Multinational Production and Corporate Labor Share*

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Abstract

This study investigates the effect of multinational enterprises (MNEs) on home country labor share by using a unique natural experiment stemming from the 2011 Thailand Floods which forced a cessation of operations by Japanese-owned subsidiaries. This external shock to foreign productivity resulted in a relative decrease in home country employment and an even larger decline in the fixed assets of MNEs impacted by the floods. Using a general equilibrium (GE) model of heterogeneous firms featuring a production function with offshore factor inputs, we introduce a solution method based on hat algebra, and 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 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

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1 Introduction

A growing body of evidence suggests that labor share has been decreasing in developed countries over recent decades, raising concerns among policymakers about widening income inequality between workers and owners of capital. Previous studies have proposed several potential explanations for this phenomenon, including rising markups and bias in technological change. However, among the many potential mechanisms that could underly technological change, there is little causal evidence for a specific one. In this paper, we examine the effect of intensified activities of multinational enterprises (MNEs) on their home country's labor share.

For our analysis, we use novel causal evidence derived from a natural experiment resulting from the 2011 Thailand Floods which caused a significant negative productivity shock to local Thai firms embedded within the global production networks of Japanese MNEs. 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 affected MNEs partially offset the negative impact on their foreign production sites by hiring home-country workers to perform labor-intensive tasks.

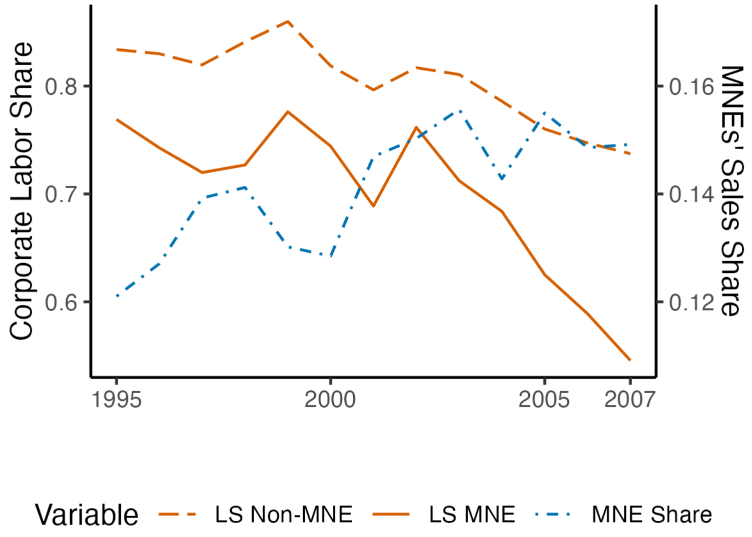
Motivated by these findings, we develop a model of heterogeneous firms that utilize home-country labor, home-country capital, and foreign factors as inputs and we then conduct a comparative statics exercise to assess changes in foreign productivity. The Thailand Floods natural experiment is used to estimate the elasticity of home-country factor demands in response to effective foreign factor prices, which is a key parameter influencing the labor share. The estimated model reveals that foreign productivity growth decreases the Japanese corporate labor share and exacerbates labor-share inequality across firms.

Figure 1 offers a simple decomposition plot highlighting the role of MNEs in the declining labor share. The blue line, which shows the trend of MNE headquarter (HQ) sales as a share of all firm sales, rises over the period. Meanwhile, the red lines display the labor share trends of MNEs (solid line) and non-MNEs (dashed line), and we can see that MNEs consistently exhibited both a lower labor share and a more rapidly decreasing labor share than non-MNEs throughout the period. Therefore, Figure 1 suggests that the decrease in the aggregate labor share is caused by both a compositional effect and a within-MNE effect.[1]

In order to explore the causal relationship of foreign productivity on labor share , we make use of the 2011 Floods, which inflicted significant damage on Thailand's production economy at an unprecedented scale. Among the manufacturing clusters affected by

[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: This figure shows trends in the labor share for multinational enterprises (MNEs) and non-MNEs. For each firm, labor share is calculated from BSJBSA data as total payroll divided by the sum of total payroll and operating surplus. MNE share is computed by the share of sales by MNEs.

the flood were numerous subsidiaries of Japanese MNEs. To analyze this unique event, we matched 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 regions, with our event-study regression indicating a decline in foreign and home employment and fixed asset formation among affected Japanese MNEs compared to Japanese MNEs with subsidiaries in Thailand that were not affected by the floods. Moreover, we find that the reduction in fixed assets was greater than that of employment in Japan, as the drop in employment in Thailand was partially offset by home-country labor-intensive activities that compensated for weakened foreign activities. These findings suggest that labor is more substitutable than capital in the foreign operations of MNEs.

We interpret these results using a standard general equilibrium model of heterogeneous firms. Factor prices, which are endogenously determined by factor market-clearing conditions, are key variables driving labor share. 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, because our model includes a term for cost-saving by engaging in foreign sourcing, 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 involves using the model-implied measure of the offshorers' cost ratio to proxy the unobserved cost-saving term. We name the hat algebra system incorporating this technique "extensive-margin hat algebra" (EMHA).

The EMHA method allows us to conduct a quantitative analysis, 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 in which the labor substitution effect of MNEs is studied. 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. Applying this method to the Thailand Floods yields an estimate of 1.4, which is significantly greater than 1 and thereby allows us to reject 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 demand for home-country labor and capital, we calculate the effect of foreign factor productivity on Japanese corporate labor, finding that 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 growth in foreign factor productivity increased labor share inequality across firms because MNEs, with an already low labor share, further reduced their labor share by satisfying home-country labor demand with foreign inputs.

This paper makes four contributions to the literature. Firstly, we provide a novel mechanism to explain the recent trend of declining labor share in high-income countries. A growing body of work has explored this phenomenon since it was documented in an influential paper by Karabarbounis and Neiman (2013).[2] For instance, Elsby et al. (2013) emphasizes the offshoring of labor-intensive activities among supply chains and, similarly, Oberfield and Raval (2021) emphasize the role of "technology, broadly defined, including automation and offshoring, rather than mechanisms that work solely through factor prices." We extend this perspective by arguing that the deepening of global value chains (GVCs), represented

[2]Mechanisms proposed in the literature include 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). Of these, Castro-Vincenzi and Kleinman (2022) investigates the impact on labor share of intermediate inputs other than labor and capital, and the current study expands this by using a natural experiment and heterogeneous firms model to study the role of foreign factors rather than intermediate inputs.

by intensified MNE operations, play a role in reducing labor share. Furthermore, as Boehm et al. (2020) recognize “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 share. 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 on the implications of the labor share decline in Japan, a country that invests more in other countries than it attracts investments from foreign countries.

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 studies have examined the impact of foreign production on the source country's labor market,[3] but 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 by drawing on another natural experiment, the impact of the 2011 Thailand floods on Japanese MNEs. Furthermore, while 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 labor share aligns with recent studies which approach this by estimating the production function. Among others, Doraszelski and Jaumandreu (2018) and Zhang (2019) estimate the production function via non-Hicks-neutral productivity shocks and study the effect of these shocks on labor share, finding that it declines. 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. Instead, our study complements this literature by explicitly examining a general equilibrium structure. This not only aids in estimation but also facilitates the discussion of the equilibrium adjustment of firm offshoring behavior and 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.

