. Quantitatively, the wage premium paid by foreign multinationals is quite large in the aggregate—accounting for 34 billion USD annually in wages (which is about 0.6 percent of the entire private sector wage bill).

In terms of policy implications, our estimates highlight sizable benefits of trade and investment policies that make it attractive for foreign firms to invest in the U.S.. Furthermore, our estimates imply incentives for local policy makers to compete for investments by foreign multinationals, since in addition to direct wage benefits, we find positive and sizable local indirect effects on domestic firms and their workers—in particular the higher earning ones. We note that while it is rational for local policy makers to compete for foreign multinational investments with subsidies, this does not imply that such subsidies are beneficial from a national welfare perspective. Our calculations suggest that the subsidies given to foreign multinationals for large plant investment or expansions account for a sizable fraction of the net present value of the wage benefits for incumbent workers. In other words, foreign multinationals are able to extract a sizable fraction of the surplus from such investments in the bargaining with local governments over mega-deals.

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A Additional Figures and Tables

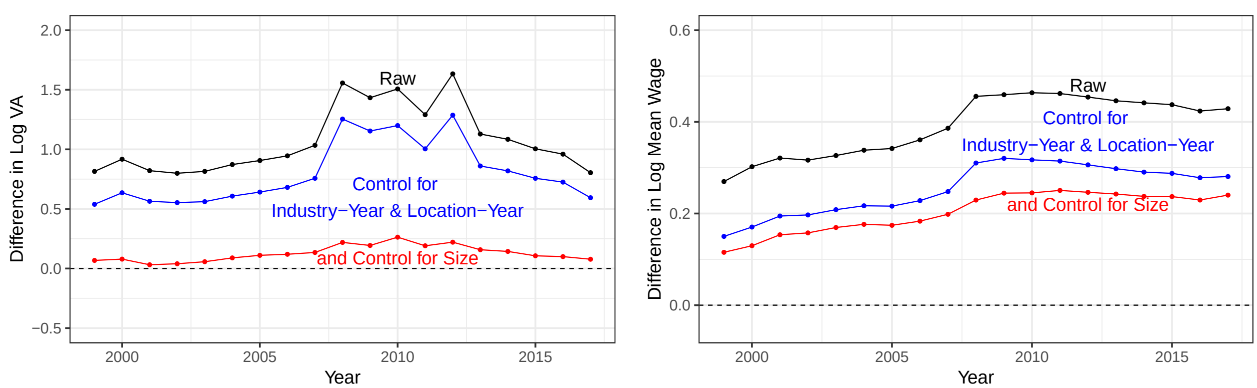
Table A1: Descriptive Statistics for the Main Sample of Firms, 2015

	Domestic	Foreign
Firms in Main Sample of Firms (thousands)	2,781.1	30.3
Firm-Location Pairs in Main Sample of Firms (thousands)	4,762.9	218.7
Number of Workers at Main Sample of Firms (millions):		
All Workers:	77.1	5.2
FTE Analysis Sample:	41.3	3.6
Mean Wage at Main Sample of Firms (thousands):		
All Workers:	41.4	60.7
FTE Analysis Sample:	62.6	75.7
Value Added per Worker at Main Sample of Firms (thousands):		
All Workers:	82.7	153.1
FTE Analysis Sample:	154.3	220.1

Notes: This table displays descriptive statistics for domestic and foreign filers of forms 1120, 1120-S, and 1065, matched to subsidiaries and W-2 forms. The set of firms is the same across all rows, and already has been restricted to satisfy the sample restrictions. The analysis sample restrictions on the workers are at least FTE earnings ($15,000 per year), the firm is the worker's highest-paying W-2 in that year, the worker is prime age (25-60 years old), and the ZIP code is non-missing and valid on the highest-paying W-2 form.

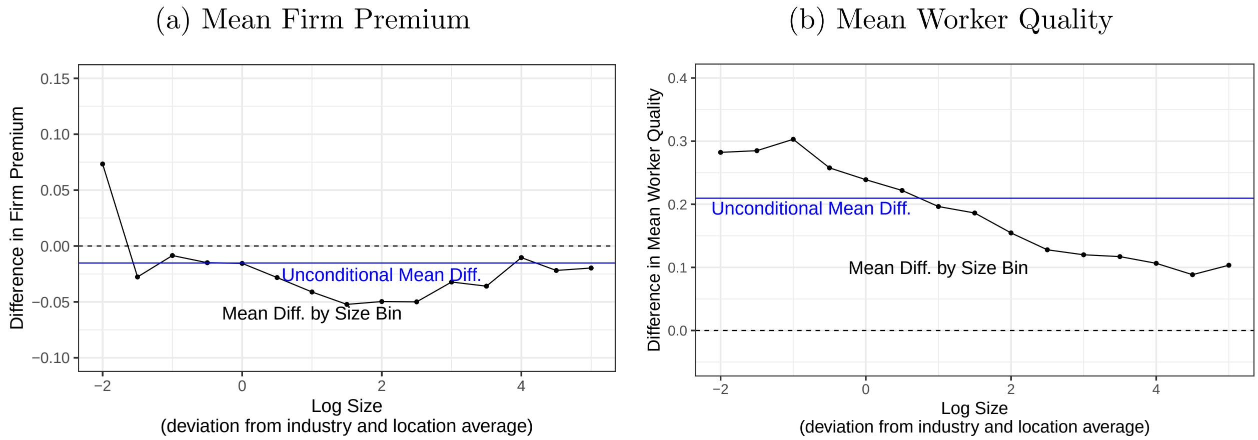
Figure A.1: Time Trends and Control Variables in Value Added and Wages

