Multinational Production and Corporate Labor Share*

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August 15, 2023

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Abstract

We investigate the role of multinational enterprises (MNEs) in affecting the labor share in their source country. We utilize a unique natural experiment stemming from the 2011 Thailand Floods, which forced a cessation of operations in Japanese-owned subsidiaries. This external shock to foreign productivity resulted in a relative decrease in the home-country employment and fixed assets of MNEs impacted by the floods, with a more profound effect on the latter. We propose a heterogeneous firm general equilibrium (GE) model that features a production function with offshore factor inputs, and we introduce a solution method based on hat algebra. We estimate the elasticity of substitution between home-country labor and foreign inputs by correlating home and foreign factor demand with the flood shock. Our quantitative analysis suggests that growth in foreign factor productivity increased the demand for capital more than labor in Japan, consequently leading to a reduction in the corporate labor share by 1.4 percentage points.

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

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

*We thank comments by Costas Arkolakis, Lorenzo Caliendo, Taiji Furusawa, Daisuke Fujii, Sam Kortum, Konstantin Kucheryavyy, Andrei Levchenko, Nitya Pandalai-Nayar, Ariell Reshef, Thomas Sampson, Peter Schott, Chang Sun, Yuta Takahashi, and seminar participants at Aarhus, Colorado Boulder, Columbia, IU Bloomington, NYU, RIETI, SNU, and Yale. This study is conducted as a part of the Project "Dynamics of Inter-organizational Network and Firm Lifecycle" undertaken at the Research Institute of Economy, Trade and Industry (RIETI) and utilizes the micro data based on the Census of Manufacture, the Basic Survey on Japanese Business Structure and Activities, and the Basic Survey on Overseas Business Activities which are administered by the Ministry of Economy, Trade and Industry (METI). We thank Takashi Iino for outstanding research assistance. All errors are ours.

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1 Introduction

A growing body of evidence suggests that labor shares have been decreasing in several developed countries over recent decades. This trend raises concerns among policymakers regarding the widening income inequality between capital owners and workers. Prior studies have proposed several potential explanations, including the bias in technological changes and rising markups. However, behind these technological changes are numerous potential mechanisms, with causal evidence for any specific mechanism being scarce. In this paper, we examine the role of the intensified activities of multinational enterprises (MNEs) in a source country's labor share.

We present novel causal evidence derived from a natural experiment. Specifically, we investigate the impact of the 2011 Thailand Floods, which caused a significant negative productivity shock to local firms embedded within Japanese MNEs' global production networks. We demonstrate that firms located in the flooded areas experienced differing trends in foreign and home-country activities, such as employment and capital demand, compared to other MNEs operating in Thailand that were not affected by the floods. Our evidence suggests that these firms partially offset the negative impact on their foreign production sites by hiring home-country workers to perform labor-intensive tasks.

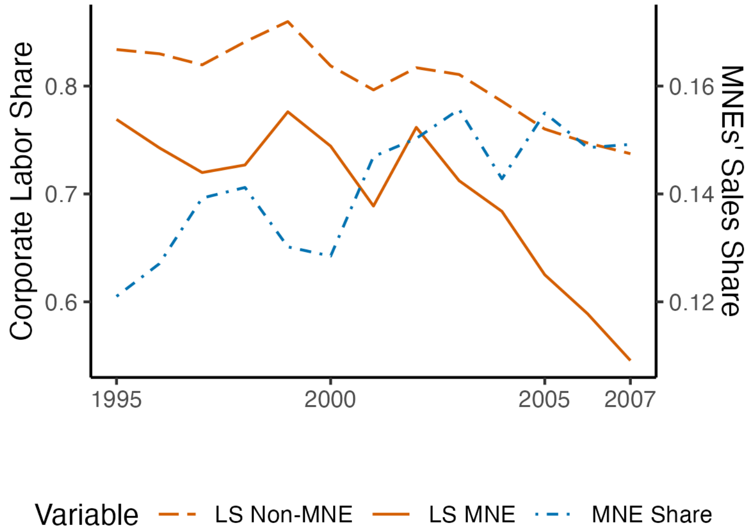
Motivated by these findings, we introduce a model of heterogeneous firms that utilize home-country labor, home-country capital, and foreign factors as inputs. We conduct a comparative statics exercise concerning changes in foreign productivity. We underscore that the elasticity of home-country factor demands in response to effective foreign factor prices is a key parameter influencing the labor share and provide an estimate of it using the Thailand Floods natural experiment. The estimated model reveals that foreign productivity growth decreases the Japanese corporate labor share and exacerbates across-firm inequality in labor shares.

Figure 1 offers a simple, illustrative decomposition plot highlighting the role of MNEs in the decrease of the labor share. The blue dot-dash line represents the trend of MNE headquarter (HQ) sales as a share of all firm sales, indicating a growth in the MNE sales share over the period. The red lines display the labor share trends of MNEs (solid line) and non-MNEs (dashed line). Throughout this period, MNEs consistently exhibited a lower labor share, and their labor share decreased more rapidly than that of non-MNEs. Therefore, Figure 1 suggests both a compositional effect and a within-MNE role contributing to the decrease in the aggregate labor share.[1]

In order to explore the causal relationship, we make use of the 2011 Floods, which in-

[1] Appendix A.1 also shows similar comparisons between offshorers and non-offshorers and between MNEs with subsidiaries in Thailand and other firms. Appendix A.2 shows additional motivational evidence from cross-country variation in the labor share change and outward MNE intensities.

Figure 1: Labor Shares of MNEs and Non-MNEs



Note: Trends of labor shares for multinational enterprises (MNEs) and non-MNEs are shown. For each firm, labor share is calculated as the fraction of total payroll over the sum of total payroll and operating surplus from BSJBSA data. MNE shares are computed by sales shares of MNEs.

flicted significant damage on Thailand's production economy at an unprecedented scale. Among the manufacturing clusters affected by the flood were numerous subsidiaries of Japanese MNEs. To analyze this unique event, we match datasets from all Japanese MNEs, incorporating detailed information on subsidiary locations, foreign operations, and home-country activities such as employment and fixed asset formation. The floods had a long-lasting impact on the activities of MNEs in the affected region, with our event-study regression indicating a decline in both employment and fixed asset formation among the Japanese MNEs' HQs affected, in comparison to those HQs not directly affected but with subsidiaries in Thailand. Moreover, we find that the reduction in fixed assets was greater than that in employment, as the drop in employment was partially offset by home-country labor-intensive activities compensating for weakened foreign activities. These findings suggest that labor is more substitutable than capital in foreign activities.

We interpret these results using a standard general equilibrium model of heterogeneous firms. To understand the implications for labor share, factor prices–endogenously determined by market-clearing conditions–are key variables driving labor shares. If labor is more substitutable with foreign inputs than capital, the productivity growth of the foreign factor decreases the relative demand for labor and thus pressures the relative wage downwards. To solve the heterogeneous firms model, we employ the "hat algebra" method. However, our model includes a term for cost-saving by engaging in foreign sourcing, and this extensive-margin term renders the standard hat algebra approach inapplicable, since we cannot observe a firm both sourcing and not sourcing from foreign countries simultaneously. Our solution to this problem involves using the model-implied measure of the offshorers' cost ratio to proxy the unobserved cost-saving term. We term the hat algebra system incorporating this technique "extensive-margin hat algebra" (EMHA).

With the EMHA method, we can conduct a quantitative exercise provided we have observable factor cost shares and elasticities of substitution. We use the Thailand Floods to identify and estimate the elasticity of substitution between home-country labor and foreign inputs, while other substitution parameters are calibrated using existing methods in the literature. To estimate the substitutability between home-country labor and foreign inputs, we employ a two-stage least square (2SLS) specification frequently used in the literature examining the labor substitution effect of MNEs. Theoretically, the 2SLS estimator is the ratio of the indirect employment effect of the foreign productivity shock and the sum of the indirect effect and the direct substitution effect. This relationship provides a method-of-moments estimator for the elasticity of substitution, and applying this method to the Thailand Floods yields an estimate of 1.4. This estimate is significantly greater than 1, thereby rejecting the null hypothesis of a Cobb-Douglas mix of home-country labor and foreign inputs.

After validating the estimated model's performance in predicting the impact of the floods on home-country labor and capital demand, we deduce the quantitative implications of foreign factor productivity growth on the decrease in the Japanese corporate labor share. We infer the aggregate evolution of foreign productivities from the trends in home-country and foreign employment. This foreign productivity growth explains a 1.4 percentage point reduction in the labor share between 1995 and 2007. We also perform a decomposition exercise of this labor share decline and discover that the foreign factor productivity growth increased labor share inequality across firms. This was due to already low labor-share MNEs further reducing their labor share by substituting their home-country labor demand with foreign inputs.

This paper contributes to four areas of literature. Firstly, we provide a novel mechanism to explain the recent trend of declining labor shares in high-income countries. A growing body of work has explored this phenomenon since it was documented by Karabarbounis and Neiman (2013).[2] For instance, Elsby et al. (2013) emphasized the offshoring of labor-intensive activities among supply chains. Similarly, Oberfield and Raval (2021) emphasize the role of "technology, broadly defined, including automation and offshoring, rather than

[2]Mechanisms proposed in the literature include the automation (e.g., Acemoglu and Restrepo, 2019), GVC participation (Reshef and Santoni, 2023), the declining relative cost of capital (e.g., Karabarbounis and Neiman, 2013; Eden and Gaggl, 2018; Hubmer, 2023), output market concentration (Autor et al., 2017; Barkai, 2017; De Loecker and Eeckhout, 2017; Autor et al., 2020), labor market concentration (Gouin-Bonenfant et al., 2018; Berger et al., 2019), and intermediate price fluctuation (Castro-Vincenzi and Kleinman, 2022). Among them, Castro-Vincenzi and Kleinman (2022) introduces another input of intermediate inputs than labor and capital, and its impact on the labor share. I complement this study by studying the role of foreign factors instead of intermediate inputs using a natural experiment and heterogeneous firms model.

mechanisms that work solely through factor prices." We extend this perspective by arguing that the deepening of global value chains (GVCs), represented by intensified MNE activities, play a role in reducing labor share. Furthermore, as Boehm et al. (2020) point out "the notorious difficulty to construct convincing instruments with sufficient power at the firm level," we contribute to this literature by providing plausibly causal evidence of the role of MNEs in labor share.

To our knowledge, Sun (2020) is the only study that delineates the role of MNEs in driving labor shares. Based on different capital intensities between foreign affiliates and domestic firms, Sun (2020) devises a model of non-factor neutral technology that describes changes in labor share in developing countries, which adopt foreign direct investment from other countries. We augment this study in two ways. Firstly, we offer causal evidence of the effect of firms' intensified foreign activities on home-country factor employment based on a natural experiment, and estimate the elasticity of factor substitution. Secondly, using these estimates, we expound the implications of labor share decline in Japan, a country that invests more in other countries than it attracts foreign investments.

Our second contribution is to the literature on the effects of MNEs on the home-country labor market, by providing evidence from natural experimental variation. Previous literature has examined the impact of foreign production on the source country's labor market.[3] However, the paucity of exogenous variation has often led to weak causal evidence. An exception is the work by Kovak et al. (2021), who exploit the variation resulting from the enactment of Bilateral Tax Treaties between the US and partner countries to find a heterogeneous impact on employment at the MNE level. We supplement this evidence with a new natural experiment, the 2011 Thailand floods' impact on Japanese MNEs. Furthermore, while these previous studies primarily focused on implications for the home-country labor market, they largely overlooked the use of capital. It is crucial, however, to examine the capital market as well as the labor market when discussing corporate labor share.

Thirdly, our focus on the effect of the productivity change of a specific factor on the labor share aligns with recent approaches via production function estimation. Among others, Doraszelski and Jaumandreu (2018) and Zhang (2019) estimate the production function with non-Hicks neutral productivity shocks and study the effect of such shocks on declining labor shares. Our study does not estimate the production function since the sample size of firms affected by the 2011 Thailand Floods is insufficient to recover the production function with enough statistical power. Rather, we complement this literature by explicitly examining a general equilibrium structure. This structure not only aids in estimation, but also facilitates the discussion of the equilibrium adjustment of firm offshoring behavior and

[3] Recent contributions drawing on firm-level data include Desai et al. (2009); Muendler and Becker (2010); Harrison and McMillan (2011); Ebenstein et al. (2014); Boehm et al. (2020).

factor prices, which critically affect the firm-level and aggregate labor shares.

Lastly, our paper is related to the literature on solving trade models using hat algebra. Since Dekle et al. (2007) proposed the method of expressing equilibrium conditions by a new-to-old ratio with hat notation, it has become popular in solving quantitative trade models due to its low data and estimation requirements, as discussed in Costinot and Rodríguez-Clare (2014). Our Extensive Margin Hat Algebra (EMHA) method expands the set of models to which 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, both of which cannot be observed simultaneously. We solve this problem by applying the model restriction and proxying the counterfactual term by entrants' cost shares, following the insight of the sufficient statistics approach of Blaum et al. (2018). They express the change in the model's consumer price index in the model of complex multi-country offshoring decisions as observable offshore cost shares. We go a step further and show that such a measure can be used to derive the general equilibrium reaction to a shock.

Our paper is structured as follows. Section 2 presents data on labor shares and the reduced-form findings from the 2011 Thailand Floods. Section 3 illustrates a heterogeneous firm general equilibrium model. Section 4 discusses the parameter estimation and Section 5 elaborates on the quantitative exercises. Section 6 offers concluding remarks.

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 two-fold. The first one is the Basic Survey on Japanese Business Structure and Activities (BSJBSA). This is an annual survey administered by the Ministry of Economy, Trade, and Industry (METI), which captures comprehensive information on firms in Japan that meet the size thresholds of more than 50 employees and JPY 30 million (≈USD 0.3 million) paid-in capital. The BSJBSA provides a comprehensive array of firm-level data, such as the firm's address, employee count categorized by divisions such as regular and non-regular workers, and balance-sheet information. This includes details like the operating surplus, the value of fixed assets, sales data by goods, cost breakdowns by type, and detailed export and import data by region. It also contains information on outsourcing activities, among other details. We have winsorized top and bottom 0.1 percent of operating surpluses. The dataset covers the period 1995-2016.

Second, to complement the data from the BSJBSA with information on foreign production, we employ the Basic Survey of Overseas Business Activities (BSOBA). The BSOBA is an annual government survey conducted by the Ministry of Economy, Trade, and Industry (METI) of Japan that covers all Japanese multinational enterprises (MNEs), encompassing both private and public firms. BSOBA comprises Headquarters and Subsidiary files. We utilize information from the Subsidiary file, which documents data pertaining to all child and grandchild foreign subsidiaries of each headquarter (HQ) 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, but does not contain information on capital stock in the subsidiary. We access the data from 1995 to 2016. Appendix A.3 shows the coverage of employment and labor compensation variables in the BSOBA Subsidiary File.

We enhance the information in BSOBA with the street-level address variable from the Orbis dataset provided by Bureau van Dijk, as location variables in BSOBA are only available at the country level. Additionally, we link these datasets using the HQ firm name, location, and phone number with a firm-level dataset gathered by a private credit agency, Tokyo Shoko Research (TSR). The match rate from BSOBA to BSJBSA is 93.0%. Due to TSR data availability, the coverage of matched BSJBSA-BSOBA data spans from 2007 to 2016. Given that the scope of BSOBA includes all Japanese MNEs, a firm is classified as multinational if and only if it appears in the BSOBA Headquarter File in the BSJBSA each year.

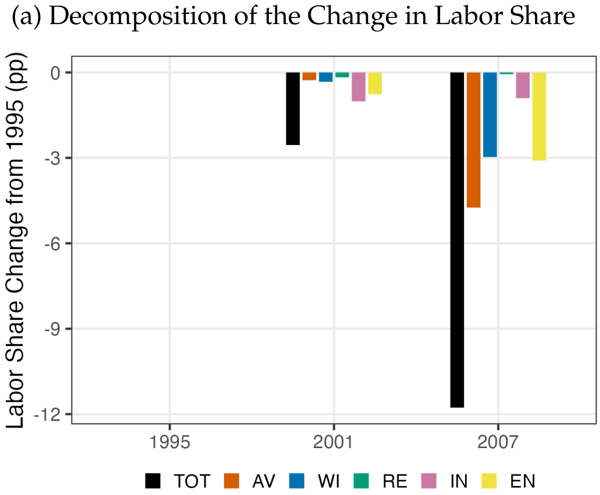
Patterns of the Firm-level Labor Share in Japan We begin our analysis with a simple decomposition analysis using the BSJBSA. We define the firm-level labor share by

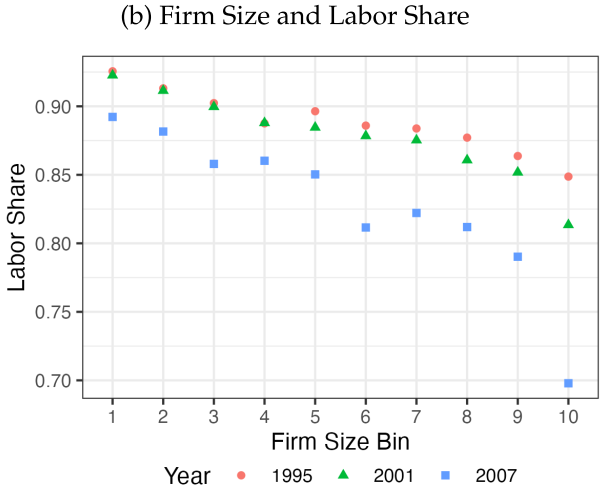
$$ls_{it} \equiv \frac{(wl)_{it}}{(wl)_{it} + (os)_{it}}, \tag{1}$$

where $(wl)_{it}$ is the labor compensation of firm i in year t, and $(os)_{it}$ is the operating surplus, following recent discussions in the measurement of corporate labor share (Bridgman, 2018; Rognlie, 2018). This approach mitigates complications associated with the mixed income of self-employed individuals and capital depreciation. However, it necessitates a careful interpretation of operating surplus, which will be discussed in the model section. It is also important to note that this measure of corporate labor share could potentially be higher than the System of National Accounts (SNA)-based measure for various reasons, such as the exclusion of depreciation from the denominator. Consequently, comparisons of labor shares should not be made between different measures, but rather across different periods

[4]We drop subsidiaries located in tax-haven countries, following the definition provided by Gravelle (2015).

Figure 2: Firm-level Labor Shares in Japan





Note: The left panel plots the decomposition of corporate labor shares based on equation (2). "TOT" stands for the total effects and equals the sum of all 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 evolution of the distribution of the corporate labor share by firm-size deciles.

within each specific measure. Further details regarding other labor share measures are provided in Appendix A.5. Using equation (1), the aggregate labor share LS_t is defined by $\sum_i (wl)_{it} / \sum_i [(wl)_{it} + (os)_{it}]$.