[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).

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 models of heterogeneous firms include a counterfactual term of the difference in 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 using the entrants' cost shares as proxies for the counterfactual term, following the insight of the sufficient statistics approach of Blaum et al. (2018). While in their model of complex multi-country offshoring decisions, Blaum et al. (2018) use observable offshore cost shares to express the change in the model's consumer price index, 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 share 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

In this section, we describe primary data sources and provide evidence from an event study based on the 2011 Thailand floods.

2.1 Data Source

The first primary data source is the Basic Survey on Japanese Business Structure and Activities (BSJBSA), 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 ($\approx$USD 0.3 million) paid-in capital. The BSJBSA provides a comprehensive array of firm-level data including 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, product-level sales data, cost breakdowns by type, and detailed export and import data by region. It also contains information on outsourcing activities, among other details. The dataset covers the period 1995-2016. In order to address outliers, we have Winsorized the top and bottom 0.1 percent of operating surpluses.

To complement the data from the BSJBSA with information on foreign production, we also use 1995-2016 data from the Basic Survey of Overseas Business Activities (BSOBA), which is an annual government survey conducted by the METI that covers all Japanese multinational enterprises (MNEs), encompassing both private and public firms. Although the BSOBA delimits Headquarters and Subsidiary activities, we utilize information only from the Subsidiary file, which documents data pertaining to all child and grandchild foreign subsidiaries of each headquarter (HQ) firm.[4] The survey contents consists of the destination country, local employment and sales, where sales are divided into the categories of destination such as Japan (home country), Asia, Europe, and America, but do not contain information on capital stock in the subsidiary. Appendix A.3 shows the coverage of employment and labor compensation variables in the BSOBA Subsidiary file.

As location in BSOBA is available only at the country level, we enhance the BSOBA data with street-level addresses from the Orbis dataset provided by Bureau van Dijk. Using the HQ firm name, location, and phone number, we further link these datasets with a firm-level dataset gathered by the private credit agency Tokyo Shoko Research (TSR). The match rate from BSOBA to BSJBSA is 93.0% and, 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. Following recent discussions in the measurement of corporate labor share (Bridgman, 2018; Rognlie, 2018), 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. This approach mitigates complications associated with the mixed income of self-employed individuals and capital depreciation but requires 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) 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 only across periods for a given 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 $\sum_i (wl)_{it} / \sum_i [(wl)_{it} + (os)_{it}]$.

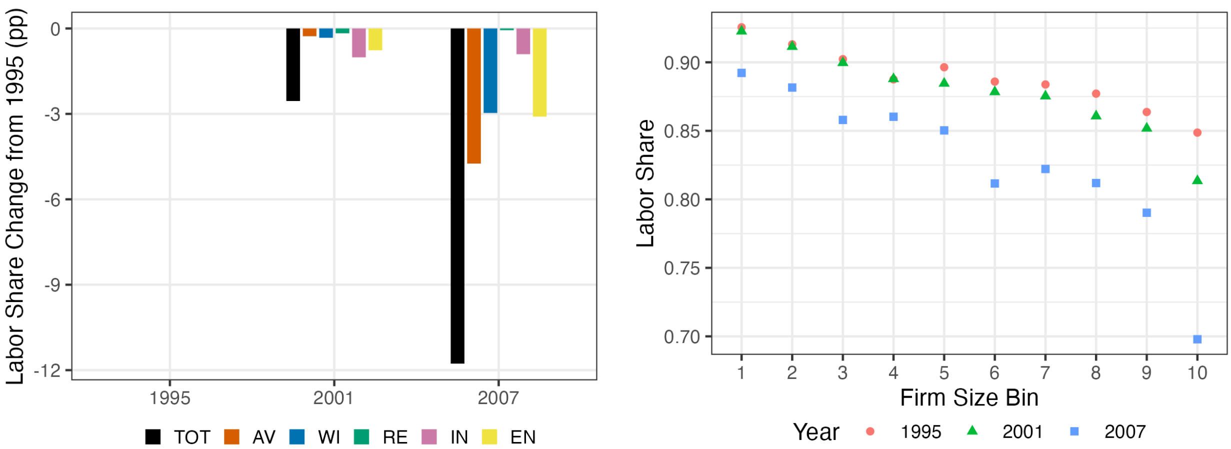
Following Kehrig and Vincent (2021), we can decompose the change in the aggregate

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

Figure 2: Firm-level Labor Shares in Japan

(a) Decomposition of the Change in Labor Share

(b) Firm Size and Labor Share



Note: The left panel plots the decomposition of corporate labor share 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, which are explained in the main text. The right panel plots the evolution of the distribution of the corporate labor share by firm-size deciles.

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. These are formally given by

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

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

Figure 2a shows the change in the labor share in Japan since 1995. We find that (i) there has been a substantial drop in the total corporate labor share in Japan, amounting to 11-12 percentage points 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 of the decline. These findings underscore the importance of mechanisms that operate both through 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 reveals that (i) there is a negative relationship 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 a lower labor share and that a reallocation of resources from low-productivity to high-productivity firms could suppress the labor share — a 'superstar' phenomenon suggested 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, markups 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 the U.S. and some other countries, the pattern for Japan observed in Figure 2b cannot be explained by a rising markup.

Thus, rather than markups, this study investigates a different mechanism of globalization that was experienced by Japanese firms during the sample period. In Appendix A.1, we exhibit trends in aggregate labor share between MNEs and non-MNEs, but interpreting these results causally poses a challenge due to the absence of exogenous shocks that could have affected all firms. However, in the next section, we examine the context of our natural experiment which affected Japanese MNEs.

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 auto-

[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.

mobile and electronics industries (see Appendix A.7) and manufactured parts used 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 serious concerns about spillover effects on the Japanese production economy (Feng and Li, 2021).

Balancing Checks. To ensure that there are no meaningful systematic differences between MNEs with subsidiaries located in the flooded regions and those without, we examined firm characteristics. In the BSOBA data, the treated group is defined 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 these 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-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.

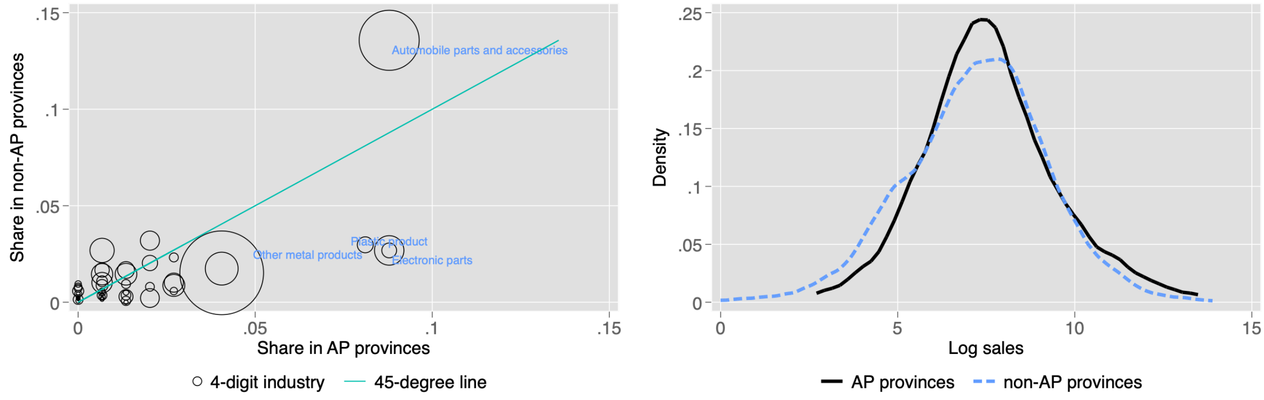
Subsidiary-level Analysis. Our analysis begins by studying the impact of the floods on Japanese subsidiaries in Thailand, utilizing the following event-study regression for the

[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

(a) Industry Share (b) Sales Distribution



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.