(a) Mean Log Value Added (b) Mean Log Wage



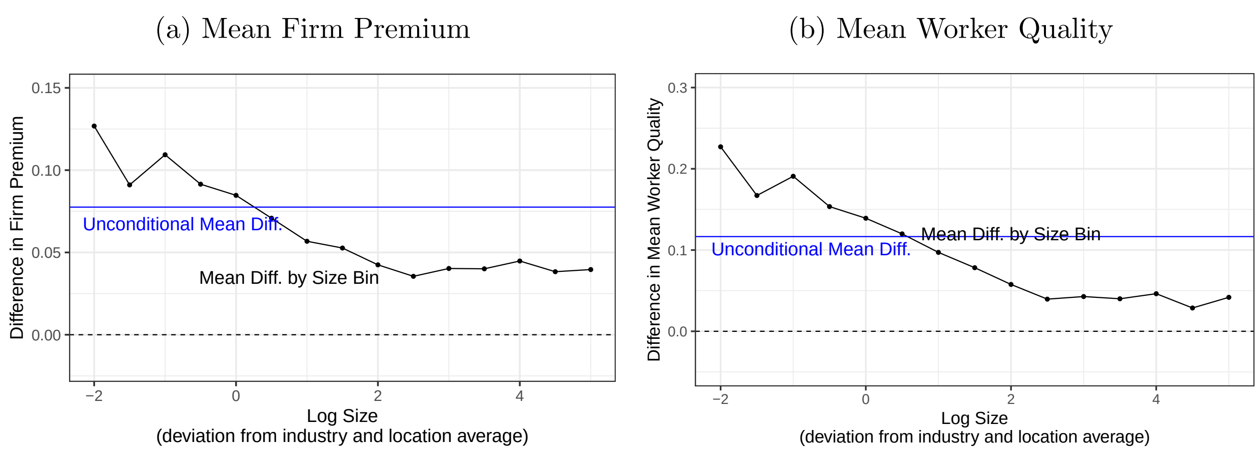
Notes: This figure displays the mean log value added and mean log wage differentials between foreign and domestic firms over time for the IRS analysis sample. It presents raw data, residuals after removing industry-year and location-year effects, and residuals when also controlling for a third-order polynomial in firm size.

Figure A.2: Estimates of Equation (6) without any Bias Correction



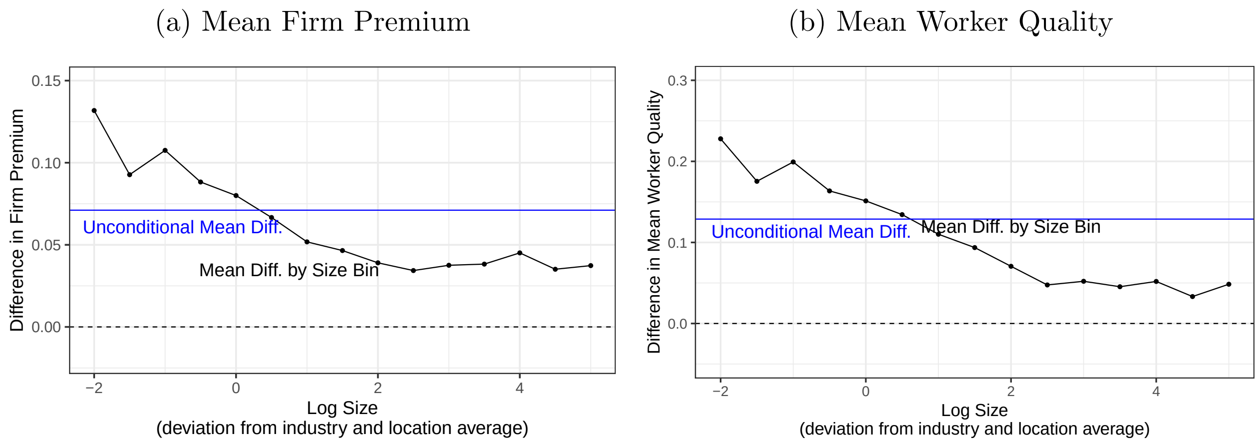
Notes: This figure presents estimates of equation (6) without the BLM bias-correction procedure during 2010-2015. The observable determinants of earnings are a cubic polynomial in worker's age and indicators for CZ-year and industry-year, so firm premiums and worker quality do not reflect differences due to location or industry selection.

