Multinational Production and Corporate Labor Share*

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Abstract

We study the role of multinational enterprises (MNEs) on the labor share in the source country. A unique natural experiment from the 2011 Thailand Floods, which forced Japanese-MNEs plants to halt operations, is employed. This foreign productivity shock leads to a relative decrease in domestic employment and fixed assets of the MNEs affected by the floods, with a stronger effect on the latter. We propose a heterogeneous firm GE model that features a production function with offshore factor inputs and an "extensive margin hat algebra" method to solve the model quantitatively without observing the cost savings of marginal offshorers. We estimate the elasticity of substitution between home labor and foreign inputs by relating the home and foreign factor demands to the floods shock. The estimated model indicates that foreign factor productivity growth increased capital demand in Japan more than labor demand, reducing the labor share in Japan by 2.26 percentage points from 1995-2007.

Keywords: Multinational enterprise, Labor share, Natural experiment, The 2011 Thailand Floods, Elasticity of factor substitution.

JEL codes: F23, E25, J23, F21, F66

1. Introduction

A growing body of evidence suggests that in recent decades, labor shares have been decreasing in several developed countries. This raises concerns among policymakers as it suggests that income inequality between capital owners and laborers grow, and challenges one of the stylized facts that is the backbone of economic growth models (Kaldor, 1961). Past studies proposed several potential explanations, including the bias in technological changes and rising markups. However, behind the technological changes are several potential mechanisms, and causal evidence of a specific mechanism is scarce. In this paper, we focus on the role of intensified activities of multinational enterprises

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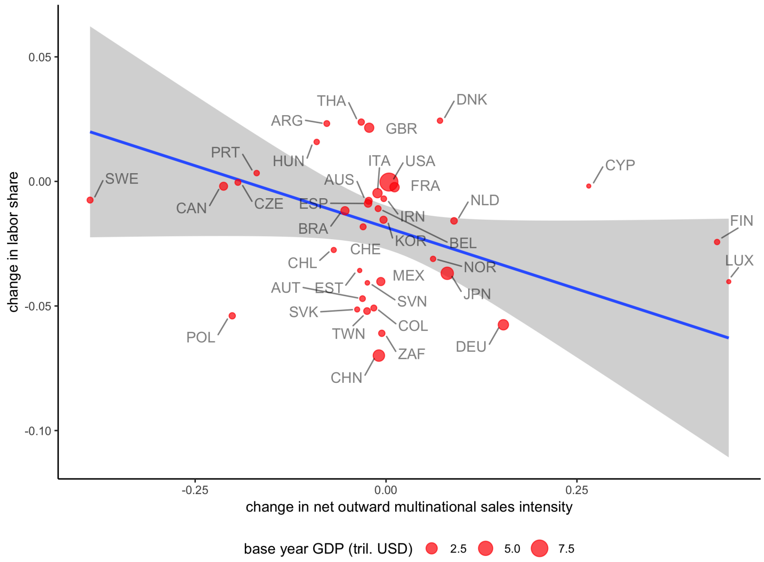
Figure 1: Net Outward Multinational Sales and Labor Shares



Note: Authors' calculation by data from Karabarbounis Neiman (2014) and UNCTAD. The horizontal axis is the change in the sum of bilateral net outward multinational sales between 1991-1995 average and 1996-2000 average. The vertical axis is the change in labor share from 1991 to 2000. Singapore is dropped because it has an outlier value for the outward multinational sales measure. Further details and results are given in Appendix B1..

(MNEs) that plays in the labor and capital markets. In fact, Figure 1 plots a cross country variation in the change of net MNE activities and the change of labor shares, which shows a statistically significant negative relationship. Although not a causal relationship, the negative relationship is consistent with outward MNE activities being substitutable to labor more than capital demand in the source country.

We provide novel causal evidence drawn from a natural experiment. Specifically, we study the 2011 Thailand Floods that had a significant negative productivity shock to the foreign subsidiaries of Japanese MNEs. We show that firms located in the flooded area experiences different trends of the intensity of foreign activities measured by sales and domestic activities such as employment and fixed asset stocks from other MNEs that operated in Thailand but were not affected by the floods. Our evidence is consistent with the view that firms partially offset the negative impact of foreign production sites by flexibly increasing workers domestically. Motivated by these findings, we provide a model of heterogeneous firms that inputs domestic labor, capital, and foreign inputs, and perform the comparative statics exercise with respect to the change in the foreign productivity. We point out that the elasticity of domestic factor demands with respect to the effective foreign factor prices is the key to drive the labor share, and provide the estimates using the Thailand Floods natural experiment. Using the estimated model, we provide a quantitative exercise to show that the effect foreign productivity growth on the decline in the Japanese labor share was significant.

The 2011 Floods left significant damage to the production economy in Thailand on an unprecedented scale. In the flooded manufacturing clusters are a number of subsidiaries of Japanese MNEs. To study this unique event, we match a dataset of the universe of Japanese MNEs with rich information on the subsidiary location, foreign operation, and domestic activities such as employment and fixed asset formation. The floods had a long-lasting effect on MNEs' activities in the flooded region, and our event study shows decline in both employment and fixed asset formation in Japan. Furthermore, we find that the reduction in the fixed asset is stronger than that of employment, as the decline in the employment is partly offset by the increased employment of non-regular workers. These workers are under flexible contracts with firms, and thus, firms can hire and fire them relatively easily. These findings suggest that labor is more substitutable than capital with foreign inputs.

To understand the relationship of foreign factor productivity and labor share, we develop a general equilibrium model of heterogeneous firms. In the model, factor prices are determined under market clearing conditions and key variables to determine the labor shares. In the model, if labor is relative substitute with foreign inputs than capital, the productivity growth of foreign factor decreases the relative demand of labor and thus pressures the labor demand downwards. To solve the heterogeneous firms model, we apply the "hat algebra" method. However, our model involves a cost saving term due to entry into the foreign sourcing, and this extensive-margin term makes the standard hat algebra approach inapplicable since we do not observe the same firm that does and does not source from foreign countries. To work around this issue and obtain the measure of the counterfactual cost savings, we use the model-implied measure of the cost ratio of offshorers, which we call an "extensive-margin hat algebra," (EMHA).

With the EMHA solution, we can perform the quantitative exercise with observable factor cost shares and elasticities of substitution. We use the Thailand Floods to identify and estimate the elasticity of substitution between domestic labor and foreign inputs, while other substitution parameters are calibrated by applying the existing methods in the literature. To estimate the domestic labor-foreign inputs substitutability, we use the empirical specification that are studied in the literature of the labor substitution effect of MNEs. We provide a theoretical interpretation of the two-stage least square estimates that is the ratio of the indirect employment effect of the foreign productivity shock and the sum of the indirect effect and direct substitution effect. This theoretical relationship provides a method-of-moments estimator for the elasticity of substitution, and applying this method to the Thailand Floods yields the estimate of 1.4, which is significantly higher than the Cobb-Douglas null hypothesis.

After checking the estimated model's performance to predict the floods' effect on domestic labor and capital demand, we derive the quantitative implication of the foreign factor productivity growth on the decrease in Japanese corporate labor share. We back out the aggregate evolution of foreign productivities from the domestic and foreign employment from the model. This foreign productivity growth explains a 2.26 percentage point reduction in the labor share between 1995 and 2007. We also perform the decomposition exercise of this labor share decline and find that the foreign factor productivity growth had the effect of expanding labor share inequality across firms since already low labor-share multinational firms further reduce labor share by substituting their domestic labor demand with the foreign inputs.

Our contribution is threefold. First, we provide a new mechanism to explain the recent trend of labor shares in advanced economies. As Karabarbounis and Neiman (2013) document the worldwide trend of labor share decline, a growing number of papers have examined the mechanism behind the phenomenon. Among them, Oberfield and Raval (2021) emphasize the role of "technology, broadly defined, including automation and offshoring, rather than mechanisms that work solely through factor prices." We take this stance but argue one step further that the deepened global value chains of firms' multinational activities play a role in depressing the labor share. In a somewhat related but distinct argument for the sizable role of globalization, Elsby et al. (2013) also conclude that the offshoring of labor-intensive activities among the supply chains are "the leading potential explanation of the decline in the U.S. labor share over the past 25 years."[1]

As far as we are aware of, it is only a contribution by Sun (2020) that provides the role of MNEs that play driving the labor shares. Based on different capital intensities between MNEs and other firms, Sun (2020) provides a model of non-factor neutral technology that describes the change in the labor share in developing countries that adopt the foreign direct investment from other countries. We complement this study in two dimensions. First, we provide causal evidence of the firms' intensified foreign activity on domestic factor employment based on a natural experiment, and the elasticity of factor substitution. Second, using these estimates, we argue the implication of labor share decline in Japan, a developed country that attracts fewer investments than it invests in other developing countries.

Second, we contribute to the literature of the effects of MNEs on the domestic labor market by providing evidence drawn from natural experimental variation. Past literature examines the impact of foreign production on the source country's labor market drawing on firm-level data (among others, Desai et al., 2009; Muendler and Becker, 2010; Harrison and McMillan, 2011; Ebenstein et al., 2014; Boehm et al., 2017). However, due to the scarcity of exogenous variation, the causality of evidence has been arguably weak. An exception is a work by Kovak et al. (2021), who use the variation brought by the enactment of Bilateral Tax Treaties between the US and partner countries to find heterogeneous impact on employment at the MNE level. We provide a complementary piece of evidence from a new natural experiment, the 2011 Thailand floods' impact on Japanese MNEs. Furthermore, these past studies were primarily concerned about the implication in the domestic labor market, but not the change in the use of capital. However, it is critical to examine the capital market as well as the labor market to discuss the corporate labor share.

Third, our paper is also related to the literature on solving the trade models using hat algebra. Since Dekle et al. (2007) proposed the method by expressing equilibrium conditions by a new-to-old ratio with hat notation, it has been quite popular in solving quantitative trade models thanks to its low requirement for data and estimation, as discussed in Costinot and Rodríguez-Clare (2014). There are also extension works to the original Dekle et al.'s method, such as the dynamic hat algebra proposed in Caliendo et al. (2019). By contrast, our EMHA method expands the set of models to

[1]In contrast, other mechanisms proposed in the literature include the automation (e.g., Acemoglu and Restrepo, 2019), the declining relative cost of capital (e.g., Karabarbounis and Neiman (2013); Hubmer (2018)), the increasing market powers in the output market (Autor et al., 2017; Barkai, 2017; De Loecker and Eeckhout, 2017; Autor et al., 2020) and the labor market (Gouin-Bonenfant et al., 2018; Berger et al., 2019), and financial market features such an increasing risk premia (e.g., Caballero et al., 2017).

which the hat algebra can be applied. In general, expressions of new-to-old ratios in heterogeneous firms models involve a counterfactual term of the difference of a marginal firm's characteristics (e.g., unit cost) between entry and non-entry. However, we cannot observe both terms simultaneously, as in a classical counterfactual unobservability problem in causal inferences. We provide a method to solve this problem by applying the model restriction and proxy the counterfactual term by entrants' cost shares.

Our paper is structured as follows. Section 2. shows data about labor shares and the reduced-form finding from the 2011 Thailand Floods. Section 3. shows the model of the labor share and foreign factor productivity shock. Section 4. discusses the parameter estimation and Section 5. the quantitative exercises. Section 6. concludes.

2. Empirical Evidence

We provide primary data sources and evidence from an event study based on the 2011 Thailand Floods.

2.1. Data Source

Our primary data sources are twofold. The first one is the Basic Survey on Japanese Business Structure and Activities (BSJBSA), an annual survey of the universe of firms above size thresholds in Japan, administered by the Ministry of Economy, Trade, and Industry (METI).[2] BSJBSA has a detailed set of variables regarding firm-level information, such as firm's address, the number of employees at the division level such as regular and non-regular workers, balance-sheet information including the value of fixed assets, sales by goods, costs by types, export and import by regions, outsourcing, among others. In Japan, non-regular workers include part-time, contract, and workers dispatched from temporary employment agencies), and its number is growing rapidly (Morikawa, 2010). The dataset covers the period 1995-2016.

Second, in order to match the foreign production information to the BSJBSA, we employ the *Basic Survey of Overseas Business Activities* (BSOBA), an annual government survey of all Japanese MNEs covering both private and public firms, administered by METI.[3] BSOBA consists of Headquarter and Subsidiary files. We use information from the Subsidiary File that records data about all child and grandchild foreign subsidiaries of each headquarter firm.[4] The questionnaire consists of the destination country, local employment and sales, where the sales are broken up into the categories of destination such as Japan (home country), Asia, Europe, and America. We access the data from

[2]The size threshold is more than 50 employees and JPY 30 million (≈USD 0.3 million) initial fund.

[3]The definition of MNEs and foreign activities in BSOBA is the following. A firm is defined as a MNE if it has a foreign subsidiary. Foreign subsidiaries can be either of "child subsidiary" or "grandchild subsidiary". A child subsidiary firm is a foreign corporation whose Japanese ownership ratio is 10% or more. A grandchild subsidiary is a foreign corporation whose ownership ratio is 50% or more by the foreign subsidiaries whose Japanese ownership ratio is 50% or more. Therefore, the definition of foreign production is not limited to the greenfield investment but includes purchases of the foreign company such as M&A.

[4]We drop subsidiaries located in tax-haven countries. For this purpose, we follow the definition of such countries by Gravelle (2015). We thank Cheng Chen for kindly sharing the code for the sample selection.

1995 to 2016. Appendix B2. confirms the coverage of employment and labor compensation variables in BSOBA Subsidiary File.

We supplement the information in BSOBA using the street-level address variable from the *Orbis* dataset from Bureau van Dijk since location variables in BSOBA are at the country level. Furthermore, we match these datasets by the headquarter firm name, location, and phone number using a firm-level dataset collected by a private credit agency, *Tokyo Shoko Research* (TSR). The match rate from BSOBA to BSJBSA is 93.0%. Due to the TSR data availability, the coverage of BSJBSA-BSOBA matched data is 2007-2016. Because the scope of BSOBA is the universe of Japanese MNEs, each firm is multinational if and only if it appears in BSOBA Headquarter File in BSJBSA in each year.

Patterns of the Firm-level Labor Share in Japan To provide an anatomy of the labor share decline in Japan, we perform a simple decomposition analysis using the BSJBSA. Specifically, we define the firm-level labor share by $(ls)_{it} = (wl)_{it} \,/\, [(wl)_{it} + (rk)_{it}]$, where $(wl)_{it}$ is labor compensation, and $(rk)_{it}$ is payment to capital measured by the current profit, for firm i in year t, and accordingly define the aggregate (corporate) labor share by $LS_t \equiv \sum_{i\in\Omega_t} (wl)_{it} \,/\, \sum_{i\in\Omega_t} [(wl)_{it} + (rk)_{it}]$, where Ω_t is the set of firms in year t.[5] Then we can decompose the change in the aggregate labor share since $t_0 \equiv 1995$ as follows:

$$\Delta LS_t \equiv LS_t - LS_{t_0} = AV_t + WI_t + RE_t + IN_t + EN_t, \tag{1}$$

where $AV_t \equiv \Delta(\bar{ls})_{it}$ is the change in the simple average of firm-level labor shares, WI_t is the within-firm effect that measures the change in the labor share within a firm, fixing the share of the firm in the baseline, RE_t is the reallocation effect that measures the across-firm reallocation of resources, fixing each firm's labor shares in the baseline, IN_t is the interaction effect of the correlation between the raised firm share and labor share, and EN_t is the entry-exit effect that measures the change in the labor share due to different sets of firms that exist in year t_0 and t, which are formally given by

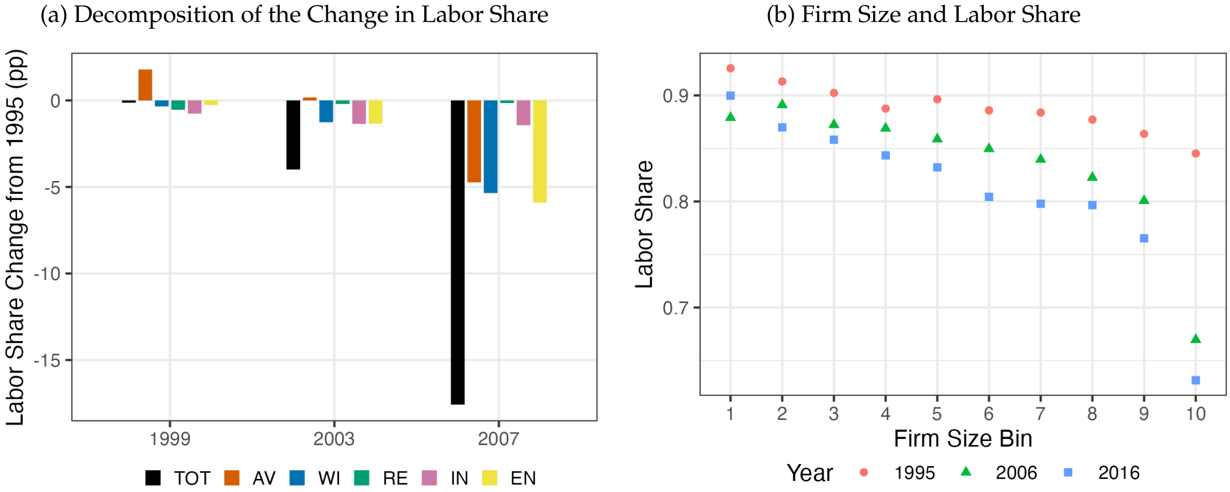
$$WI_t = \sum_{i\in\Omega_t\cap\Omega_{t_0}} \omega_{it_0}\Delta\,(ls)_{it}\,,\; RE_t = \sum_{i\in\Omega_t\cap\Omega_{t_0}} (ls)_{it_0}\,\Delta\omega_{it},\; IN_t = \sum_{i\in\Omega_t\cap\Omega_{t_0}} \Delta\omega_{it}\Delta\,(ls)_{it}\,,$$

$$EN_t = \sum_{i\in\Omega_t\setminus\Omega_{t_0}} \omega_{it}\,(ls)_{it} - \sum_{i\in\Omega_{t_0}\setminus\Omega_t} \omega_{it_0}\,(ls)_{it_0}\,.$$

Figure 2a shows the change in the labor share in Japan since 1995. We find that (i) a decline of the total corporate labor share in Japan is as large as 15 percentage point until 2007, (ii) the decline is largely explained by a combination of the average effect, within-firm effect, interaction effect, and entry-exit effects, and (iii) in 2007, each of the average effect, within-firm effect, and entry-exit effect explains roughly 5 percentage-point contribution. These findings point to the importance of mechanism that operates both through the within-firm and across-firm reallocation of factor demands.

[5] Although our measurement of labor share is one of the standards in the literature, several papers have discussed appropriate measurement of labor shares (Bridgman, 2018; Rognlie, 2018). In Appendix B3., we show that the decrease in the aggregate labor share in Japan in our sample period is robust to the alternative measurement methods proposed by these studies.

Figure 2: Firm-level Labor Shares in Japan



Note: The left panel plots the decomposition of the corporate labor share based on equation (1). "TOT" stands for the total effects and equals the sum of all the other effects, "WI" for the within-firm effect, "RE" for the reallocation effect, "IN" for the interaction effect, and "EN" for the entry-exit effect explained in the main text. The right panel plots the distribution of the corporate labor share by firm-size deciles.