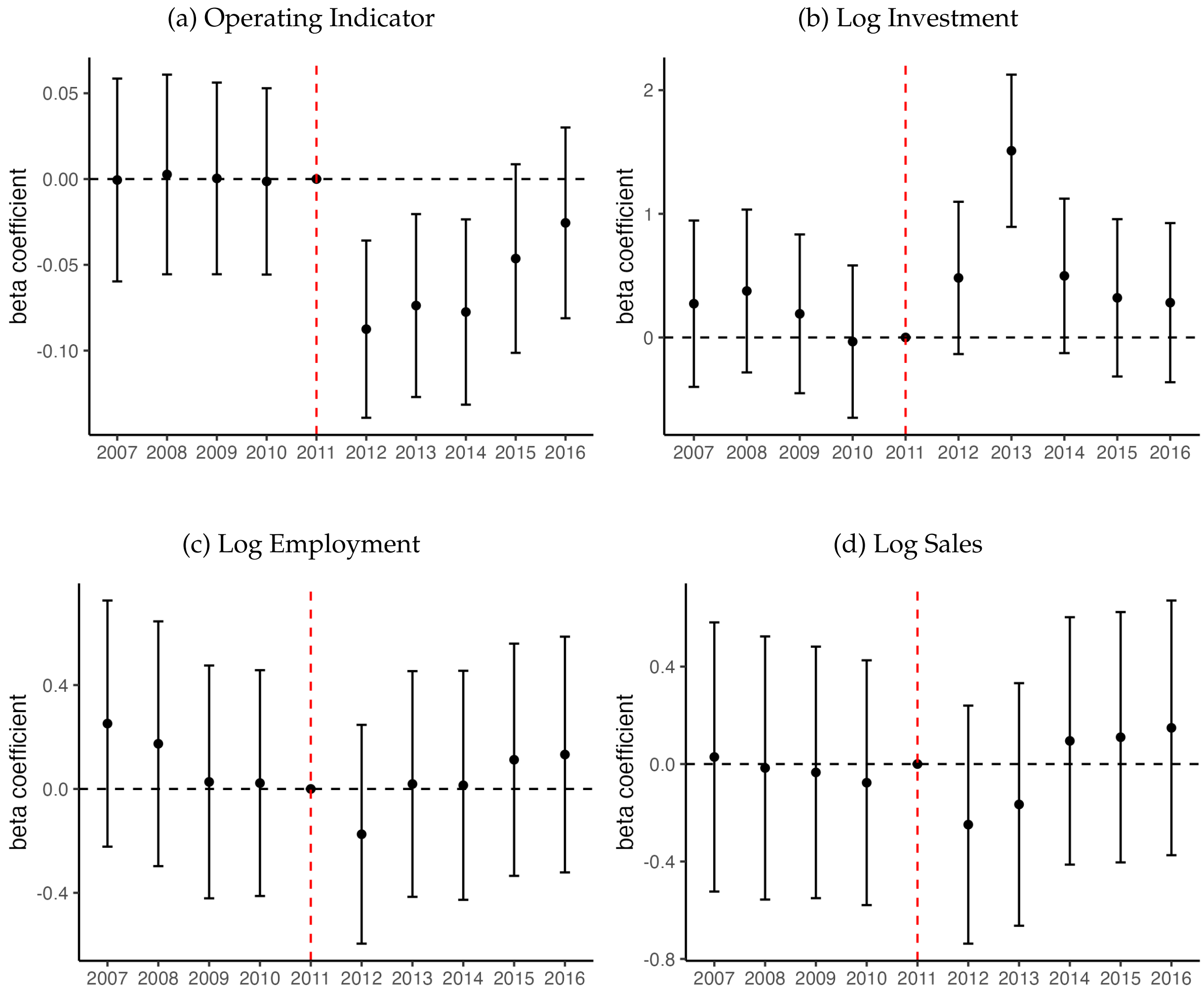
sample of Japanese subsidiaries in Thailand:

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

where s indicates subsidiary, t is calendar year, $flooded_s$ is an indicator variable that takes one if and only if s is located in the AP provinces in 2011, and X_{st} are control variables including the interaction of the pre-flood linear trend with the floods indicator. We estimate this equation using a balanced panel of firms that operated throughout the period 2007-2011 and examine the response to the shock at both the extensive and intensive margins. Specifically, we consider whether 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. We first confirm that the coefficients for the pre-flood years are not statistically significant, thus satisfying the parallel trend assumption. Additionally, in panel (a), we observe a significant negative effect at the extensive margin which persists for three 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 or sales responses for firms still operating, suggesting that the negative effects of the floods primarily affected the extensive margin.

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 the operating indicator as the outcome variable for the balanced panel of firms that operated throughout 2007-2011, and panels (b)-(d) take log investment, log employment, and log sales for the panels of firms operating in each year. Standard errors are cluster-robust at the subsidiary level, and bars indicate 95 percent confidence intervals.