Following Kehrig and Vincent (2021), we can decompose the change in the aggregate labor share since $t_0 \equiv 1995$ as follows:

$$\Delta LS_t \equiv LS_t - LS_{t_0} = AV_t + WI_t + RE_t + IN_t + EN_t, \tag{2}$$

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) there has been a significant drop in the total corporate labor share in Japan, amounting to 11-12 percentage points up until 2007, and (ii) this decline can largely be attributed to a combination of the average effect, within-firm effect, interaction effect, and entry-exit effects. Specifically, between 1995 and 2007, the average effect contributed approximately 5 percentage points, while the within-firm effect and the entry-exit effect each accounted for about 3 percentage points. These findings underscore the significance of mechanisms that operate through both within-firm and across-firm reallocation of factor demands.

To delve further into the across-firm effects, Figure 2b depicts the distribution of the firm-level labor share across different firm sizes over three years in our sample period. It uncovers that (i) there exist negative relationships between labor share and firm size, and (ii) the slope of this relationship steepens in later years, particularly at the top end of the size distribution. This pattern suggests that more productive firms tend to have lower labor shares, and the reallocation of resources from low-productivity to high-productivity firms could suppress the labor share — a 'superstar' phenomenon as advocated by Autor et al. (2020).

A few comments regarding markups are warranted. Our measure of corporate labor share aligns with one of the standard methodologies in the literature (Bridgman, 2018; Rognlie, 2018). However, it is crucial to understand that the denominator of our measure includes a markup component in the operating surplus that does not directly tie into our proposed mechanism. Nonetheless, we address this concern by pointing out that according to Nakamura and Ohashi (2019), and as shown in our Appendix A.4, markup remained constant in Japan during our sample period of 1995-2007. Furthermore, we demonstrate in Appendix A.5 that the decrease in Japanese aggregate labor share during this period is robust across alternative measures. As a result, it becomes clear that unlike in countries such as the US, the observed pattern in Figure 2b cannot be solely explained by a rising markup.

Rather, we aim to investigate another mechanism of globalization that Japanese firms experienced during the sample period. In Appendix A.1, we additionally exhibit trends in aggregate labor share between MNEs and non-MNEs. However, interpreting these results causally poses a challenge due to the absence of exogenous shocks that could have affected the foreign activities of these firms. In the next section, we examine our natural experimental context.

2.2 Responses of Japanese MNEs to the 2011 Thailand Floods

Between July 2011 and January 2012, severe floods occurred along the Mekong and Chao Phraya river basins in Thailand, causing many firms in the region to suspend operations. Areas heavily affected were primarily concentrated in the Ayutthaya and Pathum Thani

(AP hereafter) provinces, which are home to seven industrial estates.[5] These estates housed close to 800 companies, including 450 Japanese subsidiaries, many of which operated in the automobile and electronics industries (see Appendix A.7) and manufactured parts utilized in later stages of global production. Having embraced the "just-in-time" production model with minimal inventories, these companies were particularly vulnerable to the shock (Monden, 2011; Haraguchi and Lall, 2015). The economic damage caused by the floods was estimated at USD 46.5 billion, making it the fourth most expensive disaster in history (World Bank, 2011).

Building upon the arguments put forth by Benguria and Taylor (2019) that the floods primarily impacted the production side rather than the demand side, we provide evidence in Appendix A.6 that Thailand experienced a decline in exports but not imports following the floods. Although the direct inundation period lasted only one year, the effects of the floods were long-lasting, as discussed in Appendix A.8.[6] The magnitude of the floods was exceptionally large and caught Japanese headquarters (HQs) off-guard, leading to significant concerns regarding spillover effects on the Japanese production economy (Feng and Li, 2021).

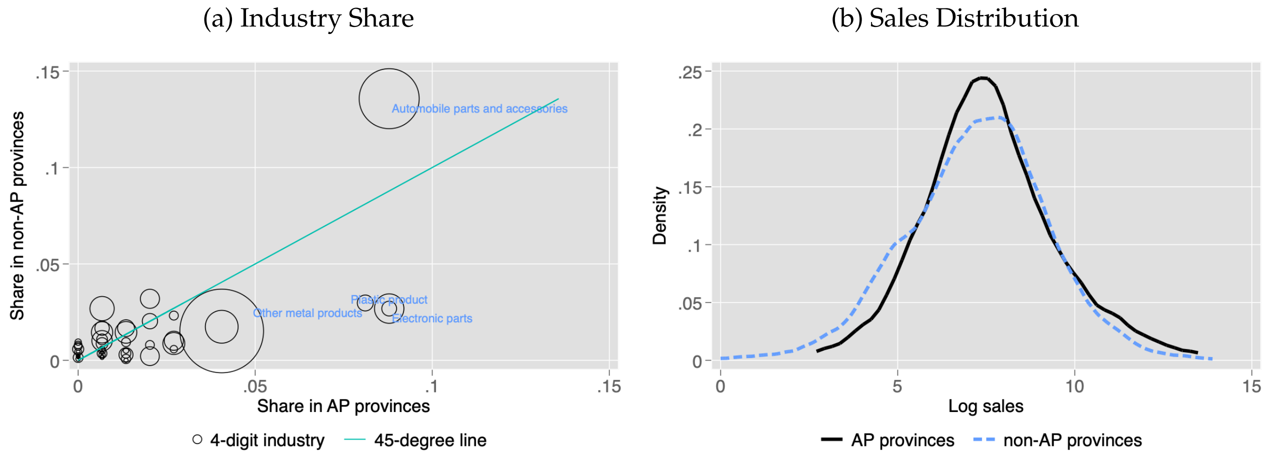
Balancing Checks. To ensure that there are no significant systematic differences between MNEs with subsidiaries located in the flooded regions and those without, we examine firm characteristics. In the BSOBA data, we define the treated group as firms operating in the AP provinces in 2011, while the subsidiary control group consists of firms located in other regions of Thailand during the same period.[7] Figure 3 presents the results of balancing checks, with the left panel showing a comparison of 4-digit industry share distributions and the right panel displaying the comparison of log sales distributions. These checks help assess whether the two groups of firms exhibit notable differences in their characteristics. The industry distributions between the treatment group and control group are relatively balanced, although there are some slight differences. In the treatment group, a higher proportion of firms are involved in the production of electronic parts (9% compared to 3% in the control group), plastic products (9% compared to 3% in the control group), and other metal products (8% compared to 3% in the control group). In the right panel, the Kolmogorov-

[5]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.

[6]Firms possibly updated their risk perception in the region (Pierce and Schott, 2016; Handley and Limão, 2017). Similar long-lasting effects from the 2011 Thailand floods are also found in Forslid and Sanctuary (2022).

[7]We control for potential cross-country differences by utilizing the variation across narrow geographic regions within Thailand. In order to demonstrate this, we present a comparison of the trend of Japanese MNE activities in Thailand with the rest of the world, and argue that such a broad comparison does not offer sufficient shock variation. Refer to Appendix A.9 for more details.

Figure 3: Balancing Checks



Note: The left panel shows the scatterplot of 4-digit industry shares for groups of firms in Ayutthaya and Pathum Thani (AP) provinces (treatment) in the horizontal axis and and those not in AP provinces (control) in the vertical axis. The green line shows the 45 degree line. 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 provinces and not in AP provinces.

Smirnov test does not reject the hypothesis of the same log sales distribution between the two groups, with an exact p-value of 0.172.

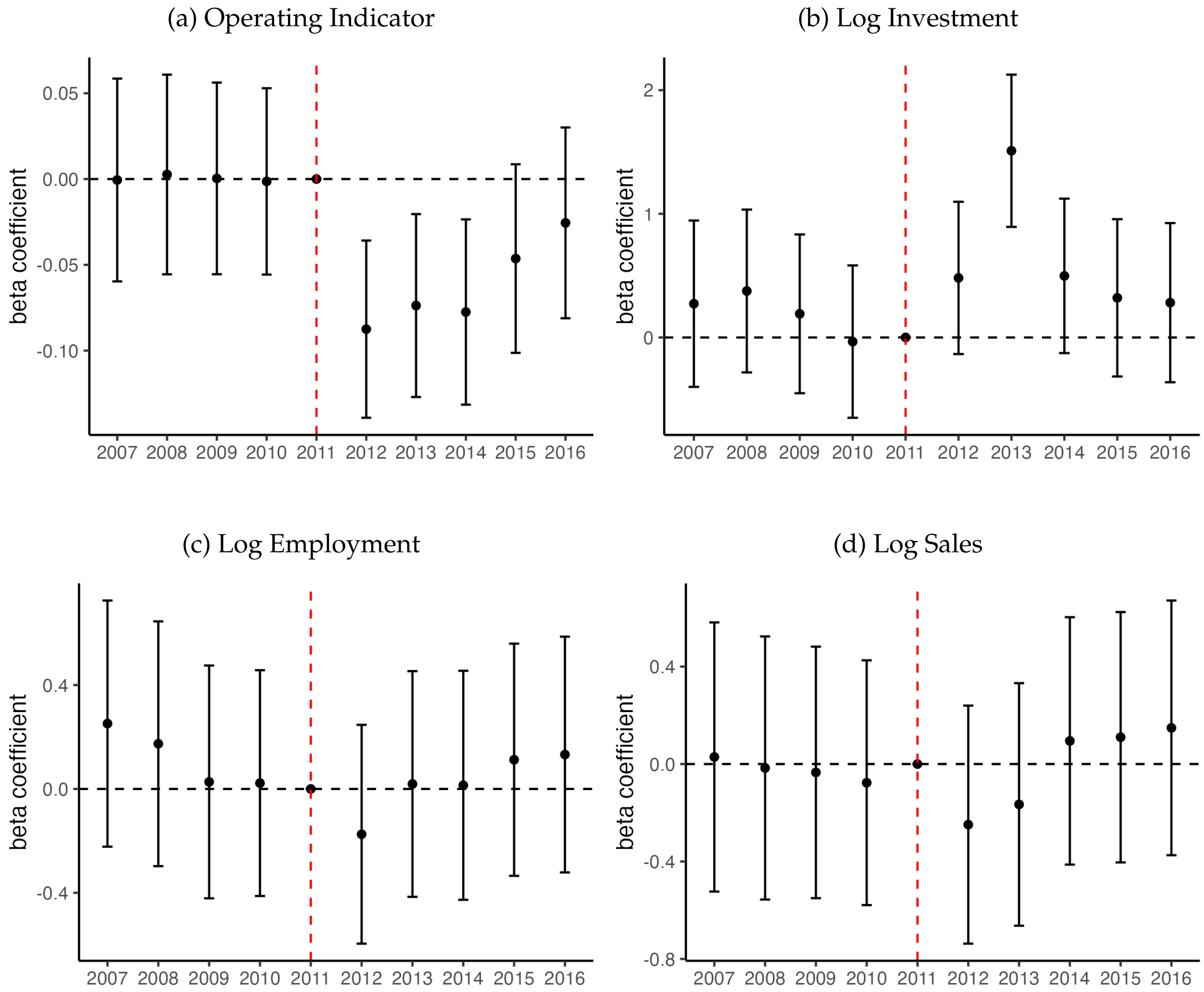
Subsidiary-level Analysis. We first study the impact of floods on Japanese subsidiaries in Thailand. For this purpose, we consider the following event-study regression for the sample of Japanese subsidiaries in Thailand:

$$y_{st} = \alpha_s^S + \alpha_{jt}^S + \sum_{\tau \neq 2011} \beta_\tau^S \times \left(flooded_s \mathbf{1}\left\{ t = \tau \right\} \right) + X_{st}\gamma^S + \varepsilon_{it}^S, \tag{3}$$

where s is subsidiary s, t is calendar year, $flooded_s$ is an indicator variable that takes one if and only if s is located in AP provinces in 2011, and X_{st} is the control variables including the pre-flood linear trend interacted with the floods indicator. We estimate this equation using a balanced panel of firms that operated throughout the period 2007-2011. We examine the response to the shock at both the extensive and intensive margins. Specifically, we analyze if firms responded to the shock by ceasing operations, using the operating indicator as the outcome variable. Additionally, we study the adjustment at the intensive margin by analyzing log variables (investment, employment, and sales) conditional on firms continuing operation.

The results are presented in Figure 4. Firstly, we confirm that the coefficients for the pre-flood years are statistically insignificant, satisfying the parallel trend assumption. Subsequently, in panel (a), we observe a significant negative effect at the extensive margin when considering the operating indicator as the outcome variable. This effect persists for three

Figure 4: Event Study at the Subsidiary Level



Note: The figure plots coefficient estimates of subsidiary-level event-study regression in equation (3). 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 bars indicate 95 percent confidence intervals.

years after the floods, albeit to a lesser extent in later years. Furthermore, panel (b) provides evidence of a substantial positive investment response among firms in the operating treatment group, which could indicate reinvestment efforts to restore damaged properties. In contrast, panels (c) and (d) do not show significant employment and sales responses conditional on operating, suggesting that the negative effects of the floods primarily affect the extensive margin.

We conduct robustness checks to assess various sample selection criteria, including whole and partial ownerships. The results of these checks are reported in Appendix A.10.

Headquarter-level Analysis. Next, we examine the cross-border effects on Japanese HQ firms by employing the following event-study specification for the sample of HQs that have subsidiaries in Thailand:

$$y_{it} = \alpha_i^H + \alpha_{jt}^H + \sum_{\tau \neq 2011} \beta_\tau^H \times \left(Z_i \mathbf{1}\left\{t = \tau\right\}\right) + X_{it}\gamma^H + \varepsilon_{it}^H, \tag{4}$$

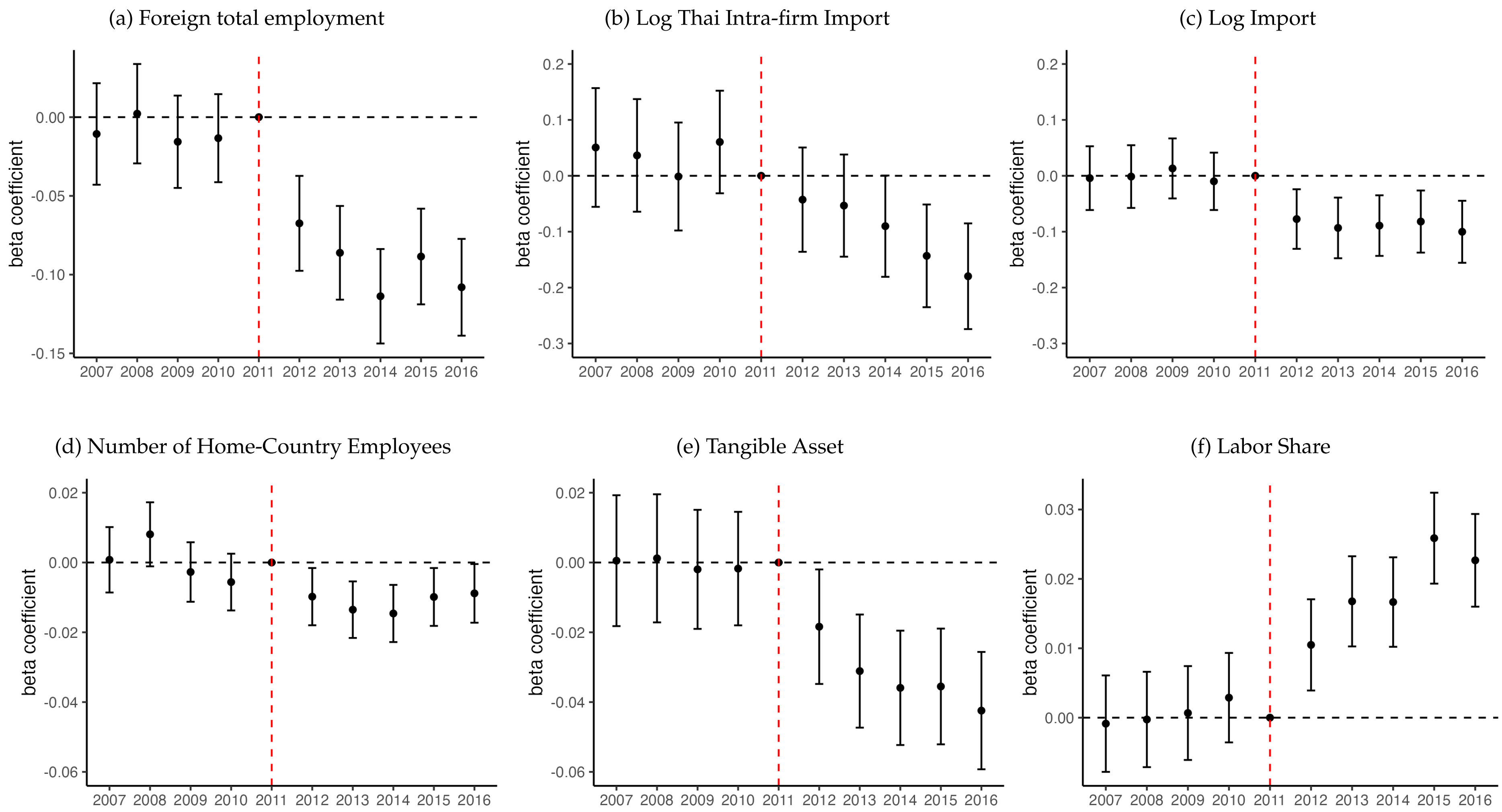
where $Z_i \equiv l_{i,2011}^{flooded} / l_{i,2011}^{world}$ is Japanese HQ i's employment share in the flooded region among the global total employment, measuring the intensity of the floods shock relative to the firm's global size, y_{it} is the outcome variable, α_i^H is the HQ firm-i fixed effect capturing unobserved and fixed firm characteristics, α_t^H is the year fixed effect, and ε_{it}^H is the error term. In the HQ-level analysis, the control variables X_{it} also include the interaction between the Tohoku earthquake flags and the after-floods dummy, following Carvalho et al. (2021), to account for potential confounding effects of supply chain disruptions due to the 2011 Tohoku earthquake (cf. Boehm et al., 2018). Our primary interest lies in the coefficient β_τ^H, which captures the within-HQ firm effect of the floods in each year. We present the estimates of β_τ^H for various outcome variables in Figure 5. Importantly, in all panels, the estimates for the pre-flood years τ are statistically insignificant, supporting the parallel trend assumption associated with the treatment variable.

Firstly, we observe a drastic decrease in total employment in foreign countries for MNEs with flooded subsidiaries. Panel 5a illustrates the persistent negative effect of the floods, which reflects the country's response "to avoid potential supply chain disruptions" in the future (Nikkei Asian Review, December 2, 2014). This reduced intensity of operation is also observed in the number of total foreign subsidiaries, Thai subsidiaries, and employment, as discussed in Appendix A.10.