To further understand the across-firm effects, Figure 2b plots the distribution of the firm-level labor share across firm sizes over three years in our sample period. It reveals that (i) there are negative relationships between labor share and firm size, and (ii) the slope of the relationship is steep in the later years, especially at the top of the size distribution. The relationship suggests that productive firms tend to have lower labor shares, and reallocation of resources from low-productivity and high-productivity firms would push down the labor share, a superstar phenomenon advocated by Autor et al. (2020).[6]

Although these descriptive analyses give insights about the proximate reason of labor share decline in Japan, it does not provide a fundamental cause (Acemoglu, 2012). For instance, a change in firms' economic environment, such as the growing availability of foreign workers and subsidiaries, drives the within-firm effect through the firm-level reaction to the change as well as the reallocation effect since such a change may alter the distribution of resources available to each firm. A challenge to understanding the fundamental cause in the past is the lack of exogenous shocks that change the firms' labor and capital demand. To provide causal evidence in this regard, we proceed to analyze our natural experimental setting.

2.2. Responses of Japanese MNEs to the 2011 Thailand Floods

Between July 2011 and January 2012, massive floods occurred along the Mekong and Chao Phraya river basins in Thailand and caused firms in the area to halt operations. The estimated economic damage was $46.5 billion, the fourth costliest disaster in history (World Bank, 2011), and its extreme

[6]Although we suggest a superstar phenomenon, we do not find conclusive evidence of the rising markup trend in Japan, as found in other countries such as the US (De Loecker and Eeckhout, 2017), but the stable trend in Appendix B4.. In the estimation section, we build on this finding to estimate the constant demand elasticity over our sample period. We also show aggregate labor share trends between MNEs and non-MNEs in Appendix B5..

size was not anticipated by then. The floods affected a number of Japanese producers. Severely damaged regions include Ayutthaya and Pathum Thani (AP hereafter) provinces, which host seven industrial estates where about 800 companies were located (Tamada et al., 2013), and 450 are Japanese subsidiaries among them.[7] These plants had embraced "just-in-time" production with small inventories, which makes them vulnerable to the shock (Monden, 2011).

Most firms in these areas was in automobile and electronics industries (Haraguchi and Lall, 2015), which is confirmed in Appendix B7.. They produce parts for manufacturing goods used for a later stage in global production. Although the floods direct inundation periods were as short as one year, afterwards economic effects were long-lasting as firms update their risk perception in the region (Pierce and Schott, 2016; Handley and Limão, 2017). Appendix B8. provides further discussion on the long-run nature of the floods shock.

Balancing Checks. To confirm no large systematic differences between MNEs that had subsidiaries located in the flooded regions and those not, we compare firm characteristics between the groups. In the BSOBA, we define a treated group as firms operating in AP provinces in 2011 and a subsidiary control group as firms not in these two provinces but in Thailand in 2011.[8] Figure 3 provides the results of balancing checks, where the left (right) panel shows the comparison of 4-digit industry share (sales) distributions. Although the treatment group is slightly more electronic parts (9% versus 3%), plastic product (9% versus 3%), and other metal product (8% versus 3%), the overall distributions are fairly spread in both groups and balanced. In the right panel, the Kolmogorov-Smirnov test does not reject the same distribution, with the exact p-value of 0.172.

Subsidiary-level Analysis. Before moving on to the main analysis on Japanese headquarters, we study the impact of floods on Thailand subsidiaries. For this purpose, we consider the following event-study regression for the sample of Japanese subsidiaries in Thailand:

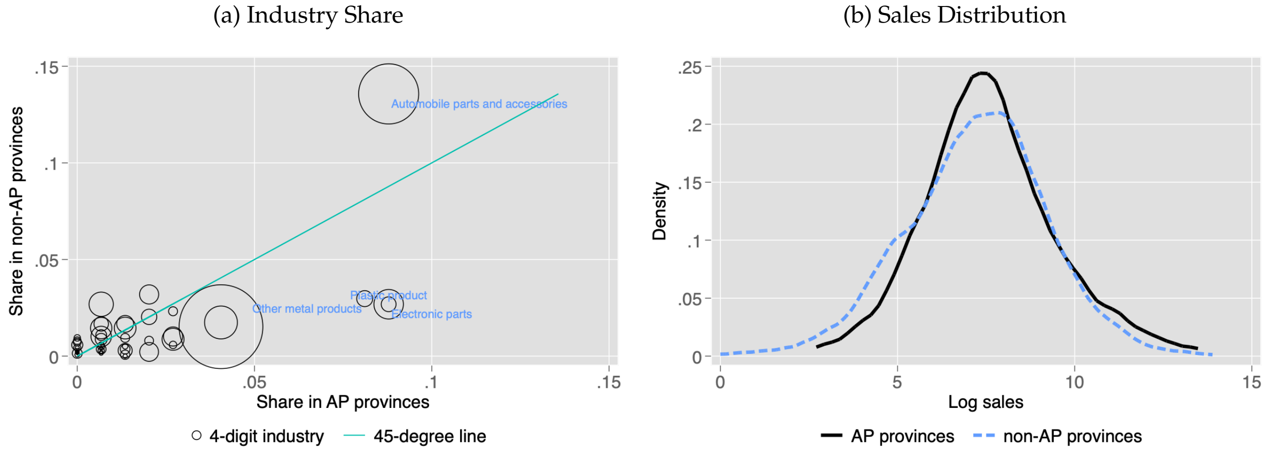
$$y_{st} = \alpha_s^S + \alpha_t^S + \sum_{\tau \neq 2011} \beta_\tau^S flood_{st,\tau} + \varepsilon_{it}^S, \tag{2}$$

where s is subsidiary s, t is calendar year, $flood_{st,\tau}$ is an indicator variable that takes one if and only if s is located in AP provinces in 2011 and $t = 2011 + \tau$ for $\tau = 2007, \ldots, 2016$. Figure 4 shows the results. First, we confirm that pre-floods year coefficients are statistically insignificant, satisfying the parallel trend requirement. Panel (a) takes the operating indicator as the outcome

[7]The flooded area and the locations of the inundated industrial clusters are reported by an insurance services firm Aon Benfield (`http://thoughtleadership.aonbenfield.com/Documents/20120314_impact_forecasting_thailand_flood_event_recap.pdf`, accessed on May 23, 2022). In the report, Exhibit 16 shows the map of inundation, while Exhibit 15 shows inundated Honda Ayutthaya Plant, located in Rojana Industrial Park, one of the seven industrial estates. Feng and Li (2021) also reports evidence of severe cross-border damages to Japanese MNEs. To further provide suggestive evidence of the negative production effect than consumption effect, Appendix B6. shows that Thailand experienced decrease in exports but not in imports after the floods, which can be seen as a piece of evidence that the floods affected production side significantly more than the demand side à la arguments by (Benguria and Taylor, 2019).

[8]It is important to focus our analysis to use the variation across narrow geographic regions within Thailand and control for potential cross-country differences. To confirm this point, Appendix B9. shows the comparison of the trend of Japanese MNE activities in Thailand and in the rest of the world.

Figure 3: Balancing Checks



Note: AP provinces mean Ayutthaya and Pathum Thani provinces. The left panel shows the comparison of 4-digit industry share distributions between firms in AP (treatment) and not in AP (control). Industry labels are shown if the industry share in AP provinces is higher than 0.05. The right panel plots the sales distributions of firms in AP and not in AP.

variable for the balanced panel of firms that operated throughout 2007-2011. We find a significant effect in this extensive margin on subsidiaries that operated in AP provinces in 2011. The effect lasted for three years after the floods, and to a lesser extent in the later years. Consistent with this finding, panel (b) shows the evidence of large investment response of the operating treatment group firms, which reflects a large reinvestment for damaged properties and potentially building disaster-resistant systems. The negative floods effect seem to operate mostly through the extensive margin, as panels (c) and (d) does not find the employment and sales response conditional on operating. Appendix B10. reports the robustness check results.

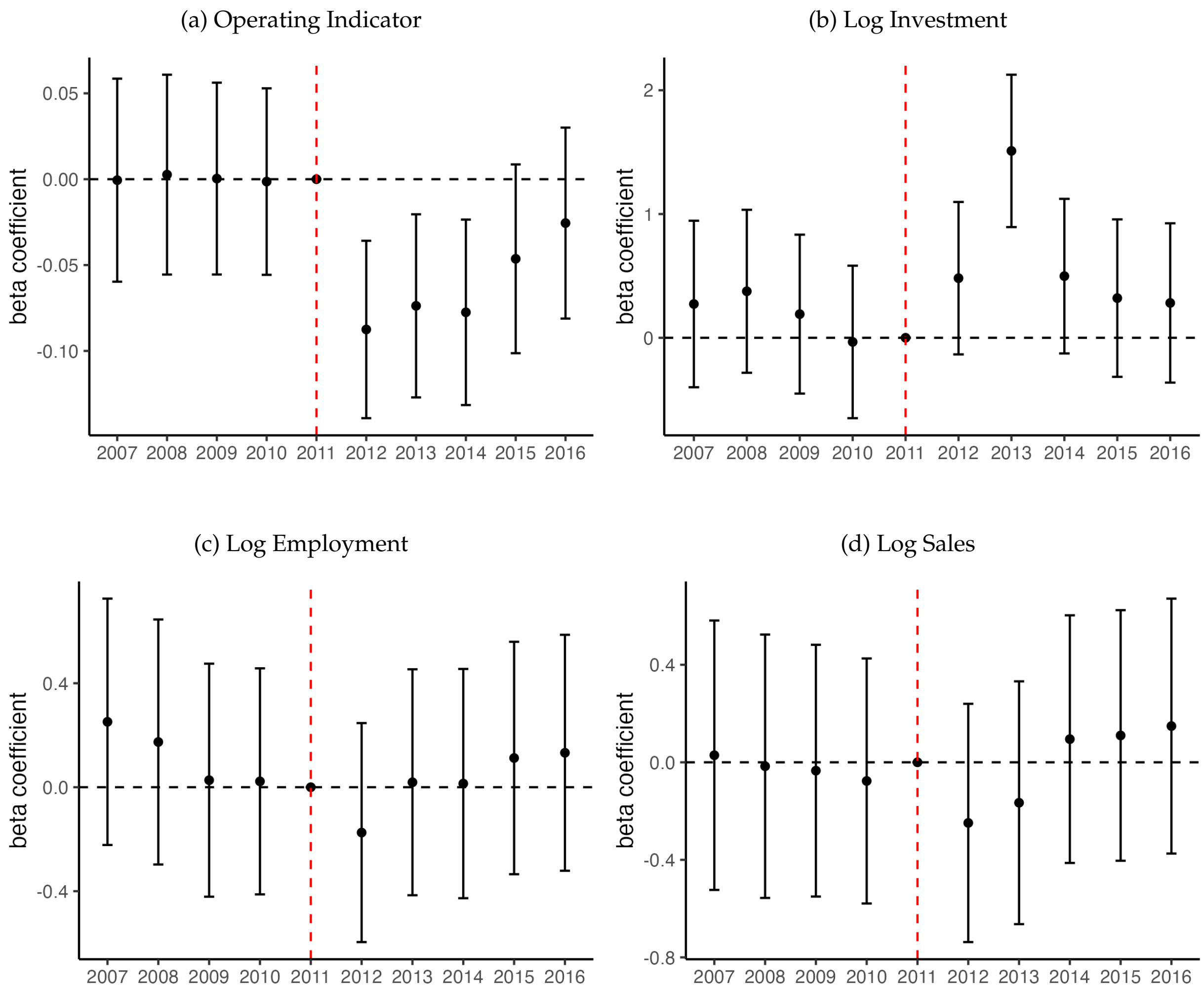
Headquarter-level Analysis. Next, we consider the following event-study regression for the sample of Japanese headquarter firms that have subsidiaries in Thailand:

$$y_{it} = \alpha_i^H + \alpha_t^H + \sum_{\tau \neq 2011} \beta_\tau^H \times \left(Z_i \mathbf{1}\left\{t = \tau\right\}\right) + \varepsilon_{it}^H, \tag{3}$$

where $Z_i \equiv l_{i,2011}^{flooded} / l_{i,2011}^{world}$ is Japanese headquarter-i's employment share in the flooded region among the global total employment, measuring the intensity of the floods shock relative to the firm's global size, y_{it} is the outcome variable, α_i^H is the headquarter firm-i fixed effect capturing unobserved and fixed firm characteristics, α_t^H is the year fixed effect, and ε_{it}^H is the error term. Our primary interest of the coefficient is β_τ^H, which captures the within-headquarter firm effect of the floods in each year. We plot the estimates of β_τ^H's for a variety of outcome variables in Figure 5. Again, in all panels, all estimates for pre-floods year τ are statistically insignificant, corroborating the parallel trend assumption associated with the treatment variable.

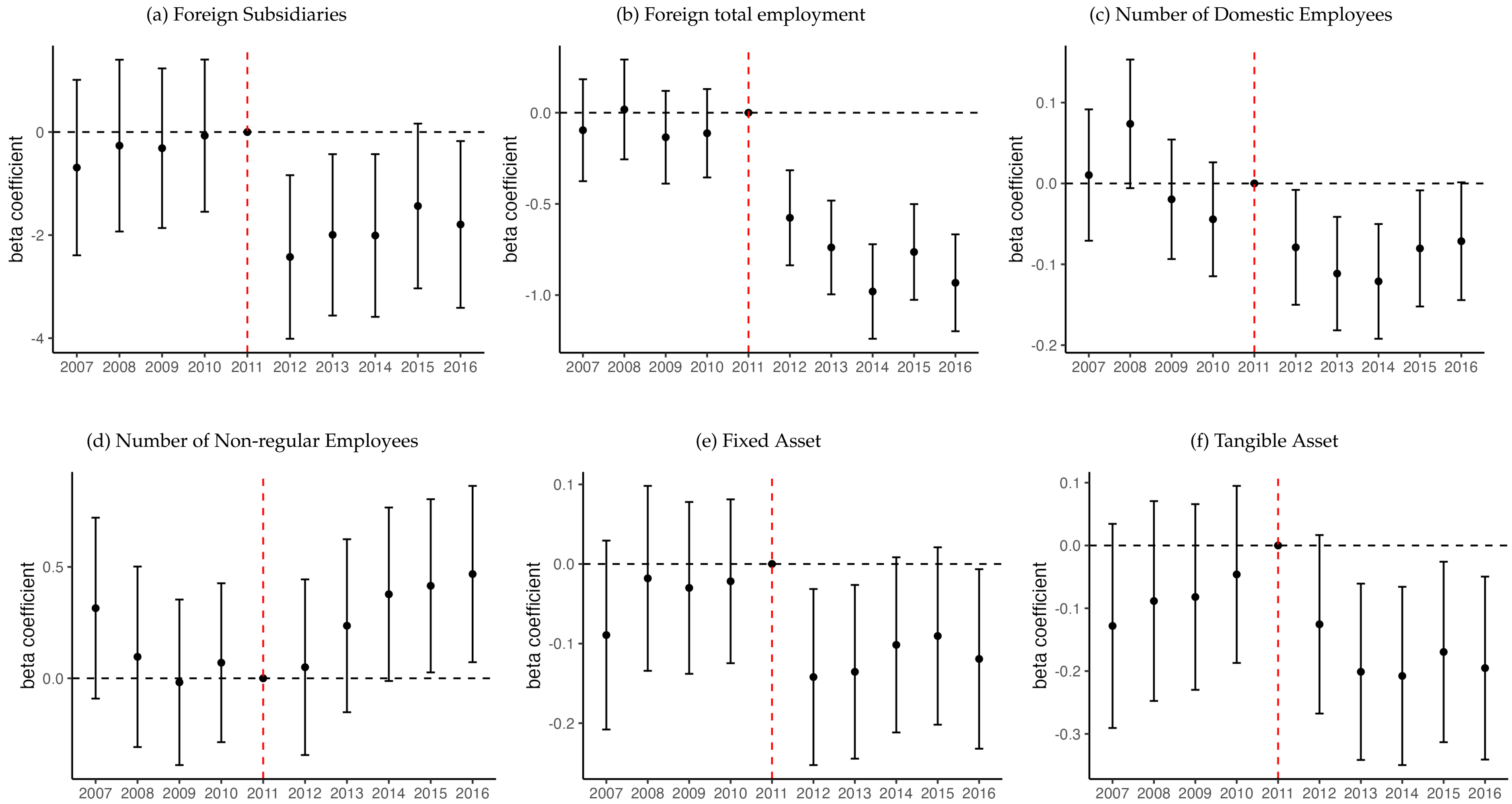
We first examine the effect on employment in Thailand in Panel 5a, and confirm that firms exposed to the floods decreases employment in Thailand significantly decreases both economically and statistically. This dramatic decrease is also reflected in the total employment in the foreign coun-

Figure 4: Event Study at the Subsidiary Level



Note: The figure plots coefficient estimates of subsidiary-level event-study regression in equation (2). Panel (a) takes operating indicator as the outcome variable for the balanced panel of firms that operated throughout 2007-2011, and panels (b)-(d) takes log investment, log employment, and log sales for the panels of operating firms in each year. Standard errors are cluster-robust at the subsidiary level, and the bars indicate the 95 percent confidence intervals.

Figure 5: Event Study at the Headquarter Level



Note: The figure plots coefficient estimates of headquarter-level event-study regression in equation (3). As an outcome variable, panel (a) takes the number of foreign subsidiaries including the flooded regions, panel (b) takes log total foreign employment including the flooded regions, panel (c) takes log Japanese employment, panel (d) takes log Japanese non-regular employment, panel (e) takes log fixed asset stock, panel (f) takes log tangible asset stock for the panels of operating firms in each year. Standard errors are cluster-robust at the firm level, and the bars indicate the 95 percent confidence intervals.

tries, as shown in Panel 5b. These results reveal that the floods had persistent negative effects on foreign activities, reflecting the country's reaction "to avoid potential supply chain disruptions" in the future. (Nikkei Asian Review, December 2, 2014)

We turn to the effect on domestic factor employment. Panel 5c shows the response of log employment in Japan. After the floods, we find negative significant effects for four years at 5 percent significance level and for all five years at 10 percent significance level. This revert to zero may be partly explained by the increase in non-regular workers in Panel 5d, which is a type of workers with flexible labor contracts and can be adjusted by firms with relative ease. Therefore, firms affected by the uncertainty in foreign production may react and substitute foreign workers with non-regular workers.

Finally, we study the reaction of capital stock. Panel 5e shows the effect on fixed asset holding. We find that the fixed asset is relatively smaller for strongly affected firms, and the point estimates are larger than the effect on the number of domestic employees in panel 5c in the absolute value. The negative effect is significant for two years after the floods, while a more persistent effect is found for the variable of tangible asset. Panel 5f shows that the effect on tangible asset is negative and even stronger and lasts for five years. Appendix B10. shows further evidence of the effects of the floods at the headquarter level.

Overall, we find that as firms face severe damage of the floods, they operate in many margins, including foreign activities, domestic employment, and domestic capital stock, with the exception of non-regular workers since they can mobilize workers with the flexible contract. We will develop a heterogeneous models based on these insights in the following section.

3. Model

We consider a heterogeneous firms model of offshore subsidiaries to study the domestic labor share effect of offshoring. For this purpose, we focus on the change in domestic and foreign factor prices reflecting the demand for these factors. These factor prices are determined in factor-market clearing conditions and driven by exogenous changes in external factors, such as foreign factor productivity growth or reduction in barriers to firms' multinational activities. The model features productivity heterogeneity that produces between-firm effect on labor share (Doraszelski and Jaumandreu, 2018), and a nested CES production function that yields within-firm labor share changes. We also consider frontier quantitative trade model features such as sectoral heterogeneity and input-output linkages to allow flexibility of production parameters (Caliendo and Parro, 2014).