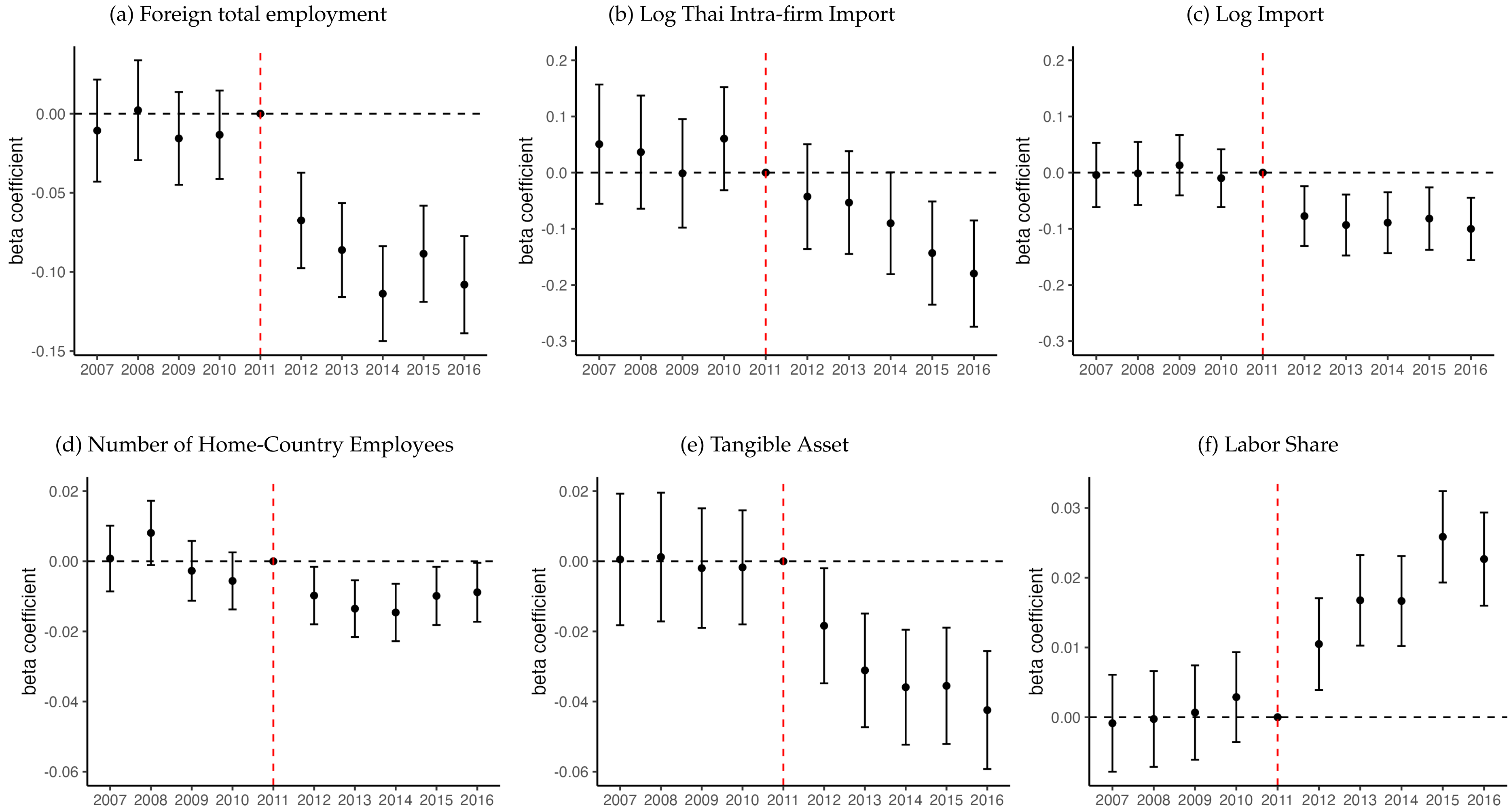
Robustness checks were conducted to assess various sample selection criteria including whole and partial ownership, and the results are reported in Appendix A.10.

Headquarter (HQ)-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 relative to its total global employment, thus measuring the intensity of the flood shock relative to

Figure 5: Event Study at the Headquarter Level



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

the firm's global size; y_{it} is the outcome variable; α_i^H is HQ firm-i's 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, following Carvalho et al. (2021), the control variables X_{it} include not only those of the subsidiary-level analysis but also the interaction between the Tohoku earthquake flags and the after-floods dummy 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 for each year. Figure 5 presents the estimates of β_τ^H for various outcome variables. Importantly, in all panels, the estimates for the pre-flood years τ are statistically insignificant, supporting the parallel trend assumption required of 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. Additionally, Appendix A.11 explores potential effects on the substitution of production in third countries, but no conclusive evidence is found.

Consistent with these findings, we observe negative effects on home-country factor employment. Panels 5d and 5e show the response of log employment and tangible asset holdings in Japan, and we find that both factor measures are negatively affected in firms severely affected by the floods. Moreover, the point estimates for asset holdings are larger in absolute value than those for employment. These findings, along with the observed reduced imports, suggest a reshoring of labor-intensive tasks from the foreign country to the home country. 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 to 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 that the observed factor bias is robust to the choice of capital measure. We also show that our main findings remain consistent even when we modify the shock variable to include only subsidiaries that export back to Japan, thus supporting the role of offshoring subsidiaries. Appendix A.10 elaborates on these additional analyses.

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 next study the role of foreign activities in influencing the labor share at both the firm and aggregate levels using a model of heterogeneous firms.

3 Model

We consider a heterogeneous firms model of offshore subsidiaries to study the home-country labor share effect of offshoring. Our model emphasizes the change in factor prices at home and abroad as a reflection of the demand for these factors, with factor prices determined in factor market-clearing conditions and driven by exogenous external changes such as foreign factor productivity growth or reduction in barriers to firms' multinational activities. The model features heterogeneity in productivity which produces a 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. 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. To focus on the role of foreign factors, we assume free trade but no factor mobility between countries. J and T are small-open, so we take sectoral price index P_j and factor prices in R as given. While this assumption may seem overly restrictive, it greatly 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 Japanese international trade but only to the much 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 later in a 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 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 described in Section 2.1 does not contain information on the capital stock of Japanese foreign subsidiaries. Secondly, to derive implications for relative factor prices and labor share in foreign countries with multiple factors, we would require detailed data regarding factor demands from firms that are not offshore subsidiaries, which is challenging to acquire.

Production in Country J. There are both producers of sectoral goods producers and producers of intermediate varieties in country J, with producers of sectoral goods aggregating 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 an intermediate variety, Ω_j the set of intermediate products in sector j, and $\varepsilon_j \geq 0$ the sectoral elasticity of substitution between intermediate varieties. Firms produce unique varieties under monopolistic competition, and their TFP ψ follows a 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 in a competitive input market with factor prices (w_J, r_J, p_T^x). Firms also choose the offshoring subsidiary location 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 the headquarter capital, $h \equiv h\left(l, x_T, x_R\right)$ are labor-intensive tasks specified below, m are 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 affect

[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. However, this assumption is beneficial when connecting the shift in the offshorer's share to the productivity cutoff, as illustrated in equation (18).

the firm-level labor share.[9] The tasks are performed internationally and determined by

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

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 of these productivities caused by floods (negative productivity shock) or globalization (positive productivity shock). Firms in J pay fixed costs for entry (f^E); production (f^P) if they operate; and, fixed costs of setting up a subsidiary (f_i^M) if they enter and offshore in country i.

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

$$s^L\left(\psi\right)=\frac{w_Jl\left(\psi\right)}{w_Jl\left(\psi\right)+\left(r_Jk\left(\psi\right)+\pi\left(\psi\right)\right)},$$

where $\pi\left(\psi\right)$ 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 $\Pi\equiv\sum_j\int_\psi\pi\left(\psi\right)dG_j\left(\psi\right)$ as the aggregate profit, we can also define the aggregate labor share by

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

What follows is a discussion about the choice of production functions (6) and (7). First, the CES production function with capital, labor-intensive tasks and intermediate inputs is standard in the most recent literature of production functions (Grieco et al., 2016; Doraszelski and Jaumandreu, 2018; Harrigan et al., 2021), and we enrich this framework by explicitly considering in our lower nest the home-country and foreign factors that perform labor-intensive tasks. Second, our nested CES implies that if $\lambda>\sigma_j$, firm-level labor share $s^L\left(\psi\right)$

[9] Although the distribution parameters α^k and α^h naturally affect labor share, we will not focus on them in this paper but instead 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), who conducted a counterfactual analysis of 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 the magnitude is minor compared to the effect of reallocation between demand for labor and capital. We will derive the implication of shocks to this labor share measure in Appendix B.4.

is decreasing in a_i $(i \in \{T, R\})$ since labor is a 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 that MNE 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 $(p_T^x / a_T)^{-\gamma}$. In country R, factor price is given at p_R^x. In equilibrium, factor prices (w_J, r_J, p_T^x) are determined so that factor markets clear.