To investigate international spillover effects, we examine the Japanese HQ's intra-firm trade values from Thailand using the BSOBA data, and total import values using the BSJBSA data in panels 5b and 5c, respectively. In both panels, we observe a decrease in imports by affected HQs, indicating negative effects of the flood shock across borders. Appendix A.10 further explores the reduced imports from Asia. We also explore potential effects on the substitution of production in third countries in Appendix A.11 but no conclusive evidence is found.

Consistent with these findings, we observe negative effects on home-country factor employment. Panel 5d and 5e demonstrate the response of log employment and tangible asset holdings in Japan, respectively. We find that both measures of factors are negatively affected in severely flooded firms. Moreover, in terms of absolute value, the point estimates for asset holdings are larger than those for employment. These findings, along with the result of reduced imports, suggest a reshoring of labor-intensive tasks from foreign to the home coun-

Figure 5: Event Study at the Headquarter Level



Note: The figure plots coefficient estimates of headquarter-level event-study regression in equation (4). As an outcome variable, panel (a) takes log total foreign employment (including the flooded regions), panel (b) takes the log value of intra-firm import from Thailand to the Japanese headquarter, panel (c) takes log import value, panel (d) takes log home-country employment, panel (e) takes the log tangible asset stock, and panel (f) takes the firm-level labor share defined in equation (1). Standard errors are cluster-robust at the firm level, and bars indicate 95 percent confidence intervals.

try. Appendix A.10 provides additional evidence supporting the hypothesis of offshoring labor-intensive tasks by examining temporary non-regular workers in the Japanese employment institution. Finally, the weaker negative employment effects imply an increased labor share at the firm level, as confirmed in Panel 5f.

Furthermore, the use of a different measure of capital demand in Panel 5e compared to the one used in equation (1) provides two arguments. First, the use of fixed asset measures helps distinguish the mechanism, as it indicates that the increase in the affected firms' labor share is not solely attributed to a decrease in profit, but also to a reduction in capital demand. Second, it demonstrates the robustness of the factor-biasedness to the choice of capital measure. We also show that our main findings remain consistent when we modify the shock variable to include only the subsidiaries that exports back to Japan, thus supporting the role of offshoring subsidiaries. Appendix A.10 elaborates on these additional analysis.

Overall, we find that as firms face severe damage from the floods, the negative effects operate on multiple margins, including foreign activities, offshore imports, home-country employment, and home-country capital stock. Furthermore, we observe that the negative effects on capital demand are stronger than those on labor demand, indicating that foreign production is a relative substitute for home-country employment. Building on these insights, we proceed to study the role of foreign activities in the labor share at the firm and aggregate levels using a heterogeneous firm model.

3 Model

We consider a heterogeneous firms model of offshore subsidiaries to study the home-country labor share effect of offshoring. For this purpose, our model emphasizes the change in home-country 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.

3.1 Setup

Environment. The time is static, and we focus on the steady state changes. 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 to focus on the role of foreign factors. J and T are small-open, so we take sectoral price index P_j and factor prices in R as given. While this assumption may seem restrictive, it significantly simplifies the analysis by eliminating the feedback effects of activities in J and T on global prices. It is also important to note that this assumption does not pertain to all of Japanese international trade, but instead to a smaller fraction of MNE activities worldwide. In J, capital $\bar{K}_J$ and labor $\bar{L}_J$ are supplied inelastically, while there is inelastic factor supply $\bar{X}_i$ in $i = T, R$. We do not need to specify household income and preferences because our small-open economy does not involve good market clearing conditions that equate expenditure to income (the trade balance condition). This suffices for examining the implications on the labor share, however, we will revisit this issue in the subsequent welfare analysis.

Given our model's assumption of a solitary factor originating from country J, it does not address labor share implications for countries other than the offshoring parent country. While theoretically, the model can accommodate multiple factors in foreign countries, we intentionally adopt a single factor assumption for two key reasons. Firstly, the BSOBA data, as referenced in Section 2.1, does not contain the capital stock variable of Japanese foreign subsidiaries. Secondly, to derive implications for relative factor prices and labor share in foreign countries, we would require detailed data regarding factor demands from firms that are not offshore subsidiaries; such data is challenging to acquire.

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

$$Q_j \equiv \left[\int_{\omega \in \Omega_j} \left(q_j \left(\omega \right) \right)^{\frac{\varepsilon_j - 1}{\varepsilon_j}} d\omega \right]^{\frac{\varepsilon_j}{\varepsilon_j - 1}}, \tag{5}$$

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 sector-specific Pareto distribution $G_j(\cdot)$ with shape parameter θ_j and scale parameter $\underline{\psi}_j$.[8] 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^x). Firms also choose offshoring subsidiary location

[8]The choice to use a model of monopolistic competition with CES demand is informed by the observed consistency in the markup in Japan over our sample period, as discussed in the data section. Nevertheless, our model can accommodate changes in the aggregate markup through mechanisms of sectoral reallocation. Moreover, most of the derivations in our model do not depend on the Pareto assumption. This assumption proves beneficial when connecting the shift in the offshorer's share to the productivity cutoff, as illustrated in equation (18).

in $i = T, R$ and produces with production function

$$q_j = \psi \left[\alpha_j^k k^{\frac{\sigma_j - 1}{\sigma_j}} + \alpha_j^h h^{\frac{\sigma_j - 1}{\sigma_j}} + \left(1 - \alpha_j^k - \alpha_j^h\right) m^{\frac{\sigma_j - 1}{\sigma_j}} \right]^{\frac{\sigma_j}{\sigma_j - 1}}, \tag{6}$$

where k is headquarter capital, $h \equiv h\left(l, x_T, x_R\right)$ is labor-intensive tasks specified below, m is intermediate inputs, and $\sigma_j \geq 0$ is the sectoral elasticity of substitution between capital and production inputs, and $\alpha_j^k, \alpha_j^h \in (0, 1)$ capture the input shares that exogenously affects the firm-level labor share.[9] The tasks are performed internationally and determined by

$$h\left(l, x_T, x_R\right) \equiv \left[\left(1 - \beta_j^T - \beta_j^R\right) l^{\frac{\lambda - 1}{\lambda}} + \beta_j^T \left(a_T x_T\right)^{\frac{\lambda - 1}{\lambda}} + \beta_j^R \left(a_R x_R\right)^{\frac{\lambda - 1}{\lambda}} \right]^{\frac{\lambda}{\lambda - 1}}, \tag{7}$$

where l is the home-country labor input, x_i the offshore inputs from subsidiaries in $i = T, R$, and $\lambda > 1$ the elasticity of substitution between these factors.[10] 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 (lack of) barriers to firms headquartered in J to operate in i.[11] We will study the comparative statics with respect to these productivities caused by floods (negative productivity shock) or globalization (positive productivity shock). 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.

We relate our firm ψ-level labor share measure (1) to the model counterpart by

$$s^L(\psi) = \frac{w_J l(\psi)}{w_J l(\psi) + \left(r_J k(\psi) + \pi(\psi)\right)},$$

where $\pi(\psi)$ is the profit. The idea is that the operating profit in the data includes not only return to capital but also profit, and our monopolistic competition model yields positive profit in equilibrium.[12] Writing $\Pi \equiv \sum_j \int_\psi \pi(\psi)\, dG_j(\psi)$ as the aggregate profit, we can also

[9] Although the distribution parameters α^k and α^h naturally affects the labor share, we will not focus on them in this paper but study a more nuanced mechanism of foreign offshoring.

[10] The international task allocation is inspired by the task-based framework of Grossman and Rossi-Hansberg (2008). Adachi (2023) shows that a task-based framework combined with Fréchet distribution implies the same unit cost function as equation (7).

[11] 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.

[12] Note that, combined with the heterogeneous demand elsticity ε_j, this implies that the shock to the economy creates reallocation effects of economic profits, although its quantitative importance is minor relative to the effect of reallocation between labor and capital demands. We will derive the implication of shocks to this labor share measure in Appendix B.4.

define the aggregate labor share by

$$S^L = \frac{w_J \bar{L}_J}{w_J \bar{L}_J + r_J \bar{K}_J + \Pi}. \tag{8}$$

Discussions regarding our choice of the production functions (6) and (7) follow. First, the CES production function with capital, labor-intensive tasks, and intermediate inputs is standard in the latest literature of production functions (Grieco et al., 2016; Doraszelski and Jaumandreu, 2018; Harrigan et al., 2021). We enrich their framework by explicitly considering the home-country and foreign factors that perform labor-intensive tasks in our lower nest. Second, our nested CES implies that if $\lambda > \sigma_j$, a firm-level labor share $s^L(\psi)$ is decreasing in a_i $(i \in \{T, R\})$ since labor is relative substitute of foreign inputs (relative to capital). This assumption of the relative values of the elasticities is consistent with the observation that operations in foreign subsidiaries are labor intensive and MNEs' capital is often knowledge-intensive (Carr et al., 2001).[13] Third, as a special case, $\lambda = \sigma_j$ would imply a standard single-nest CES production function, which yields the same firm-level unit cost structure as in Antras et al. (2017).

Equilibrium. In country T, a representative producer uses input X_T with demand function $(p^x_T / a_T)^{-\gamma}$. In country R, factor price is given at p^x_R. In equilibrium, factor prices (w_J, r_J, p^x_T) are determined so that factor markets clear.

3.2 The Extensive Margin Hat Algebra

The offshore subsidiary decision can be summarized by productivity thresholds $\psi_{i,j}$, $i \in \{T, R\}$. To simplify the model, we impose a parameter restriction such that $\psi_{T,j} > \psi_{R,j}$, based on the fact that observed productivity of firms operating in Thailand is higher than those not, as shown in Appendix Figure B.1. Given this restriction, firms' entry choice is made among $d = 00$ (non-offshoring), $d = 01$ (R-offshoring), and $d = 11$ (R- and T-offshoring), and so we rewrite the productivity thresholds by $\psi_{01,j}$ (the threshold between $d = 00$ and $d = 01$) and $\psi_{11,j}$ (the threshold between $d = 01$ and $d = 11$) from now. We call firm's decision d as an offshoring strategy in the following. Firm ψ's marginal cost can be written as

$$c_{d,j}(\psi) = \frac{\tilde{c}_{d,j}}{\psi}, \; \tilde{c}_{d,j} \equiv \left[\alpha^k_j (r_J)^{1-\sigma_j} + \alpha^h_j \left(p^h_d\right)^{1-\sigma_j} + \left(1 - \alpha^k_j - \alpha^h_j\right) (p^m)^{1-\sigma_j} \right]^{\frac{1}{1-\sigma_j}} \tag{9}$$

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

where $\tilde{c}_{d,j}$ is the productivity-controlled unit cost index, and p_d^h is the cost of production input given by

$$p_{d,j}^h = \begin{cases} w_J & \text{if } d = 00 \\ \left[\left(1-\tilde{\beta}_j^R\right) w_J^{1-\lambda} + \tilde{\beta}_j^R \left(\frac{p_R^x}{a_R}\right)^{1-\lambda}\right]^{\frac{1}{1-\lambda}} & \text{if } d = 01 \\ \left[\left(1-\beta_j^T-\beta_j^R\right) w_J^{1-\lambda} + \beta_j^R \left(\frac{p_R^x}{a_R}\right)^{1-\lambda} + \beta_j^T \left(\frac{p_T^x}{a_T}\right)^{1-\lambda}\right]^{\frac{1}{1-\lambda}} & \text{if } d = 11 \end{cases}, \tag{10}$$

where $\tilde{\beta}_j^R \equiv \beta_j^R / \left(1-\beta_j^T\right)$ is the modified distribution parameter for non-T offshorers. Firm ψ's entry decision is given by the cutoff $\psi_{d,j}$ strategy. For instance, the threshold $\psi_{11,j}$ can be derived by equating profit gain by entry in T to the fixed cost, $\pi_{11,j}\left(\psi_{11,j}\right) - \pi_{01}\left(\psi_{11,j}\right) = f_T$, or

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

where $CS_{11,j} \equiv \left[\left(\tilde{c}_{11,j}\right)^{1-\varepsilon_j} - \left(\tilde{c}_{01,j}\right)^{1-\varepsilon_j}\right]^{\frac{1}{1-\varepsilon_j}}$ is the cost-saving term due to entry in T. Note that $CS_{11,j}$ is a counterfactual term of the marginal firm and is hard to measure in the data. Conditional on the optimal entry decision d^* for each firm ψ, monopolistic competition implies firms' pricing rule $p_{d^*,j}(\psi) = \frac{\varepsilon_j}{\varepsilon_j-1} c_{d^*,j}(\psi)$. With this strategy, firm-level factor demand functions can be derived from the CES formulation

$$r_J k_{d^*,j}(\psi) = \left(\frac{r_J}{c_{d^*,j}(\psi)}\right)^{1-\sigma_j} \left(\frac{p_{d^*,j}(\psi)}{P_j}\right)^{1-\varepsilon_j} P_j Q_j, \tag{12}$$

$$p_{d^*}^h h_{d^*,j}(\psi) = \left(\frac{p_{d^*,j}^h}{c_{d^*,j}(\psi)}\right)^{1-\sigma_j} \left(\frac{p_{d^*,j}(\psi)}{P_j}\right)^{1-\varepsilon_j} P_j Q_j, \tag{13}$$

$$w_J l_{d^*,j}(\psi) = \left(\frac{w_J}{p_{d^*,j}^h}\right)^{1-\lambda} p_{d^*}^h h_{d^*,j}(\psi), \tag{14}$$

and

$$p_T^x x_{T,d^*,j}(\psi) = \left(\frac{p_T^x / a_T}{p_{d^*,j}^h}\right)^{1-\lambda} p_{d^*}^h h_{d^*,j}(\psi). \tag{15}$$

Integrated over productivity distribution, these firm-level factor demand functions become the aggregate capital demand K, labor demand L, and J-firm's factor demand in T, X_T. Factor prices (w_J, r_J, p_T^x) are the solution to the factor market clearing conditions $K^D = \bar{K}_J$, $L^D = \bar{L}_J$, and $X_T^D + (p_T^x / a_T)^{-\gamma} = \bar{X}_T$.

To solve these equilibrium conditions, we follow the "hat algebra" approach (Dekle et al., 2007). A strength of this approach is low data requirement; We do not have to estimate all unobserved objects such as input share parameters. To do so, we express all variables x in change, with the hat notation $\hat{z} = z'/z$, where z is a generic variable and represents the baseline value and z' is its value after change. From now on, 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 B.2. There, we show that

$$\hat{K}^D = \sum_j S_j^K \hat{\tilde{C}}_j^K, \tag{16}$$

where $S_j^K = \frac{r_J K_j}{\sum_k r_J K_k}$ is the sectoral capital cost share, and $\hat{\tilde{C}}_j^K$ is the change in the average relative cost term for capital demand given by, with a slight abuse of notation,

$$\hat{\tilde{C}}_j^K = \left(\hat{r}_J\right)^{-\sigma_j} \sum_{d \in \{00,01,11\}} S_{d,j}^K \left(\hat{\tilde{c}}_{d,j}\right)^{\sigma_j - \varepsilon_j} \hat{s}_{d,j}, \tag{17}$$

where $S_{d,j}^K = \frac{\int_{\psi \in d} r_J k_j(\psi) dG_j(\psi)}{r_J K_j}$ is capital cost share of firms with entry decision d in sector j, and $\hat{s}_{d,j}$ is the share change of firms with entry decision d. Derivation of the productivity-controlled cost change $\hat{\tilde{c}}_{d,j}$ is standard and given in Appendix B.2. The presence of $\hat{s}_{d,j}$ term is a novel feature in the heterogeneous firm model, since firms may change their offshoring strategy given shocks according to their productivity ψ.

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 $d = 11$, it implies

$$\hat{s}_{11,j} = \left(\hat{\psi}_{11,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)} = \left(\hat{CS}_{11,j}\right)^{-\theta_j - \left(\varepsilon_j - \sigma_j\right)}, \tag{18}$$

where the last equality holds thanks to equation (11). To workaround the difficulty that $\hat{CS}_{11,j}$ is a counterfactual marginal cost that is hard to measure, we propose the following Extensive Margin Hat Algebra (EMHA). First, note that the CES restriction implies the sectoral cost ratio, or $CR_{11,j} \equiv \left(\tilde{c}_{11,j}/\tilde{c}_{01,j}\right)^{1-\varepsilon_j} - 1$, as follows:

$$CR_{11,j} = \left[\left(1 - s_{01,j}^h\right) + s_{01,j}^h \left(1 - s_{11,j}^{T|h}\right)^{-\frac{1-\sigma_j}{1-\lambda}}\right]^{\frac{1-\varepsilon_j}{1-\sigma_j}} - 1. \tag{19}$$

where

$$s_{01,j}^h = \frac{\int_{\psi_{01,j}}^{\psi_{11,j}} p_{01,j}^h h_{01,j}\left(\psi\right) dG_j\left(\psi\right)}{\int_{\psi_{01,j}}^{\psi_{11,j}} c_{01,j} q_{01,j}\left(\psi\right) dG_j\left(\psi\right)}, \text{ and } s_{11,j}^{T|h} = \frac{\int_{\psi_{11,j}}^{\infty} p_T^x x_{T,j}\left(\psi\right) dG_j\left(\psi\right)}{\int_{\psi_{11,j}}^{\infty} p_{11,j}^h h_{11,j}\left(\psi\right) dG_j\left(\psi\right)}$$

are the cost share of labor-intensive task for firms with entry decision $d = 01$ and the cost share of the factor in Thailand among production inputs of firms with entry decision $d = 11$, respectively, which can be observed in the data. Using this cost ratio expression, we can write $CS_{11,j} = \left(\tilde{c}_{11,j}^{1-\varepsilon_j} - \tilde{c}_{01,j}^{1-\varepsilon_j}\right)^{1/(1-\varepsilon_j)} = \tilde{c}_{01,j}\left(CR_{11,j}\right)^{1/(1-\varepsilon_j)}$. Hence, the change in the cost saving can be written as

$$\hat{CS}_{11,j} = \hat{\tilde{c}}_{01,j}\left(\frac{CR'_{11,j}}{CR_{11,j}}\right)^{\frac{1}{1-\varepsilon_j}}, \tag{20}$$

where $\hat{\tilde{c}}_{01,j}$ can be derived from standard hat algebra shown in Appendix B.2, and $CR_{11,j}$ and $CR'_{11,j}$ are both derived in data before and after the change.[14] We can derive similar expressions of equation (18) for other entry strategies $d = 00, 01$, which are shown in Appendix B.2.