3.1. Setup

Environment. There are S sectors indexed by j, and three countries $i \in \mathcal{I} \equiv \{J, T, R\}$ where J stands for Japan, T for Thailand, and R for the Rest of the World. We assume free trade and no factor mobility between countries. J and T are small-open, so we take sectoral price index P_j and factor prices in R as given. This assumption excludes feedback effects of activities in J and T that affect world prices. In J, capital $\bar{K}_J$ and labor $\bar{L}_J$ are supplied inelastically, while there is inelastic factor supply $\bar{M}_i$ in $i = T, R$. We do not need to specify household income and preferences because our small-open economy is free from determining good market clearing conditions, which equates expenditure to income (trade balance condition). We will come back to this point in quantitative analysis.

Production in Country J. There are sectoral good producers and intermediate-producing firms in country J. Sectoral good producers aggregate intermediate varieties by

$$Q_j \equiv \left[\int_{\omega \in \Omega_j} \left(q_j(\omega) \right)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} d\omega \right]^{\frac{\varepsilon_j}{\varepsilon_j - 1}}, \tag{4}$$

where ω is variety produced by intermediate producers, Ω_j the set of varieties in sector j, $\varepsilon_j \geq 0$ the sectoral elasticity of substitution between varieties. Firms produce unique variety under monopolistic competition, and their TFP ψ follows Pareto distribution with shape parameter θ_j.[9] Conditional on the subsidiary location set, each firm hires production factors of capital, labor, and foreign inputs at competitive input market with factor prices (w_J, r_J, p_T^m). Firms also choose offshoring subsidiary location in $i = T, R$ and produces with production function

$$q_j = f_j\left(k, m_j^P; \psi\right) = \psi \left[\alpha_j k^{\frac{\sigma_j - 1}{\sigma_j}} + (1 - \alpha_j) \left(m_j^P \right)^{\frac{\sigma_j - 1}{\sigma_j}} \right]^{\frac{\sigma_j}{\sigma_j - 1}}, \tag{5}$$

where k is the headquarter capital input, $m_j^P \equiv m_j^P(l, m_T, m_R, m)$ the production input further specified below, and $\sigma_j \geq 0$ the sectoral elasticity of substitution between capital and production inputs. The production input is determined by

$$m_j^P(l, m_T, m_R, m) \equiv \left[l^{\frac{\lambda - 1}{\lambda}} + (a_T m_T)^{\frac{\lambda - 1}{\lambda}} + (a_R m_R)^{\frac{\lambda - 1}{\lambda}} + m_j^{\frac{\lambda - 1}{\lambda}} \right]^{\frac{\lambda}{\lambda - 1}}, \tag{6}$$

where l is the domestic labor input, m_i the offshore inputs from subsidiaries in $i = T, R$ (e.g., Helpman et al., 2004; Ramondo and Rodríguez-Clare, 2013; Arkolakis et al., 2017)., and m_j other outsourced inputs in sector j, which is produced by combining sectoral inputs from other sector k, so $m_j \equiv \prod_k m_{kj}^{\delta_{kj}}$, and $\lambda > 1$ the elasticity of substitution between these factors. Here, a_i is an exogenous productivity of country $i = T, R$, which can represent an factor productivity in foreign country i from country J, or barriers to firms headquartered in J to operate in i.[10] We will study the comparative statics with respect to these productivities caused by floods or globalization. Firms in J pay a fixed cost of entry f^E, production f^P, and setting up a subsidiary in country i, or entry and investment in country i, f_i^M.

[9]Most of the model derivation does not rely on the Pareto assumption. The assumption is convenient when relating the change in the offshorers share to the productivity cutoff. See equation (16).

[10]This is similar to the approach taken by Sun (2020) since he conducted the counterfactual analysis with respect to bilateral multinational production cost without identifying the source of bilateral productivity.

Discussions follow regarding our choice of the production functions (5) and (6). First, our nested CES assumption implies that if $\lambda > \sigma_j$, a firm-level labor share defined by $w_J l_j(\omega) / \left(w_J l_j(\omega) + r_J k_j(\omega)\right)$ is decreasing in a_i^M since labor is relative substitute of foreign inputs (relative to capital). Second, we choose this nested CES structure to model the within-firm change in labor share due to changes in a_i, based on the observation that operations in foreign subsidiaries are labor intensive and MNEs' capital is often knowledge-intensive (Carr et al., 2001).[11] Third, there are several special cases worth mentioning. If $\lambda = \sigma$, our nested CES assumption implies a standard single-nest CES production function, which yields the same MNE-level unit cost structure as Antras et al. (2017). If firms do not set up a subsidiary and so do not hire foreign factor m_i, our production function boils down to another CES function $\left(\left(a_i^K k\right)^{\frac{\sigma-1}{\sigma}} + \left(a_i^L l\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$, which is the one used to discuss the decline in the labor share in several papers (e.g., Oberfield and Raval, 2021).

Equilibrium. In country T, a representative producer uses input M_T with demand function $M_T = \left(p_T^m / A_T\right)^{-\gamma}$. In country R, factor price is given at p_R^m. In equilibrium, factor prices (w_J, r_J, p_T^m) are determined so that factor markets clear. In this economy, the aggregate labor share in Japan is defined by

$$LS_J \equiv \frac{w_J \bar{L}_J}{w_J \bar{L}_J + r_J \bar{K}_J}. \tag{7}$$

3.2. The Extensive Margin Hat Algebra Solution

To solve this model, we write D_i as the indicator if a firm enters country $i = T, R$. Firm ψ's marginal cost depends on the entry decision and offshored inputs as

$$c_j = c_j\left(\psi; D_R, D_T\right) = \frac{\tilde{c}_j\left(D_R, D_T\right)}{\psi}, \tag{8}$$

where $\tilde{c}_j\left(D_R, D_T\right) \equiv \left[\alpha_j \left(r_J\right)^{1-\sigma_j} + \left(1-\alpha_j\right)\left(p_j^{m,P}\right)^{1-\sigma_j}\right]^{\frac{1}{1-\sigma_j}}$ and $p_j^{m,P} \equiv p_j^{m,P}\left(D_R, D_T\right)$ is the cost of production input given by

$$p_j^{m,P}\left(D_R, D_T\right) = \left(w_J^{1-\lambda} + D_T\left(\frac{p_T^m}{a_T}\right)^{1-\lambda} + D_R\left(\frac{p_R^m}{a_R}\right)^{1-\lambda} + \left(p_j^m\right)^{1-\lambda}\right)^{\frac{1}{1-\lambda}}. \tag{9}$$

Given the monopolistic competition, firm prices by $p_j = \frac{\varepsilon_j}{\varepsilon_j - 1} c_j$. Firm ψ enters country i if and only if $\psi > \psi_{i,j}$. We impose parameter restrictions such that $\psi_{T,j} > \psi_{R,j}$, based on the observed productivity differences between firms operating in Thailand and those not, shown in Appendix Figure A.1. Given this restriction, firms' entry choice is among $d = 00$ (domestic), $d = 01$ (R-investing), and $d = 11$ (R- and T-investing), and from now we rewrite productivity thresholds by $\psi_{01,j}$ (the threshold between $d = 00$ and $d = 01$) and $\psi_{11,j}$ (the threshold between $d = 01$ and $d = 11$). For instance, threshold $\psi_{11,j}$ can be obtained by equating profit gain by entry to the fixed

[11] The structure that the outsourced inputs is direct substitutes with (low-skill) labor is shared in Hummels et al. (2014).

cost $\pi_j\left(\psi_{T,j}; d=11\right) - \pi_j\left(\psi_{T,j}; d=01\right) = f_T$, or

$$\psi_{11,j} = \left(\frac{f_T}{\tilde{\varepsilon}_j P_j^{\varepsilon_j - 1} Q_j CS_{11,j}}\right)^{\frac{1}{\varepsilon_j - 1}},$$

where $CS_{11,j} \equiv c_j\left(\psi; d=11\right)^{1-\varepsilon_j} - c_j\left(\psi; d=01\right)^{1-\varepsilon_j}$ is the cost-saving term due to entry to T. Note that $CS_{11,j}$ is a firm-level counterfactual term and is hard to measure. Conditional on optimal entry decision d^* for each firm ψ, firm-level factor demand functions can be derived from the CES formulation

$$r_J k_j\left(\psi; d^*\right) = \left(\frac{r_J}{c_j^*}\right)^{1-\sigma_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} \left(c_j^*\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j, \tag{10}$$

$$p_j^{m,P*} m_j^P\left(\psi; d^*\right) = \left(\frac{p_j^{m,P*}}{c_j^*}\right)^{1-\sigma_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} \left(c_j^*\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j, \tag{11}$$

$$w_J l_j\left(\psi; d^*\right) = \left(\frac{w_J}{p_j^{m,P*}}\right)^{1-\lambda} p_j^{m,P*} m_j^P\left(\psi; d^*\right), \tag{12}$$

$$p_T^m m_{T,j}\left(\psi; d^*\right) = \left(\frac{p_T^m / a_T}{p_j^{m,P*}}\right)^{1-\lambda} p_j^{m,P*} m_j^P\left(\psi; d^*\right), \tag{13}$$

where $c_j^* \equiv c_j\left(\psi; d^*\right)$ and $p_j^{m,P*} \equiv p_j^{m,P}\left(d^*\right)$. These firm-level factor demand functions can be integrated over productivity ψ to be the aggregate capital demand K^D, labor demand L^D, and Japanese MNEs' factor demand in Thailand M_T^D. Factor prices $\left(w_J, r_J, p_T^m\right)$ are the solution to the factor market clearing conditions $K^D = \bar{K}_J$, $L^D = \bar{L}_J$, and $M_T^D + \left(\frac{p_T^m}{A_T}\right)^{-\gamma} = \bar{M}_T$.

To solve these equilibrium conditions, we follow the "hat algebra" approach (Dekle et al., 2007). A strength of this approach is low data requirement since we do not have to estimate all unobserved objects such as productivity shocks. We express all variables x in change, with the hat notation $\hat{x} = x'/x$. Let us consider the change in aggregate capital demand $\hat{K}^D$, as derivations are similar for the labor demand change $\hat{L}^D$ and Thailand factor demand change $\hat{M}_T^D$ and given in Appendix A2.. We can show that

$$\hat{K}^D = \sum_j S_j^K \left(\hat{r}_J\right)^{-\sigma_j} \hat{\bar{C}}_j^K, \tag{14}$$

and $\hat{\bar{C}}_j^K$ is the change in the average unit cost term for capital demand given by, with a slight abuse of notation,

$$\hat{\bar{C}}_j^K = \sum_{d \in \{00,01,11\}} S_{d,j}^K \left(\hat{\bar{c}}_{d,j}\right)^{\sigma_j - \varepsilon_j} \hat{s}_{d,j}, \tag{15}$$

where $S_j^K = \frac{r_J K_j}{\sum_k r_J K_k}$ is the sectoral capital cost share, $S_{d,j}^K = \frac{\int_{\psi \in d} r_J k_j(\psi) dG_j(\psi)}{r_J K_j}$ is capital cost share of firms with entry decision d in sector j, $\hat{s}_{d,j}$ is the share change of firms with entry decision d. The productivity-controlled cost change $\hat{\bar{c}}_{d,j}$ is standard is given in Appendix A2..

The Pareto distribution assumption implies that $\hat{s}_{d,j}$ depends on the cost-savings change $\hat{CS}_{d,j}$. For example, in case of $d = 11$, we have

$$\hat{s}_{11,j} = \left(\hat{\psi}_{11,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)} = \left(\hat{CS}_{11,j}\right)^{-\frac{\theta_j - \left(\varepsilon_j - \sigma_j\right)}{\varepsilon_j - 1}}. \tag{16}$$

Recall that $\hat{CS}_{11,j}$ involves unobservable *counterfactual* marginal costs. To workaround this difficulty, we propose the following Extensive Margin Hat Algebra (EMHA). First, note that the CES restriction implies the sectoral cost ratio, or $CR_{11,j} \equiv \left(c_{11,j}/c_{01,j}\right)^{1-\varepsilon_j} - 1$, as follows:

$$CR_{11,j} = \left[s_{01,j}^{K} + \left(1 - s_{01,j}^{K}\right)\left(1 - s_{11,j}^{m_T|m^P}\right)^{-\frac{1-\sigma_j}{1-\lambda}}\right]^{\frac{1-\varepsilon_j}{1-\sigma_j}} - 1. \tag{17}$$

where $s_{d,j}^{K} = \frac{\int_{\psi \in d} r_J k_j(\psi) d\psi}{\int_{\psi \in d} c_j q_j(\psi) d\psi}$ is the capital cost share of firms with entry decision $d = 00, 01, 11$, and $s_{d,j}^{m_T|m^P} = \frac{\int_{\psi \in d} p_T^m m_{T,j}(\psi) d\psi}{\int_{\psi \in d} p^{m,P} m^P(\psi) d\psi}$ is the Thailand factor cost share among production inputs of firms with entry decision d. Using this cost ratio expression, we can write $CS_{11,j} = c_{11,j}^{1-\varepsilon_j} - c_{01,j}^{1-\varepsilon_j} = c_{01,j}^{1-\varepsilon_j} CR_{11,j}$. Hence, the change in the cost saving can be written as

$$\hat{CS}_{11,j} = \left(\hat{\hat{c}}_{01,j}\right)^{1-\varepsilon_j}\left(\frac{CR'_{11,j}}{CR_{11,j}}\right), \tag{18}$$

where $\hat{\hat{c}}_{01,j}$ can be derived from standard hat algebra shown in Appendix A2., and $CR_{11,j}$ and $CR'_{11,j}$ are both derived in data before and after the change. We can derive similar expressions of equation (16) for other entry strategies $d = 00, 01$, which are shown in Appendix A2..

The intuition for EMHA is provided in the following. The key expression in EMHA is equation (17), which equates the sectoral cost ratio to a weighted average of the shares of capital cost and conditional Thailand factor costs. If Thailand investors depend heavily on production inputs in sector j (hence high $1 - s_{01,j}^{K}$) and the Thailand factor among production inputs (hence high $s_{11,j}^{m_T|m^P}$), then the optimal demand for production factors imply that the cost ratio between investing in Thailand and not is large. The nested CES production function provides a specific one-to-one relationship shown in equation (17). Therefore, we can measure counterfactual cost savings by model-implied observed cost shares.

4. Estimation

To solve the EMHA conditions, we need a set of parameters $\left(\theta_j, \varepsilon_j, \sigma_j, \lambda\right)$. First, we calibrate sectoral parameters $\left(\theta_j, \varepsilon_j, \sigma_j\right)$ by applying methods developed in the literature to the Japanese microdata. Second, we follow the literature on MNE's employment to estimate the remaining substitution parameter λ. We will describe these steps in the following.

Table 1: Parameter Calibration

Code	Label	θ_j	ε_j	σ_j
9	Food	6.57	3.76	0.23
11	Textile	13.58	4.99	0.57
15	Wood	6.17	4.15	0.19
16	Chemical	5.93	2.73	0.22
18	Plastic	10.29	4.62	0.23
19	Rubber	19.78	3.85	0.03
21	Ceramics	4.68	3.07	0.32
22	Metal	7.57	4.38	0.28
23	Non-ferrous Metal	53.2	5.48	0.01
24	Metal Product	8.56	4.1	0.21
25	General Machine	7.45	4.71	0.07
28	Electronics	8.03	4.7	0.22
29	Electric Machine	8.86	4.85	0.36
30	ICT Machine	8.03	4.7	0.22
31	Transportation Machine	8.2	5.35	0.19
32	Other Manufacturing	5.79	4.77	0.4

Note: The table shows the calibrated parameters using the method described in the main text. θ_j is the shape parameter of sectoral Pareto productivity distribution, ε_j is the sectoral elasticity of substitution between intermediates goods (cf. equation 4), and σ_j is the sectoral elasticity of substitution between capital and production inputs (cf. equation 5).

4.1. Calibrating Sectoral Parameters

First, we fit Pareto shape parameter θ_j to the sectoral tail sales distribution. Following Eaton et al. (2011), we fit $\ln\left(x_j^q\right) = a_j - \left(\theta_j\right)^{-1}\ln\left(1-q\right)$, where q stands for percentile, a_j for the sector-specific intercept, and x_j^q for q-th percentile sales in sector j. We use sample firms with $q > 0.99$ for each sector as the top tail of the distribution follows Pareto distribution (Simon and Bonini, 1958). Second, we obtain demand elasticity ε_j to sectoral average markups. We compute markups for each firm by dividing the sales by the sum of costs associated with production of labor compensation, capital cost, and purchase of intermediate goods. Finally, we calibrate capital-production input elasticity σ_j to the relative capital demand with respect to local wage using Japanese manufacturing plant-level data, with the Bartik instrument of local sectoral employment share and national sectoral employment growth (Oberfield and Raval, 2021). Calibration details are given in Appendix B11.. These parameters are calibrated at the three-digit level in manufacturing sector, as shown in Table 1. Calibrated parameters satisfy restrictions of Pareto shape parameter $\theta_j > \varepsilon_j - \sigma_j$ for all j so that the power averages are well defined. Furthermore, Oberfield and Raval (2021) also estimated $\sigma < 1$ using the U.S. plant-level data.

4.2. Estimating Labor-Foreign Input Substitution Elasticity λ

To estimate the elasticity of substitution between labor and foreign production factors λ, we focus on a sample of MNEs that have subsidiaries in Thailand to eliminate the differences in country-level trends. We then follow a two-stage least square (2SLS) difference-in-difference (DiD) specification at the headquarter i level (Kovak et al., 2021):

$$\ln\left(l_{it}\right) = a_i + a_{jt} + b \ln\left(m_{it}^T\right) + e_{it}, \tag{19}$$

where l_{it} is employment in Japan, m_{it}^T the value added in Thailand, a_i the headquarter fixed effect that absorbs any unobserved firm-specific characteristics, a_{jt} the industry-time fixed effect that absorbs any industry j-specific time trends, and e_{it} the error term.[12] An issue of this regression is the difficulty to find an appropriate instrumental variable for $\ln\left(m_{it}^T\right)$.[13] To this issue, we propose a floods shock IV defined as $Z_{it} \equiv Z_i \times \mathbf{1}\left\{t \geq 2012\right\}$ where Z_i is the same as the intensity term in equation (3). If we relate the change in the IV as the negative productivity shock as argued in Section 2.2., we have $dZ_{it} = -kd\ln a_T$ for some positive constant k that relates the empirical measure dZ_{it} and the theoretical productivity reduction $d\ln a_T$. With this relationship, factor demand functions (12) and (13), the 2SLS-DiD estimator of b converges to

$$E\left[\frac{d\ln l_{it}/dZ_{it}}{d\ln m_{it}^T/dZ_{it}}\right] = \frac{\Xi\left(\lambda\right)}{\Xi\left(\lambda\right) - \lambda}, \tag{20}$$

where $\Xi\left(\lambda\right) = \lambda \sum_j S_j^L s_{T,j}^{m_T|m^P} + \sum_j S_j^L s_{T,j}^{m_T|m^P}\left[-\sigma_j + \left(\sigma_j - \varepsilon_j\right) s_{T,j}^{m^P}\right]$.

To interpret equation (20), consider the numerator and denominator separately in the left-hand side and relate them to their model counterpart in equations (12) and (13). On the one hand, $d\ln l_{it}/dZ_{it}$ comes solely from the inflated cost index since Z_{it}, or productivity in Thailand a_T, affects labor demand through the cost index c_j^* in labor demand equation (12). This effect is summarized in the term $\Xi\left(\lambda\right)$ and depends on λ through the elasticity of the change in labor demand with respect to the change in the productivity of the factor in Thailand. On the other hand, $d\ln m_{it}^T/dZ_{it}$ is derived from both the increase in cost index and direct substitution effect since productivity in Thailand a_T affects not only c_j^* but also a_T in the effective unit cost directly. These effects are summarized in $\Xi\left(\lambda\right)$ and $-\lambda$ in the denominator of equation (20), respectively. Given the condition (20), the 2SLS-DiD estimate of b provides the estimate of λ. Note that the value of k does not affect our estimation procedure because it appears both in the numerator and denominator of equation (20) and cancels out, so this estimation method is robust to the assumption of the severeness of the floods. Furthermore, a standard Delta method provides the estimate of standard error, which is described in detail in Appendix Section B14..