Figure A.3: Estimates of equation (7) allowing for Firm-Worker Interactions in BLM



Notes: This figure presents estimates of equation (7) from the BLM bias-correction procedure with 10 clusters during 2010-2015 when allowing for firm-worker interactions. The observable determinants of earnings are a cubic polynomial in worker's age and indicators for CZ-year and industry-year, so firm premiums and worker quality do not reflect differences due to location or industry selection.

Figure A.4: Robustness of Equation (6) Estimates to 20 Cluster BLM

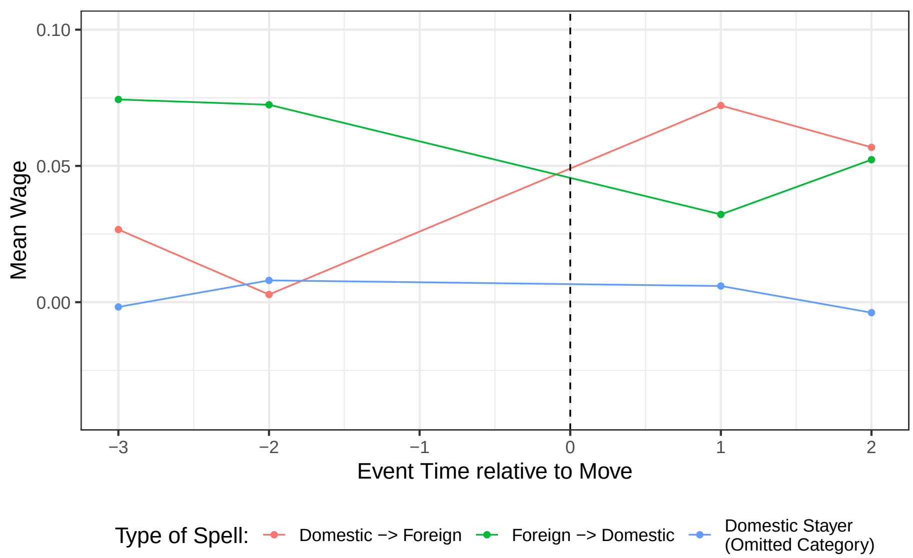


Notes: This figure presents estimates of equation (6) from the BLM bias-correction procedure with 20 clusters during 2010-2015. The observable determinants of earnings are a cubic polynomial in worker's age and indicators for CZ-year and industry-year, so firm premiums and worker quality do not reflect differences due to location or industry selection.

Figure A.5: Foreign Ownership, Firm Premiums, and Worker Quality: 2001-2006

Notes: This figure presents estimates of Equation (6) from the BLM bias-correction procedure with 10 clusters during 2010-2015. The observable determinants of earnings are a cubic polynomial in worker's age and indicators for CZ-year and industry-year, so firm premiums and worker quality do not reflect differences due to location or industry selection.

Figure A.6: Event Study for Movers to and from Foreign Firms



Notes: This figure presents the mean wages for domestic to foreign movers, foreign to domestic movers, and domestic stayers (the reference category in the movers regression) during event times before and after the mover.

Table A2: Indirect Effect Estimates: OLS and IV Results

	(1)	**(2)**	**(3)**
Panel A.	**Outcome: Log Value Added**		
Indirect Effect Estimate	-1.21***	0.32**	0.64**
	(0.22)	(0.13)	(0.27)
Firm Observations (Millions)	41.7	41.7	41.7
Specification:			
Controls for CZ-Year, Industry-Year, and Size	✗	✓	✓
Instrument for FDI Growth	✗	✗	✓
Panel B.	**Outcome: Log Full-time Workers**		
Indirect Effect Estimate	-0.07	0.17***	0.45***
	(0.07)	(0.04)	(0.12)
Firm Observations (Millions)	45.9	45.9	45.9
Specification:			
Controls for CZ-Year, Industry-Year, and Size	✗	✓	✓
Instrument for FDI Growth	✗	✗	✓
Panel C.	**Outcome: Log Full-time Wage Bill**		
Indirect Effect Estimate	-0.60***	0.23***	0.47***
	(0.14)	(0.05)	(0.14)
Firm Observations (Millions)	45.9	45.9	45.9
Specification:			
Controls for CZ-Year, Industry-Year, and Size	✗	✓	✓
Instrument for FDI Growth	✗	✗	✓

Notes: Controls are 3-digit-industry-year fixed effects, Census Divison-year fixed effects, CZ fixed effects, and a polynomial in $t-1$ firm size. In the continuing workers sample, a polynomial in age is also included as a control. Recall that firm fixed effects are removed through the first-differenced specification. Standard errors are clustered at the CZ-year level. Observations are weighted by lagged firm size. The sample only includes continuing domestic firms.

B Model Appendix

In this Appendix section we provide more details on the model and prove several claims made in Section 3.