The intuition for EMHA is that, in the key expression of equation (19), the sectoral cost ratio is equated to the weighted average of the shares of capital cost and conditional Thailand factor costs. If firms depend heavily on production inputs in sector j (hence high $s_{01,j}^{h}$), and if the factors in Thailand among labor-intensive tasks (hence high $s_{11,j}^{T|h}$) are intensively used in firms offshoring in Thailand, then the optimal factor demands imply that the cost ratio between investing in Thailand and not investing is large. The nested CES production function provides a specific one-to-one relationship of this type shown in equation (19). 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 $(\theta_j, \varepsilon_j, \sigma_j, \lambda)$. First, we calibrate sectoral parameters $(\theta_j, \varepsilon_j, \sigma_j)$ 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. This approach is a simplified version of the production function estimation approach explicitly using FOC conditions (Gandhi et al., 2020; Doraszelski and Jaumandreu, 2018; Harrigan et al., 2023), where the simplification rests on the specified model structure that was needed to solve for the general equilibrium.

[14] The use of aggregate data before and after the shock is also employed in Arkolakis (2010) in his application to the analysis of trade liberalization.

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 methods 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 firm outputs (see equation 5), and σ_j is the sectoral elasticity of substitution between capital and production inputs (see equation 6).

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), and apply the correction to the OLS estimation proposed by Gabaix and Ibragimov (2011). 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 A.12. 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 the Labor-Foreign Input Substitution Elasticity λ

We use our model, data, and the Thailand Floods shock to identify and estimate the elasticity of substitution between labor and foreign production factors λ. Our estimation methodology is explained as follows.

Separation of the Effects of the Thailand Floods. Starting with our factor demand functions (14) and (15), we decompose the effect of the Thailand productivity shock $d\ln a_{it}^{T}$ into two distinct components: an individual-firm component and a general equilibrium component as follows.

$$d\ln l_{d^*,j}(\psi) = -s_j^{T|h}\left[(\lambda-\sigma_j)+s_j^h(\sigma_j-\varepsilon_j)\right]d\ln a^T + D_{d^*,j}^l, \tag{21}$$

$$d\ln x_{d^*,j}^T(\psi) = \lambda d\ln a^T - s_j^{T|h}\left[(\lambda-\sigma_j)+s_j^h(\sigma_j-\varepsilon_j)\right]d\ln a^T + D_{d^*,j}^T \tag{22}$$

where $s_j^{T|h}$ represents the factor cost share in T among production input h, and s_j^h is the production input share. $D_{d^*,j}^l$ and $D_{d^*,j}^T$ are offshoring-strategy- and sector-specific general equilibrium effects through changes in prices that remain constant across firms. In both equations, terms excluding general equilibrium effects are defined as individual-firm components.

Intuition for Identification. A careful inspection of the individual-firm components in equations (21) and (22) reveals underlying logic for identification. Two effects stand out. On the one hand, the employment effect $d\ln l_{d^*,j}(\psi)$ solely depends on the inflated cost index, revealing an "indirect effect." The indirect effect occurs because the productivity change in Thailand $d\ln a^T$ affects labor demand through the production input cost index $p_{d^*}^h$ in labor demand equation (14) and unit cost index $c_{d^*,j}(\psi)$ in production input demand (13). This effect is linked to λ through the elasticity of the change in labor demand with respect to the change in production input price index.

On the other hand, the Thailand factor demand $d\ln x_{d^*,j}^T(\psi)$ is derived from not only the indirect effect but also a direct substitution effect; Productivity in Thailand a_T affects not only $c_{d^*,j}(\psi)$ but also a_T in the effective Thailand factor price directly. Therefore, the effect on labor and Thailand factor demand are different through the direct productivity effect, and their relative size is an informative moment for identification through the different functional form dependence of the direct and indirect effects on parameter λ.

Econometric Setup. To be more precise, we need to introduce notations for regressions and formalize the Thailand flood shock in several steps. First, we focus on a sample of

MNEs that have subsidiaries in Thailand to eliminate the differences in country-level trends. This implies $d^* = 11$ in the model notation, and thus we drop this subscript from now. Second, we rewrite each observation by index i and year by t. Third, we define Thailand floods instrumental variable (IV) as $Z_{it} \equiv Z_i \times \mathbf{1}\{t \geq 2012\}$ where Z_i is the intensity term in equation (4). We regard the change in the IV as the negative productivity shock as argued in Section 2.2 and formulate $dZ_{it} = -kd \ln a_T$ for some unknown positive constant k that relates the empirical measure dZ_{it} and the theoretical productivity reduction $d \ln a_T$ for those affected by the floods. Finally, we use the tilde notation to partial out all variables across sector j and year t to eliminate the general equilibrium effects in regressions, for example, $d \ln \tilde{l}_{it} = d \ln l_{it} - |j|^{-1} \sum_{i \in j} d \ln l_{it}$. With the above setup, aggregating the partialled-out versions of equations (21) and (22) across all firms and industries and taking ratio, we have

$$\frac{E\left[d \ln \tilde{l}_{it} / d\tilde{Z}_{it}\right]}{E\left[d \ln \tilde{x}_{it}^T / d\tilde{Z}_{it}\right]} = \frac{\Xi(\lambda)}{\Xi(\lambda) - \lambda}, \tag{23}$$

where $\Xi(\lambda) = \sum_j S_j^H s_j^{T|h} \left[(\lambda - \sigma_j) + s_j^h (\sigma_j - \varepsilon_j)\right]$ summarizes the indirect effect across firms with S_j^H being the sector-j share of production factor employment. Note that the unknown constant k cancels out in the numerator and denominator of equation (23), and therefore we do not need to know the exact size of the productivity shock for the flooded firms. This is a strength of using the ratio of equations (21) and (22). Since the LHS of (23) is estimable and all the other terms in the RHS are observed, we can identify the EoS λ in the RHS.

Implementation: Two-Stage Least Square (2SLS) Regression. To implement the above idea, we consider the following two-way fixed-effect regression:

$$\ln(l_{it}) = a_i + a_{jt} + b \ln\left(x_{it}^T\right) + e_{it}, \tag{24}$$

where l_{it} is employment in Japan, x_{it}^T is the factor expenditure in Thailand, a_i is the headquarter fixed effect that absorbs any unobserved firm-specific characteristics, a_{jt} is the industry-time fixed effect that absorbs any industry j-specific time trends, and e_{it} is the error term. We use the Thailand floods IV Z_{it} as the instrument $\ln\left(x_{it}^T\right)$. We then use the 2SLS estimator of b to approximate equation (23), which then provides the estimate of λ. A standard Delta method provides the estimate of standard error, which is described in detail in Appendix Section A.13. Note that equation (23) is a modified version of a standard 2SLS two-way fixed-effect specification in the literature (e.g., Kovak et al., 2021) to our setting of the multiple factor production function. Therefore, our model provides a theoretical interpretation to the frequently used empirical specification.

Despite the availability of capital and labor data for Japan in the BSJBSA data, capital stock data for Thailand is absent, with only employment data available in the BSOBA data. Consequently, in our primary analysis, we use employment in Thailand as our preferred proxy for the factor expenditure measure. Nonetheless, we also carry out analysis using various alternative measures of activities in Thailand, including value added, total sales, and within-firm trade from Thailand to Japan. These measures align closely with our model, although they exhibit tenuous links to the existing literature.

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^x/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.

4.3 Estimation Result

Table 2 shows the result of regression equation (24). In Panel A, in column (1), we study the effect of the floods intensity on employment in Japan, while in columns (2)-(5), we study the impact on different measures of activities in Thailand subsidiaries. Specifically, column (2) takes our preferred Thai activity measure of employment Thailand, column (3) uses value added in Thailand, column (4) takes Thai total sales, and column (5) uses within-firm export from Thailand to Japan. Consistent with the findings in Section 2.2, we find significantly negative effects across all these outcome variables. Furthermore, Table 2 also reveal a significantly stronger effects on Thai activities (columns 2-5) than Japanese employment (column 1) in Panel B. Consequently, the implied 2SLS estimates are positive but smaller than 1.

Based on our preferred estimate in column (2) in Table 2, equation (23) 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.

The 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.,

Table 2: The Effects of the Thailand Floods IV and the 2SLS Estimates

VARIABLES	(1) $\ln l_{it}^{JPN}$	(2) $\ln l_{it}^{THA}$	(3) $\ln VA_{it}^{THA}$	(4) $\ln sales_{it}^{THA}$	(5) $\ln trade_{it}^{THA \to JPN}$
Panel A: The Effects of the Thailand Floods IV					
Z_{it}	-0.140**	-0.728***	-0.762***	-0.561***	-0.527***
	(0.0589)	(0.177)	(0.172)	(0.145)	(0.190)
Panel B: The Impact of Thai Activities on Japanese Employment					
2SLS Estimate		0.192**	0.173**	0.239**	0.274*
		(0.0832)	(0.0828)	(0.109)	(0.166)
Observations	5,563	5,563	5,460	5,503	3,993

Note: Panel A presents the effects of variable Z_{it}, which is the interaction term of the share of employment in the flooded region in 2011 the post-flood indicator, on Japanese employment (column 1) and several measures of economic activity in Thailand. The latter includes employment in Thailand ($\ln l_{it}^{THA}$, column 2), value added in Thailand ($\ln VA_{it}^{THA}$, column 3), total sales in Thailand ($\ln sales_{it}^{THA}$, column 4), and intra-firm trade from Thailand to Japan ($\ln trade_{it}^{THA \to JPN}$, column 5). Panel B displays the 2SLS estimates of the impact of these Thai economic activity measures on Japanese employment, as outlined in equation (24). Standard errors are clustered at both the firm and industry-year levels and shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

2014; Boehm et al., 2020). In Appendix Section A.14, we perform sensitivity checks with respect to the definition of shock intensity Z_i and control groups to confirm the robustness of our results. Furthermore, in Appendix Section A.15, we show estimation results by industry.

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

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. Columns (1) and (2) show the result of log employment regression from the simulated data and observed data, respectively. Columns (3) and (4) show the result of log capidal demand regression from the simulated data and observed data, respectively. The capital demand from observed data is measured by the asset value interacted by the 5% long-run return on capital (Rognlie, 2018). In observed data-based regressions (2) and (4), industry-fixed effects are controlled. Standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

model with the EMHA method to obtain the changes in equilibrium factor prices $(\hat{r}_J, \hat{w}_J, \hat{x}_T)$ and the model-predicted change in employment $\hat{l}(\omega)$ and capital $\hat{k}(\omega)$, and regress $\hat{l}(\omega)$ and capital $\hat{k}(\omega)$ 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 (24), 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 by inverting the relative demand functions (14) and (15). For instance, in Appendix B.3, we show that the Thailand factor productivity term can be backed up by

$$a_T = \frac{\frac{p_T^x}{w_J}\left(\frac{\overline{p_T^x x_T}}{w_J L}\right)_{11}}{\bar{p}_{11}} \tag{25}$$

where $\left(\frac{\overline{p_T^x x_T}}{w_J L}\right)_{11} \equiv \sum_j E\left[\left(\frac{p_T^x x_{T,d^*,j}(\psi)}{w_J l_{d^*,j}(\psi)}\right)^{\frac{1}{\lambda-1}} |d^* = 11\right]$ summarizes the conditional weighted average of the relative expenditure for factor in T, and $\bar{p}_{11} \equiv \sum_j \left(1 - G_j\left(\psi_{11,j}\right)\right)$ captures how selective the entry into T. This equation reveals that a_T is high if (i) relative T-factor price p_T^x / w_J is high, (ii) average relative T-factor demand conditional on factor elasticity, $\left(\frac{\overline{p_T^x x_T}}{w_J L}\right)_{11}$, is high, or (iii) entry into Thailand is selective and $\bar{p}_{11}$ is low. Since our estimated λ is larger than one, a factor augmenting productivity shock is biased to itself. Hence, as for point (ii), conditional on the relative factor price p_T^x / w_J, a large foreign factor demand implies that the foreign factor is productive. We proxy firm-level T-factor demand $x_T(\psi)$ by the total labor compensation employment in country i and the T-factor price p_T^x by the total labor compensation divided by the size of employment.

Due to the selection and unobservability of the cutoff $\psi_{11,j}$, taking equation (25) to the data is not straightforward. Therefore, we perform hat algebra to obtain

$$\hat{a}_T = \frac{\frac{\hat{p}_T^x}{w_J}\left(\frac{\hat{\overline{p_T^x x_T}}}{w_J L}\right)_{11}}{\hat{\bar{p}}_{11}}. \tag{26}$$

Applying the similar idea to the EMHA, we can measure this change in the data. Specifically, in Appendix B.3, we show that the change in the average of relative Thailand factor demand is measured by

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

where $s_j^r(\psi) \equiv \left(\frac{p_T^x x_{T,11,j}(\psi)}{w_J l_{11,j}(\psi)}\right)^{\frac{1}{\lambda-1}} / \int_{\psi'_{11,j}}^{\infty} \left(\frac{p_T^x x_{T,11,j}(\psi)}{w_J l_{11,j}(\psi)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)$ is the firm ψ's share of the relative factor demand in T, and $S_j^m \equiv \frac{\left(1-G_j\left(\psi_{11,j}\right)\right)}{\sum_j\left(1-G_j\left(\psi_{11,j}\right)\right)}$ is sector-j mass share of offshorers in T. Note that the change in the selection into Thailand by

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

where $\hat{c}_{01,j}$ can be measured by non-Thailand investors employment cost changes. Here, we measure the cost savings of the marginal firm by the model-implied cost ratio of offshorers in T before and after the change in the foreign productivity. Applying the above method, 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^L_d. For example, the labor share of Thailand investors is given by

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

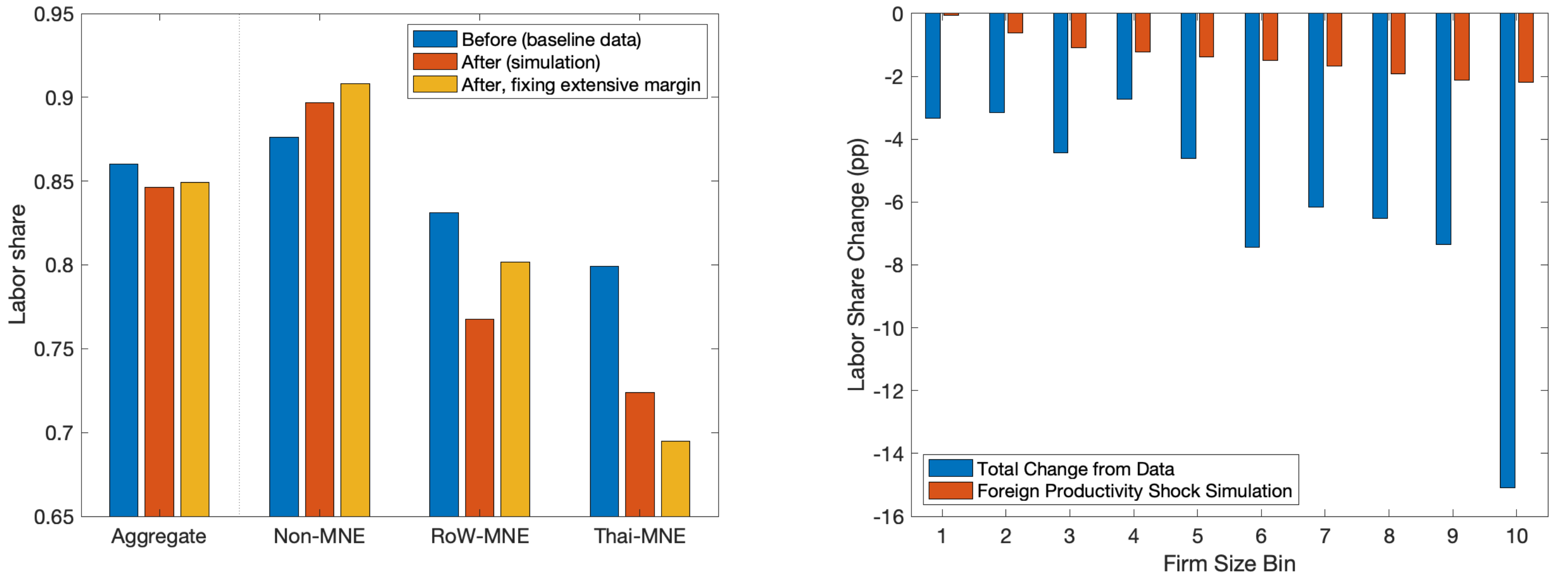
Our EMHA solution method also provides a natural way to control for the effect of selection in our model-based decomposition exercise. Namely, to obtain the labor-share effect with fixing selection into MNEs, we perform the following exercise. First, we solve the model by EHMA for the selection-fixed (SF) factor price changes $\left(\hat{r}^{SF}_J, \hat{w}^{SF}_J, \hat{p}^{x,SF}_T\right)$ 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 $\left(\hat{r}^{SF}_J, \hat{w}^{SF}_J, \hat{p}^{x,SF}_T\right)$ and $\hat{\psi}_{d,j} = 1$ for $d \in \{01, 11\}$. 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. In Appendix B.4, we show how to compute the change in group-specific labor shares, such as $\hat{S}^L_d$.

The simulation results are shown in Figure 6. To the left of Panel 6a, we show the simulation result regarding the aggregate labor share, while to the right, decomposition of labor shares into three groups of firms–non-MNEs, MNEs in the Rest of the World (RoW-MNE), and MNEs in Thailand (Thai-MNE)–are shown. In the left diagram, the aggregate labor share reduction as a result of the baseline simulation is 1.37 percentage points and explains 11.9% of observed decline in 1995-2007. When we fix the extensive margin changes, we find that the labor share decrease is slightly smaller and 1.06 percentage points. Therefore, we find that a major part 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 Panel 6a, 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 non-MNEs and MNEs in Thailand is 7.70 percentage points. Furthermore, this sizable difference in the labor share is

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

(a) By MNE Status (b) By Firm Size



Note: The left panel 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 the baseline year, 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 "Non-MNE," "RoW-MNE," and "Thai-MNE" groups to the right of the diagram shows the corresponding exercises for the group of non-offshoring firms ($d = 00$ in the model), offshoring firms to the Rest of the World (R-offshoring or $d = 01$ in the model), offshoring firms to Thailand (T-offshoring or $d = 11$ in the model). The right panel shows the labor share implication across firm-size deciles. The horizontal axis is the firm-size decile in the baseline year. The blue bar shows the total changes in the labor share observed from the data, and the red bar indicates the implied labor share change from the baseline share and equilibrium factor price changes due to the simulated foreign productivity shock.

expanded by the foreign factor productivity growth. Non-MNEs' labor share increases by 2.09 percentage points, while RoW-MNEs' and Thai-MNEs' labor shares decrease by 6.32 and 7.52 percentage points, respectively. Hence, firms' intensified MNE activities 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; non-MNEs' labor share rises by as large as 3.19 percentage points compared to the baseline, while Thai-MNEs' labor share falls by as large as 10.43 percentage points from the baseline. This finding reveals that the selection mechanism mitigates the disparity-expansion effect. For example, marginal firms that become a Thai-MNE from a RoW-MNE is relatively high-labor share among the set of Thai-MNE firms. Therefore, their inclusion in the Thai-MNE firms is a increasing force to Thai-MNEs' labor shares.