Table 2 shows the result of regression equation (19). We find that there is a positive relationship between Japanese employment and Thailand value-added in the OLS (column 1) and FE (column 2) specifications, which remains when we use the variation caused by the Thailand Floods, Z_{it}, in column (3). This is because of a strong negative effect of the flooding on the Thailand value added in column (4) and of a weaker but still negative effect on Japanese employment in column (5). The

[12]We have checked several measures for the regressor such as employment and sales in Thailand and confirmed the results are robust. See Appendix B12. for detail.

[13]For example, Boehm et al. (2017) mentioned "the notorious difficulty to construct convincing instruments with sufficient power at the firm level."

Table 2: 2SLS-DiD Estimates with the Floods Instrument

VARIABLES	(1) $\ln l_{it}^{JPN}$	(2) $\ln l_{it}^{JPN}$	(3) $\ln l_{it}^{JPN}$	(4) $\ln m_{it}^{T}$	(5) $\ln l_{it}^{JPN}$
$\ln m_{it}^{T}$	0.446***	0.0604***	0.192***		
	(0.00686)	(0.0106)	(0.0502)		
Z_{it}				-0.728***	-0.140***
				(0.108)	(0.0367)
Observations	5,563	5,563	5,563	5,563	5,563
Model	OLS	FE	2SLS	2SLS-1st	2SLS-reduced
Firm FE	-	YES	YES	YES	YES
Industry-Year FE	-	YES	YES	YES	YES

Note: Regression results of equation (19) with the sample of Japanese headquarter firms operating in Thailand are shown. In the model row, "2SLS-1st" stands for the first stage regression of equation (19), while "2SLS-reduced" the reduced-form regression of equation (19). Standard errors are clustered at the firm-level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

positive 2SLS result is consistent with part of the literature (Desai et al., 2009; Kovak et al., 2021), while others find negative effects of multinational activities (Ebenstein et al., 2014; Boehm et al., 2017). In Appendix Section B12., we perform robustness checks regarding the choice of the regressor, the shock measure, and the control groups and confirm the robustness. Furthermore, in Appendix Section B13., we show results by industry.

Based on the column (3) estimate in Table 2, equation (20) implies $\lambda = 1.40$ with the standard error of 0.133. This estimate reveals that the factors in foreign countries and Japanese labor are substitutes at a conventional significance level ($t = 3.08$). Furthermore, in all industries, we have shown that $\lambda > \sigma_j$, which implies that labor is relative substitute of foreign inputs. As discussed in the model section, an increase in the factor-augmenting productivity shock in the foreign country implies lower labor demand more strongly than capital demand, thereby reduces firm-level labor shares of Japanese firms.

It is worthwhile to mention the nature of our identification strategy. A typical method for identifying the production function parameter, such as λ in our production function, is to use a labor supply shock, such as a surge in migration. The presumption is that labor supply shocks affect wages in an exogenous way to firms (Ottaviano and Peri, 2012). By contrast, a strength of our approach is that we are free from such an exogeneity assumption since our approach only depends on the change in effective factor prices p_T^m/a_T specific to firms through the productivity term a_T. This implies that our identification method does not require any assumptions about the labor market, such as market delineation or the competition structure within the labor market.

Finally, it is worth noticing that the year of our natural experiment coincides with another natural disaster that affected Japan significantly, *the 2011 Tohoku Earthquake.* However, few firms located in the severely affected region of eastern Tohoku region (Iwate, Miyagi, and Fukushima prefectures) are MNEs. Rather, most MNEs locate in larger cities and prefectures such as Tokyo and Osaka. In fact, our result is robust to excluding firms directly suffered from the earthquake, as shown in Appendix

B15.. This robustness exercise indicates that our finding is not driven by the earthquake in Japan but by the flooding in Thailand.

5. Quantitative Exercises

5.1. Model Fit

To check if the estimated model can predict data patterns of the Thailand Floods, we perform a simulation analysis. For this purpose, first, we simulate the same number of firms for each sector j from the observed firm number distribution in 2011 and. Second, among these firms, we randomly select those who were affected by the floods shock based on the observed share of firms located in the Ayutthaya and Pathum Thani provinces. This procedure reflects our identification assumption that the floods damage is concentrated in these two provinces and is as good as random. Third, we hit productivity shock $\hat{a}_T = 0.1$ to the selected firms. Although we have to take a stance about the size of the floods shock, the qualitative results are insensitive to the value of the productivity reduction as long as the value captures a significant reduction in productivity due to the floods. Finally, we solve the model with the EMHA method to obtain the changes in equilibrium factor prices $\left(\hat{r}_J, \hat{w}_J, \hat{p}_T^M\right)$ and the model-predicted change in employment $\hat{l}\left(\omega\right)$ and capital $\hat{k}\left(\omega\right)$, and regress $\hat{l}\left(\omega\right)$ and capital $\hat{k}\left(\omega\right)$ on AP dummy and the industry-fixed effect. We measure the capital demand in data by the asset value interacted by the long-run return on capital.

The results are shown in Table 3. As expected from the empirical specification (19), we find that the model-based regression in column (1) fits well with the data-based counterpart in column (2). More strikingly, the results between column (3) and (4) shows the estimated model's performance to predict the decline in the capital demand in Japan since our estimation procedure does not rely on the variable of capital demand. The difference between model prediction and observed correlation are statistically insignificant. Furthermore, by comparing the size of the coefficients between employment and capital, we confirm that the floods shock reduced labor demand less than capital demand, in both model prediction and data. This is consistent with our model's prediction that labor and foreign inputs are relative substitutes, so that the negative demand impact through the cost index is mitigated by the direct substitution effect.

5.2. Quantifying the Role of Foreign Productivity Growth

Using the estimated model, we assess the role of MNEs in reducing the corporate labor share in Japan. First, we obtain the size of the growth in foreign productivity terms a_T and a_R. For instance, in Appendix C1., we show that the Thailand factor productivity term can be backed up by

$$a_T = \frac{\frac{p_T^m}{w_J}\left(\frac{p_T^{\bar{m}} m_T}{w_J L}\right)_{11}}{\bar{p}_{11}}$$

Table 3: Model Fit Exercise

	Employment		Capital	
	Model	Data	Model	Data
	(1)	(2)	(3)	(4)
Shocked (AP)	-0.032^{***}	-0.038^{*}	-0.056^{***}	-0.048^{***}
	(0.002)	(0.021)	(0.003)	(0.012)
N of firms	595	595	595	595

Note: The regression coefficents of factor demands with respect to the floods shock from model-simulated and observed data are shown. The detail of simulation is described in the main text. Column (1) and (2) show the result of employment from the simulated data and observed data, respectively. Column (3) and (4) show the result of capidal demand from the simulated data and observed data, respectively. The capital demand from observed data is measured by the asset value interacted by the long-run return on capital. In observed data-based regressions (2) and (4), industry-fixed effects are controlled. Standard errors are clustered at the firm-level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

where $\left(\frac{\overline{p_T^m m_T}}{w_J L}\right)_{11} \equiv \sum_j E\left[\left(\frac{p_T^m m_{T,j}(\psi;d^*)}{w_J l_j(\psi;d^*)}\right)^{\frac{1}{\lambda-1}} |d^* = 11\right]$ summarizes the weighted average of relative Thailand factor demand, and $\bar{p}_{11} \equiv \sum_j \left(1 - G_j\left(\psi_{11,j}\right)\right)$ summarizes the ease of entry into Thailand. Therefore, Thailand factor productivity a_T is revealed to be high if (i) relative Thailand factor price p_T^m / w_J is high, (ii) average relative Thailand factor demand conditional on factor elasticity, $\left(\frac{\overline{p_T^m m_T}}{w_J L}\right)_{11}$, is high, or (iii) entry into Thailand is selective and $\bar{p}_{11}$ is low. Note that, since our estimated λ is larger than one, factor augmentation within production input is biased to that factor. Hence, as for point (ii), conditional on the relative factor prices, relatively large foreign factor demand implies relatively productive foreign factor. Since we do not have a measure of the user cost of capital but of employment and total labor compensation for each foreign subsidiary, we proxy firm-level foreign factor demand $m_i(\psi)$ by the size of employment in country i and the foreign factor price p_i^m by the total labor compensation divided by the size of employment.

Since we do not directly observe the productivity cutoff $\psi_{11,j}$, we perform the hat algebra to obtain

$$\hat{a}_T = \frac{\frac{\hat{p}_T^m}{w_J}\left(\frac{\hat{\overline{p_T^m m_T}}}{w_J L}\right)_{11}}{\hat{\bar{p}}_{11}}.$$

In Appendix C1., we show that the change in the average of relative Thailand factor demand can be measured by

$$\left(\frac{\hat{\overline{p_T^m m_T}}}{w_J L}\right)_{11} = \sum_j S_j^r\left[1 - G_j\left(\psi'_{11,j}\right)\right] E\left[s_j^r(\psi)\left(\frac{p_T^m \widehat{m_{T,j}}(\psi;d^*)}{w_J l_j\left(\hat{\psi};d^*\right)}\right)^{\frac{1}{\lambda-1}} |d^{*\prime} = 11\right]$$

and the change in the selection into Thailand by

$$\hat{p}_{11} = \sum_j S_j^m \left(\left(\hat{c}_{01,j}\right) \left(\frac{CR'_{11,j}}{CR_{11,j}} \right)^{\frac{1}{1-\varepsilon_j}} \right)^{-\theta_j},$$

where $\hat{c}_{01,j}$ can be measured by non-Thailand investors employment cost changes. In the last expression, we again use the idea of the EMHA. Namely, the change in the selection that depends on the productivity threshold threshold and so the cost savings of a marginal firm. We measure such a cost saving by the model-implied cost ratio of Thailand investors before and after the change in the foreign productivity. Applying these methods, we obtain $\hat{a}_T = 2.36$ and $\hat{a}_R = 2.92$.

Using these productivity growth estimates, we can derive the reduction in the aggregate labor share. We further study how labor share implications differ across firms' globalization strategy, compute the labor share of firm groups S_d^L. For example, the labor share of Thailand investors is given by

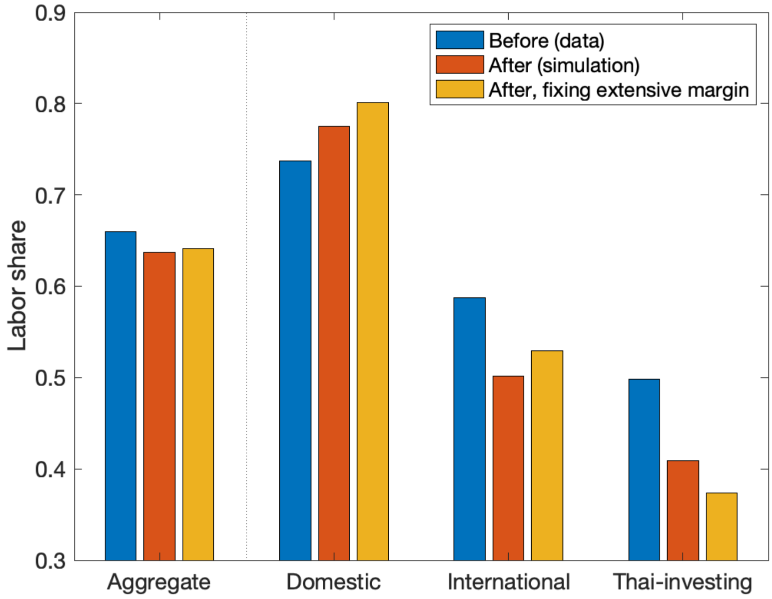
$$S_{11}^L = \frac{\sum_j \int_{\psi_{T,j}}^{\infty} w_J l_j(\psi)\, dG_j(\psi)}{\sum_j \int_{\psi_{T,j}}^{\infty} \frac{\varepsilon_j}{\varepsilon_j - 1} \left[w_J l_j(\psi) + r_J k_j(\psi) \right] dG_j(\psi)}.$$

Our EMHA solution method also provides a natural way to control for the effect of selection in our model-based decomposition exercise. Namely, to obtain the labor-share effect with fixing selection into MNEs, we perform the following exercise. First, we solve the model by EHMA for the selection-fixed (SF) factor price changes $\left(\hat{r}_J^{SF}, \hat{w}_J^{SF}, \hat{p}_T^{M,SF}\right)$ with setting $\hat{\psi}_{d,j} = 1$ for all d and j exogenously, which means that there is no change in the entry threshold for foreign countries. Therefore, the resulting solution yields the counterfactual factor price changes if there is no change in the foreign entry-exit decision of MNEs. Given this, we can then compute the change in labor share measures with $\left(\hat{r}_J^{SF}, \hat{w}_J^{SF}, \hat{p}_T^{M,SF}\right)$ and $\hat{\psi}_{T,j} = \hat{\psi}_{R,j} = 1$. Such a change reveals the counterfactual labor share change when there was no entry-exit decision. Therefore, the difference between the baseline decomposition result with endogenous threshold change $\hat{\psi}_{d,j}$ provides the effect of selection.

The simulation results are shown in Figure 6. To the left of the diagram, we show the simulation result regarding the aggregate labor share, while to the right, decomposition of labor shares into three groups of firms (domestic, international but not investing in Thailand, and Thailand investors) are shown. In the left diagram, the aggregate labor share reduction as a result of the baseline simulation is 2.26 percentage points and explains 13.5% of observed decline in 1995-2007. When we fix the extensive margin changes, we find that the labor share decrease is slightly smaller and 1.86 percentage points. Therefore, we find that the most of the change due to the foreign factor productivity growth is the mechanism through the within-firm change in the labor share.

In the right part of Figure 6, we find that the baseline labor shares are dramatically different between firm groups. Overall, the more international firms are, the smaller the baseline labor shares are; the baseline difference between domestic firms and Thailand investors is as large as 23.90 percentage points. Furthermore, this sizable difference in the labor share is expanded by the foreign factor productivity growth. Domestic firms' labor share increases by 3.80 percentage points, while inter-

Figure 6: The Role of MNEs in the Labor Share Decline



Note: The figure shows the result of the quantitative exercise described in the main text. The "Aggregate" group to the left of the diagram shows the observed corporate labor share in 1995 (blue bar), the model-implied labor share in 2007 (orange bar), and the model-implied labor share, fixing the changes in selection into MNEs, in 2007 (yellow bar). The "Domestic," "International," and "Thai-investing" groups to the right of the diagram shows the corresponding exercises for the group of domestic firms, international firms that do not have subsidiaries in Thailand but in the rest of the world, and those that have Thailand subsidiaries.

national and Thailand investors' decreases by 8.53 and 8.86 percentage points, respectively. Hence, firms' intensified offshoring expanded the across-firm group disparity in the labor share. Interestingly, this disparity-expansion effect is even stronger when we fix the extensive margin in the model; domestic firms' labor share rises by as large as 6.38 percentage points compared to the baseline, while Thailand investors' falls by as large as 12.43 percentage points, from the baseline. This finding reveals the selection mechanism that mitigates the disparity-expansion effect, since marginal firms that become international from domestic is relatively low-labor share among originally domestic firms, and thus their leave from the group of domestic firms is a decreasing force to domestic firms' labor shares. To the Thailand-investor group, the opposite mechanism works as an increasing force of the labor share.

5.3. Welfare

Finally, we briefly discuss the welfare implication of foreign factor productivity growths. Although our small-open economy did not require specifying the total expenditure and income in determining the factor prices, we need to introduce a household. For simplicity, suppose that there is a representative consumer in $i = J$. In this case, the welfare change can be measured by the nominal income change since the price index is determined by the rest of the world. Between 1995 and 2007, we can compute the changes in GDP in our economy as

$$G\hat{D}P_J = (r_J K \hat{+} w_J L) = 5.2\%.$$

Since our model has MNEs that claim income in the foreign countries, we can also think about another welfare measure of GNI. Although we do not specify the value added distribution within foreign countries since our model has only one factor in foreign countries, the upper bound for the change in GNI can be obtained by assuming that all generated income are claimed by $i = J$ and $(r_J K + w_J L + p_T^{\hat{M}} M_T + p_R^M M_R) = 5.3\%$. Both these changes are translated into 0.4% in the compound annual growth rate. Therefore, while MNE activities had negative impacts on the aggregate corporate domestic labor shares, it has moderate positive effects on welfare, mainly due to the increased marginal productivities of domestic capital and labor and foreign inputs that are reflected in the increased factor prices.

6. Conclusion

In this paper, we study the role of MNEs' increased foreign factors usages in reducing the home-country corporate labor share. We begin by providing a decomposition analysis of Japanese corporate labor share to study the source of its decline, and estimate the effect of the 2011 Thailand Floods. Motivated by these findings, we develop an heterogeneous firms model of production with foreign factor employment with a nested CES production function. Applying the floods shock as an instrumental variable, we estimate a key substitution elasticity of a foreign factor and domestic labor, with the result indicating that the home and foreign labor are gross substitutes. The estimated model reveals that the increase in the foreign factor productivity contributes to the corporate labor share decline in Japan during 1995-2007 by 2.26 percentage point.

References

Acemoglu, Daron, "Introduction to economic growth," *Journal of economic theory*, 2012, *147* (2), 545–550.

_ **and Pascual Restrepo**, "Automation and New Tasks: How Technology Displaces and Reinstates Labor," Technical Report, National Bureau of Economic Research 2019.

Antras, Pol, Teresa C Fort, and Felix Tintelnot, "The margins of global sourcing: theory and evidence from US firms," *American Economic Review*, 2017, *107* (9), 2514–64.

Arkolakis, Costas, Natalia Ramondo, Andrés Rodrıguez-Clare, and Stephen Yeaple, "Innovation and Production in the Global Economy," 2017.

Autor, David, David Dorn, Lawrence F Katz, Christina Patterson, and John Van Reenen, "Concentrating on the Fall of the Labor Share," *American Economic Review*, 2017, *107* (5), 180–85.

_ , _ , _ , _ , and _ , "The fall of the labor share and the rise of superstar firms," *The Quarterly Journal of Economics*, 2020, *135* (2), 645–709.

Barkai, Simcha, "Declining labor and capital shares," *University of Chicago*, 2017.

Benguria, Felipe and Alan M Taylor, "After the Panic: Are Financial Crises Demand or Supply Shocks? Evidence from International Trade," Working Paper 25790, National Bureau of Economic Research April 2019.

Berger, David W, Kyle F Herkenhoff, and Simon Mongey, "Labor Market Power," Technical Report, National Bureau of Economic Research 2019.

Boehm, Christoph E, Aaron Flaaen, and Nitya Pandalai-Nayar, "Multinationals, offshoring, and the decline of US manufacturing," 2017.

Bridgman, Benjamin, "IS LABOR'S LOSS CAPITAL'S GAIN? GROSS VERSUS NET LABOR SHARES," *Macroeconomic Dynamics*, 2018, *22* (08), 2070–2087.

Caballero, Ricardo J, Emmanuel Farhi, and Pierre-Olivier Gourinchas, "Rents, technical change, and risk premia accounting for secular trends in interest rates, returns on capital, earning yields, and factor shares," *American Economic Review*, 2017, *107* (5), 614–20.

Caliendo, Lorenzo and Fernando Parro, "Estimates of the Trade and Welfare Effects of NAFTA," *The Review of Economic Studies*, 11 2014, *82* (1), 1–44.

_ , Maximiliano Dvorkin, and Fernando Parro, "Trade and labor market dynamics: General equilibrium analysis of the china trade shock," *Econometrica*, 2019, *87* (3), 741–835.