3.2 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 observation that the productivity of firms operating in Thailand is higher than those that are not, as shown in Appendix Figure B.1. Given this restriction, the entry choice of firms is made among $d = 00$ (non-offshoring), $d = 01$ (R-offshoring), and $d = 11$ (R- and T-offshoring), so we rewrite the productivity thresholds as $\psi_{01,j}$ (the threshold between $d = 00$ and $d = 01$) and $\psi_{11,j}$ (the threshold between $d = 01$ and $d = 11$), and a firm's decision d is called an offshoring strategy hereafter. Firm ψ's marginal cost can be written as

$$c_{d,j}(\psi) = \frac{\tilde{c}_{d,j}}{\psi},\ \tilde{c}_{d,j} \equiv \left[\alpha_j^k (r_J)^{1-\sigma_j} + \alpha_j^h \left(p_d^h\right)^{1-\sigma_j} + \left(1 - \alpha_j^k - \alpha_j^h\right)(p^m)^{1-\sigma_j}\right]^{\frac{1}{1-\sigma_j}} \tag{9}$$

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 entering T to the fixed cost, $\pi_{11,j}\left(\psi_{11,j}\right) - \pi_{01}\left(\psi_{11,j}\right) =$

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

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 entering T. Note that $CS_{11,j}$ is a counterfactual term of the marginal firm and is difficult to measure empirically. Conditional on the optimal entry decision d^* for each firm ψ, monopolistic competition implies that 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

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

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

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

and

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

Integrated over the 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^x_T) are the solution to the factor market clearing conditions $K^D = \bar{K}_J$, $L^D = \bar{L}_J$, and $X^D_T + (p^x_T/a_T)^{-\gamma} = \bar{X}_T$.

To solve these equilibrium conditions, we follow the "hat algebra" approach (Dekle et al., 2007). A strength of this approach is its low data requirement, as we do not need to estimate all unobserved objects such as input share parameters. To proceed, we express all variables x as changes, with the hat notation $\hat{z} = z'/z$, where z is the baseline value of a generic variable and z' is its changed value. For brevity, we hereafter discuss only the change in aggregate capital demand $\hat{K}^D$. Derivations for the changes in labor demand $\hat{L}^D$ and Thailand factor demand $\hat{M}^D_T$ are similar and are provided in Appendix B.2. There, we show that

$$\hat{K}^D = \sum_j S^K_j \hat{\tilde{C}}^K_j, \tag{16}$$

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

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

where $S_{d,j}^K = \frac{\int_{\psi \in d} r_J k_j(\psi) dG_j(\psi)}{r_J K_j}$ is the 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 $\hat{\hat{c}}_{d,j}$ is standard and given in Appendix B.2. The presence of the $\hat{s}_{d,j}$ 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-saving change $\hat{CS}_{d,j}$. For example, when $d = 11$, it implies that

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

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

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

are, respectively, the cost share of the 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 $d = 11$, which can be observed in the data. Using this cost ratio expression, we can write $CS_{11,j} = \left(\tilde{c}_{11,j}^{1-\varepsilon_j} - \tilde{c}_{01,j}^{1-\varepsilon_j}\right)^{1/\left(1-\varepsilon_j\right)} = \tilde{c}_{01,j}\left(CR_{11,j}\right)^{1/\left(1-\varepsilon_j\right)}$. Hence, the change in cost saving can be written as

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

where $\hat{\hat{c}}_{01,j}$ can be derived from standard hat algebra shown in Appendix B.2, and $CR_{11,j}$ and $CR'_{11,j}$ are both derived from data before and after the change.[14] We can derive sim-

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

ilar 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 $s^h_{01,j}$), and if the factors in Thailand among labor-intensive tasks (hence high $s^{T|h}_{11,j}$) are intensively used in firms offshoring in Thailand, then the optimal factor demands imply that the cost ratio between investing and not investing in Thailand 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 employment to estimate the remaining substitution parameter λ. These steps are described in the following subsections but, generally, the 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 needed to solve for the general equilibrium.

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 $\ln\left(x^q_j\right) = a_j - \left(\theta_j\right)^{-1} \ln\left(1-q\right)$, where q stands for percentile, a_j for the sector-specific intercept, and x^q_j for q-th percentile sales in sector j. We use sample firms with $q > 0.99$ for each sector as the top tail follows a Pareto distribution (Simon and Bonini, 1958), and apply the correction to the OLS estimation proposed by Gabaix and Ibragimov (2011). Second, we obtain the 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: 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

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).

the three-digit level in the 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, this is consistent with Oberfield and Raval (2021) who estimated $\sigma < 1$ using U.S. plant-level data.

4.2 Estimating λ, the Labor-Foreign Input Substitution Elasticity

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

Separation of the Effects of the Thailand Floods. Starting with 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 (d^*) and sector (j)-specific general equilibrium effects arising from 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 the 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" that 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 the unit cost index $c_{d^*,j}(\psi)$ in production input demand equation (13). This effect is linked to λ through the elasticity of the change in labor demand with respect to the change in the 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 effects of the shock on labor and Thailand factor demand are different, and the 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 any differences in country-level trends. This implies that $d^* = 11$ in the model notation, so we drop this subscript hereafter. Second, we rewrite each observation by index i and year t. Third, we define the 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 a 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 the 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), so 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 factor expenditure in Thailand, a_i is a headquarter fixed effect that absorbs any unobserved firm-specific characteristics, a_{jt} is an 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 $\ln\left(x_{it}^T\right)$, and then use the 2SLS estimator of b to approximate equation (23), which provides the estimate of λ. A standard Delta method provides the estimate of the standard error, which is described in detail in Appendix A.13. Note that equation (23) is a standard 2SLS two-way fixed-effect specification in the literature (e.g., Kovak et al., 2021) that has been modified to our setting of a multiple factor production function. Therefore, our model provides a theoretical interpretation of a frequently used empirical specification.

Although capital and labor data for Japan is available in the BSJBSA data, capital stock data for Thailand is absent, and only employment data is 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 supplementary analyses using various alternative measures of activities in Thailand including value added, total sales, and within-firm trade from Thailand to Japan. These supplementary measures align closely with our model but exhibit tenuous links to the existing literature.

It is worthwhile to highlight 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 assumption of exogeneity 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 competition

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) $\ln trade_{it}^{THA\rightarrow JPN}$
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 and the post-flood indicator, on Japanese employment (column 1) and several measures of economic activity in Thailand including employment ($\ln l_{it}^{THA}$, column 2), value added ($\ln VA_{it}^{THA}$, column 3), total sales ($\ln sales_{it}^{THA}$, column 4), and intra-firm trade from Thailand to Japan ($\ln trade_{it}^{THA\rightarrow JPN}$, 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 are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

structure.

4.3 Estimation Results

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

Based on our preferred estimate in column 2 of Table 2, equation (23) implies $\lambda = 1.40$ with a standard error of 0.133. This estimate reveals that factors of production in foreign countries and Japanese labor are substitutes at a conventional level of significance ($t = 3.08$). Furthermore, in all industries, we have shown that $\lambda > \sigma_j$, which implies that labor is a relative substitute of foreign inputs. As discussed in the model section, an increase in the factor-augmenting productivity shock in the foreign country implies a stronger decrease in labor demand than of capital demand, thereby reducing firm-level labor shares of Japanese firms.