Finally, Panel 6b, which shows the labor share implication across the firm-size deciles. We confirm that the foreign productivity shock partly explains the reduction in the labor share across firm sizes. Notably, we find that the labor share reduction in larger firms is greater, revealing both the substitution of home-country labor demand by foreign inputs by already multinational firms as well as the extensive-margin effect of relative labor demand reduction due to more firms becoming MNEs. The data support this view, although they show a more pronounced heterogeneity of labor share reduction across firm sizes.

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

$$G\hat{D}P_J = (r_J K \hat{+} w_J L) = 1.4\%.$$

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 $\left(r_J K + w_J L + \hat{p}_T^x X_T + p_R^x X_R\right)$, where X_i is the aggregate factor demand in country $i \in \{T, R\}$, is also 1.4%. Taken together, while MNE activities had negative impacts on the aggregate home-country corporate labor shares, it has moderate positive effects on welfare, mainly due to the increased marginal productivities of home-country capital and labor and foreign inputs that are reflected in the increased factor prices.

6 Conclusion

In this paper, we examine the impact of increased utilization of foreign factors by multinational enterprises (MNEs) on the corporate labor share in the home country. We begin by conducting a decomposition analysis of the Japanese corporate labor share to investigate the factors contributing to its decline. Additionally, we estimate the effect of the 2011 Thailand Floods. Based on these findings, we develop a heterogeneous firms model of production that incorporates foreign factor employment using a nested CES production function. By treating the floods shock as an instrumental variable, we estimate a crucial substitution elasticity between foreign factors and home-country labor, which indicates that they are gross substitutes. The estimated model highlights that the increase in foreign factor productivity accounts for a decline of 1.4 percentage points in the corporate labor share in Japan from 1995 to 2007.

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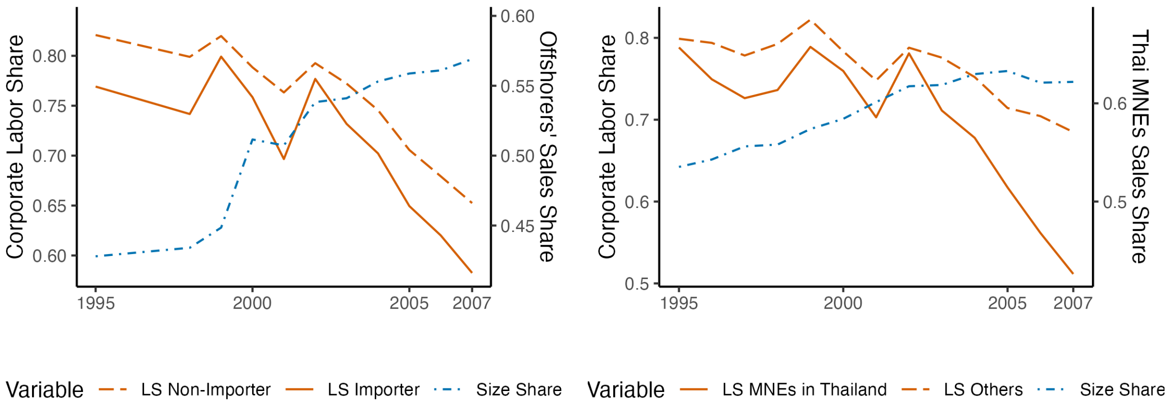
Figure A.1: Alternative Simple Decomposition of Labor Shares

(a) Offshorers and Non-Offshorers (b) MNEs with Thailand Subsidiaries and Others



Note: Trends of labor shares for offshorers and non-offshorers (left panel) and for multinational enterprises (MNEs) having subsidiaries in Thailand and other firms (right panel) are shown. For each firm, labor share is calculated as the fraction of total payroll over the sum of total payroll and operating surplus from BSJBSA data. Size shares are computed by the sales share of offshorers (left panel) and MNEs having subsidiaries in Thailand.

Appendix

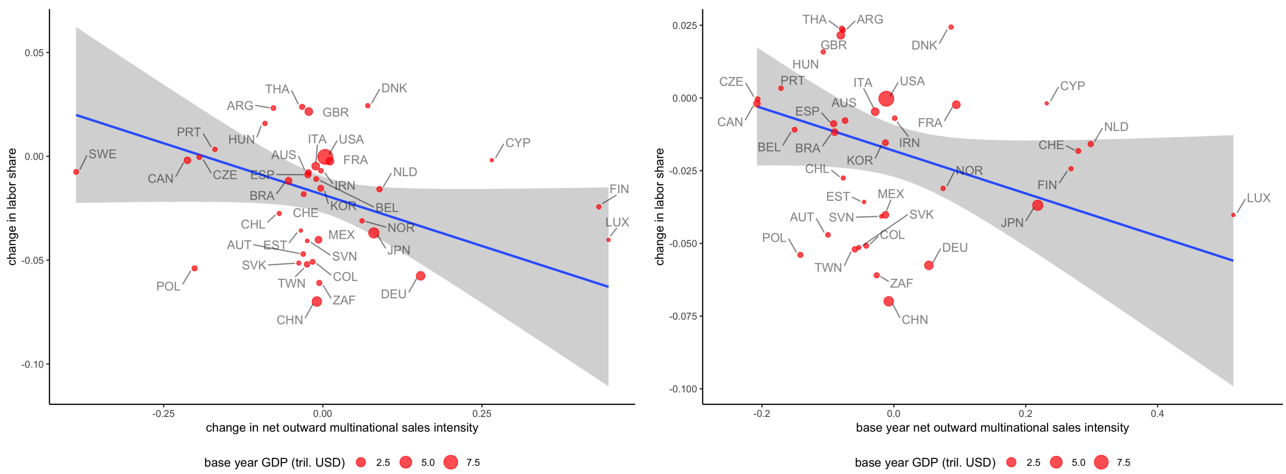
A Empirical Appendix

A.1 Comparison of Offshorers and Non-Offshorers

Since our model is largely about offshoring, we also show the simple decomposition analysis across offshorers (firms that imports positive amount in each year) and non-offshorers in Figure A.1a. Furthermore, as we emphasize the role of Thailand throughout the paper, we also study the difference between MNEs with subsidiaries in Thailand and other firms in Figure A.1a. They convey qualitatively similar findings to Figure 1.

Figure A.2: Outward Multinational Activity and Labor Share

(a) Outward Multinational Changes (b) Outward Multinational Levels



Note: Data are from Karabarbounis and Neiman (2013) and UNCTAD. In both panels, the vertical axis is the change in labor share from 1991 to 2000, and fitted lines weighted by the base-year GDP are drawn with the 95 percent confidence intervals. In the left panel, the change in labor share from 1991 to 2000. The vertical axis is the horizontal axis is the level of the sum of bilateral net outward multinational sales between 1991-1995 average.

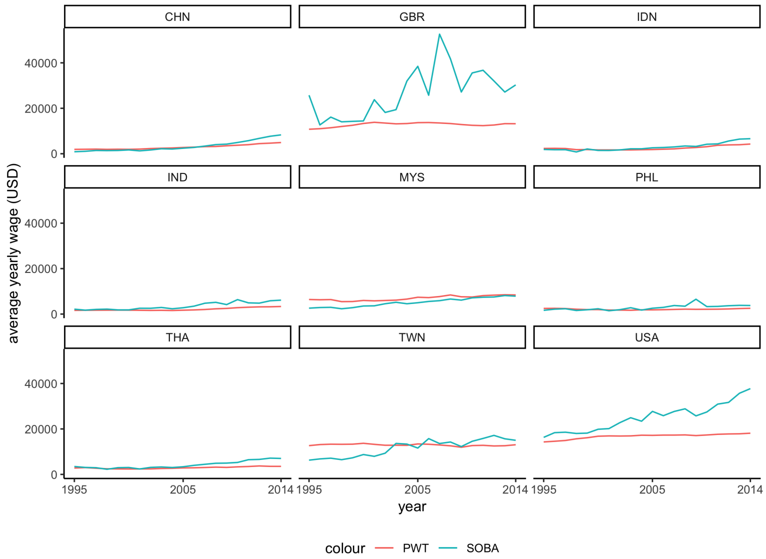
A.2 MNEs and Labor Share Across Country

To empirically motivate our analysis, we check a cross-country correlation between the intensity of outward MNE activities and the change in labor shares. For this purpose, we take data on multinational activities from UNCTAD. First, to calculate the level of outward multinational activities, we take a 1996-2000 average net outward multinational sales and normalize them by each country's GDP, which we call as MNE intensity. The change is taken between 1991-1995 average and 1996-2000 average. Second, the labor share data are derived from Karabarbounis and Neiman (2013), and we take the change in the labor share between 1991 and 2000. Singapore is dropped because it has an outlier value for the outward multinational sales measure. The resulting number of countries observed in both data sets is 36. Figure A.2 shows a statistically significant negative relationship between the labor share change and the change of the MNE intensity (Panel A.2a) and its baseline level (Panel A.2b). Although not causal, the negative correlation is consistent with outward MNE activities being substitutable to labor more than capital demand in the source country.

A.3 Comparison of BSOBA and PWT

We 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

Figure A.3: Comparison of BSOBA and PWT



Note: This figure shows the average yearly wage in the BSOBA compared to the PWT data. 9 top countries of Japanese MNE destination are shown.

wage difference emerges if Japanese parented subsidiaries hire a different type of workers than more general firms in each country. Figure A.3 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 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. Therefore, 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 US. 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 A.1.

A.4 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 but versatile method to back out the markups from the firm- or plant-level data and concluded the markup in the US has been increasing remarkably since around 1980. We apply their method to our Japanese firm-level data of the BSJBSA. The result shows a smaller increase in markups relative to the US, which is in line with the past literature

Table A.1: Similarity between BSOBA and PWT

	All	All	Top 9	Top 9
	(1)	(2)	(3)	(4)
	0.905***	0.540***	1.043***	0.869***
	(0.038)	(0.106)	(0.038)	(0.095)
Country FE		YES		YES
Year FE		YES		YES
Observations	1,350	1,350	180	180
R^2	0.300	0.740	0.805	0.973

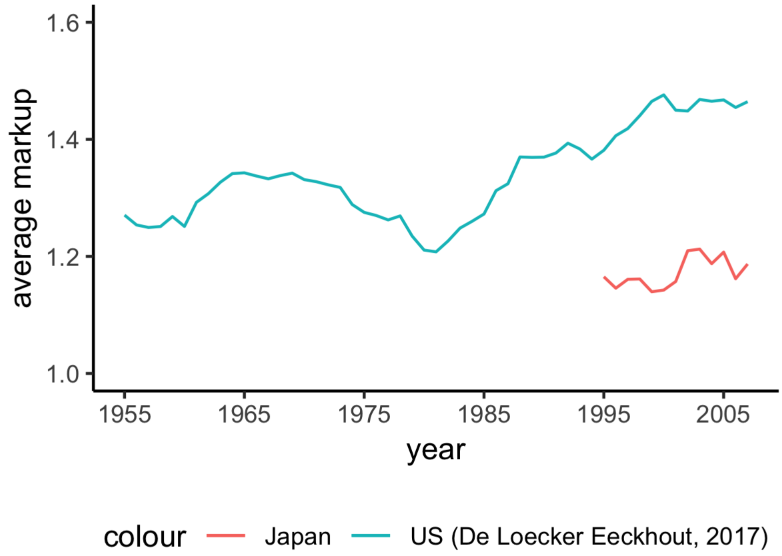
Note: The regression coefficients obtained by correlating the log wage of BSOBA with the log wages of PWT are presented. Each observation corresponds to a unique country-year pair. The first two columns encompass the entire sample, whereas the final two columns isolate the top nine destinations for Japanese MNEs. The first and third columns employ pooled OLS, while the second and fourth columns incorporate two-way fixed effects accounting for both country- and year- fixed effects.

(De Loecker and Eeckhout, 2018; Nakamura and Ohashi, 2019).

A.5 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 A.5, 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 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.

Figure A.4: Markup Estimates



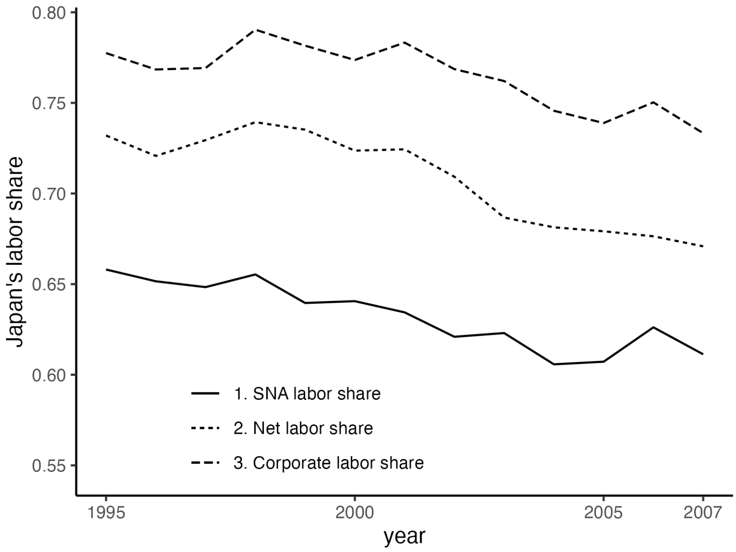
Note: Authors' calculation based on De Loecker and Eeckhout (2017) with Basic Survey on Japanese Business Structure and Activities (BSJBSA) 1995-2016. The variable input cost is the sum of labor compensation and intermediate purchase. The output elasticity is estimated by Olley and Pakes's (1996) method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

A.6 Thailand Gross Export and Import Trend

Figure A.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.

An overview of Thailand's economic policies follows. For international liberalization, Thailand went ahead other Southeastern countries. It is one of the original member countries of the *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 US 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. Consistent with this history, between 2007 and 2016, we do

Figure A.5: 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 home-country 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.

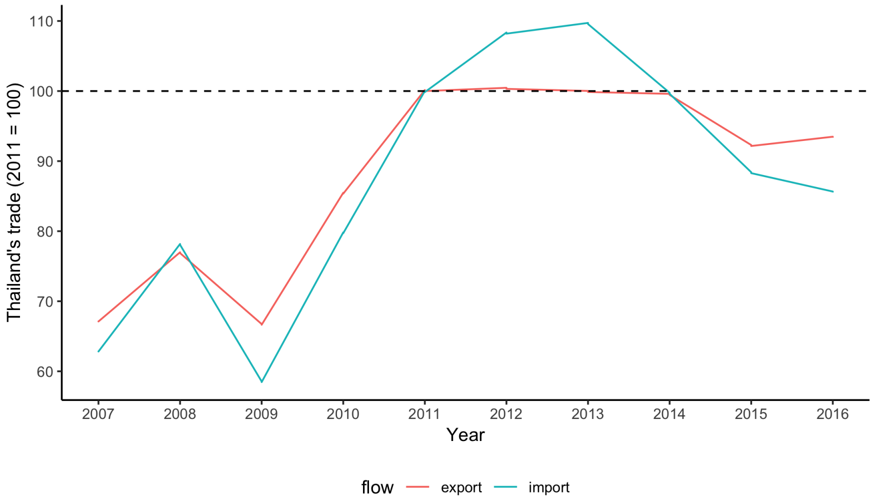
not find large-scale globalization in the international economic policy sphere.[15] The gross trade trends in Figure A.6 show the consistent pattern with this fact–the drivers behind the changes of trade trends are external business cycles (e.g., the global great recession since 2008) or political upheaval (e.g., coup d'état in 2014) rather than large trade policy changes.

A.7 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 A.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.

[15]Several exceptions include the ASEAN-South Korea FTA that reduced the tariff between South Korea and Thailand in 2010 and Chile-Thailand FTA that went effective in 2015.

Figure A.6: Trend of Thailand's Trade

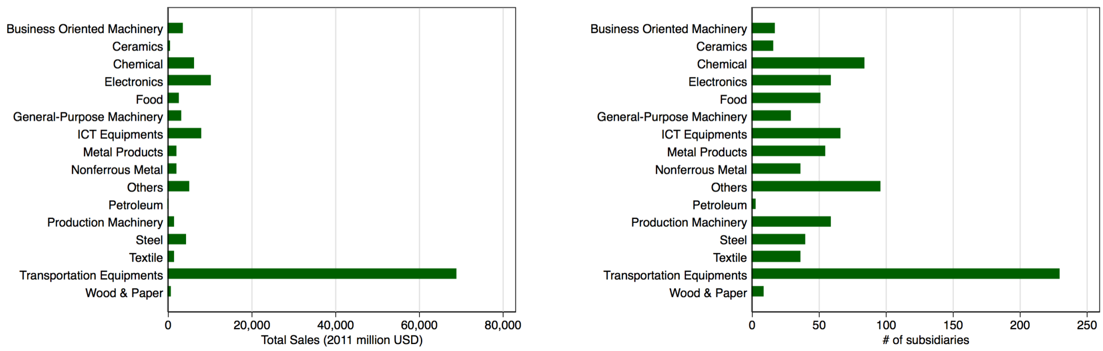


Note: Export and import trends of Thailand taken from COMTRADE are shown. The trend is normalized at 100 in 2011.