Wage setting

Recall that all firms produce the same homogeneous good whose price is normalized to one. Each firm solves the following problem:

$$\max_{w_{js}, w_{ju}} \phi_j \left(w_{ju}^{\eta} \left(\frac{\bar{L}_u}{W_u} \right) + \bar{\phi}_{js} w_{js}^{\eta} \left(\frac{\bar{L}_s}{W_s} \right) \right) - w_{js}^{\eta+1} \frac{\bar{L}_s}{W_s} - w_{ju}^{\eta+1} \frac{\bar{L}_u}{W_u}$$

The F.O.C. to this problem imply the wage setting in equation (4).

Claim 1 *If the initial employment share at foreign-owned firms is small and employment is roughly constant during the counterfactual, the model suggests that the following equation approximates the wage effect at domestic owned firms.*

$$\log(w'_{Dh}) - \log(w_{Dh}) \approx \tau(\phi_F - 1) \frac{L'_F - L_F}{L_D + L_F}$$

From equation (4), for $h \in \{s, u\}$,

$$\begin{aligned} w_{Dh} &= \frac{\eta}{\eta+1} \phi_D \bar{\phi}_{Dh} \\ &= \frac{\eta}{\eta+1} \left[1 + \tau \frac{L_F}{L_F + L_D} (\phi_F - 1) \right] \bar{\phi}_{Dh} \end{aligned}$$

Define wage change at domestic firms as $\hat{w}_{Dh} = \frac{w'_{Dh}}{w_{Dh}}$. Therefore,

$$\hat{w}_{Dh} = \frac{\phi'_D}{\phi_D} = \frac{1 + \tau \frac{L'_F}{L'_F + L'_D} (\phi_F - 1)}{1 + \tau \frac{L_F}{L_F + L_D} (\phi_F - 1)},$$

and

$$\begin{aligned} \log(\hat{w}_{Dh}) &= \log(w'_{Dh}) - \log(w_{Dh}) \\ &= \log \left(1 + \tau \frac{L'_F}{L'_F + L'_D} (\phi_F - 1) \right) - \log \left(1 + \tau \frac{L_F}{L_F + L_D} (\phi_F - 1) \right) \\ &\approx \tau \frac{L'_F}{L'_F + L'_D} (\phi_F - 1) - \tau \frac{L_F}{L_F + L_D} (\phi_F - 1) \\ &\approx \tau (\phi_F - 1) \frac{L'_F - L_F}{L_F + L_D}. \end{aligned}$$

The first approximation utilizes the assumption that the initial employment share at foreign owned firms is small and the relation where $\log(1+x) \approx x$ for small x. The second approximation utilizes the condition that employment is roughly constant during the counterfactual, which implies $L'_F + L'_D \approx L_F + L_D$.

Claim 2 *When there is a technology spillover (i.e., $\tau > 0$), an increase in the number of foreign firms improves domestic firms productivity. If there is no technology spillover, domestic technology does not change.*

$$\frac{d\phi_D}{dM_F} \quad \begin{cases} = 0 & if \quad \tau = 0 \\ > 0 & if \quad \tau > 0 \end{cases}$$

When $\tau = 0$, from $\phi_D = 1 + \tau \frac{L_F}{L_D + L_F}(\phi_F - 1)$, $\frac{d\phi_D}{dM_F} = 0$.
When $\tau > 0$, let

$$F(\phi_D, M_F) \equiv 1 + (\phi_F - 1)\tau \frac{L_F}{L_F + L_D} - \phi_D.$$

From Implicit Function Theorem, we know that $\frac{d\phi_D}{dM_F} = -\frac{F_{M_F}}{F_{\phi_D}}$. First, we provide the elements that are used to compute the numerator, F_{M_F}.

$$\begin{aligned} F_{M_F} &= (\phi_F - 1)\tau \frac{\partial \frac{L_F}{L_F + L_D}}{\partial M_F} \\ &= (\phi_F - 1)\tau \frac{\frac{\partial L_F}{\partial M_F}(L_F + L_D) - L_F \frac{\partial (L_F + L_D)}{\partial M_F}}{(L_F + L_D)^2} \\ &= (\phi_F - 1)\tau \frac{\frac{\partial L_F}{\partial M_F} L_D - L_F \frac{\partial L_D}{\partial M_F}}{(L_F + L_D)^2} \end{aligned}$$

Using equations (3) and (4),

$$\begin{aligned} L_D &= \frac{M_D(\gamma\phi_D)^\eta}{M_F(\gamma\phi_F)^\eta + M_D(\gamma\phi_D)^\eta + w_0}\bar{L}_u + \frac{M_D(\gamma\phi_D\bar{\phi}_{Ds})^\eta}{M_F(\gamma\phi_F\bar{\phi}_{Fs})^\eta + M_D(\gamma\phi_D\bar{\phi}_{Ds})^\eta + w_0}\bar{L}_s \\ L_F &= \frac{M_F(\gamma\phi_F)^\eta}{M_F(\gamma\phi_F)^\eta + M_D(\gamma\phi_D)^\eta + w_0}\bar{L}_u + \frac{M_F(\gamma\phi_F\bar{\phi}_{Fs})^\eta}{M_F(\gamma\phi_F\bar{\phi}_{Fs})^\eta + M_D(\gamma\phi_D\bar{\phi}_{Ds})^\eta + w_0}\bar{L}_s \\ L_0 &= \frac{w_0^\eta}{M_F(\gamma\phi_F)^\eta + M_D(\gamma\phi_D)^\eta + w_0^\eta}\bar{L}_u + \frac{w_0^\eta}{M_F(\gamma\phi_F\bar{\phi}_{Fs})^\eta + M_D(\gamma\phi_D\bar{\phi}_{Ds})^\eta + w_0^\eta}\bar{L}_s \end{aligned}$$