Carr, David L, James R Markusen, and Keith E Maskus, "Estimating the knowledge-capital model of the multinational enterprise," *American Economic Review*, 2001, *91* (3), 693–708.

Carvalho, Vasco M, Makoto Nirei, Yukiko U Saito, and Alireza Tahbaz-Salehi, "Supply chain disruptions: Evidence from the great east japan earthquake," 2016.

Costinot, Arnaud and Andrés Rodríguez-Clare, "Trade theory with numbers: Quantifying the consequences of globalization," in "Handbook of international economics," Vol. 4, Elsevier, 2014, pp. 197–261.

Dekle, Robert, Jonathan Eaton, and Samuel Kortum, "Unbalanced Trade," *American Economic Review*, May 2007, *97* (2), 351–355.

Desai, Mihir A, C Fritz Foley, and James R Hines, "Domestic effects of the foreign activities of US multinationals," *American Economic Journal: Economic Policy*, 2009, *1* (1), 181–203.

Doraszelski, Ulrich and Jordi Jaumandreu, "Measuring the Bias of Technological Change," *Journal of Political Economy*, 2018, *126* (3), 1027 – 1084.

Eaton, Jonathan, Samuel Kortum, and Francis Kramarz, "An Anatomy of International Trade: Evidence From French Firms," *Econometrica*, 2011, *79* (5), 1453–1498.

Ebenstein, Avraham, Ann Harrison, Margaret McMillan, and Shannon Phillips, "Estimating the Impact of Trade and Offshoring on American Workers Using the Current Population Surveys," *The Review of Economics and Statistics*, 2014, *96* (4), 581–595.

Elsby, Michael WL, Bart Hobijn, and Ayşegül Şahin, "The decline of the US labor share," *Brookings Papers on Economic Activity*, 2013, *2013* (2), 1–63.

Feng, Alan and Haishi Li, *We are all in the same boat: Cross-border spillovers of climate risk through international trade and supply chain*, International Monetary Fund, 2021.

Fukao, Kyoji and Cristiano Perugini, "The Long-Run Dynamics of the Labor Share in Japan," *Review of Income and Wealth*, 2021, *67* (2), 445–480.

Gouin-Bonenfant, Emilien et al., "Productivity dispersion, between-firm competition and the labor share," 2018.

Gravelle, Jane G, "Tax Havens: International Tax Avoidance and Evasion," 2015.

Handley, Kyle and Nuno Limão, "Policy uncertainty, trade, and welfare: Theory and evidence for china and the united states," *American Economic Review*, 2017, *107* (9), 2731–83.

Haraguchi, Masahiko and Upmanu Lall, "Flood risks and impacts: A case study of Thailand's floods in 2011 and research questions for supply chain decision making," *International Journal of Disaster Risk Reduction*, 2015, *14*, 256–272.

Harrison, Ann and Margaret McMillan, "Offshoring jobs? Multinationals and US manufacturing employment," *Review of Economics and Statistics*, 2011, *93* (3), 857–875.

Helpman, Elhanan, Marc J Melitz, and Stephen R Yeaple, "Export versus FDI with heterogeneous firms," *American economic review*, 2004, *94* (1), 300–316.

Hubmer, Joachim, "The Race Between Preferences and Technology," Technical Report, MIMEO, Yale University 2018.

Hummels, David, Rasmus Jørgensen, Jakob Munch, and Chong Xiang, "The wage effects of offshoring: Evidence from Danish matched worker-firm data," *American Economic Review*, 2014, *104* (6), 1597–1629.

Kaldor, Nicholas, "Capital accumulation and economic growth," in "The theory of capital," Springer, 1961, pp. 177–222.

Karabarbounis, Loukas and Brent Neiman, "The global decline of the labor share," *The Quarterly journal of economics*, 2013, *129* (1), 61–103.

Kovak, Brian K, Lindsay Oldenski, and Nicholas Sly, "The labor market effects of offshoring by us multinational firms: Evidence from changes in global tax policies," *Review of Economics and Statistics*, 2021, *103* (2), 381–396.

Loecker, Jan De and Jan Eeckhout, "The rise of market power and the macroeconomic implications," Technical Report, National Bureau of Economic Research 2017.

_ **and** _ , "Global market power," Technical Report, National Bureau of Economic Research 2018.

Monden, Yasuhiro, *Toyota production system: an integrated approach to just-in-time*, CRc Press, 2011.

Morikawa, Masayuki, "Volatility, nonstandard employment, and productivity: An empirical analysis using firm-level data," Technical Report, Research Institute of Economy, Trade and Industry (RIETI) 2010.

Muendler, Marc-Andreas and Sascha O Becker, "Margins of multinational labor substitution," *The American Economic Review*, 2010, *100* (5), 1999–2030.

Oberfield, Ezra and Devesh Raval, "Micro data and macro technology," *Econometrica*, 2021.

Ottaviano, Gianmarco IP and Giovanni Peri, "Rethinking the effect of immigration on wages," *Journal of the European economic association*, 2012, *10* (1), 152–197.

Pierce, Justin R and Peter K Schott, "The surprisingly swift decline of US manufacturing employment," *American Economic Review*, 2016, *106* (7), 1632–62.

Ramondo, Natalia and Andrés Rodríguez-Clare, "Trade, multinational production, and the gains from openness," *Journal of Political Economy*, 2013, *121* (2), 273–322.

Rognlie, Matthew, "Comment on" Accounting for Factorless Income"," in "NBER Macroeconomics Annual 2018, volume 33," University of Chicago Press, 2018.

Simon, Herbert A. and Charles P. Bonini, "The Size Distribution of Business Firms," *The American Economic Review*, 1958, *48* (4), 607–617.

Steinberg, Joseph et al., "Brexit and the macroeconomic impact of trade policy uncertainty," in "2017 Meeting Papers" number 216 Society for Economic Dynamics 2017.

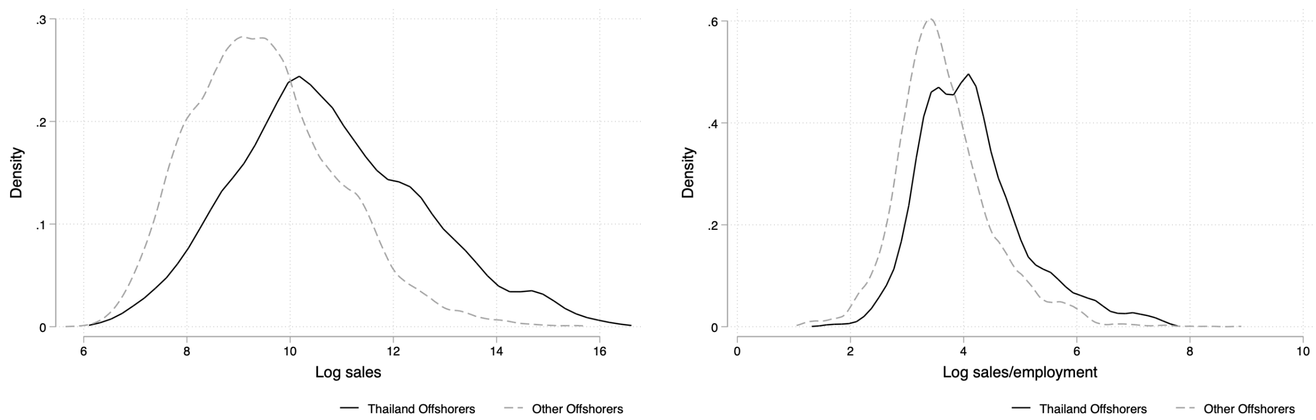
Sun, Chang, "Multinational Production with Non-neutral Technologies," *Journal of International Economics*, 2020, *123*, 103294.

Tamada, Yoshifumi, Keisuke Hoshikawa, and Tsuruyo Funatsu, *The 2011 Thailand Flood–the record and lessons– (in Japanese)*, Japan External Trade Organization (JETRO) Asian Institute, 2013.

Figure A.1: Thai Investors Sales Distribution vis-a-vis Other MNEs

(a) Log Sales

(b) Log Sales per Employment



Note: The figure shows the distribution of log sales (left panel) and log sales-to-employment ratio (right panel) of group of multinational firms that have subsidiaries in Thailand ("Thailand Offshorers") and not ("Other Offshorers") in 2011.

Appendix

A Theory Appendix

This appendix details some proofs and extensions of the model in Section 3..

A1. Productivity Comparison between Firms Entering Thailand and Others

Figure A.1 shows the distribution of log sales (left panel) and log sales-to-employment ratio (right panel) of group of multinational firms that have subsidiaries in Thailand ("Thailand Offshorers") and not ("Other Offshorers") in 2011. The Thailand Offshorers distribution first order-stochastically dominates the Other Offshorers one in both panels.

A2. Derivation of Equations (14) and (15)

In this section, we derive equation (14) and the counterpart for labor and Thailand factor demands. Note that the capital demand is the aggregate across sectors and three internationalization modes $K^D = \sum_j \sum_d K^D_{d,j}$, where $K^D_{d,j}$ are aggregate capital demand of the domestic firms ($d = 00$), non-Thailand investing international firms ($d = 01$), and Thailand investors ($d = 11$), given by

$$K^D_{00,j} = \int_{\psi_j}^{\psi_{01,j}} \left((r_J)^{-\sigma_j} \left(c_j\left(\psi;00\right)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j-1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j-1} Q_j \right) dG_j\left(\psi\right), \tag{A.1}$$

$$K^D_{01,j} = \int_{\psi_{01,j}}^{\psi_{11,j}} \left((r_J)^{-\sigma_j} \left(c_j\left(\psi;01\right)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j-1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j-1} Q_j \right) dG_j\left(\psi\right), \tag{A.2}$$

$$K_{11,j}^{D}=\int_{\psi_{11,j}}^{\infty}\left(\left(r_{J}\right)^{-\sigma_{j}}\left(c_{j}\left(\psi;11\right)\right)^{\sigma_{j}-\varepsilon_{j}}\left(\frac{\varepsilon_{j}}{\varepsilon_{j}-1}\right)^{1-\varepsilon_{j}}P_{j}^{\varepsilon_{j}-1}Q_{j}\right)dG_{j}\left(\psi\right). \tag{A.3}$$

Using these expressions, the change in the aggregate capital demand can be rewritten as

$$\hat{K}^{D}=\frac{\sum_{j}K_{j}^{D'}}{\sum_{j}K_{j}^{D}}=\sum_{j}\frac{K_{j}^{D}}{\sum_{j}K_{j}^{D}}\frac{K_{j}^{D'}}{K_{j}^{D}}=\sum_{j}S_{j}^{K}\hat{K}_{j}^{D},$$

where the second equality use the division and multiplication of the same terms K_j^D. Equations (A.1), (A.2), and (A.3) imply

$$K_{j}^{D}=\left(r_{J}\right)^{-\sigma_{j}}\bar{C}_{j}^{K}\left(\frac{\varepsilon_{j}}{\varepsilon_{j}-1}\right)^{1-\varepsilon_{j}}P_{j}^{\varepsilon_{j}-1}Q_{j}, \tag{A.4}$$

where $\bar{C}_j^K$ is the average unit cost term for capital demand given by

$$\bar{C}_{j}^{K}\equiv\int_{\underline{\psi}_{j}}^{\psi_{01,j}}\left(c_{j}\left(\psi;00\right)\right)^{\sigma_{j}-\varepsilon_{j}}dG_{j}\left(\psi\right)+\int_{\psi_{01,j}}^{\psi_{11,j}}\left(c_{j}\left(\psi;01\right)\right)^{\sigma_{j}-\varepsilon_{j}}dG_{j}\left(\psi\right)+\int_{\psi_{11,j}}^{\infty}\left(c_{j}\left(\psi;11\right)\right)^{\sigma_{j}-\varepsilon_{j}}dG_{j}\left(\psi\right). \tag{A.5}$$

Taking the new-to-old ratio of equation (A.4) proves equation (14). To derive equation (15), substituting unit cost expression (8) in equation (A.5), we have

$$\bar{C}_{j}^{K}=\left(\tilde{c}_{00,j}\right)^{\sigma_{j}-\varepsilon_{j}}\int_{\underline{\psi}_{j}}^{\psi_{01,j}}\psi^{\varepsilon_{j}-\sigma_{j}}dG_{j}\left(\psi\right)+\left(\tilde{c}_{01,j}\right)^{\sigma_{j}-\varepsilon_{j}}\int_{\psi_{01,j}}^{\psi_{11,j}}\psi^{\varepsilon_{j}-\sigma_{j}}dG_{j}\left(\psi\right)+\left(\tilde{c}_{11,j}\right)^{\sigma_{j}-\varepsilon_{j}}\int_{\psi_{11,j}}^{\infty}\psi^{\varepsilon_{j}-\sigma_{j}}dG_{j}\left(\psi\right).$$

Taking the new-to-old ratio yields equation (15). Accordingly, the aggregate labor demands for the three groups of internationalization modes are

$$L_{00,j}^{D}=\int_{\underline{\psi}_{j}}^{\psi_{01,j}}\left(\left(w_{J}\right)^{-\lambda}\left(p_{j}^{m,P}\left(00\right)\right)^{\lambda-\sigma_{j}}\left(c_{j}\left(\psi;00\right)\right)^{\sigma_{j}-\varepsilon_{j}}\left(\frac{\varepsilon_{j}}{\varepsilon_{j}-1}\right)^{1-\varepsilon_{j}}P_{j}^{\varepsilon_{j}-1}Q_{j}\right)dG_{j}\left(\psi\right),$$

$$L_{01,j}^{D}=\int_{\psi_{01,j}}^{\psi_{11,j}}\left(\left(w_{J}\right)^{-\lambda}\left(p_{j}^{m,P}\left(01\right)\right)^{\lambda-\sigma_{j}}\left(c_{j}\left(\psi;01\right)\right)^{\sigma_{j}-\varepsilon_{j}}\left(\frac{\varepsilon_{j}}{\varepsilon_{j}-1}\right)^{1-\varepsilon_{j}}P_{j}^{\varepsilon_{j}-1}Q_{j}\right)dG_{j}\left(\psi\right),$$

$$L_{11,j}^{D}=\int_{\psi_{11,j}}^{\infty}\left(\left(w_{J}\right)^{-\lambda}\left(p_{j}^{m,P}\left(11\right)\right)^{\lambda-\sigma_{j}}\left(c_{j}\left(\psi;11\right)\right)^{\sigma_{j}-\varepsilon_{j}}\left(\frac{\varepsilon_{j}}{\varepsilon_{j}-1}\right)^{1-\varepsilon_{j}}P_{j}^{\varepsilon_{j}-1}Q_{j}\right)dG_{j}\left(\psi\right),$$

and similarly for the Thailand factor demand,

$$M_{T,00,j}^{D}=\int_{\underline{\psi}_{j}}^{\psi_{01,j}}\left(\left(\frac{p_{T}^{m}}{a_{T}}\right)^{-\lambda}\left(p_{j}^{m,P}\left(00\right)\right)^{\lambda-\sigma_{j}}\left(c_{j}\left(\psi;00\right)\right)^{\sigma_{j}-\varepsilon_{j}}\left(\frac{\varepsilon_{j}}{\varepsilon_{j}-1}\right)^{1-\varepsilon_{j}}P_{j}^{\varepsilon_{j}-1}Q_{j}\right)dG_{j}\left(\psi\right),$$

$$M_{T,01,j}^{D}=\int_{\psi_{01,j}}^{\psi_{11,j}}\left(\left(\frac{p_{T}^{m}}{a_{T}}\right)^{-\lambda}\left(p_{j}^{m,P}\left(01\right)\right)^{\lambda-\sigma_{j}}\left(c_{j}\left(\psi;01\right)\right)^{\sigma_{j}-\varepsilon_{j}}\left(\frac{\varepsilon_{j}}{\varepsilon_{j}-1}\right)^{1-\varepsilon_{j}}P_{j}^{\varepsilon_{j}-1}Q_{j}\right)dG_{j}\left(\psi\right),$$

$$M_{T,11,j}^{D}=\int_{\psi_{11,j}}^{\infty}\left(\left(\frac{p_{T}^{m}}{a_{T}}\right)^{-\lambda}\left(p_{j}^{m,P}\left(11\right)\right)^{\lambda-\sigma_{j}}\left(c_{j}\left(\psi;11\right)\right)^{\sigma_{j}-\varepsilon_{j}}\left(\frac{\varepsilon_{j}}{\varepsilon_{j}-1}\right)^{1-\varepsilon_{j}}P_{j}^{\varepsilon_{j}-1}Q_{j}\right)dG_{j}\left(\psi\right).$$

Hence, using the similar method, we have

$$\hat{L}^D = \sum_j S_j^L \hat{L}_j^D,\ \hat{L}_j^D = (\hat{w}_J)^{-\lambda} \hat{\hat{C}}_j^L,\ \hat{\hat{C}}_j^L = \sum_{d\in\{00,01,11\}} S_{d,j}^L \left(\hat{p}_{d,j}^{m,P}\right)^{\lambda-\sigma_j} \left(\hat{\hat{c}}_{d,j}\right)^{\sigma_j-\varepsilon_j} \hat{s}_{d,j}$$

$$\hat{M}_T^D = \sum_j S_j^{M_T} \hat{M}_{T,j}^D,\ \hat{M}_{T,j}^D = \left(\frac{\hat{p}_T^m}{\hat{a}_T}\right)^{-\lambda} \hat{\hat{C}}_j^{M_T},\ \hat{\hat{C}}_j^{M_T} = \sum_{d\in\{00,01,11\}} S_{d,j}^{M_T} \left(\hat{p}_{d,j}^{m,P}\right)^{\lambda-\sigma_j} \left(\hat{\hat{c}}_{d,j}\right)^{\sigma_j-\varepsilon_j} \hat{s}_{d,j},$$

where

$$S_j^L = \frac{w_J L_j}{\sum_k w_J L_k},\ S_{d,j}^L \equiv \frac{w_J L_{d,j}}{w_J L_j},\ S_j^{M_T} = \frac{p_T^m M_{T,j}}{\sum_k p_T^m M_{T,k}},\ S_{d,j}^{M_T} \equiv \frac{p_T^m M_{T,d,j}}{p_T^m M_{T,j}},$$

and $\hat{p}_{d,j}^{m,P}$ is the change in the production input price index for internationalization mode d in sector j that will derived below.