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

(a) Total Sales

(b) Number of Subsidiaries

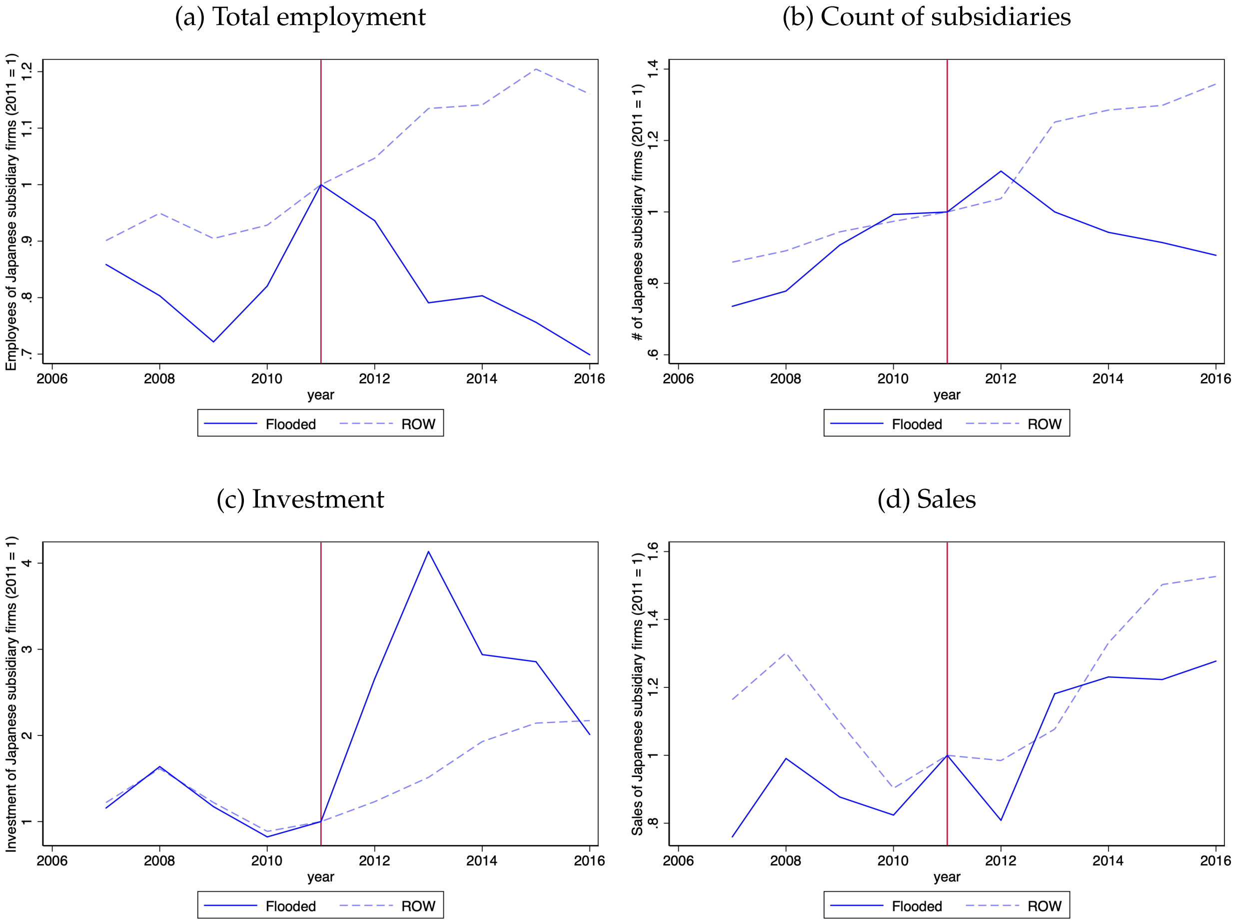


Note: Industry distribution of the subsidiaries in the flooded area (*Ayutthaya* and *Pathum Thani* Province) are shown. Panel A.7a shows the distribution of total sales, and Panel A.7b shows the distribution of the number of subsidiaries.

A.8 The Floods and Aggregate Trends

We show aggregate statistics of Japanese MNEs in our dataset described in Section 2.1. Figure A.8 shows the normalized trend of total employment (Panel A.8a) and the number of subsidiaries (Panel A.8b) in flooded regions (the solid line) versus the rest of the world excluding Japan (the dashed line). First, we find that, by both measures, the ROW trend is increasing over the sample period, which reflects that more firms become MNEs and hire foreign workers. Second, the trend in the flooded regions is broken at the floods year, after the increasing trend before 2011 that is similar as or even more rapid than ROW. The *persistence* of such a decrease is also noteworthy. Even though the floods were short-lived and had gone away in most regions by early 2012, the decreasing trend of both the total employ-

Figure A.8: Trends of Aggregate Variables in Flooded Regions

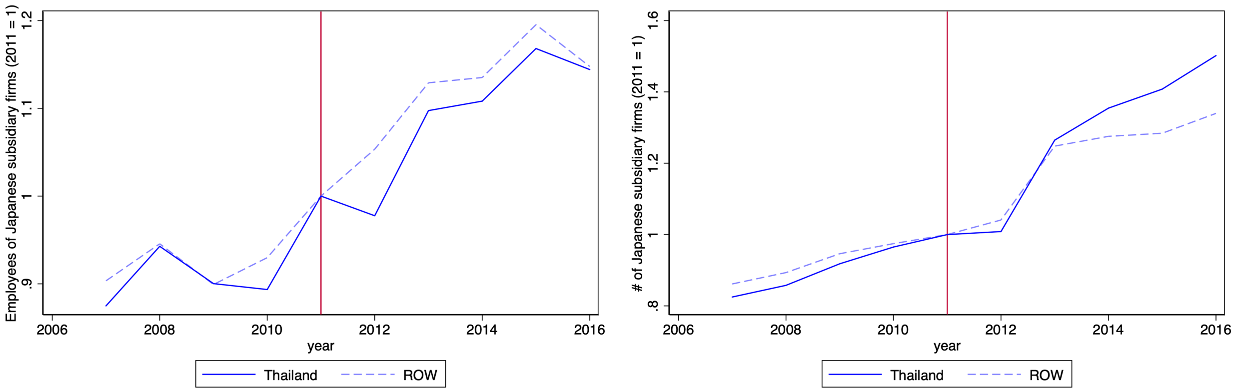


Note: The trends of aggregate variables in flooded regions and the rest of the world, excluding Japan, are shown. In all panels, "Flooded" shows the evolution of total employment in plants located in the flooded area (*Ayutthaya* and *Pathum Thani* Province), and "ROW" shows that out of the flooded area. Trends are normalized to 1 in 2011. Panel A.8a shows the trend of total employment, Panel A.8b shows the count of subsidiaries, Panel A.8c shows the investment, and Panel A.8d shows the subsidiary sales.

ment and count of subsidiaries continued at least 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 A.8, we also show the trend of investment (Panel A.8c) and sales (Panel A.8d). 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 A.9: Trends of Japanese MNEs, Thailand versus ROW



(a) Total employment (b) Count of subsidiaries

Note: The trends of aggregate variables in Thailand and the rest of the world, excluding Japan, are shown. In all panels, "Thailand" shows the evolution of total employment in plants located in Thailand, and "ROW" shows that in the rest of the world. Trends are normalized to 1 in 2011. Panel A.8a shows the trend of total employment, and Panel A.8b shows the count of subsidiaries.

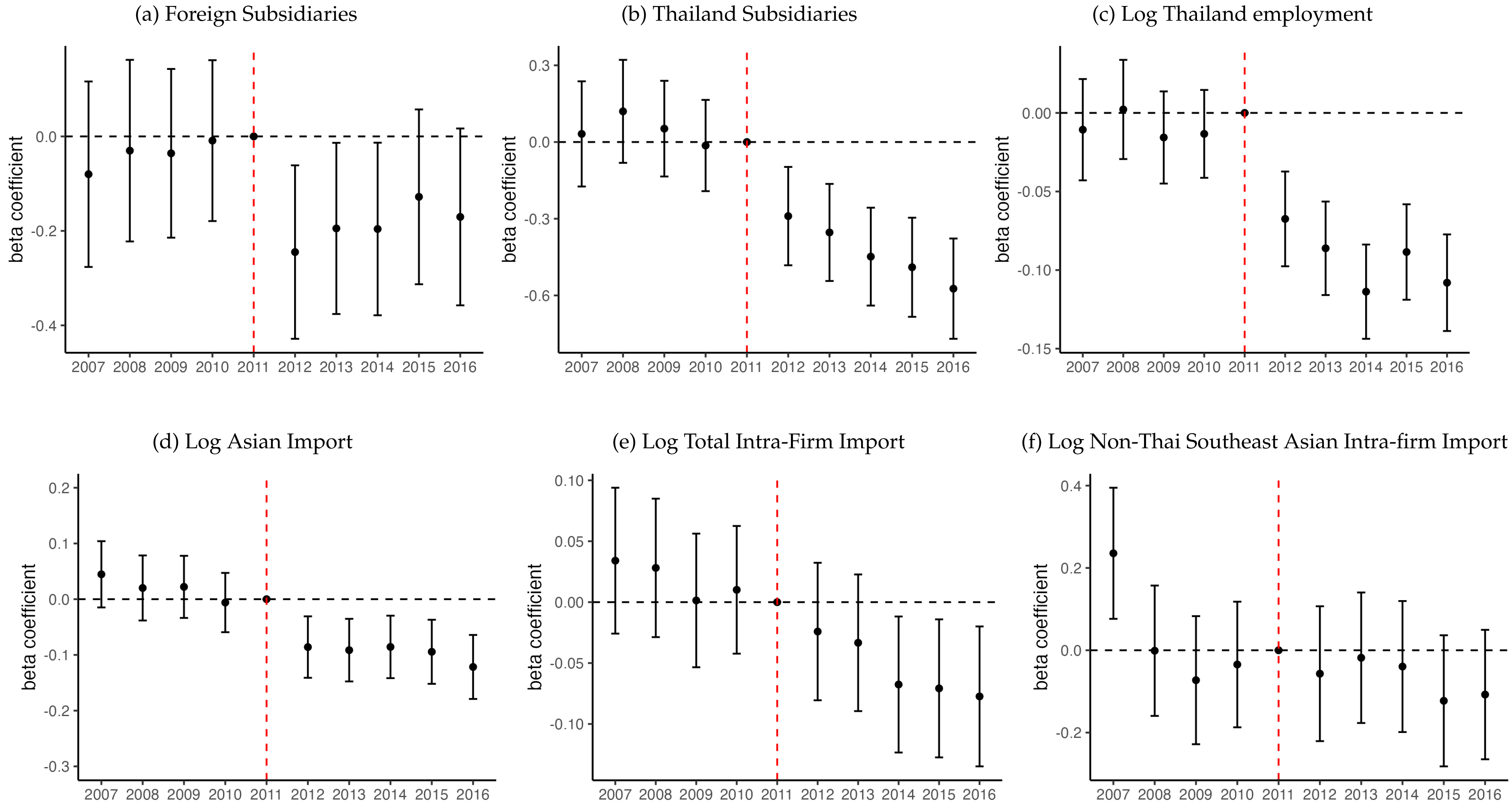
A.9 Notes on the Choice of the Treatment Group

As we review in Section A.8, the 2011 Thailand Floods severely affected Ayutthaya and Pathum Thani Province. It is important to focus on 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 demonstrated in Figure A.9, which shows the trends of the employment and the count of subsidiaries in and out of Thailand, rather than the comparison of flooded provinces versus non-flooded provinces in Thailand, as in Figure A.8. Figure A.9 reveals that the impact on the total employment and count of subsidiaries is not stark as Figure A.8.

A.10 Mechanisms and Robustness Checks

Figure A.10 shows the result of regression in equation 3 with alternative outcome variables. Panel A.10a (resp. A.10b) shows the result with the number of the total foreign subsidiaries (resp. subsidiaries in Thailand), while Panel A.10c the log Thailand employment. Consistent with the subsidiary-level results in Figure 4, there are sizable negative effects on the number of operating subsidiaries and the size of employment. Accordingly, imports from Asia and intra-firm network reduces after the floods, as Panels A.10d and A.10e indicate, which confirms the result in Figure 5b.

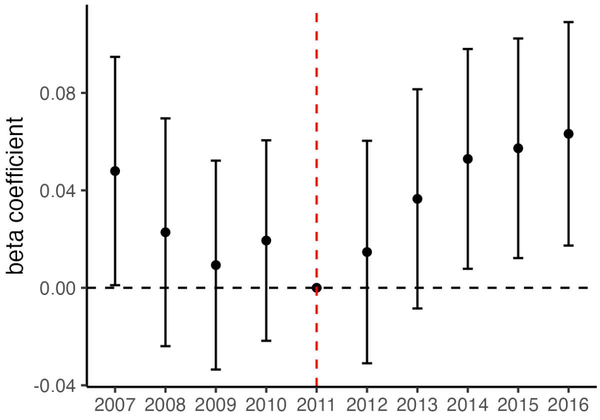
Figure A.10: More Evidence of The Effects of the Thailand Floods on Headquarters



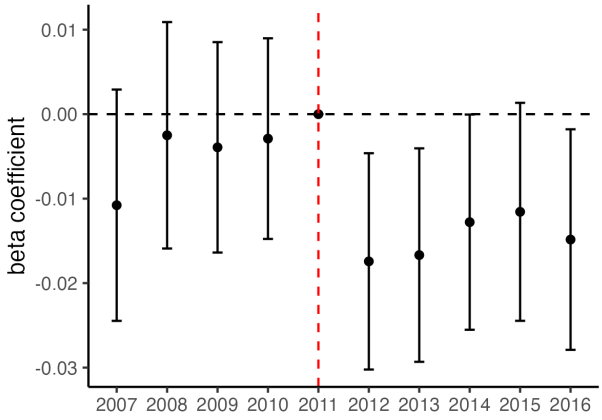
Note: The figure plots coefficient estimates of headquarter-level event-study regression in equation (4). As an outcome variable, panel (a) takes the number of foreign subsidiaries (including the flooded regions), panel (b) takes the number of subsidiaries in Thailand, panel (c) takes log employment in Thailand, panel (d) takes the log import value from Asia, panel (e) takes log total intra-firm import value, and panel (f) takes log non-Thai Southeast Asian intra-firm import value. Standard errors are cluster-robust at the firm level, and bars indicate 95 percent confidence intervals.

Figure A.11: More Evidence of The Effects of the Thailand Floods on Headquarters (Continued)

(a) Number of Non-regular Employees



(b) Fixed Asset



Note: The figure plots coefficient estimates of headquarter-level event-study regression in equation (4). 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.

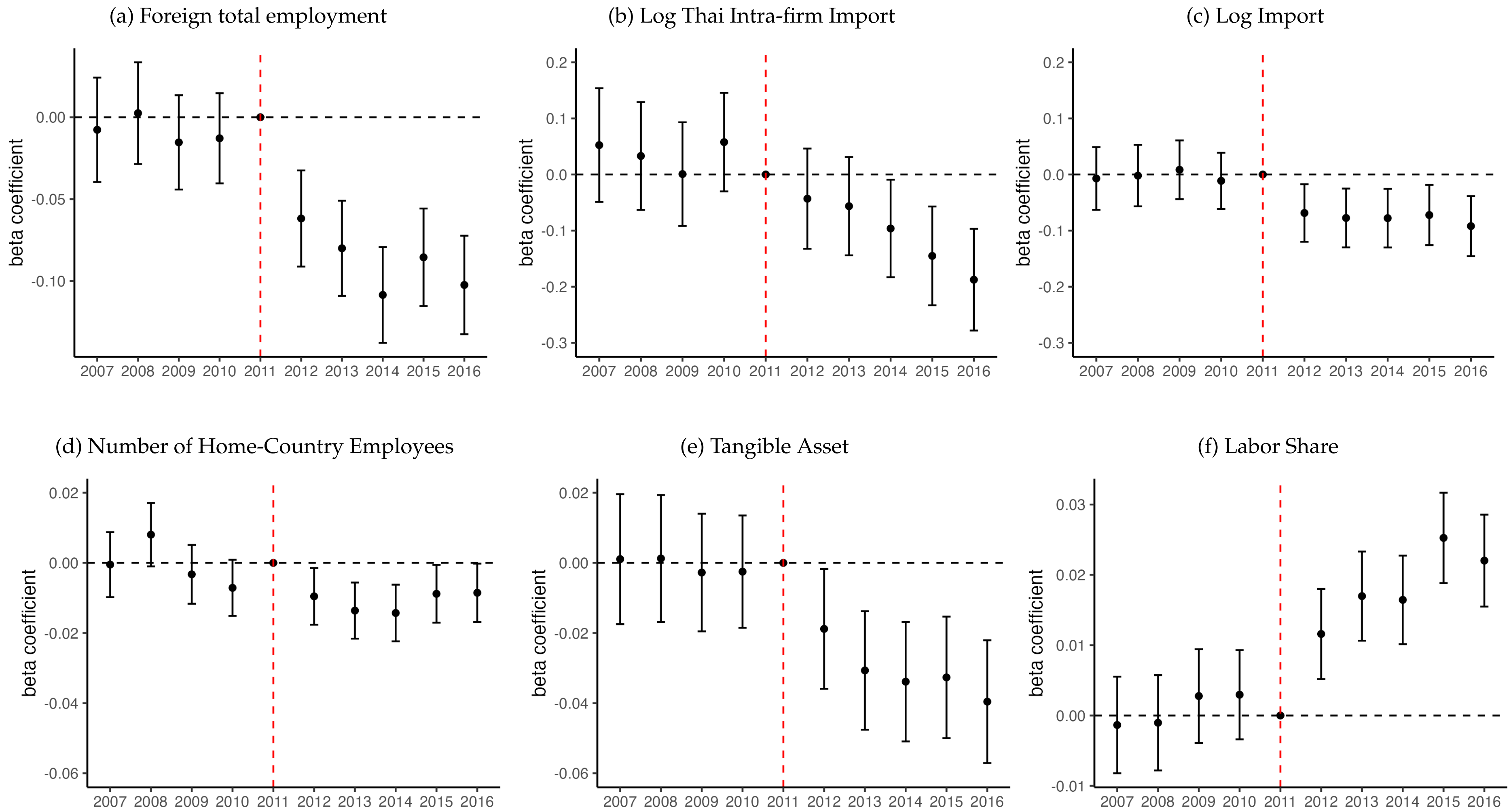
The weaker effect on employment than on capital demand suggested in Figure 5 may be partly explained by the increase in non-regular workers. In Japan, non-regular workers include part-time, contract, and workers dispatched from temporary employment agencies, and its number is growing rapidly (Morikawa, 2010). Overall, they are a type of workers with flexible labor contracts and can be adjusted by firms with relative ease. Panel A.11a reveals a view consistent with this as the temporary workers are increased after the floods and offshore activities are weakened. Therefore, firms affected by the floods may react and substitute foreign workers with non-regular workers. Furthermore, Panel A.11b shows that the effect on fixed asset is as negative that on tangible asset as found in Figure 5e.

Since our model considers vertical multinational production where the foreign factors provide value added to the global production process, our main regression results in Table 5 should also hold with the MNEs that have subsidiaries that sells their products to the Japanese headquarters (HQ). To formalize this idea, we define an alternative shock variable by

$$Z_i^{ALT} \equiv \frac{l_{i,2011}^{\text{flooded, exporting to HQ}}}{l_{i,2011}^{world}}, \tag{A.1}$$

where the denominator is the same as the original shock variable, while the numerator is the number of employment in the subsidiaries that are in Ayutthaya and Pathum Thani provinces and export back to Japanese headquarter. Table A.12 shows the result of event study specification (4) with this alternative shock variable, confirming the robustness to this change.

Figure A.12: Event Study Results with the Alternative Shock Variable



Note: The figure plots coefficient estimates of headquarter-level event-study regression in equation (4) with the alternative shock variable defined in equation (A.1). As an outcome variable, panel (a) takes log total foreign employment (including the flooded regions), panel (b) takes the log value of intra-firm import from Thailand to the Japanese headquarter, panel (c) takes log import value, panel (d) takes log home-country employment, panel (e) takes the log tangible asset stock, and panel (f) takes the firm-level labor share defined in equation (1). Standard errors are cluster-robust at the firm level, and bars indicate 95 percent confidence intervals.