Therefore,

$$\frac{\partial L_D}{\partial M_F} = -\frac{(\gamma\phi_F)^\eta(\gamma\phi_D)^\eta M_D}{W_u^2}\bar{L}_u - \frac{(\gamma\phi_F\bar{\phi}_{Fs})^\eta(\gamma\phi_D\bar{\phi}_{Ds})^\eta M_D}{W_s^2}\bar{L}_s < 0$$
$$\frac{\partial L_F}{\partial M_F} = \frac{(\gamma\phi_F)^\eta[(\gamma\phi_D)^\eta M_D + w_0^\eta]}{W_u^2}\bar{L}_u + \frac{(\gamma\phi_F\bar{\phi}_{Fs})^\eta[(\gamma\phi_D\bar{\phi}_{Ds})^\eta M_D + w_0^\eta]}{W_s^2}\bar{L}_s > 0$$

which implies

$$F_{M_F} > 0.$$

Next, we provide the elements that are used to compute the denominator, F_{ϕ_D}.

$$\begin{aligned}
F_{\phi_D} &= (\phi_F - 1)\tau\frac{\partial\frac{L_F}{L_F+L_D}}{\partial\phi_D} - 1 \\
&= (\phi_F - 1)\tau\frac{\frac{\partial L_F}{\partial\phi_D}(L_F + L_D) - L_F\frac{\partial(L_F+L_D)}{\partial\phi_D}}{(L_F + L_D)^2} - 1 \\
&= (\phi_F - 1)\tau\frac{\frac{\partial L_F}{\partial\phi_D}L_D - L_F\frac{\partial L_D}{\partial\phi_D}}{(L_F + L_D)^2} - 1
\end{aligned}$$

where

$$\begin{aligned}
\frac{\partial L_D}{\partial\phi_D} =& \frac{(\gamma\phi_D)^{\eta-1}\gamma\eta M_D[M_F(\gamma\phi_F)^\eta + w_0^\eta]}{W_u^2}\bar{L}_u \\
&+ \frac{(\gamma\phi_D\bar{\phi}_{Ds})^{\eta-1}\gamma\eta\bar{\phi}_{Ds}M_D[M_F(\gamma\phi_F\bar{\phi}_{Fs})^\eta + w_0^\eta]}{W_s^2}\bar{L}_s > 0 \\
\frac{\partial L_F}{\partial\phi_D} =& -\frac{(\gamma\phi_F)^\eta(\gamma\phi_D)^{\eta-1}\gamma\eta M_D M_F}{W_u^2}\bar{L}_u \\
&- \frac{(\gamma\phi_F\bar{\phi}_{Fs})^\eta(\gamma\phi_D\bar{\phi}_{Ds})^{\eta-1}\gamma\eta\bar{\phi}_{Ds}M_D M_F}{W_s^2}\bar{L}_s < 0
\end{aligned}$$

Therefore,

$$F_{\phi_D} < 0$$
$$\frac{d\phi_D}{dM_F} = -\frac{F_{M_F}}{F_{\phi_D}} > 0.$$

Claim 3 *The wage of unskilled workers at domestic firms increases with the number of foreign firms when there is a technology spillover. There is no effect on the wage at domestic* *firms if there is no technology spillover.*

$$\frac{dw_{Du}}{dM_F} \quad \begin{cases} > 0 & \textit{if} \quad \tau > 0 \\ = 0 & \textit{if} \quad \tau = 0 \end{cases}$$

From here on, we let $\gamma \equiv \frac{\eta}{\eta+1}$ to save on notation. Based on the results from Claim 2,

$$\frac{dw_{Du}}{dM_F} = \frac{d(\gamma\phi_D)}{dM_F} = \gamma\frac{d\phi_D}{dM_F} \quad \begin{cases} > 0 & \text{if} \quad \tau > 0 \\ = 0 & \text{if} \quad \tau = 0 \end{cases}$$

Claim 4 *The wage of skilled workers at domestic firms increases with the number of foreign firms when there is a technology spillover.*

$$\frac{dw_{Ds}}{dM_F} \quad \begin{cases} > 0 & \textit{if} \quad \tau > 0 \\ = 0 & \textit{if} \quad \tau = 0 \end{cases}$$