Finally, $\hat{\hat{c}}_{d,j}$ is obtained in a standard way as follows.

$$\hat{\hat{c}}_{d,j} = \frac{\left[\alpha_j \left(r_J'\right)^{1-\sigma_j} + (1-\alpha_j)\left(p_{d,j}^{m,P'}\right)^{1-\sigma_j}\right]^{\frac{1}{1-\sigma_j}}}{\left[\alpha_j \left(r_J\right)^{1-\sigma_j} + (1-\alpha_j)\left(p_{d,j}^{m,P}\right)^{1-\sigma_j}\right]^{\frac{1}{1-\sigma_j}}} = \left(\frac{\alpha_j \left(r_J'\right)^{1-\sigma_j} + (1-\alpha_j)\left(p_{d,j}^{m,P'}\right)^{1-\sigma_j}}{\alpha_j \left(r_J\right)^{1-\sigma_j} + (1-\alpha_j)\left(p_{d,j}^{m,P}\right)^{1-\sigma_j}}\right)^{\frac{1}{1-\sigma_j}}$$

$$= \left(\frac{\alpha_j \left(r_J\right)^{1-\sigma_j}}{\alpha_j \left(r_J\right)^{1-\sigma_j} + (1-\alpha_j)\left(p_{d,j}^{m,P}\right)^{1-\sigma_j}}\left(\frac{r_J'}{r_J}\right)^{1-\sigma_j} + \frac{(1-\alpha_j)\left(p_{d,j}^{m,P}\right)^{1-\sigma_j}}{\alpha_j \left(r_J\right)^{1-\sigma_j} + (1-\alpha_j)\left(p_{d,j}^{m,P}\right)^{1-\sigma_j}}\left(\frac{p_{d,j}^{m,P'}}{p_{d,j}^{m,P}}\right)^{1-\sigma_j}\right)^{\frac{1}{1-\sigma_j}}$$

$$= \left(s_{d,j}^K \left(\hat{r}_J\right)^{1-\sigma_j} + \left(1-s_{d,j}^K\right)\left(\hat{p}_{d,j}^{m,P}\right)^{1-\sigma_j}\right)^{\frac{1}{1-\sigma_j}},$$

where $s_{d,j}^K \equiv \frac{\alpha_j \left(r_J\right)^{1-\sigma_j}}{\alpha_j \left(r_J\right)^{1-\sigma_j} + (1-\alpha_j)\left(p_{d,j}^{m,P}\right)^{1-\sigma_j}}$ is the baseline capital share of internationalization mode d in sector j. Similarly, $\hat{p}_{d,j}^{m,P}$ can be obtained as

$$\hat{p}_{d,j}^{m,P} = \left(s_{d,j}^{L|m^P} \left(\hat{w}_J\right)^{1-\lambda} + s_{d,j}^{m_T|m^P}\left(\frac{\hat{p}_T^m}{\hat{a}_T}\right)^{1-\lambda} + s_{d,j}^{m_R|m^P}\left(\frac{\hat{p}_R^m}{\hat{a}_R}\right)^{1-\lambda} + s_{d,j}^{m|m^P}\left(\hat{p}_j^m\right)^{1-\lambda}\right)^{\frac{1}{1-\lambda}},$$

where, with slight abuse of notation,

$$s_{d,j}^{L|m^P} \equiv \frac{w_J^{1-\lambda}}{w_J^{1-\lambda} + D_T\left(\frac{p_T^m}{a_T}\right)^{1-\lambda} + D_R\left(\frac{p_R^m}{a_R}\right)^{1-\lambda} + \left(p_j^m\right)^{1-\lambda}},$$

$$s_{d,j}^{m_T|m^P} \equiv \frac{D_T\left(\frac{p_T^m}{a_T}\right)^{1-\lambda}}{w_J^{1-\lambda} + D_T\left(\frac{p_T^m}{a_T}\right)^{1-\lambda} + D_R\left(\frac{p_R^m}{a_R}\right)^{1-\lambda} + \left(p_j^m\right)^{1-\lambda}},$$

$$s_{d,j}^{L|m^P} \equiv \frac{D_R\left(\frac{p_R^m}{a_R}\right)^{1-\lambda}}{w_J^{1-\lambda} + D_T\left(\frac{p_T^m}{a_T}\right)^{1-\lambda} + D_R\left(\frac{p_R^m}{a_R}\right)^{1-\lambda} + \left(p_j^m\right)^{1-\lambda}},$$

and

$$s_{d,j}^{L|m^P} \equiv \frac{\left(p_j^m\right)^{1-\lambda}}{w_J^{1-\lambda} + D_T\left(\frac{p_T^m}{a_T}\right)^{1-\lambda} + D_R\left(\frac{p_R^m}{a_R}\right)^{1-\lambda} + \left(p_j^m\right)^{1-\lambda}}.$$

B Empirical Appendix

B1. MNEs and Labor Share, Cross Country

In this section, we describe the details of constructing of Figure 1 and some further results. To see the first pass evidence that the multinational activities have an implication to labor shares, we take the cross country variation in the change of outward multinational activities and the change in labor shares. To see this, we take the labor share data from Karabarbounis and Neiman (2013). We also assemble the data on multinational activities from UNCTAD. We calculate the level and change in outward multinational activities as follows. For the level, we take a snap-shot (1996-2000 average) net outward multinational sales. We take five-year average to control the noise in the raw data. For the change we obtain the change in net outward multinational sales between 1991-1995 average and 1996-2000 average.

We show the results of correlation plot in Figure 1. To allow the lagged response in the labor share to the multinational intensity changes, we take the change in the labor share between 1995 and 2007. The left panel shows the result with the level of outward multinational sales, and the right the change. We fit the correlation by the weighted regression by country size measured by the base-year GDP. The numbers of countries in the plots are 36 in the both plots. Even with such a small number of samples, both in the level of multinational intensity and the change, we see a remarkably significant negative relationship. Both regression slope coefficients are negatively significant at two-sided 95 percent.

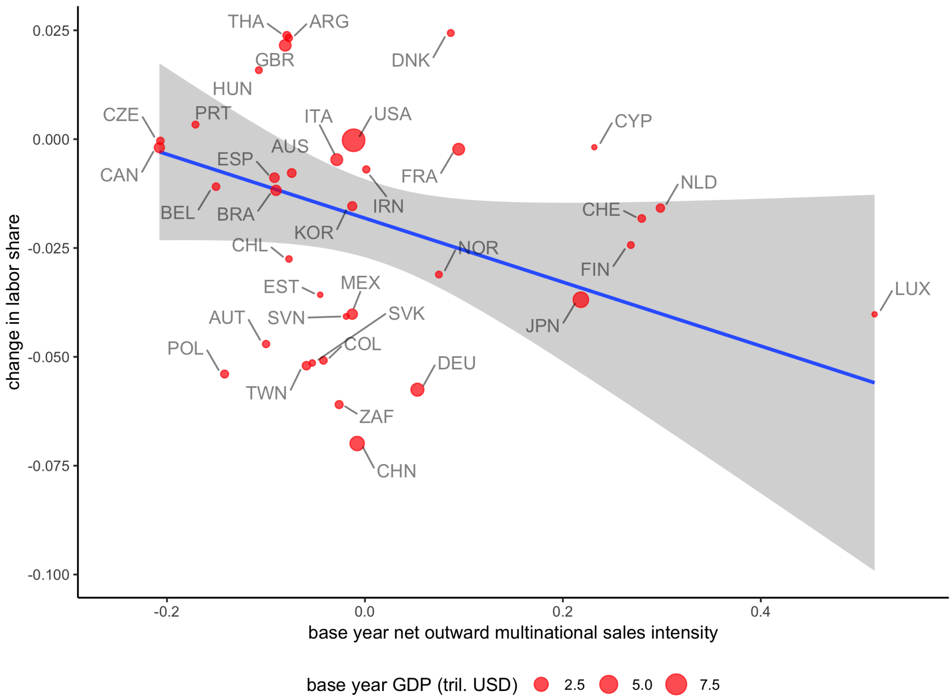
An interpretation of this negative relationship is that the outward multinational activities substitute labor in home country more than capital there. Hence the demand for the labor in the home country decreases more than proportionately to the decrease in the capital demand. Theory in Section 3. details.

Figure B.1 shows the plot between the levels of net multinational sales (1991-1995) and the changes of labor shares (1991-2000). Again, the countries that have higher multinational sales have relatively larger decreases in labor shares in the next 10 years.

B2. Comparison of BSOBA and PWT

We then check the differences in the aggregate (average) wage measures from PWT and our primary source of data about multinational production, BSOBA. Note that PWT aggregate wage is calculated from the total labor cost and total employment in each country. Thus, the wage difference emerges if Japanese parented subsidiaries hire a different type of workers than more general firms in each country. Figure B.2 shows the comparison of BSOBA and PWT for a selected set of countries. We select these nine countries by the order of the number of total employment by Japanese subsidiaries

Figure B.1: Net Outward Multinational Sales and Labor Shares



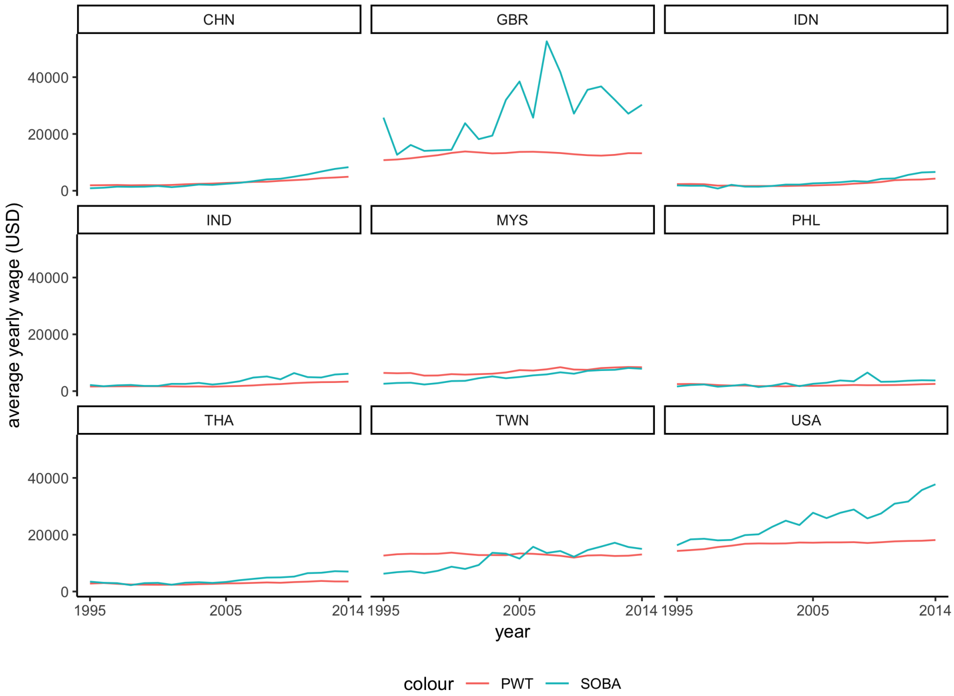
Note: The horizontal axis is the level of the sum of bilateral net outward multinational sales between 1991-1995 average. The vertical axis is the change in labor share from 1991 to 2000 taken from Karabarbounis and Neiman (2013). Singapore is dropped because it has an outlier value for the outward multinational sales measure.

as of the end of FY2015. From the Figure, one can see that overall the BSOBA and PWT shows a similar trend for each country. To this extent, we interpret that Japanese subsidiary firms hire workers from the similar labor market as other firms in each country. There are several interesting deviation from this pattern, particularly in high-income countries such as the UK and the U.S.. This might reflect the fact that the subsidiaries in these countries focus on high-value added activities such as finance, and therefore the hiring structure of Japanese subsidiaries is different from the rest of the firms. We also show the results of the regression of the PWT wage on BSOBA wage with or without fixed effects to show that the fit is remarkably high for a cross-section-cross-year data in Table B.1.

Table B.1: Discrepancies between SOBA and PWT

	All	All	Top 9	Top 9
	(1)	(2)	(3)	(4)
PR	0.332***	0.038***	0.772***	0.409***
	(0.014)	(0.007)	(0.028)	(0.045)
Country FE		YES		YES
Year FE		YES		YES
Observations	1,350	1,350	180	180
R^2	0.300	0.950	0.805	0.983
Notes:	*** p<0.01, ** p<0.05, * p<0.1			

Figure B.2: Comparison of BSOBA and PWT



B3. Alternative Labor Share Measures

It is not trivial to measure the labor share and the literature has extensively discussed appropriate measurements. Instead of taking a strong stance, we review several measures of the labor share in Japan between 1995 and 2007, the period of our analysis, to show robust evidence of the labor share decline in our context. In Figure B.3, we show three measures of labor shares proposed in the literature. First, the SNA labor share, which is the total labor cost divided by GDP and one of the most standard measures employed by SNA standards, shows the decreasing trend. However, since the GDP or value added contains the capital depreciation, it overstates the net capital income (Bridgman, 2018). To overcome the shortcoming, we take the Japan's Cabinet Office Long-run Economic Statistics and calculate the trend of net labor share, or the share of nominal employee compensations over nominal national income, which excludes the capital depreciation (and excludes the indirect tax and includes the subsidy). Next, another issue is the treatment of the mixed income of self-employees. Since self-employees typically own the production capital and labor by themselves, the allocation of the generated income to the labor and capital (e.g., Rognlie, 2018). To remove any biases due to the misallocation of such mixed income, we take the trend of corporate factor income and their compensation payment to the labor. In all measures we considered, the labor share has declined significantly over our sample period.

B4. Markup Trend in Japan

As another explanation for the decrease in the labor share, De Loecker and Eeckhout (2017) argued that the surge in market power explains the labor share decline. They developed a parsimonious

Figure B.3: Alternative Labor Share Measures

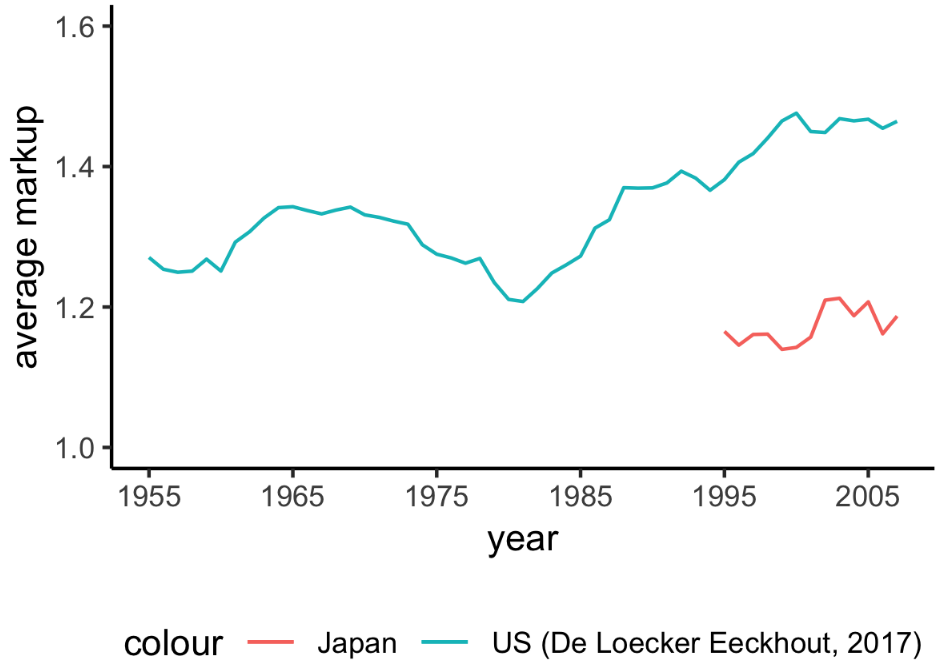
Note: Several labor share measures in Japan from 1995 to 2007 are shown. Taken from the Japan Industrial Productivity (JIP) Database 2015 administered by the Research Institute of Economy, Trade and Industry (RIETI), the JIP labor share is calculated by the share of nominal labor cost in nominal value added of JIP market economies (Fukao and Perugini, 2021). Net labor share is the fraction of nominal employee compensations over nominal national income from the Cabinet Office Long-run Economic Statistics (COLES). Corporate labor share is the net labor share of domestic corporate factor income, calculated from the SNA, by the fraction of the wages and salaries over the sum of wages and salaries and net operating surplus.

but versatile method to back out the markups from the firm- or plant-level data and concluded the markup in the U.S. has been increasing remarkably since around 1980. We apply their method to our Japanese firm-level data (BSJBSA). The result shows a smaller increase in markups relative to the U.S., which is in line with De Loecker and Eeckhout (2018).

B5. Comparison of MNEs and Non-MNEs

To study the role of MNEs in the decrease in labor shares, we conduct a simple decomposition analysis across MNEs and non-MNEs. To do so, we aggregate total sales, labor compensation and net income separately for MNEs and non-MNEs. We then calculate the labor share by the two groups. Figure B.5 shows the trends of labor share and composition of MNEs. First, the blue line depicts the trends of the share of the sum of MNEs' sales (made by headquarters) relative to the sum of sales of all firms. In 1995, the share was roughly 12 percent, which rose to close to 15 percent in 2007. Therefore, the composition of sales became skewed toward MNEs over the period. In Figure B.5, the red lines show the within-MNEs and within-non-MNEs labor share trends. Two findings emerge; First, the labor share of MNEs decreases more rapidly than that of non-MNEs. Second, throughout the period of time, MNEs had lower labor share in levels. Since the composition of MNEs increased (as shown in the blue line), both of the two facts are the decreasing force of the aggregate labor shares. One of the interpretations of these facts is that the payment to labor relative to capital decreased over the period within MNEs, and more firms become such MNEs. In the model section, we develop a framework in which *both* of these may be explained by the foreign factor augmentations.

Figure B.4: Markup Estimates with the Method of De Loecker and Eeckhout (2017)



Note: Authors' calculation based on De Loecker and Eeckhout (2017) with Basic Survey on Japanese Business Structure and Activities (BSJBSA) 1995-2016. Variable input cost is the sum of labor compensation and intermediate purchase. Output elasticity is estimated by Olley and Pakes' (1996) method for each JSIC 3-digit industry. The average is taken with the weight of each firm's sales.

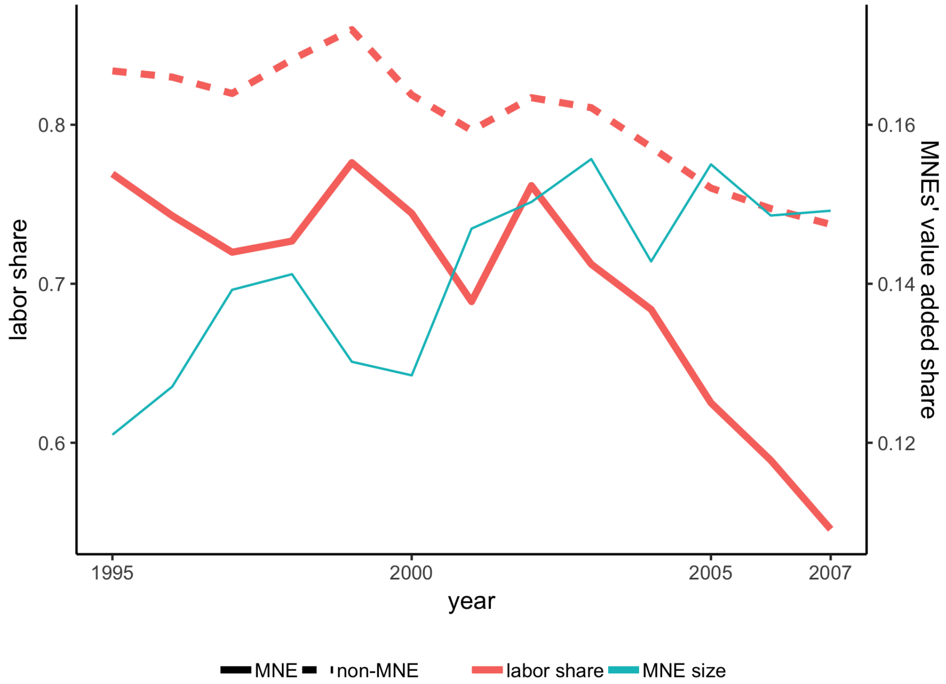
B6. Thailand Gross Export and Import Trend

Figure B.6 shows the trend of Thailand's export and import. The data source is the UN Comtrade. Recall that 2011 was the year of the floods. Before the floods year, the export and import shows roughly a parallel trend, while after the export trend breaks and halted to increase relative to the trend of import. This finding is consistent with our interpretation of the shock that the flooding hit heavily the supply-side of the economy, given that several large-scale manufacturing industrial parks were inundated. Benguria and Taylor (2019) discuss the method to tell demand and supply shocks from the gross export and import data, in the context of financial crises and claim that the "firm deleveraging shocks are mainly supply shocks and contract exports," while leaving imports largely unchanged.