Figure A.13: Event Study of Subsidiary Operating Indicator

Note: The figure plots coefficient estimates of subsidiary-level event-study regression in equation (3) 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.

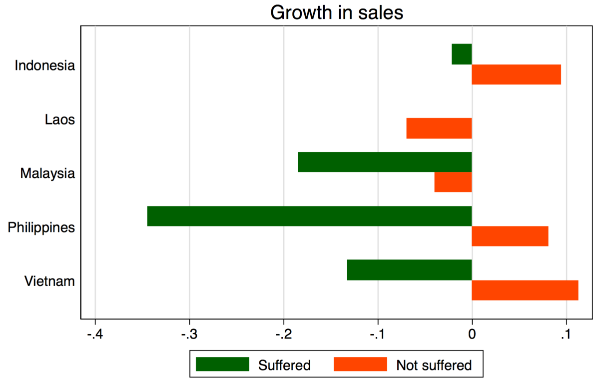
Finally, we examine the heterogeneity of the subsidiary characteristics. In the BSOBA data, an MNE is defined as a firm that owns at least one foreign subsidiary. This subsidiary could either be a "child subsidiary" or a "grandchild subsidiary". A child subsidiary refers to a foreign corporation in which the Japanese firm owns 10% or more of the ownership stake. On the other hand, a grandchild subsidiary is a foreign corporation in which the foreign subsidiary of a Japanese firm (with the Japanese firm owning 50% or more of the ownership stake of this foreign subsidiary) owns 50% or more of the ownership stake. With this definition, foreign production is not limited to greenfield investments, which are new operations set up in foreign locations. It also includes the acquisition of foreign companies, such as through mergers and acquisitions (M&A).

Figure A.13 shows the result of regression in equation 3 with selected samples. Panel A.13a shows the result with the sample of Thailand subsidiaries of Japanese MNEs with 100% ownership. Panel A.13b 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 3 is driven by perfectly owned subsidiaries and child subsidiaries.

A.11 Substitution in Third Countries

To investigate whether multinational enterprises (MNEs) shifted production to other countries following the floods, we first compare the growth of subsidiaries in Southeast Asian countries near Thailand (Indonesia, Laos, Malaysia, Philippines, and Vietnam) between

Figure A.14: Sales Growth Comparison between Firms Located in Thailand in 2011 and Those not



2011 and 2012 among firms affected by the floods and those that were not. If substitution occurred, then the first group might show a relatively greater increase in sales in these countries. Figure A.14illustrates the sales growth rates of foreign subsidiaries in each Southeast Asian country for MNEs with Thailand subsidiaries in the flooded region (labeled as "suffered") and those without (labeled as "not suffered"). However, we do not observe any such relative increase for all third countries, except for Laos.

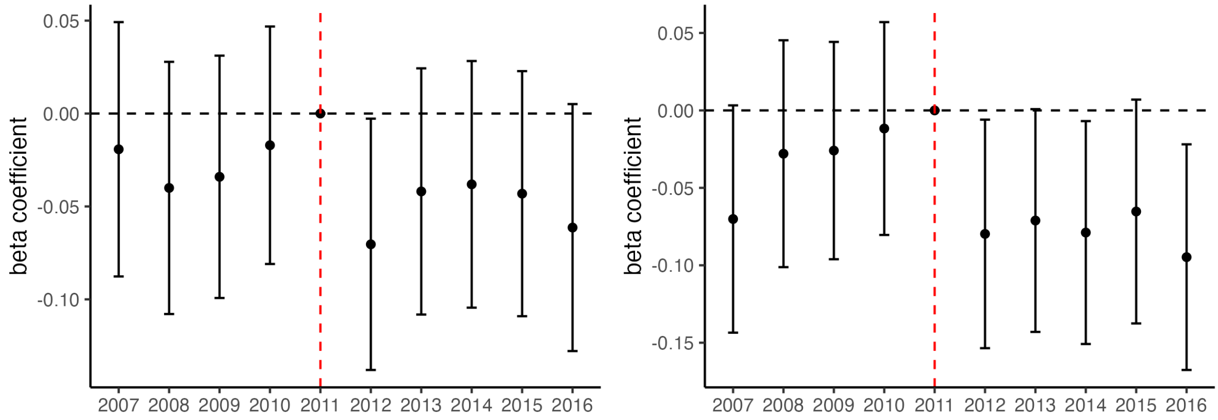
To further examine substitution after the floods using our headquarters-level specification (4), we construct the outcome variable of log total employment and sales of subsidiaries in non-Thailand Southeast Asian countries. Figure A.15 displays the outcome, and we do not find any positive substitution effect from the flooded regions to non-flooded third countries. Perhaps surprisingly, we do detect some marginally negative impacts on third country employment and sales in the short-term (one year after the flood). This is consistent with our model's mechanism that the floods raised the overall cost of production for the MNEs affected, leading them to decrease factor employment and sales, including those in third countries.

A.12 Calibration Details of the Top Nest Elasticity σ_j

To calibrate the top nest elasticity between (k, h, m), we follow the insight of Oberfield and Raval (2021) and use the local labor market-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 subsidiaries in foreign countries. Specifically, the cost-minimizing factor demands (12)

Figure A.15: Headquarter-Level Third Country Effects

(a) Non-Thailand Southeast Asian Employment (b) Non-Thailand Southeast Asian Sales



Note: The figure plots coefficient estimates of headquarter-level event-study regression in equation (4). As an outcome variable, panel (a) takes log total employment of subsidiaries in non-Thailand Southeastern countries, and panel (b) takes log total sales of subsidiaries in non-Thailand Southeastern countries. Standard errors are cluster-robust at the firm level, and the bars indicate the 95 percent confidence intervals.

and (13) for non-offshorers $d^* = 00$ imply

$$\ln\left(\frac{r_J k_{00,j}}{w_J l_{00,j}}\right) = (\sigma_j - 1)\ln\left(\frac{w_J}{r_J}\right)$$

since $p^h_{00,j} h_{00,j} = w_J l_{00.j}$. Thus, the regression specification is

$$\ln\left(\frac{rk}{wl}\right)_i = b_{0,j} + b_1 \ln\left(w_{(i)}\right) + X_i b_2 + e_i, \tag{A.2}$$

where city (i) is the municipality where i is located, X_i is plant-level control variable, $b_{0,j}$ is an industry-j fixed effect. The log local wage term $\ln\left(w_{\text{city}(i)}\right)$ is instrumented with with a shift-share measure $z_{\text{city}} = \sum_{j \in \mathcal{J}^{NM}} \omega_{\text{city},j-10} g_j$, where $\mathcal{J}^{NM}$ is the set of non-manufacturing industries, $\omega_{\text{city},j-10}$ is the employment share of industry j in the municipality in ten-year prior to the analysis period, and g_j is leave-one-municipality-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). We find that wage variation vary across local labor markets are significant and persistent empirically, so we interpret the coefficient obtained by such variation provides the long-run elasticity of substitution.

We apply this method to Japan's Census of Manufacture plant-level data. To obtain the factor expenditure ratio $(r_J k / w_J l)_i$, we use the *Census of Manufacture* (CoM). The CoM is the plant-level data, so we can capture the factor use reaction to the local labor market shock more appropriately than firm-level data such as the BSJBSA. Following Oberfield and Raval

(2021), we measure $r_J k$ by the initial stock of tangible asset in the next year survey. The rental rate term drops with the industry-fixed effect in specification (A.2) as we use the estimate at the industry level. To obtain the total payment to workers, we use the variable total payroll for all 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, and having other offices. We include the fixed effect for all of these values in specification (A.2). There are 1700 municipality, which is a fine delineation of local labor market resembling counties in the US. 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.

A.13 The Delta Method

By inverting equation (23), we have

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

where $b = E\left[\left(d \ln l_{it} / dZ_{it}\right) / \left(d \ln x_{it}^T / dZ_{it}\right)\right]$, $\Xi = \sum_j S_j^L s_{T,j}^{T|h}\left[-\sigma_j + \left(\sigma_j - \varepsilon_j\right) s_j^h\right]$, and $\bar{s}_T^{T|h} \equiv \sum_j S_j^L s_{T,j}^{T|h}$. Applying the continuous mapping theorem and central limit theorem to this expression, we have the asymptotic standard error of λ given by

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

where σ_b^2 is the standard error of our 2SLS-DiD estimator. The sample analogue of σ_λ^2 yields 0.13. Given our point estimate $\widehat{\lambda} = 1.40$, we reject the null hypothesis of $H_0 : \lambda \leq 1$ at the conventional value of the significance level 0.1 percent.

A.14 Robustness Checks for Alternative Control Groups and Extensive Margin Shock

In conducting a robustness check with various control groups, we consider all firms in Japan in contrast to firms operating in Thailand. We also take the balanced panel of firms in Japan (Desai et al., 2009) as the control group. In addition, we investigate to gauge the impact of the flood shock by an extensive margin. Specifically, an MNE is affected by the floods if and

Table A.2: Robustness Checks for Regression Equation (24)

VARIABLES	(1) $\ln l_{it}^{JPN}$	(2) $\ln l_{it}^{JPN}$	(3) $\ln l_{it}^{JPN}$	(4) $\ln l_{it}^{JPN}$
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
Shock measure	Extensive	Intensive	Extensive	Intensive
Balanced panel?			YES	YES

Note: Regression results of equation (24) with an alternative sample of Japanese headquarter firms and an alternative definition of the Thailand Floods IV are shown. Columns 1 and 2 use all firms in Japan, and columns 3 and 4 use all firms in Japan with the balanced panel. The variable "shock" is the interaction term of the shock intensity and the after-the-floods indicator. Columns 1 and 3 use our preferred intensive margin IV defined by the share of pre-flood employment share in the flooded area interacted by the after-flood dummy, while columns 2 and 4 use alternative extensive margin IV that interacts the dummy of employing more than one employee in the flooded region with the after-floods dummy. Standard errors are clustered at the firm and industry-year level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

only if it was operating in the flooded region. For this purpose, we define the extensive-margin floods shock by $Z_{it}^{EXT} = \mathbf{1}\left\{l_{i,2011}^{flooded} > 0 \cap t \geq 2012\right\}$, where, again, $l_{i,2011}^{flooded}$ is the MNE i's employment in the flooded region in 2011. The regression results are shown in Table A.2, and they are qualitatively consistent with those in Table 2. This outcome alleviates concerns that Thai investors may be on a different trend than the remaining firms in Japan, thereby validating the use of the estimated elasticity of substitution for the quantitative analysis.

A.15 Estimation Results of Equation (24) by Industry

Table A.3 shows the regression results of equation (24) by industry.

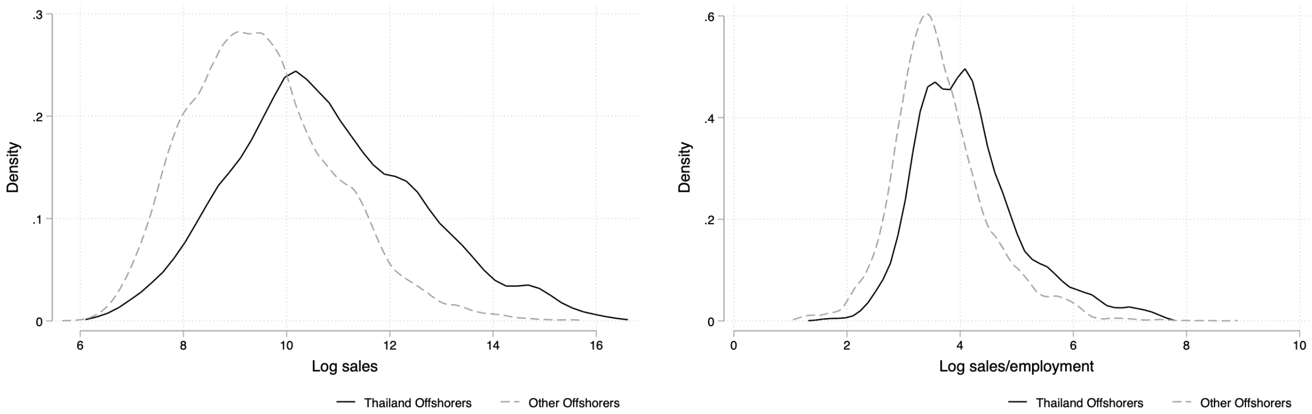
Table A.3: 2SLS-DiD Estimates by Industry

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A	1st	1st	1st	1st	1st	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)
Panel B	reduced	reduced	reduced	reduced	reduced	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)
Panel C	2SLS	2SLS	2SLS	2SLS	2SLS	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

Note: Regression results of equation (24) with the sample of Japanese headquarter firms operating in Thailand at the industry level are shown. In panel A, the regressor is employment in Thailand, and in panel B and C, the regressor is employment in Japan. In the industry row, "manuf." stands for all manufacturing, "chem" stands for chemical, and "elec" stands for electronics. Standard errors are clustered at the firm-level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure B.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.

B Theory Appendix

This appendix details some proofs and extensions of the model in Section 3 and its quantification in Section 5.

B.1 Productivity Comparison between Firms Entering Thailand and Others

Figure B.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.

B.2 Derivation of Equations (16) and (17)

In this section, we derive equation (16) and the counterpart for labor and Thailand factor demands. Note that the capital demand is the aggregate across sectors and three offshoring strategies $K^D = \sum_j \sum_d K^D_{d,j}$, where $K^D_{d,j}$ are aggregate capital demand of the non-offshorers ($d = 00$), R-offshorers ($d = 01$), and R- and T-offshorers ($d = 11$), given by

$$K^D_{00,j} = \int_{\psi_j}^{\psi_{01,j}} \left((r_J)^{-\sigma_j} \left(c_{00,j}(\psi)\right)^{\sigma_j - \varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1} \right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j(\psi) , \qquad \text{(B.1)}$$

$$K_{01,j}^{D}=\int_{\psi_{01,j}}^{\psi_{11,j}}\left(\left(r_{J}\right)^{-\sigma_{j}}\left(c_{01,j}\left(\psi\right)\right)^{\sigma_{j}-\varepsilon_{j}}\left(\frac{\varepsilon_{j}}{\varepsilon_{j}-1}\right)^{1-\varepsilon_{j}}P_{j}^{\varepsilon_{j}-1}Q_{j}\right)dG_{j}\left(\psi\right), \tag{B.2}$$

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

Using these expressions, the change in the aggregate capital demand can be derived as follows. First, it 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 term K_j^D. Second, equations (B.1), (B.2), and (B.3) imply

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

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

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

Finally, taking the new-to-old ratio of equation (B.4) proves equation (16).

To derive equation (17), substituting unit cost expression (9) in equation (B.5), we have

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

Taking the new-to-old ratio yields equation (17). Accordingly, the aggregate labor demands for the three groups of offshoring strategy are

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

$$L^D_{01,j} = \int_{\psi_{01,j}}^{\psi_{11,j}} \left((w_J)^{-\lambda} \left(p^h_{01,j}\right)^{\lambda-\sigma_j} \left(c_{01,j}(\psi)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j(\psi),$$

$$L^D_{11,j} = \int_{\psi_{11,j}}^{\infty} \left((w_J)^{-\lambda} \left(p^h_{11,j}\right)^{\lambda-\sigma_j} \left(c_{11,j}(\psi)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j(\psi),$$

and similarly for the Thailand factor demand,

$$X^D_{T,00,j} = \int_{\underline{\psi}_j}^{\psi_{01,j}} \left(\left(\frac{p^x_T}{a_T}\right)^{-\lambda} \left(p^h_{00,j}\right)^{\lambda-\sigma_j} \left(c_{00,j}(\psi)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j(\psi),$$

$$X^D_{T,01,j} = \int_{\psi_{01,j}}^{\psi_{11,j}} \left(\left(\frac{p^x_T}{a_T}\right)^{-\lambda} \left(p^h_{01,j}\right)^{\lambda-\sigma_j} \left(c_{01,j}(\psi)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j(\psi),$$

$$X^D_{T,11,j} = \int_{\psi_{11,j}}^{\infty} \left(\left(\frac{p^x_T}{a_T}\right)^{-\lambda} \left(p^h_{11,j}\right)^{\lambda-\sigma_j} \left(c_{11,j}(\psi)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j(\psi).$$

Hence, using the similar method, we have

$$\hat{L}^D = \sum_j S^L_j \hat{L}^D_j,\ \hat{L}^D_j = (\hat{w}_J)^{-\lambda} \hat{C}^L_j,\ \hat{C}^L_j = \sum_{d \in \{00,01,11\}} S^L_{d,j} \left(\hat{p}^h_{d,j}\right)^{\lambda-\sigma_j} \left(\hat{c}_{d,j}\right)^{\sigma_j-\varepsilon_j} \hat{s}_{d,j}$$

$$\hat{X}^D_T = \sum_j S^{X_T}_j \hat{X}^D_{T,j},\ \hat{X}^D_{T,j} = \left(\frac{\hat{p}^x_T}{\hat{a}_T}\right)^{-\lambda} \hat{C}^{X_T}_j,\ \hat{C}^{X_T}_j = \sum_{d \in \{00,01,11\}} S^{X_T}_{d,j} \left(\hat{p}^h_{d,j}\right)^{\lambda-\sigma_j} \left(\hat{c}_{d,j}\right)^{\sigma_j-\varepsilon_j} \hat{s}_{d,j},$$

where

$$S^L_j = \frac{w_J L_j}{\sum_k w_J L_k},\ S^L_{d,j} \equiv \frac{w_J L_{d,j}}{w_J L_j},\ S^{X_T}_j = \frac{p^x_T X_{T,j}}{\sum_k p^x_T X_{T,k}},\ S^{X_T}_{d,j} \equiv \frac{p^x_T X_{T,d,j}}{p^x_T X_{T,j}},$$

and $\hat{p}^h_{d,j}$ is the change in the production input price index for offshoring strategy d in sector j that will derived below.