While the positive 2SLS result is consistent with some studies in the literature (Desai et al., 2009; Kovak et al., 2021), others find negative effects of multinational activities (Ebenstein et al., 2014; Boehm et al., 2020). Appendix Section A.14 shows the results of sensitivity checks with respect to the definition of shock intensity Z_i and control groups, confirming the robustness of our results. Additionally, estimation results by industry are presented in Appendix Section A.15.

5 Quantitative Exercises

5.1 Model Fit

To check if the estimated model could predict the actual data patterns of the Thailand floods, we performed a simulation analysis. First, we simulated the same number of firms for each sector j as that observed in 2011. Second, among these firms, we randomly selected those which were affected by the flood shock based on the observed share of firms located in Ayutthaya and Pathum Thani provinces. This procedure reflects our identification assumption that the flood damage was concentrated in these two provinces and is as good as random. Third, we hit the selected firms with productivity shock $\hat{a}_T = 0.1$. Although this procedure requires us to take a stance about the size of the flood 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 solved the 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 regressed $\hat{l}(\omega)$ and capital $\hat{k}(\omega)$ on the AP dummy and the industry-fixed effect. We measured the capital demand in the data by the interaction of asset value and long-run return on capital.

The results are shown in Table 3. As expected from 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, comparing the results in columns 3 and 4 show the estimated model's strong performance in predicting the decline in capital demand in Japan since our estimation procedure does not rely on the variable of capital demand. The difference between the model's prediction and the observed correlation are not statistically significant. Furthermore, by comparing the size of the coefficients between employment and capital, we confirm that the flood shock reduced labor demand less than capital demand in both model's prediction and actual data. This is consistent with our model's prediction that labor and foreign inputs are relative substitutes, so that the negative demand impact through

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. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

the cost index is mitigated by the direct substitution effect.

5.2 Quantifying the Role of Foreign Productivity Growth

In this section, we use the estimated model to 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 is 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 unto 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

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

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

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

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 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 the 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 employment cost changes for non-Thai investors. 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 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 globalization strategies of firms and compute the labor share of firm groups S_d^L. For example, the labor share of Thailand investors is given by

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

Our EMHA 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 fixed selection into MNEs, we perform the following exercise. First, we solve the model by EHMA for the selection-fixed (SF) factor price changes $\left(\hat{r}_J^{SF}, \hat{w}_J^{SF}, \hat{p}_T^{x,SF}\right)$ with setting

$\hat{\psi}_{d,j} = 1$ for all d and j exogenously, which means that there is no change in the entry threshold for foreign countries. Therefore, the resulting solution yields the counterfactual factor price changes if there is no change in the foreign entry-exit decision of MNEs. Given this, we can then compute the change in labor share measures with $\left(\hat{r}_J^{SF}, \hat{w}_J^{SF}, \hat{p}_T^{x,SF}\right)$ and $\hat{\psi}_{d,j} = 1$ for $d \in \{01, 11\}$. Such a change reveals the counterfactual labor share change with 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 $\hat{S}_d^L$.

The simulation results are shown in Figure 6, which shows the role of MNEs in the decline in corporate labor share, both by MNE status (Panel a) and firm size (Panel b). Beginning with Panel 6a, the simulation result for the aggregate labor share is presented on the left, while to the right, labor shares are decomposed into three groups of firms–non-MNEs, MNEs in the Rest of the World (RoW-MNE), and MNEs in Thailand (Thai-MNE). On the left, we see that the aggregate labor share reduction as a result of the baseline simulation is 1.37 percentage points, explaining 11.9% of the observed decline between 1995-2007. When we fix the extensive margin changes, we find that the labor share decrease is only slightly smaller at 1.06 percentage points. Thus we find that a major part of the change due to foreign factor productivity growth occurred through the change in the labor share within firms.

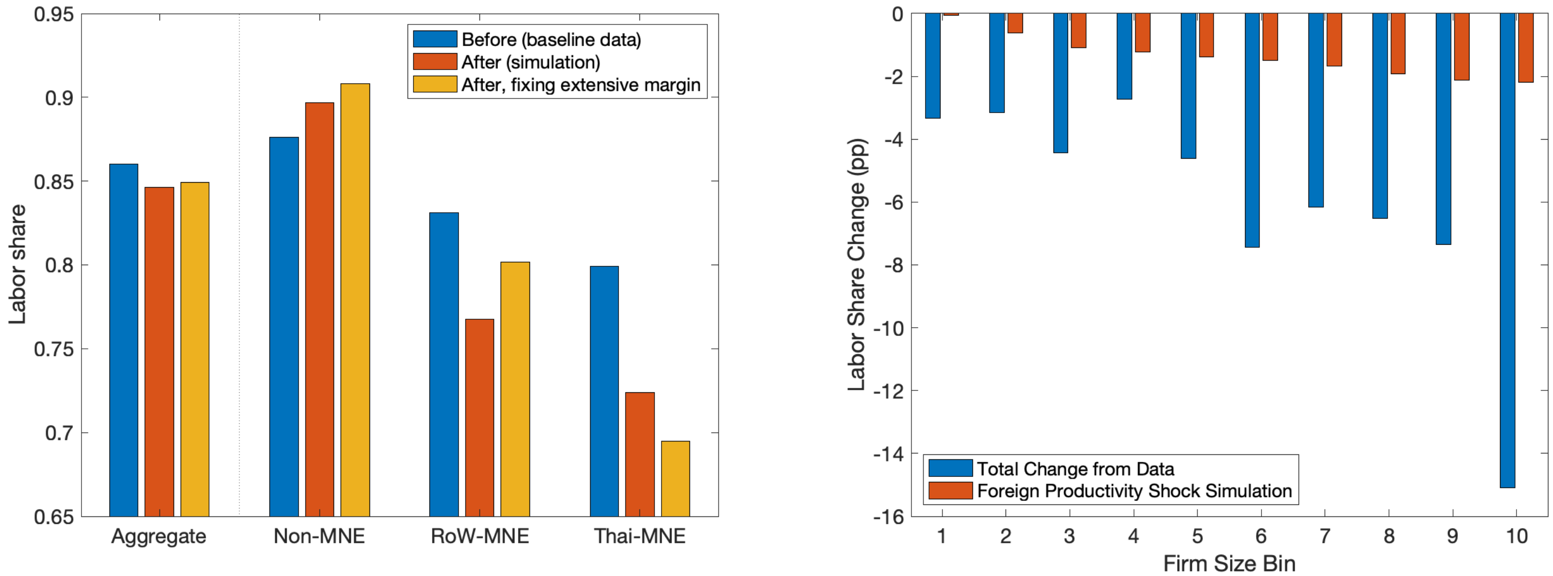
The remaining part of Panel 6a shows that the baseline labor shares are dramatically different when the aggregate change is decomposed into MNE types. Overall, the more international a firm is, the smaller is its baseline labor share, with the baseline difference between non-MNEs and MNEs in Thailand being 7.70 percentage points. Moreover, this sizable difference in the baseline labor share is further expanded by foreign factor productivity growth, with non-MNE labor share increasing by 2.09 percentage points but RoW-MNE and Thai-MNE labor shares decreasing by 6.32 and 7.52 percentage points, respectively. Hence, intensified MNE activities expanded the disparity in the labor share across firm types. Interestingly, this increase in disparity is even stronger when we fix the extensive margin in the model, with non-MNE labor share rising by as much as 3.19 percentage points compared to the baseline but Thai-MNE labor share falling by as much as 10.43 percentage points. This finding reveals that the selection mechanism mitigates disparity. For example, a marginal firm that shifts from being a RoW-MNE to a Thai-MNE has a relatively high labor share among Thai MNEs. Therefore, its inclusion as a Thai MNE increases total Thai-MNE labor share.