We also overview Thailand's economic policies. For international liberalization, Thailand went ahead other Southeastern countries. It is one of the original member countries of *Association of Southeast Asian Nations* (ASEAN) and entered GATT in 1982. In early 2000's, it made FTAs with several large economies (India in 2003, the U.S. in 2004, Australia and Japan in 2005). ASEAN as an association also made some major internal and external FTAs. The internal FTA went effective in 1993. By 2003, the internal tariffs were driven down to below five percent. The external FTA with other large economies include the one with China in 2003. Given these history, over the period of our data between 2007 and 2016, we do not see a large number and scale of institutional internationalization.[14]

[14]Several exceptions include the ASEAN-South Korea FTA that reduced the tariff between South Korea and Thailand in

Figure B.5: Labor Shares of MNEs and Non-MNEs



Note: Authors' calculation based on Basic Survey on Overseas Business Activities (BSOBA) 2007-2016, Basic Survey on Japanese Business Structure and Activities (BSJBSA) 1996-2017, and JIP 2015. Multinational is defined as the firms that appeared in BSOBA at least once during 2007-2016. For each firm, labor share is calculated as the fraction of total payroll over the sum of total payroll and current profit from BSJBSA. We then aggregate to multinational groups and non-multinationals. Share of MNE size is calculated as the fraction of aggregated sales of all multinational firms over the total nominal output from JIP 2015.

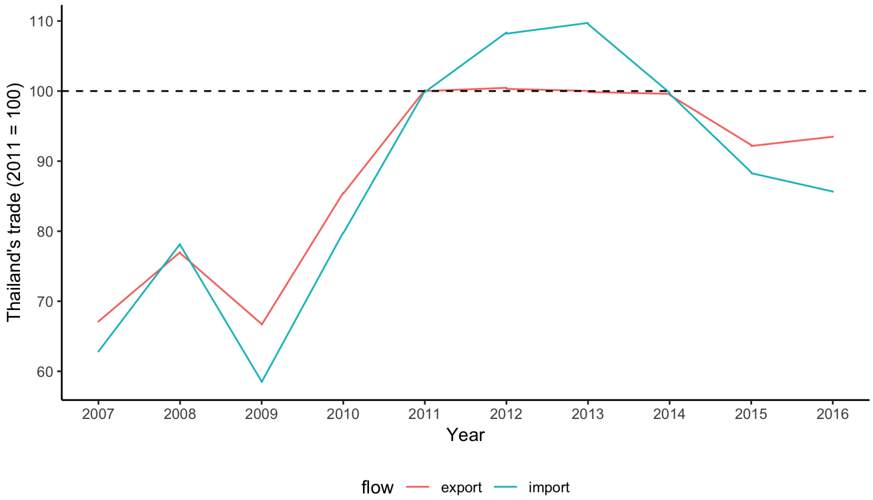
The gross trade trends in Figure B.6 show the consistent pattern with this fact–the drivers behind the changes of trade trends are external business cycles (e.g., the global great recession since 2008) or political upheaval (e.g., coup d'état in 2014) rather than large trade policy changes.

B7. Overview of Japanese Subsidiaries in Thailand

Using the datasets described above, we show some statistics about the production in the flooded region. First, to understand the industry clustering patterns in detail, Figure B.7 shows the distribution of industry of the Japanese subsidiaries in the flooded region in Thailand in sales in 2011. As we mentioned, most of the subsidiaries in the flooded region engage in the production of Transportation Equipment, including automobiles, both in total sales and the number of local subsidiaries. In total sales, the second largest sector is Electronics, whereas it is Others and Chemicals. The difference between Transportation Equipment and other industries is less dramatic when we see by the number of subsidiaries than the one by total sales. Part of the reasons is that the unit value of Transportation Equipments is high.

2010 and Chile-Thailand FTA that went effective in 2015.

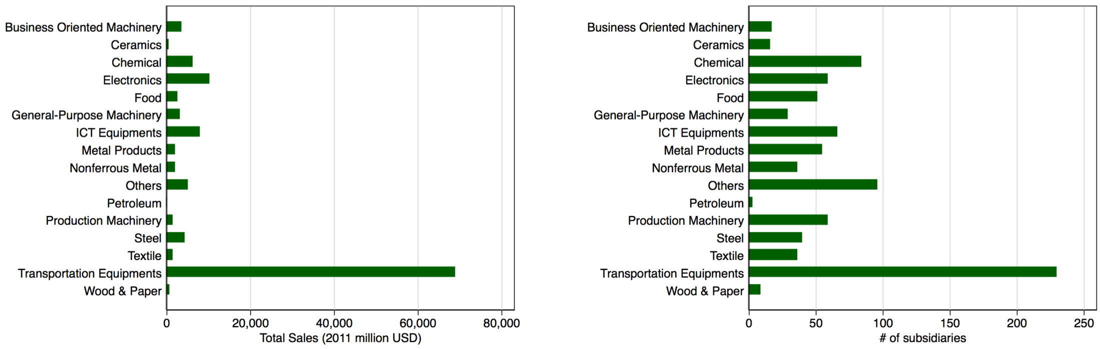
Figure B.6: Trend of Thailand's Trade



Note: Export and import trends of Thailand taken from COMTRADE are shown. The trend is normalized at 100 in 2011.

Figure B.7: Industry Distribution of the Treated Subsidiaries of Japanese firms, 2011

(a) Total Sales (b) Number of Subsidiaries

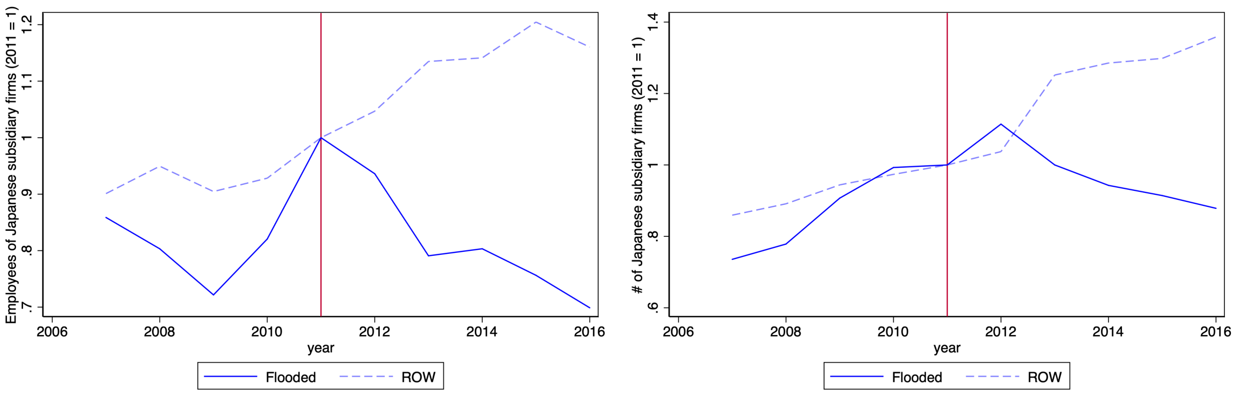


B8. The Floods and Aggregate Trends

In this section, we review an aggregate statistics about the effect of the floods on Japanese MNEs by our combined dataset detailed in Section 2.1.. Figure B.8 shows the relative trend of total employment (Panel B.8a) and the number of subsidiaries (Panel B.8b) in flooded regions (the solid line) versus the rest of the world excluding Japan (the dashed line). First, we confirm that, for both statistics, the ROW trend is increasing over the sample period, which reflects that more firms are entering the pool of MNEs and hire foreign factors. Panel B.8a reflects both of these possibilities, whereas Panel B.8b the first. Second, we focus on the relative trend in the flooded regions, the pattern is broken after the floods year. Indeed, the increasing trend before 2011 is similarly or even more rapid as ROW, reflecting the fast growth in the flooded regions. However, the trend abruptly broke in the year or after the floods and began to decrease *in level*. What is further noteworthy is the *persistence* of such a decrease. Even though the floods were short-lived and went away in most regions by early 2012, the decreasing trend of both the total employment and count of subsidiaries continued at least

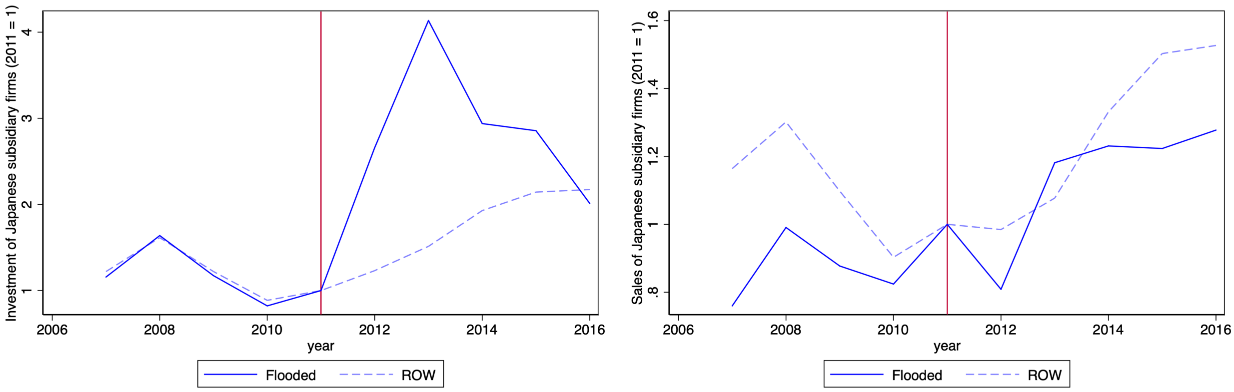
Figure B.8: Relative Trends of Aggregate Variables in Flooded Regions

(a) Total employment (b) Count of subsidiaries



Note: The relative trends of aggregate variables in flooded regions versus the rest of the world, excluding Japan, are shown. Panel B.8a shows the trend of total employment, whereas Panel B.8b the count of subsidiaries. "Flooded" shows the evolution of total employment in plants located in the flooded area (*Ayutthaya* and *Pathum Thani* Province). "ROW" shows that out of the flooded area. Both trends are normalized to 1 in 2011.

Figure B.9: Relative Trend of Japanese MNEs, Detailed

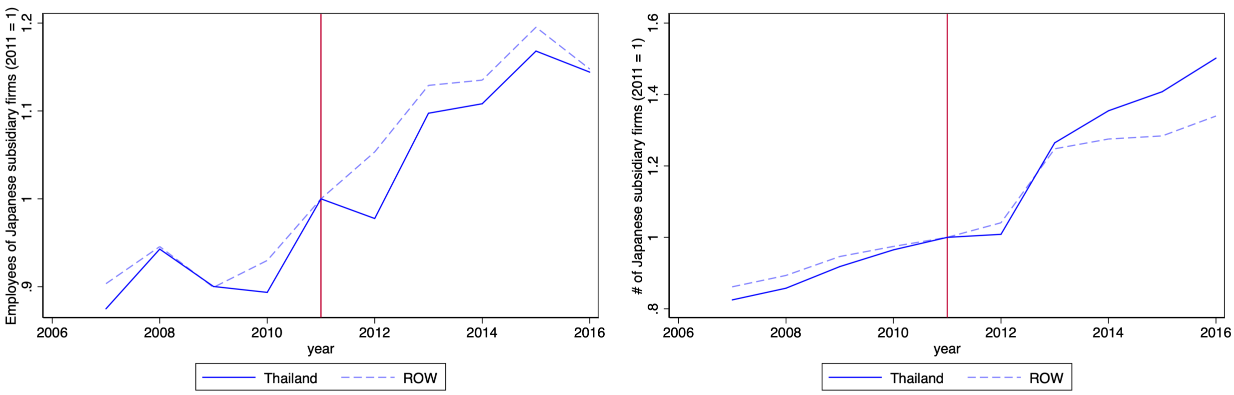


(a) Investment (b) Sales

up to 2016. Anecdotal evidence suggests a potential explanation in line with the negative effects of uncertainty on international trade and investment (Pierce and Schott, 2016; Handley and Limão, 2017; Steinberg et al., 2017). Namely, because the one-time event was large enough for companies to update their risk perception of the future floods, they "move to avoid potential supply chain disruptions" (Nikkei Asian Review, 2014). Given these findings, we estimate the long-run elasticity.

Furthermore, in Figure B.9, we show the trend of investment (the left panel) and sales (the right panel) using a similar diagram. Interestingly, the investment trend in the flooded region and the rest of the world follows the parallel path before the floods, while the trend breaks sharply after the floods. This reflects that for the purpose of reconstruction after the floods damage the plants in the damaged area differentially increase the investment. On the other hand, the sales trend on the right hand side does not show the parallel pattern before the floods.

Figure B.10: Relative Trend of Japanese MNEs, Thailand versus ROW



(a) Total employment

(b) Count of subsidiaries

B9. Notes on the Choice of Treatment Groups

As we overview in Section B8., the floods severely affected Ayutthaya and Pathum Thani Province. It is important to acknowledge these particular provinces, because overall Thailand did not relatively decrease the employment or counts of subsidiaries from Japanese MNEs after the floods. This point is clarified in Figure B.10, which shows the differential trend of the employment and the count of subsidiaries in and out of Thailand, rather than the flooded provinces. As one can see, the impact on the total employment and count of subsidiaries is not stark as it is when we compare the flooded provinces versus the rest of the world in Figure B.8. Therefore, in our main analysis, we take the particularly flooded provinces as the shocked regions and construct the IV based on the idea. Note again that, for this purpose, it is critical to link our BSOBA data, which only contains the country information of each plant of Japanese MNEs, to Orbis BvD that contains the specific address of the plant.

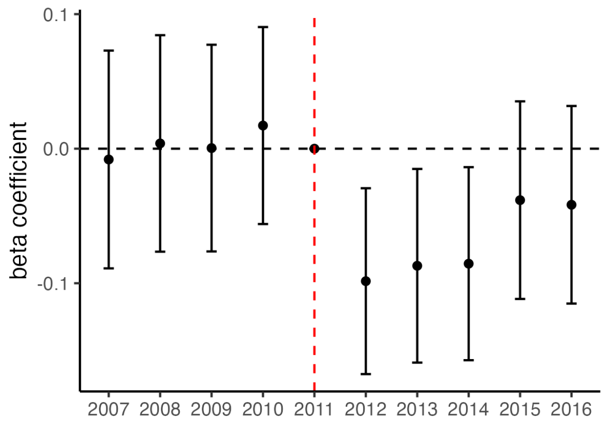
B10. Robustness Checks

Ownership and Subsidiary Operation after the Floods. Figure B.11 shows the result of regression in equation 2 with selected samples. Panel B.11a shows the result with the sample of Thailand subsidiaries of Japanese MNEs with 100% ownership. Panel B.11b shows the result with the sample of Thailand subsidiaries that are direct child firms (but not grandchild firms). We confirm that our main result in Figure 2 is driven by perfectly owned subsidiaries and child subsidiaries.

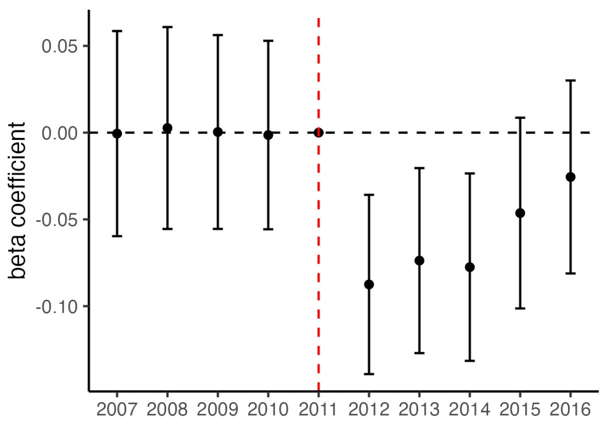
Further Evidence of Headquarter-level Effect of the Floods. Figure B.12 shows the result of regression in equation 2 with alternative outcome variables. Panel B.12a shows the number of Thailand subsidiaries, while Figure B.12b log Thailand employment. Consistent with the subsidiary-level analysis, there are sizable negative effects on the number of operating subsidiaries and the size of employment.

Figure B.11: Event Study of Subsidiary Operating Indicator

(a) 100% Ownership



(b) Only Child Subsidiaries



Note: The figure plots coefficient estimates of subsidiary-level event-study regression in equation (2) with the operating indicator as the outcome variable for the balanced panel of firms that operated throughout 2007-2011. In panel (a), the sample is the set of Thailand subsidiaries of Japanese MNEs with 100% ownership. In panel (b), the sample is the set of Thailand subsidiaries that are direct child firms (but not grandchild firms). Standard errors are cluster-robust at the subsidiary level, and the bars indicate the 95 percent confidence intervals.

B11. Calibration Details of Capital-Production Input Elasticity σ_j

The cost-minimizing factor demands (10) and (11) imply

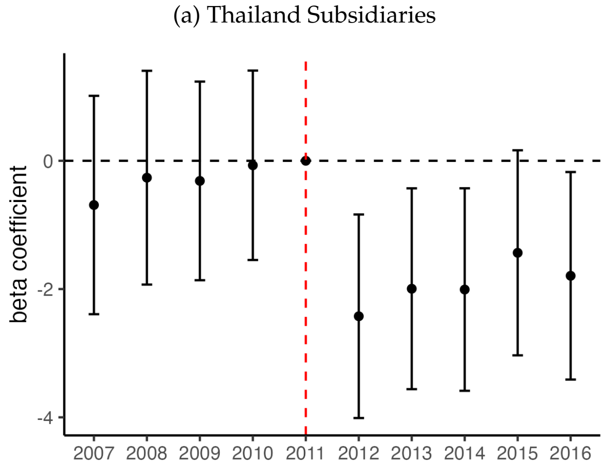
$$\ln\left(\frac{r_J k_j^*}{p_j^{m,P*} m_j^{P*}}\right) = (\sigma_j - 1)\ln\left(\frac{p_j^{m,P*}}{r_J}\right).$$

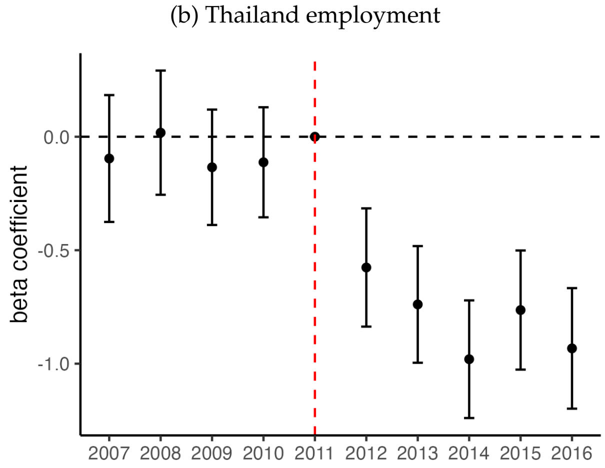
To obtain the log-relative factor price term in the right-hand side, we follow Oberfield and Raval (2021) and use the local labor market m-level wage variation and a shift-share instrument based on non-manufacturing sectoral employment growth that affects each local labor market differently. To minimize the bias due to unobserved correlation between the entry condition to foreign countries and local labor market conditions, we select firms that do not have plants in foreign countries. Since $p_j^{m,P*} m_j^{P*} = wl + p^m m$ for non-MNEs, the regression specification is

$$\ln\left(\frac{rk}{wl + p^m m}\right)_i = b_{0,j} + b_1 \ln\left(w_{m(i)}\right) + X_i b_2 + e_i, \tag{B.1}$$

where X_i is plant-level control variable, $b_{0,j}$ is an industry-j fixed effect. The log local wage term $\ln\left(w_{m(i)}\right)$ is instrumented with with a shift-share measure $z_m = \sum_{j\in\mathcal{J}^{NM}} \omega_{mj,-10} g_j$, where $\mathcal{J}^{NM}$ is the set of non-manufacturing industries, $\omega_{mj,-10}$ is the employment share of industry j in location m in ten-year prior to the analysis period, and g_j is leave-m-out growth rate of national employment in industry j over the ten year that preceded the analysis year taken from the Employment Status Survey (ESS). Note that, we find that wage variation vary across local labor markets are significant and persistent empirically, which implies that the coefficient obtained by such variation provides the long-run elasticity of substitution.