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

$$\begin{aligned} \hat{c}_{d,j} &= \left(\frac{\alpha^k_j \left(r'_J\right)^{1-\sigma_j} + \alpha^h_j \left(p^{h\prime}_{d,j}\right)^{1-\sigma_j} + \left(1 - \alpha^k_j - \alpha^h_j\right) \left(p^m_j\right)^{1-\sigma_j}}{\alpha^k_j \left(r_J\right)^{1-\sigma_j} + \alpha^h_j \left(p^h_{d,j}\right)^{1-\sigma_j} + \left(1 - \alpha^k_j - \alpha^h_j\right) \left(p^m_j\right)^{1-\sigma_j}} \right)^{\frac{1}{1-\sigma_j}} \\ &= \left(s^K_{d,j} \left(\hat{r}_J\right)^{1-\sigma_j} + s^H_{d,j} \left(\hat{p}^h_{d,j}\right)^{1-\sigma_j} + \left(1 - s^K_{d,j} - s^H_{d,j}\right) \right)^{\frac{1}{1-\sigma_j}}, \end{aligned} \tag{B.6}$$

where

$$s_{d,j}^{K} \equiv \frac{\alpha_j^k (r_J)^{1-\sigma_j}}{\alpha_j^k (r_J)^{1-\sigma_j} + \alpha_j^h \left(p_{d,j}^h\right)^{1-\sigma_j} + \left(1-\alpha_j^k-\alpha_j^h\right)\left(p_j^m\right)^{1-\sigma_j}}$$

and

$$s_{d,j}^{H} \equiv \frac{\alpha_j^h \left(p_{d,j}^h\right)^{1-\sigma_j}}{\alpha_j^k (r_J)^{1-\sigma_j} + \alpha_j^h \left(p_{d,j}^h\right)^{1-\sigma_j} + \left(1-\alpha_j^k-\alpha_j^h\right)\left(p_j^m\right)^{1-\sigma_j}}$$

are the baseline capital and labor-intensive task share among firms with offshoring strategy d in sector j. Similarly, $\hat{p}_{d,j}^h$ can be obtained as

$$\hat{p}_{d,j}^h = \left(s_{d,j}^{L|h} (\hat{w}_J)^{1-\lambda} + s_{d,j}^{T|h} \left(\frac{\hat{p}_T^x}{\hat{a}_T}\right)^{1-\lambda} + s_{d,j}^{R|h} \left(\frac{\hat{p}_R^x}{\hat{a}_R}\right)^{1-\lambda} \right)^{\frac{1}{1-\lambda}},$$

where

$$s_{d,j}^{L|h} \equiv \frac{\left(1-\beta^R-\beta^T\right) w_J^{1-\lambda}}{\left(1-\beta^R-\beta^T\right) w_J^{1-\lambda} + \mathbf{1}\{d \neq 00\} \beta^R \left(\frac{p_R^x}{a_R}\right)^{1-\lambda} + \mathbf{1}\{d = 11\} \beta^T \left(\frac{p_T^x}{a_T}\right)^{1-\lambda}},$$

$$s_{d,j}^{R|h} \equiv \frac{\mathbf{1}\{d \neq 00\} \beta^R \left(\frac{p_R^x}{a_R}\right)^{1-\lambda}}{\left(1-\beta^R-\beta^T\right) w_J^{1-\lambda} + \mathbf{1}\{d \neq 00\} \beta^R \left(\frac{p_R^x}{a_R}\right)^{1-\lambda} + \mathbf{1}\{d = 11\} \beta^T \left(\frac{p_T^x}{a_T}\right)^{1-\lambda}},$$

and

$$s_{d,j}^{T|h} \equiv \frac{\mathbf{1}\{d = 11\} \beta^T \left(\frac{p_T^x}{a_T}\right)^{1-\lambda}}{\left(1-\beta^R-\beta^T\right) w_J^{1-\lambda} + \mathbf{1}\{d \neq 00\} \beta^R \left(\frac{p_R^x}{a_R}\right)^{1-\lambda} + \mathbf{1}\{d = 11\} \beta^T \left(\frac{p_T^x}{a_T}\right)^{1-\lambda}}.$$

B.3 Derivation of the Foreign Factor Productivity Growth

In this section, we show the expressions of the level and the change in the foreign factor productivity a_i, $i \in \{T, R\}$, in terms of observables by inverting the factor demand equations. Since derivations of a_T and a_R are analogous, we only show the case of a_T. By taking ratio of equations (14) and (15) for $d = 11$, we have

$$\frac{w_J l_{11,j}(\psi)}{p_T^x x_{11,j}(\psi)} = \left(\frac{w_J}{p_T^m / a_T}\right)^{1-\lambda}$$

Rearranging, we have

$$a_T = \frac{p_T^x}{w_J} \left(\frac{p_T^x x_{11,j}(\psi)}{w_J l_{11,j}(\psi)} \right)^{\frac{1}{\lambda-1}}.$$

We aggregate this expression across all offshorers in T to get

$$\sum_j \int_{\psi_{11,j}}^{\infty} a_T dG_j(\psi) = \frac{p_T^x}{w_J} \sum_j \int_{\psi_{11,j}}^{\infty} \left(\frac{p_T^x x_{11,j}(\psi)}{w_J l_{11,j}(\psi)} \right)^{\frac{1}{\lambda-1}} dG_j(\psi)$$

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

which is equation (25).

Next, taking the change of expression (25), we have

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

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

$$\hat{\overline{\left(\frac{p_T^x x_T}{w_J L} \right)}}_{11} = \sum_j S_j^r \int_{\psi'_{11,j}}^{\infty} \frac{\left(\frac{p_T^x x_{11,j}(\psi)}{w_J l_{11,j}(\psi)} \right)^{\frac{1}{\lambda-1}}}{\int_{\psi_{11,j}}^{\infty} \left(\frac{p_T^x x_{11,j}(\psi)}{w_J l_{11,j}(\psi)} \right)^{\frac{1}{\lambda-1}} dG_j(\psi)} \left(\frac{p_T^x \hat{x_{11,j}}(\psi)}{w_J \hat{l_{11,j}}(\psi)} \right)^{\frac{1}{\lambda-1}} dG_j(\psi)$$

where

$$S_j^r \equiv \frac{\int_{\psi_{11,j}}^{\infty} \left(\frac{p_T^x x_{11,j}(\psi)}{w_J l_{11,j}(\psi)} \right)^{\frac{1}{\lambda-1}} dG_j(\psi)}{\overline{\left(\frac{p_T^x x_T}{w_J L} \right)}_{11}}$$

summarizes the sectoral relative demand share. To derive the remaining terms, we focus on the case $\psi_{11,j} > \psi'_{11,j}$, so the new equilibrium is such that the entry is less selective than the old one as the other case is analogous. In this case, we have $p_T^x x_{d^*,j}(\psi) = 0$ for $\psi \in \left(\psi'_{11,j}, \psi_{11,j}\right)$, so

$$\frac{\int_{\psi'_{11,j}}^{\infty} \left(\frac{p_T^x x_{11,j}(\psi)}{w_J l_{11,j}(\psi)} \right)^{\frac{1}{\lambda-1}} \left(\frac{p_T^x \hat{x_{11,j}}(\psi)}{w_J \hat{l_{11,j}}(\psi)} \right)^{\frac{1}{\lambda-1}} dG_j(\psi)}{\int_{\psi_{11,j}}^{\infty} \left(\frac{p_T^x x_{11,j}(\psi)}{w_J l_{11,j}(\psi)} \right)^{\frac{1}{\lambda-1}} dG_j(\psi)} = \int_{\psi'_{11,j}}^{\infty} s_j^r(\psi) \left(\frac{p_T^x \hat{x_{11,j}}(\psi)}{w_J \hat{l_{11,j}}(\psi)} \right)^{\frac{1}{\lambda-1}} dG_j(\psi)$$

summarizes a firm's relative demand share in sector j. Note that

$$E\left[s_j^r(\psi)\left(\frac{p_T^x \widehat{x_{d^*,j}}(\psi)}{w_J \widehat{l_{d^*,j}}(\psi)}\right)^{\frac{1}{\lambda-1}} | d^{*'} = 11\right] = \frac{\int_{\psi'_{11,j}}^{\infty} s_j^r(\psi)\left(\frac{p_T^x \widehat{x_{11,j}}(\psi)}{w_J \widehat{l_{11,j}}(\psi)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)}{1 - G_j\left(\psi'_{11,j}\right)}$$

$$\Longleftrightarrow \int_{\psi'_{11,j}}^{\infty} s_j^r(\psi)\left(\frac{p_T^x \widehat{x_{11,j}}(\psi)}{w_J \widehat{l_{11,j}}(\psi)}\right)^{\frac{1}{\lambda-1}} dG_j(\psi)$$
$$= \left[1 - G_j\left(\psi'_{11,j}\right)\right] E\left[s_j^r(\psi)\left(\frac{p_T^x \widehat{x_{d^{*'},j}}(\psi)}{w_J \widehat{l_{d^{*'},j}}(\psi)}\right)^{\frac{1}{\lambda-1}} | d^{*'} = 11\right].$$

Hence, we have

$$\left(\frac{\widehat{p_T^x x_T}}{w_J L}\right)_{11} = \sum_j S_j^r \left[1 - G_j\left(\psi'_{11,j}\right)\right] E\left[s_j^r(\psi)\left(\frac{p_T^m \widehat{x_{d^{*'},j}}(\psi)}{w_J \widehat{l_{d^{*'},j}}(\psi)}\right)^{\frac{1}{\lambda-1}} | d^{*'} = 11\right].$$

Furthermore, we can obtain

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

the threshold change can be obtained by the same way in equation (20). This completes the derivation of equation (26).

B.4 Deriving Group-Specific Changes in Labor Shares

In this subsection, we derive the labor share of the group g of firms and its change in our model. The group g can be arbitrary, such as the MNE status d, firm size quartile s, or simply all firms. First, define the g-specific aggregate labor share by

$$S_g^L \equiv \left(\frac{w_J L_g}{w_J L_g + r_J K_g + \Pi_g}\right), \tag{B.7}$$

where $L_g \equiv \int_{i\in g} l_i di, K_g \equiv \int_{i\in g} k_i di$, and $\Pi_g \equiv \int_{i\in g} \pi_i di$. Write $x_i^J = w_J l_i + r_J k_i + \pi_i$ as the sum of labor compensation and operating surplus in firm i, and $Z_g^J = \int_{i\in g} z_i^J di$ as its group-g aggregate of any variable z. Furthermore, we use a pair of subscripts to denote the sum within the intersection of all subscript categories, and curly bracketed tuples to denote the set of firms in the intersection. For example, $L_{d,g,j}^J = \int_{i\in\{d,g,j\}} l_i di$ is the sum of home-country employment of the firms in group g that are also in industry j and taking MNE status d. Recall that d can take either 00 (domestic), 01, (offshoring in R but not in T), and 11 (offshoring in T). The following proposition holds.

Proposition 1. *The change in the group g-specific labor share can be solved as*

$$\hat{S}_g^L = \hat{S}_g^{L|C}\hat{S}_g^X,$$

where $S_g^{L|C} \equiv w_J L_g / \left(w_J L_g + r_J K_g\right)$ *is the group-specific cost share, and* $\hat{S}_g^X$ *is the sectoral weighted average of the change in* X_g^J *that can be written as*

$$\hat{S}_g^X = \sum_j \bar{S}_{g,j}^C \frac{\hat{X}_{g,j}^J}{\hat{X}_g^J},\ \bar{S}_{g,j}^C = \frac{\frac{\varepsilon_j - 1}{\varepsilon_j} X_{g,j}^J}{\sum_k \frac{\varepsilon_k - 1}{\varepsilon_k} X_{g,k}^J}, \tag{B.8}$$

$$\hat{X}_{g,j}^J = \frac{\varepsilon_j}{\varepsilon_j - 1} S_{g,j}^L \hat{w}_J \hat{L}_{g,j} + \left(1 - \frac{\varepsilon_j}{\varepsilon_j - 1} S_{g,j}^L\right) \hat{r}_J \hat{K}_{g,j}, \tag{B.9}$$

and

$$\begin{aligned}
\hat{K}_{g,j} = & \left(\hat{r}_J\right)^{-\sigma_j} \left(\hat{c}_{00,j}\right)^{\sigma_j - \varepsilon_j} \left(1 - \left(S_{01,j|g}^K + S_{11,j|g}^K\right) \left(\hat{\psi}_{01,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)}\right) \\
& + \left(\hat{r}_J\right)^{-\sigma_j} \left(\hat{c}_{01,j}\right)^{\sigma_j - \varepsilon_j} \left[\left(S_{01,j|g}^K + S_{11,j|g}^K\right) \left(\hat{\psi}_{01,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)} \right. \\
& \left. - S_{11,j|g}^K \left(\hat{\psi}_{11,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)}\right] \\
& + \left(\hat{r}_J\right)^{-\sigma_j} \left(\hat{c}_{11,j}\right)^{\sigma_j - \varepsilon_j} S_{11,j|g}^K \left(\hat{\psi}_{11,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)},
\end{aligned} \tag{B.10}$$

$$\begin{aligned}
\hat{L}_{g,j} = & \left(\hat{w}_J\right)^{-\lambda} \left(\hat{p}_{00,j}^{m,P}\right)^{\lambda - \sigma_j} \left(\hat{c}_{00,j}\right)^{\sigma_j - \varepsilon_j} \left(1 - \left(S_{01|j,g}^L + S_{11|j,g}^L\right) \left(\hat{\psi}_{01,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)}\right) \\
& + \left(\hat{w}_J\right)^{-\lambda} \left(\hat{p}_{01,j}^{m,P}\right)^{\lambda - \sigma_j} \left(\hat{c}_{01,j}\right)^{\sigma_j - \varepsilon_j} \left[\left(S_{01|j,g}^L + S_{11|j,g}^L\right) \left(\hat{\psi}_{01,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)} \right. \\
& \left. - S_{11|j,g}^L \left(\hat{\psi}_{11,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)}\right] \\
& + \left(\hat{w}_J\right)^{-\lambda} \left(\hat{p}_{11,j}^{m,P}\right)^{\lambda - \sigma_j} \left(\hat{c}_{11,j}\right)^{\sigma_j - \varepsilon_j} S_{11|j,g}^L \left(\hat{\psi}_{11,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)}
\end{aligned} \tag{B.11}$$

with the sector j-group g-specific MNE status d's factor shares are given by

$$S_{d|j,g}^L = \frac{\int_{i \in \{d,j,g\}} w_J l_i di}{\int_{i \in \{j,g\}} w_J l_i di},\ S_{d,j|g}^K = \frac{\int_{i \in \{d,j,g\}} r_J k_i di}{\int_{i \in \{j,g\}} r_J k_i di}, \tag{B.12}$$

the threshold change for $d = 11$, $\hat{\psi}_{11,j}$, *is given in equations* (18) *and* (20), *and* $\hat{\psi}_{01,j}$ *is given analo-*

gously.

Proof. Using equation (B.7), we have

$$S_g^L \equiv \frac{w_J L_g}{X_g^J} = \frac{w_J L_g}{w_J L_g + r_J K_g} \sum_j \frac{w_J L_{g,j} + r_J K_{g,j}}{X_{g,j}^J}.$$

Taking the new-old ratio, it is immediate that $\hat{S}_g^L = \hat{S}_g^{L|C} \left[\sum_j \widehat{\left(w_J L_{g,j} + r_J K_{g,j} \right) / X_{g,j}^J} \right]$. Therefore, it remains to show that $\left[\sum_j \widehat{\left(w_J L_{g,j} + r_J K_{g,j} \right) / X_{g,j}^J} \right] = \hat{S}_g^X$. For this purpose, we will derive equations (B.8), (B.9), (B.10), (B.11), and (B.12). First, fix an industry j. Then we have

$$X_{g,j} = \frac{\varepsilon_j}{\varepsilon_j - 1} \left(w_J L_{g,j} + r_J K_{g,j} \right) \tag{B.13}$$

since we fix the industry and the markup rate is constant within industry thanks to the CES demand assumption. Therefore, we have

$$\begin{aligned}
\frac{w_J L_g + r_J K_g}{X_g} &= \frac{\sum_j \left(w_J L_{g,j} + r_J K_{g,j} \right)}{\sum_{j'} \frac{\varepsilon_{j'}}{\varepsilon_{j'} - 1} \left(w_J L_{g,j'} + r_J K_{g,j'} \right)} \\
&= \sum_j \frac{\frac{\varepsilon_j}{\varepsilon_j - 1} \left(w_J L_{g,j} + r_J K_{g,j} \right)}{\sum_{j'} \frac{\varepsilon_{j'}}{\varepsilon_{j'} - 1} \left(w_J L_{g,j'} + r_J K_{g,j'} \right)} \frac{\left(w_J L_{g,j} + r_J K_{g,j} \right)}{\frac{\varepsilon_j}{\varepsilon_j - 1} \left(w_J L_{g,j} + r_J K_{g,j} \right)} \\
&= \sum_j \frac{X_{g,j}}{X} \frac{\varepsilon_j - 1}{\varepsilon_j}.
\end{aligned}$$

In terms of changes, we have

$$\begin{aligned}
\left(\widehat{\frac{w_J L_g + r_J K_g}{X_g}} \right) &= \left(\sum_j \widehat{\frac{\varepsilon_j - 1}{\varepsilon_j} \frac{X_{g,j}}{X}} \right) = \frac{\sum_j \frac{\varepsilon_j - 1}{\varepsilon_j} \frac{X'_{g,j}}{X'_g}}{\sum_k \frac{\varepsilon_k - 1}{\varepsilon_k} \frac{X_{g,k}}{X_g}} \\
&= \sum_j \frac{\frac{\varepsilon_j - 1}{\varepsilon_j} \frac{X_{g,j}}{X_g}}{\sum_k \frac{\varepsilon_k - 1}{\varepsilon_k} \frac{X_{g,k}}{X_g}} \frac{\frac{\varepsilon_j - 1}{\varepsilon_j} \frac{X'_{g,j}}{X'_g}}{\frac{\varepsilon_j - 1}{\varepsilon_j} \frac{X_{g,j}}{X_g}} \\
&= \sum_j \bar{S}_{g,j}^C \frac{\hat{X}_{g,j}}{\hat{X}_g},
\end{aligned}$$

which completes the proof of equation (B.8).

Next, using equation (B.13), we have

$$\hat{X}_{g,j} = \left(w_J L_{g,j} \hat{+} r_J K_{g,j}\right)$$
$$= \frac{w_J L_{g,j}}{w_J L_{g,j} + r_J K_{g,j}} \hat{w}_J \hat{L}_{g,j} + \frac{r_J K_{g,j}}{w_J L_{g,j} + r_J K_{g,j}} \hat{r}_J \hat{K}_{g,j}. \tag{B.14}$$

Note that

$$\frac{w_J L_{g,j}}{w_J L_{g,j} + r_J K_{g,j}} = \frac{w_J L_{g,j}}{X_{g,j}} \frac{X_{g,j}}{w_J L_{g,j} + r_J K_{g,j}} = S^L_{g,j} \frac{\varepsilon_j}{\varepsilon_j - 1},$$

and $\frac{r_J K_{g,j}}{w_J L_{g,j} + r_J K_{g,j}} = 1 - S^L_{g,j} \frac{\varepsilon_j}{\varepsilon_j - 1}$ likewise. Substituting these equations in equation (B.14) completes the proof of equation (B.9).

Finally, deriving equations (B.10) (B.11), and (B.12) is analogous to the one in Appendix B.2, with conditions on group g is added in each derivation there. □