Finally, Panel 6b shows the labor share implication across firm-size deciles, and confirms that the foreign productivity shock contributes to the reduction in the labor share across firm sizes. Notably, we find that the labor share reduction in larger firms is greater, revealing both

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

(a) By MNE Status

(b) By Firm Size



Note: Panel a on the left shows the results of the quantitative exercise described in the main text. The "Aggregate" group on the left of Panel a shows the observed corporate labor share in the 1995 baseline year (blue bar), the 2007 model-implied labor share (orange bar), and the 2007 model-implied labor share with MNE selection fixed (yellow bar). The rest of Panel a shows the corresponding exercises for the group of non-offshoring firms ("Non-MNE", $d = 00$ in the model), offshoring firms to the Rest of the World ("RoW-MNE", R-offshoring or $d = 01$ in the model), and offshoring firms to Thailand ("Thai-MNE", T-offshoring or $d = 11$ in the model). Panel b on the right of Figure 6 shows the labor share implication across firm-size deciles, with the horizontal axis 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 due to the simulated foreign productivity shock.

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, but show an even more pronounced heterogeneity of labor share reduction across firm sizes.

5.3 Welfare

Finally, we briefly discuss the welfare implication of foreign factor productivity growth. While our small open economy did not require specifying total expenditure and income to determine factor prices, here 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: 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 is also 1.4%, which can be obtained by assuming that all generated income is 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 $i \in \{T, R\}$. Taking these together, while MNE activities had a negative impact on aggregate home-country corporate labor share, it has a moderate positive effect 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 examined the impact of increased utilization of foreign factors by multinational enterprises (MNEs) on corporate labor share in the home country. We began by conducting a decomposition analysis of the Japanese corporate labor share to investigate the factors contributing to its decline. Additionally, we estimated the effect of the major floods in Thailand in 2011 and, based on these findings, we developed a heterogeneous firms model of production, incorporating foreign factor employment using a nested CES production function. By treating the flood shock as an instrumental variable, we then estimated a crucial substitution elasticity between foreign factors and home-country labor, finding that they are gross substitutes. From the estimated model, we found that the increase in foreign factor productivity accounted for a 1.4 percentage point decline in the corporate labor share in Japan from 1995 to 2007.

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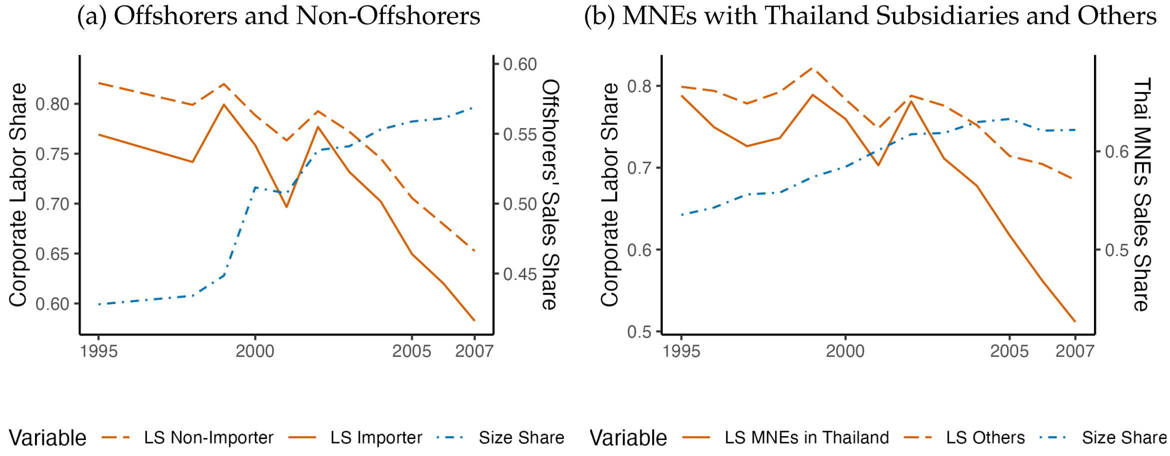
Online Appendix

A Empirical Appendix

A.1 Comparison of Offshorers and Non-Offshorers

Since our model is largely about offshoring, with MNE operations in Thailand, this section presents the results of a simple decomposition analysis comparing offshorers (firms that import a positive amount each year) and non-offshorers (Figure A.1a) and MNEs with subsidiaries in Thailand and other firms (Figure A.1a). The findings are qualitatively similar to those shown in Figure 1.

Figure A.1: Alternative Simple Decomposition of Labor Shares



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

A.2 MNEs and Labor Share Across Country

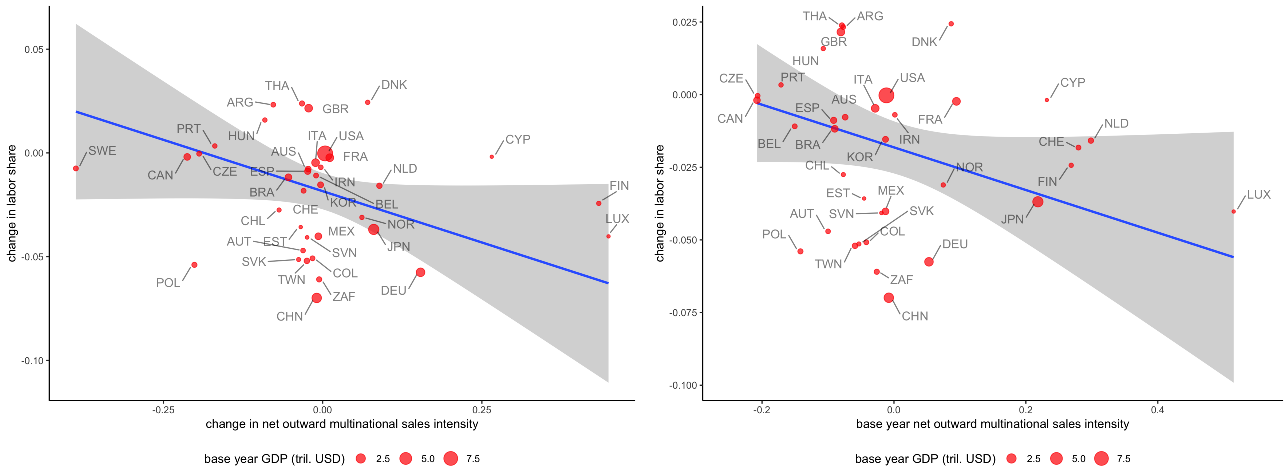
To empirically motivate our analysis, we conducted a cross-country correlation between the intensity of outward MNE activities and the change in labor shares using UNCTAD data on multinational activities. First, the level of outward multinational activities is calculated by taking the 1996-2000 average net outward multinational sales normalized by each country's GDP, which we call *MNE intensity*. The change is then calculated between the 1991-1995 average and 1996-2000 average. Second, the change in the labor share between 1991 and 2000 is calculated using labor share data derived from Karabarbounis and Neiman (2013). 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 in 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 for labor more than capital demand in the source country.