Based on the results from Claim 2,

$$\frac{dw_{Ds}}{dM_F} = \frac{d(\gamma\phi_D\bar{\phi}_{Ds})}{dM_F} = \gamma\bar{\phi}_{Ds}\frac{d\phi_D}{dM_F} \quad \begin{cases} > 0 & \text{if} \quad \tau > 0 \\ = 0 & \text{if} \quad \tau = 0 \end{cases}$$

Claim 5 *Employment of unskilled workers at a domestic firm decreases with the number of foreign firms if there is no technology spillover. If there is technology spillover, the employment of unskilled workers at domestic firms may decrease or increase with the number of foreign firms—depending on other parameters.*

$$\frac{dl_{Du}}{dM_F} \quad \begin{cases} \leq 0 \ \textit{or} > 0 & \textit{if} \quad \tau > 0 \\ < 0 & \textit{if} \quad \tau = 0 \end{cases}$$

From equation (3),

$$
\begin{aligned}
l_{Du} &= w_{Du}^{\eta}\frac{\bar{L}_u}{W_u} = \frac{(\gamma\phi_D)^{\eta}}{M_D(\gamma\phi_D)^{\eta} + M_F(\gamma\phi_F)^{\eta} + w_0^{\eta}}\bar{L}_u \\
\frac{dl_{Du}}{dM_F} &= \underbrace{\frac{\gamma^{\eta}\eta\phi_D^{\eta-1}\frac{d\phi_D}{dM_F}W_u}{W_u^2}\bar{L}_u}_{\text{Spillover effect}} - \underbrace{\frac{(\gamma\phi_D)^{\eta}[M_D\gamma^{\eta}\eta\phi_D^{\eta-1}\frac{d\phi_D}{dM_F} + (\gamma\phi_F)^{\eta}]}{W_u^2}\bar{L}_u}_{\text{Labor market competition effect}} \\
&= \frac{\gamma^{\eta}\eta\phi_D^{\eta-1}\frac{d\phi_D}{dM_F}[W_u - (\gamma\phi_D)^{\eta}M_D] - (\gamma\phi_D)^{\eta}(\gamma\phi_F)^{\eta}}{W_u^2}\bar{L}_u \\
&= \frac{\gamma^{\eta}\eta\phi_D^{\eta-1}\frac{d\phi_D}{dM_F}[(\gamma\phi_F)^{\eta}M_F + w_0^{\eta}] - (\gamma\phi_D)^{\eta}(\gamma\phi_F)^{\eta}}{W_u^2}\bar{L}_u \\
&= \eta\frac{(\gamma\phi_D)^{\eta}(\gamma\phi_F)^{\eta}\bar{L}_u}{W_u^2}\left[\frac{M_F}{\phi_D}\frac{d\phi_D}{dM_F}\left(1 + \frac{w_0^{\eta}}{M_F(\gamma\phi_F)^{\eta}}\right) - \frac{1}{\eta}\right]
\end{aligned}
$$

$\frac{dl_{Du}}{dM_F}$ is positive (negative or zero) if and only if $\frac{M_F}{\phi_D}\frac{d\phi_D}{dM_F}\left(1 + \frac{w_0^{\eta}}{M_F(\gamma\phi_F)^{\eta}}\right) - \frac{1}{\eta}$ is positive (negative or zero). In particular, when $\tau = 0$, there is no spillover of foreign technology into domestic technology. Therefore, $\frac{dl_{Du}}{dM_F} < 0$ as $\frac{M_F}{\phi_D}\frac{d\phi_D}{dM_F} = \frac{d\log\phi_D}{d\log M_F} = 0$. Moreover, we show $\frac{dl_{Du}}{dM_F} > 0$ by providing a numerical example, where we choose a set of parameters under which $\frac{dl_{Du}}{dM_F} > 0$ holds. Given parameters specified in Table A3, $\frac{dl_{Du}}{dM_F} > 0$. By continuity, there exists a $\bar{\tau} > 0$ such that $\frac{dl_{Du}}{dM_F} \leq 0$ for $\tau \in (0, \bar{\tau}]$. Note in addition that there exists a set of parameters such that $\frac{dl_{Du}}{dM_F} = 0$, which is a result of continuity and the intermediate value theorem.

Table A3: Numerical Example

M_F	M_D	ϕ_F	$\bar{L}_u$	$\bar{L}_s$	w_0	$\bar{\phi}_{Ds}$	$\bar{\phi}_{Fs}$	η	τ
0.05	1	1.1	1	1	1.5	1.5	1.5	6	0.9