Figure B.12: Further Headquarter Effects of the Thailand Floods





Note: The figure plots coefficient estimates of headquarter-level event-study regression in equation (3). As an outcome variable, panel (a) takes the number of Thailand subsidiaries, and panel (b) takes log Thailand employment. Standard errors are cluster-robust at the firm level, and the bars indicate the 95 percent confidence intervals.

We apply this method to Japan's Census of Manufacture plant-level data. To obtain the factor payment ratio $\left(\frac{rk}{wl+p^m m}\right)_i$, we use the *Census of Manufacture* (CoM). The strength of the CoM is the plant-level survey. Hence, we can capture the factor use reaction to the local labor market shock more appropriately with the CoM than the firm-level survey like the BSJBSA. However, there is no plant-level operating surplus measure in the CoM. To overcome this difficulty and measure rk, we use the initial stock of tangible asset in the next year survey. The rental rate term drops with the industry-fixed effect in specification (B.1) since we use the estimate of it at industry level. To obtain the total payment to workers, we use the variable total payroll for all workers, including both full-time and part-time workers. The CoM also has variables on municipality, 4-digit industry, and multi-plant status. The multi-plant status includes three values: no other plants or headquarter office; no other plant but with headquarter office; have other offices. We include the fixed effect for all of these values in specification (B.1).

We define the unit of location m as 1700 municipality, which is a fine delineation of local labor market that resembles counties in the U.S. We explore several municipality-level wage data sources. First, Japan's Cabinet Office (CO) offers the municipality-level average wage. Second, *Basic Survey on Wage Structures* (BSWS) administered by Japan's Ministry of Health, Labour and Welfare offers the national survey-based estimates of the municipality average wages for each industry.

B12. Robustness Checks for Regression (19)

Foreign Employment as a Regressor. One may be concerned to more directly measure a factor input in Thailand as a regressor. However, in BSOBA data, we can measure only labor employment variable but not capital input measures such as fixed asset or operating surpluses. Therefore, to directly measure Thailand factor input, I use the employment in Thailand as a regressor in equation (19). The results are shown in Table B.2 and qualitatively the same as in Table 2.

Table B.2: 2SLS-DiD Estimates with Thailand Employment as the Regressor

VARIABLES	(1) $\ln l_{it}^{JPN}$	(2) $\ln l_{it}^{JPN}$	(3) $\ln l_{it}^{JPN}$	(4) $\ln l_{it}^{ROW}$	(5) $\ln l_{it}^{JPN}$
$\ln m_{it}$	0.446***	0.0604***	0.192***		
	(0.00686)	(0.0106)	(0.0502)		
Z_{it}				-0.728***	-0.140***
				(0.108)	(0.0367)
Observations	5,563	5,563	5,563	5,563	5,563
Model	OLS	FE	2SLS	2SLS-1st	2SLS-reduced
Firm FE	-	YES	YES	YES	YES
Year FE	-	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results of equation (19) with the sample of Japanese headquarter firms operating in Thailand are shown. The regressor is employment in Thailand. In the model row, "2SLS-1st" stands for the first stage regression of equation (19), while "2SLS-reduced" the reduced-form regression of equation (19). Standard errors are clustered at the firm-level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Extensive-margin instrument. Instead of the intensity measure, one can also measure the extent of the floods shock by an extensive margin–if the MNE was operating in the flooded region at all, although the measure is slightly more coarse than our original measure Z_{it}. For this purpose, we define the extensive-margin floods shock by $Z_{it}^{EXT} = \mathbf{1}\left\{L_{i,2011}^{treated} > 0 \cap t \geq 2012\right\}$ and perform the 2SLS-DiD regression in equation (19). The results are shown in Table B.3 and qualitatively the same as in Table 2.

Alternative Control Groups. As a robustness to the different control groups, we consider all firms in Japan and all firms in Japan with balanced panel (Desai et al., 2009). The results are shown in Table B.3 and qualitatively the same as in Table 2.

B13. Estimation Results of Equation (19) by Industry

Table B.5 shows the regression results of equation (19) by industry, while Tables B.6 and B.7 show the first stage and reduced form of such regressions.

B14. The Delta Method

By inverting equation (20), we have

$$\lambda = \frac{\Xi b - \Xi}{\left(1 - \bar{s}_T^{m_T|m^P}\right) b + \bar{s}_T^{m_T|m^P}},$$

where $b = E\left[\left(d \ln l_{it} / dZ_{it}\right) / \left(d \ln m_{it}^T / dZ_{it}\right)\right]$, $\Xi = \sum_j S_j^L s_{T,j}^{m_T|m^P} \left[-\sigma_j + \left(\sigma_j - \varepsilon_j\right) s_{T,j}^{m^P}\right]$, and $\bar{s}_T^{m_T|m^P} \equiv \sum_j S_j^L s_{T,j}^{m_T|m^P}$. Applying the continuous mapping theorem and central limit theorem to this expression,

Table B.3: 2SLS-DiD Estimates with Thailand Employment as the Regressor

VARIABLES	(1) $\ln l_{it}^{JPN}$	(2) $\ln l_{it}^{JPN}$
$\ln l_{it}^{ROW}$	0.284***	0.0271***
	(0.00394)	(0.00435)
Observations	22,795	22,795
Model	OLS	FE
Firm FE	-	YES
Year FE	-	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results of equation (19) with the sample of Japanese headquarter firms operating in Thailand are shown. The instrument is an extensive-margin measure Z_{it}^{EXT} defined in the main text. In the model row, "2SLS-1st" stands for the first stage regression of equation (19), while "2SLS-reduced" the reduced-form regression of equation (19). Standard errors are clustered at the firm-level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table B.4: 2SLS-DiD Estimates with Alternative Control Groups

VARIABLES	(1) extensive	(2) intensive	(3) extensive	(4) intensive
shock	-0.0497***	-0.172***	-0.0490***	-0.249***
	(0.0126)	(0.0667)	(0.0139)	(0.0774)
Observations	185,703	185,703	91,690	91,690
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Balanced panel?			YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results of equation (19) with alternative sample of Japanese headquarter firms are shown. Standard errors are clustered at the firm-level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

we have the asymptotic standard error of λ given by

$$\sigma_\lambda^2 = \frac{\Xi\left(\left(1-\bar{s}_T^{m_T|m^P}\right)b+\bar{s}_T^{m_T|m^P}\right)-(\Xi b-\Xi)\left(1-\bar{s}_T^{m_T|m^P}\right)}{\left[\left(1-\bar{s}_T^{m_T|m^P}\right)b+\bar{s}_T^{m_T|m^P}\right]^2}\sigma_b^2,$$

where σ_b^2 is the asymptotic standard error of our 2SLS-DiD estimator. The sample analogue of σ_λ^2 yields 0.13. Given our point estimate $\widehat{\lambda} = 1.4$, we can reject the null hypothesis of $H_0 : \lambda \leq 1$, namely, the home labor and foreign labor are gross complements with the significance level 0.1 percent.

B15. The 2011 Tohoku Earthquake

Furthermore, we consider a robustness of our results regarding the 2011 Tohoku Earthquake. Carvalho et al. (2016) give a concise description as follows: "On March 11, 2011, a magnitude 9.0 earth-

Table B.5: 2SLS-DiD Estimates by Industry

VARIABLES	(1) 2SLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) 2SLS	(6) 2SLS
Log Subsidiary Employment	0.120**	-0.00447	0.168***	0.0774	-0.184	0.507*
	(0.0501)	(0.610)	(0.0486)	(0.0694)	(0.162)	(0.292)
Observations	3,704	773	540	563	521	915
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry	manuf	chem	metal	machine	elec	auto

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results of equation (19) with the sample of Japanese headquarter firms operating in Thailand at the industry level are shown. The regressor is employment in Thailand. Standard errors are clustered at the firm-level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table B.6: 2SLS-DiD Estimates by Industry, First Stage

VARIABLES	(1) 1st	(2) 1st	(3) 1st	(4) 1st	(5) 1st	(6) 1st
Thai Flood Shock	-0.730***	-0.152	-1.655***	-2.223**	-0.655***	-0.303**
	(0.169)	(0.173)	(0.358)	(1.101)	(0.161)	(0.132)
Observations	3,704	773	540	563	521	915
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry	manuf	chem	metal	machine	elec	auto

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results of equation (19) with the sample of Japanese headquarter firms operating in Thailand at the industry level are shown. The regressor is employment in Thailand. Standard errors are clustered at the firm-level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

quake occurred off the northeast coast of Japan. This was the largest earthquake in the history of Japan and the fifth largest in the world since 1900. The earthquake brought a three-fold impact on the residents of northeast Japan: (i) the main earthquake and its aftershocks, directly responsible for much of the material damage that ensued; (ii) the resulting tsunami, which flooded 561 square kilometers of the northeast coastline; and (iii) the failure of the Fukushima Dai-ichi Nuclear Power Plant that led to the evacuation of 99,000 residents of the Fukushima prefecture." (Carvalho et al., 2016)

Since our data is annual and the Thailand Floods began to happen four months after the earthquake, one might be concerned that our results are qualitatively affected by the cooccurrence of the earthquake. There are two ways to address this concern. First, our specification in equation (19) include the fixed effects of firms. Therefore, we leverage the variation within the firm across years, but not the differences between firms that may or may not experience the earthquake. Second, in order to further mitigate the concern that the existence of the flooded firms in the main sample still biases

Table B.7: 2SLS-DiD Estimates by Industry, Reduced Form

VARIABLES	(1) reduced	(2) reduced	(3) reduced	(4) reduced	(5) reduced	(6) reduced
Thai Flood Shock	-0.0874**	0.000677	-0.277***	-0.172	0.120	-0.154**
	(0.0428)	(0.0923)	(0.0594)	(0.225)	(0.105)	(0.0700)
Observations	3,704	773	540	563	521	915
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Industry	manuf	chem	metal	machine	elec	auto

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: Regression results of equation (19) with the sample of Japanese headquarter firms operating in Thailand at the industry level are shown. The regressor is employment in Thailand. Standard errors are clustered at the firm-level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

the fixed effect estimator, we conduct the following robustness check exercise. We drop firms located in four severely hit prefectures in Japan–Aomori, Iwate, Miyagi, and Fukushima (called "damaged prefectures" below). These damaged prefectures include 36 municipalities that were designated by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan after the earthquake. The definition is also employed by Carvalho et al. (2016), which an interested reader may refer to for the details of the reasons for the choice.[15]

Table B.8 shows the result of the 2SLS-DiD regression based on equation (19) for the sample without firms in the damaged prefectures. We do not find statistically significant differences of the estimates between the two samples. The finding is expected given the similar samples considered. Because the 2011 Tohoku Earthquake hit severely the northeast regions in Japan, while the firms that intensively engages in FDI and multinational activities are skewed to large cities facing such as Tokyo and Osaka metropolitan areas. Given this fact, since our original estimation sample was the multinational firms, dropping the firms that suffered from the earthquake did not alter the sample largely. Therefore, we find the similar estimates in Tables 2 and B.8, which indicates the effect of the 2011 Tohoku Earthquake on our estimate is limited at most.

C Quantification Appendix

[15] Although the propagation of the shock due to the input-output linkages makes it not trivial to measure the exact incident of the earthquake on each firm, we view our choice as a conservative test for the existence of the earthquake effect on our estimator. Namely, since the firms located in the defined four prefectures suffered the earthquake most, if there is any confounding effects of the earthquake on our estimator, dropping such firms should alter the estimate quantitatively. Thus, null differences between our full sample and sample without four prefectures are suggestive of the fact that the earthquake effects are not quantitatively significant.

Table B.8: Regression Results without Earthquake-hit Firms

VARIABLES	(1) $\ln l_{it}^{JPN}$	(2) $\ln l_{it}^{JPN}$	(3) $\ln l_{it}^{JPN}$	(4) $\ln l_{it}^{ROW}$	(5) $\ln l_{it}^{JPN}$
$\ln l_{it}^{ROW}$	0.448***	0.0601***	0.192***		
	(0.00684)	(0.0107)	(0.0502)		
Z_{it}				-0.730***	-0.140***
				(0.108)	(0.0368)
Observations	5,551	5,551	5,551	5,551	5,551
Model	OLS	FE	2SLS	2SLS-1st	2SLS-reduced
Firm FE	-	YES	YES	YES	YES
Year FE	-	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

C1. Derivation of the Foreign Factor Productivity Growth

By taking ratio of equations (12) and (13), we have

$$\frac{w_J l_j(\psi; d^*)}{p_T^m m_{T,j}(\psi; d^*)} = \left(\frac{w_J}{p_T^m / a_T}\right)^{1-\lambda}$$

Rearranging, we have

$$a_T = \frac{p_T^m}{w_J}\left(\frac{p_T^m m_{T,j}(\psi; d^*)}{w_J l_j(\psi; d^*)}\right)^{\frac{1}{\lambda-1}}.$$

Since this measure is sensitive to the choice of firm ψ, we can aggregate this expression across all Thailand investors to get

$$\sum_j \int_{\psi_{11,j}}^{\infty} a_T dG_j(\psi) = \frac{p_T^m}{w_J}\sum_j \int_{\psi_{11,j}}^{\infty}\left(\frac{p_T^m m_{T,j}(\psi; d^*)}{w_J l_j(\psi; d^*)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)$$

$$\iff a_T = \frac{\frac{p_T^m}{w_J}\left(\frac{\overline{p_T^m m_T}}{w_J L}\right)_{11}}{\bar{p}_{11}}$$

where $\bar{p}_{11} \equiv \sum_j \left(1 - G_j\left(\psi_{11,j}\right)\right)$ summarizes the ease of entry into Thailand and

$$\left(\frac{\overline{p_T^m m_T}}{w_J L}\right)_{11} \equiv \sum_j E\left[\left(\frac{p_T^m m_{T,j}(\psi; d^*)}{w_J l_j(\psi; d^*)}\right)^{\frac{1}{\lambda-1}} | d^* = 11\right]$$

is the weighted average of relative Thailand factor demand conditional on entry into Thailand.

Next, consider the hat algebra

$$\hat{a}_T = \frac{\frac{\hat{p}_T^m}{w_J}\left(\widehat{\frac{\overline{p_T^m m_T}}{w_J L}}\right)_{11}}{\hat{\bar{p}}_{11}},$$

where the change in the average relative Thailand factor demand can be obtained by

$$\left(\frac{\hat{\overline{p_T^m m_T}}}{w_J L}\right)_{11} = \sum_j S_j^r \int_{\psi'_{11,j}}^{\infty} \frac{\left(\frac{p_T^m m_{T,j}(\psi;d^*)}{w_J l_j(\psi;d^*)}\right)^{\frac{1}{\lambda-1}}}{\int_{\psi_{11,j}}^{\infty} \left(\frac{p_T^m m_{T,j}(\psi;d^*)}{w_J l_j(\psi;d^*)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)} \left(\frac{p_T^m \hat{m_{T,j}}(\psi;d^*)}{w_J \hat{l_j}(\psi;d^*)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)$$

where

$$S_j^r \equiv \frac{\int_{\psi_{11,j}}^{\infty} \left(\frac{p_T^m m_{T,j}(\psi;d^*)}{w_J l_j(\psi;d^*)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)}{\left(\frac{\overline{p_T^m m_T}}{w_J L}\right)_{11}}$$

summarizes the sectoral relative demand share. To think about the remaining terms, consider the case $\psi_{11,j} > \psi'_{11,j}$, so the new equilibrium is such that the entry is less selective than the old one. In this case,

$$\frac{\int_{\psi'_{11,j}}^{\infty} \left(\frac{p_T^m m_{T,j}(\psi;d^*)}{w_J l_j(\psi;d^*)}\right)^{\frac{1}{\lambda-1}} \left(\frac{p_T^m \hat{m_{T,j}}(\psi;d^*)}{w_J \hat{l_j}(\psi;d^*)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)}{\int_{\psi_{11,j}}^{\infty} \left(\frac{p_T^m m_{T,j}(\psi;d^*)}{w_J l_j(\psi;d^*)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)} = \int_{\psi'_{11,j}}^{\infty} s_j^r(\psi) \left(\frac{p_T^m \hat{m_{T,j}}(\psi;d^*)}{w_J l_j(\hat{\psi};d^*)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi),$$

where

$$s_j^r(\psi) \equiv \frac{\left(\frac{p_T^m m_{T,j}(\psi;d^*)}{w_J l_j(\psi;d^*)}\right)^{\frac{1}{\lambda-1}}}{\int_{\psi'_{11,j}}^{\infty} \left(\frac{p_T^m m_{T,j}(\psi;d^*)}{w_J l_j(\psi;d^*)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)}$$

summarizes a firm's relative demand share in sector j, and the third equality follows since $p_T^m m_{T,j}(\psi;d^*) = 0$ for $\psi \in \left(\psi'_{11,j}, \psi_{11,j}\right)$. Note that

$$E\left[s_j^r(\psi) \left(\frac{p_T^m \hat{m_{T,j}}(\psi;d^*)}{w_J l_j(\hat{\psi};d^*)}\right)^{\frac{1}{\lambda-1}} |d^{*'} = 11\right] = \frac{\int_{\psi'_{11,j}}^{\infty} s_j^r(\psi) \left(\frac{p_T^m \hat{m_{T,j}}(\psi;d^*)}{w_J l_j(\hat{\psi};d^*)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)}{1 - G_j\left(\psi'_{11,j}\right)}$$

$$\iff \int_{\psi'_{11,j}}^{\infty} s_j^r(\psi) \left(\frac{p_T^m \hat{m_{T,j}}(\psi;d^*)}{w_J l_j(\hat{\psi};d^*)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi) = \left[1 - G_j\left(\psi'_{11,j}\right)\right] E\left[s_j^r(\psi) \left(\frac{p_T^m \hat{m_{T,j}}(\psi;d^*)}{w_J l_j(\hat{\psi};d^*)}\right)^{\frac{1}{\lambda-1}} |d^{*'} = 11\right].$$

Hence, we have

$$\left(\frac{\hat{\overline{p_T^m m_T}}}{w_J L}\right)_{11} = \sum_j S_j^r \left[1 - G_j\left(\psi'_{11,j}\right)\right] E\left[s_j^r(\psi) \left(\frac{p_T^m \hat{m_{T,j}}(\psi;d^*)}{w_J l_j(\hat{\psi};d^*)}\right)^{\frac{1}{\lambda-1}} |d^{*'} = 11\right].$$

Furthermore, we can obtain

$$\hat{p}_{11} = \sum_j S_j^m \left(\hat{\psi}_{11,j}\right)^{-\theta_j}$$

where $S_j^m \equiv \frac{\left(1-G_j\left(\psi_{11,j}\right)\right)}{\sum_j\left(1-G_j\left(\psi_{11,j}\right)\right)}$ is sector-j mass share, and the threshold change can be obtained by modifying equations (16) and (18), or

$$\hat{\psi}_{11,j} = \left(\hat{CS}_{11,j}\right)^{\frac{1}{1-\varepsilon_j}} = \left[\left(\hat{c}_{01,j}\right)^{1-\varepsilon_j}\left(\frac{CR'_{11,j}}{CR_{11,j}}\right)\right]^{\frac{1}{1-\varepsilon_j}} = \left(\hat{c}_{01,j}\right)\left(\frac{CR'_{11,j}}{CR_{11,j}}\right)^{\frac{1}{1-\varepsilon_j}},$$

where $\hat{c}_{01,j}$ can be measured by non-Thailand investors employment cost changes.