Claim 6 *Employment of skilled workers at a domestic firm decreases with the number of foreign firms if there is no technology spillover. If there is technology spillover, the employment of skilled workers at domestic firms may decrease or increase with the number of foreign firms—depending on other parameters.*

$$
\frac{dl_{Ds}}{dM_F} \quad \begin{cases} \leq 0 \ \textit{or} > 0 & \textit{if} \quad \tau > 0 \\ < 0 & \textit{if} \quad \tau = 0 \end{cases}
$$

$$
\begin{aligned}
l_{Ds} &= w_{Ds}^{\eta}\frac{\bar{L}_s}{W_s} = \frac{(\gamma\phi_D\bar{\phi}_{Ds})^{\eta}}{M_D(\gamma\phi_D\bar{\phi}_{Ds})^{\eta} + M_F(\gamma\phi_F\bar{\phi}_{Fs})^{\eta} + w_0^{\eta}}\bar{L}_s \\
\frac{dl_{Ds}}{dM_F} &= \underbrace{\frac{(\gamma\bar{\phi}_{Ds})^{\eta}\eta\phi_D^{\eta-1}\frac{d\phi_D}{dM_F}W_s}{W_s^2}\bar{L}_s}_{\text{Spillover effect}} - \underbrace{\frac{(\gamma\bar{\phi}_{Ds}\phi_D)^{\eta}[M_D(\gamma\bar{\phi}_{Ds})^{\eta}\eta\phi_D^{\eta-1}\frac{d\phi_D}{dM_F} + (\gamma\bar{\phi}_{Fs}\phi_F)^{\eta}]}{W_s^2}\bar{L}_s}_{\text{Labor market competition effect}} \\
&= \frac{(\gamma\bar{\phi}_{Ds})^{\eta}\eta\phi_D^{\eta-1}\frac{d\phi_D}{dM_F}[W_s - (\gamma\bar{\phi}_{Ds}\phi_D)^{\eta}M_D] - (\gamma\bar{\phi}_{Ds}\phi_D)^{\eta}(\gamma\bar{\phi}_{Fs}\phi_F)^{\eta}}{W_s^2}\bar{L}_s \\
&= \frac{(\gamma\bar{\phi}_{Ds})^{\eta}\eta\phi_D^{\eta-1}\frac{d\phi_D}{dM_F}[(\gamma\bar{\phi}_{Fs}\phi_F)^{\eta}M_F + w_0^{\eta}] - (\gamma\bar{\phi}_{Ds}\phi_D)^{\eta}(\gamma\bar{\phi}_{Fs}\phi_F)^{\eta}}{W_s^2}\bar{L}_s \\
&= \eta\frac{(\gamma\phi_D\bar{\phi}_{Ds})^{\eta}(\gamma\phi_F\bar{\phi}_{Fs})^{\eta}\bar{L}_s}{W_u^2}\left[\frac{M_F}{\phi_D}\frac{d\phi_D}{dM_F}\Big(1 + \frac{w_0^{\eta}}{M_F(\gamma\phi_F\bar{\phi}_{Fs})^{\eta}}\Big) - \frac{1}{\eta}\right]
\end{aligned}
$$

$\frac{dl_{Ds}}{dM_F}$ is positive (negative or zero) if and only if $\frac{M_F}{\phi_D}\frac{d\phi_D}{dM_F}\Big(1 + \frac{w_0^{\eta}}{M_F(\gamma\phi_F\bar{\phi}_{Fs})^{\eta}}\Big) - \frac{1}{\eta}$ is positive (negative or zero). In particular, when $\tau = 0$, there is no spillover of foreign technology into domestic technology. Therefore, $\frac{dl_{Ds}}{dM_F} < 0$ as $\frac{M_F}{\phi_D}\frac{d\phi_D}{dM_F} = \frac{d\log\phi_D}{d\log M_F} = 0$. Moreover, we show $\frac{dl_{Ds}}{dM_F} > 0$ by providing a numerical example, where we choose a set of parameters under which $\frac{dl_{Ds}}{dM_F} > 0$ holds. Given parameters specified in Table A3, $\frac{dl_{Ds}}{dM_F} > 0$. By continuity, there exists a $\bar{\tau} > 0$ such that $\frac{dl_{Ds}}{dM_F} \leq 0$ for $\tau \in (0, \bar{\tau}]$. Note in addition that there exists a set of parameters such that $\frac{dl_{Ds}}{dM_F} = 0$, which is a result of continuity and the intermediate value theorem.

Claim 7 *Total labor demand at domestic firms decreases with the number of foreign firms if there is no technology spillover. If there is technology spillover, the total labor demand at domestic firms may decrease or increase with the number of foreign firms—depending on other parameters.*

$$
\frac{dL_D}{dM_F} \quad \begin{cases} \leq 0 \ \textit{or} > 0 & \textit{if} \quad \tau > 0 \\ < 0 & \textit{if} \quad \tau = 0 \end{cases}
$$

$$
\begin{aligned}
L_D &= M_D \cdot (l_{Du} + l_{Ds}) \\
\frac{dL_D}{dM_F} &= M_D \cdot \Big(\frac{dl_{Du}}{dM_F} + \frac{dl_{Ds}}{dM_F}\Big)
\end{aligned}
$$

From Claims 5 and 6, it is sufficient to prove that $\frac{dL_D}{dM_F} < 0$ when $\tau = 0$. Moreover, given parameters specified in Table A3, $\frac{dL_D}{dM_F} > 0$. By continuity, there exists a $\bar{\tau} > 0$ such that $\frac{dL_D}{dM_F} \leq 0$ for $\tau \in (0, \bar{\tau}]$. Note in addition that there exists a set of parameters such that $\frac{dL_D}{dM_F} = 0$, which is a result of continuity and the intermediate value theorem.

Claim 8 *Total wage bill at domestic firms decreases with the number of foreign firms if there is no technology spillover. If there is technology spillover, the total wage bill at domestic firms may decrease or increase with the number of foreign firms—depending on other parameters.*

$$\frac{dWB_D}{dM_F} \quad \begin{cases} \leq 0 \ \ or > 0 & if \quad \tau > 0 \\ < 0 & if \quad \tau = 0 \end{cases}$$

$$\begin{aligned} WB_D &= M_D(w_{Du}l_{Du} + w_{Ds}l_{Ds}) \\ \frac{dWB_D}{dM_F} &= M_D\Big(\frac{dw_{Du}}{dM_F}l_{Du} + \frac{dl_{Du}}{dM_F}w_{Du} + \frac{dw_{Ds}}{dM_F}l_{Ds} + \frac{dl_{Ds}}{dM_F}w_{Ds}\Big) \end{aligned}$$

From Claims 3, 4, 5, and 6, it is sufficient to prove that $\frac{dWB_D}{dM_F} < 0$ when $\tau = 0$. Moreover, given parameters specified in Table A3, $\frac{dWB_D}{dM_F} > 0$. By continuity, there exists a $\bar{\tau} > 0$ such that $\frac{dWB_D}{dM_F} \leq 0$ for $\tau \in (0, \bar{\tau}]$. Note in addition that there exists a set of parameters such that $\frac{dWB_D}{dM_F} = 0$, which is a result of continuity and the intermediate value theorem.

Claim 9 *Production at a domestic firm decreases with the number of foreign firms if there is no technology spillover. If there is technology spillover, the production at a domestic firm may decrease or increase with the number of foreign firms—depending on other parameters.*

$$\frac{dq_D}{dM_F} \quad \begin{cases} \leq 0 \ \ or > 0 & if \quad \tau > 0 \\ < 0 & if \quad \tau = 0 \end{cases}$$

$$\begin{aligned} q_D &= \phi_D(l_{Du} + \bar{\phi}_{Ds}l_{Ds}) \\ \frac{dq_D}{dM_F} &= \frac{d\phi_D}{dM_F}(l_{Du} + \bar{\phi}_{Ds}l_{Ds}) + \phi_D\Big(\frac{dl_{Du}}{dM_F} + \bar{\phi}_{Ds}\frac{dl_{Ds}}{dM_F}\Big) \end{aligned}$$

From Claims 2, 5, and 6, it is sufficient to prove that $\frac{dq_D}{dM_F} < 0$ when $\tau = 0$. Moreover, given parameters specified in Table A3, $\frac{dq_D}{dM_F} > 0$. By continuity, there exists a $\bar{\tau} > 0$ such that $\frac{dq_D}{dM_F} \leq 0$ for $\tau \in (0, \bar{\tau}]$. Note in addition that there exists a set of parameters such that $\frac{dq_D}{dM_F} = 0$, which is a result of continuity and the intermediate value theorem.

Claim 10 *Total value added at domestic firms decreases with the number of foreign firms if there is no technology spillover. If there is technology spillover, the production at domestic firms may decrease or increase with the number of foreign firms—depending on other* *parameters.*

$$\frac{dVA_D}{dM_F} \quad \begin{cases} \leq 0 \ or > 0 & if \quad \tau > 0 \\ < 0 & if \quad \tau = 0 \end{cases}$$

As prices are normalized to one, we can write total value added at domestic firms as follows.

$$VA_D = M_D q_D \cdot 1$$
$$\frac{dVA_D}{dM_F} = M_D \frac{dq_D}{dM_F}$$

Thus, the claim holds directly as a result of Claim 9.

C Input/Output Equations

Use firms' countries of ownership to construct

$$S^o_{cz,\iota,t} \equiv \frac{L^{F_o}_{cz,\iota,t}}{\sum_{cz'} L^{F_o}_{cz',\iota,t}} \tag{17}$$

Construct IV for horizontal term:

$$Z^{\text{Horizontal}}_{cz,\iota,t} = \frac{\sum_o (\sum_{cz' \neq cz} L^{F_o}_{cz',\iota,t} - L^{F_o}_{cz',\iota,t-1}) S^o_{cz,\iota,t-5}}{L^F_{cz,\iota,t-5} + L^D_{cz,\iota,t-5}} \tag{18}$$

Construct IV for Downstream term:

$$Z^{\text{Downstream}}_{cz,\iota,t} = \sum_{\kappa \neq \iota} \sigma_{\iota,\kappa} Z^{\text{Horizontal}}_{cz,\kappa,t} \tag{19}$$

Construct IV for Upstream term:

$$Z^{\text{Upstream}}_{cz,\iota,t} = \sum_{\kappa \neq \iota} \alpha_{\kappa\iota} Z^{\text{Horizontal}}_{cz,\kappa,t} \tag{20}$$