A.3 Comparison of BSOBA and PWT

In this section, we compare aggregate wage measures from BSOBA, our primary source of data about multinational production, and an alternative source, PWT. Note that PWT aggregate wage is calculated from the total labor cost and total employment in each country. Thus, a wage difference emerges if Japanese-parented subsidiaries hire a different mix of

Figure A.2: Outward Multinational Activity and Labor Share

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



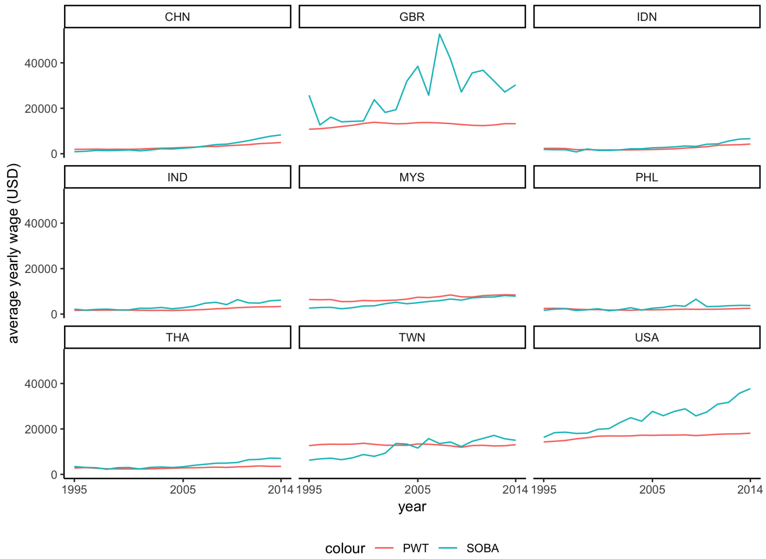
Note: Data are from Karabarbounis and Neiman (2013) and UNCTAD. In both panels a and b, the vertical axis is the change in labor share from 1991 to 2000, and fitted lines weighted by the base-year GDP are drawn with the 95 percent confidence intervals. In panel a on the left, the horizontal axis is the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

workers than other firms in each country. Figure A.3 shows the comparison of BSOBA and PWT for the nine countries with the highest total employment by Japanese subsidiaries at the end of FY2015. From the figure, one can see that for most countries, the BSOBA and PWT show a similar trend, so we conclude that Japanese subsidiary firms hire workers from a similar labor market as other firms in each country. However, there are several interesting deviations from this pattern, particularly in high-income countries such as the UK and the US. This might reflect the fact that the Japanese subsidiaries in these countries focus on high value-added activities such as finance, which would cause the hiring structure of Japanese subsidiaries to be different from other firms. Table A.1 presents the results of a regression of the PWT wage on the BSOBA wage with or without fixed effects, showing that the fit is remarkably high for cross-section, cross-year data.

A.4 Markup Trend in Japan

This section discusses another possible explanation for the observed decrease in labor share presented by De Loecker and Eeckhout (2017), who argue that declining labor share can be explained by a surge in market power. Using a parsimonious but versatile method to back out the markups from firm- or plant-level data, they conclude that the markup in the US has been increasing steadily since around 1980. When we apply their method to our Japanese firm-level BSJBSA data, however, we find a considerably smaller increase in markups relative to the US, which is in line with the previous literature (De Loecker and

Figure A.3: Comparison of BSOBA and PWT



Note: This figure shows a comparison of the average yearly wage in the BSOBA and PWT data among the nine top Japanese MNE destination countries.

Eeckhout, 2018; Nakamura and Ohashi, 2019). Thus, the decrease in labor share in Japan is less able to be explained by increasing markups than in the US.

A.5 Alternative Labor Share Measures

Measuring labor share is not a trivial matter, and the research literature includes extensive discussions of appropriate measurements. In this section, 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. Figure A.5, exhibits three measures of labor shares proposed in the literature. First, the SNA labor share, which is the total labor cost divided by GDP from the System of National Accounts, shows a decreasing trend. However, since GDP or value added contains capital depreciation, it overstates 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 capital depreciation (and also excludes indirect taxes but includes subsidies). Next, another issue is the treatment of the mixed income of those who are self-employed. Since self-employees typically own the production capital and labor themselves, the allocation of generated income to labor and capital (e.g., Rognlie, 2018) needs to be made with a strong assumption, possibly causing a misallocation bias. To remove such biases, we take the trend of corporate factor income and the compensation payment to the labor. In all measures we considered, the labor share has declined significantly over our sample period.

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

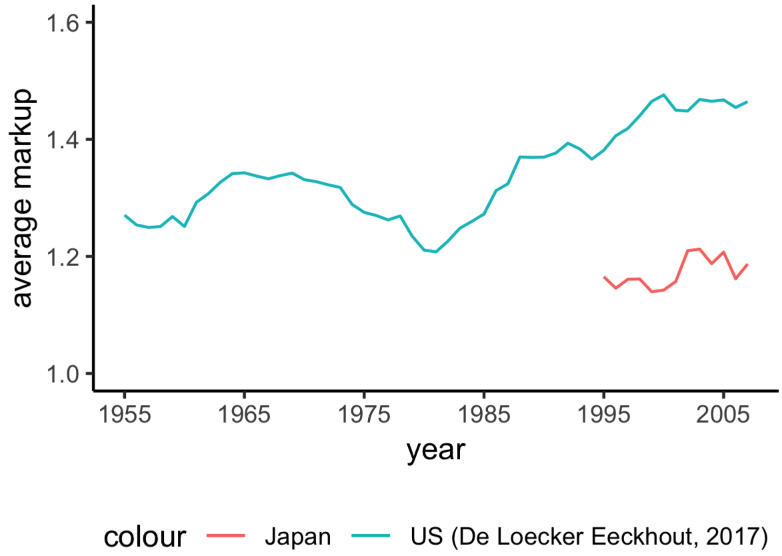
Note: The table presents the regression coefficients obtained by correlating the log wages of BSOBA and PWT. Each observation corresponds to a unique country-year pair. The first two columns include the entire sample, whereas the final two columns isolate the top nine destination countries for Japanese 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.

A.6 Thailand Gross Export and Import Trends

Figure A.6 shows the trends of Thailand's exports and imports, using data from UN Comtrade. Recalling that 2011 was the year of the floods, we see that Thai export and import trends were roughly parallel before the floods, but this pattern was broken when the floods caused exports to flatline until 2014 while imports continued to rise for several years. This observation is consistent with our interpretation that the flood shock heavily impacted the supply side of the economy, given that several large-scale manufacturing industrial parks were inundated. This is also consistent with Benguria and Taylor (2019), who discuss a method for identifying demand and supply shocks from gross export and import data during financial crises. They find that "firm-deleveraging shocks are mainly supply shocks and contract exports," while imports are left largely unchanged.

To provide context that the trends in Thailand's international trade were due to exogenous events rather than policy shifts during the period under study, the following is a brief overview of Thailand's economic policies prior to the floods of 2011. First, regarding international liberalization, Thailand moved prior to its Southeast Asian neighbors, becoming one of the original member countries of the *Association of Southeast Asian Nations* (ASEAN) and entering GATT in 1982. In the early 2000s, it established FTAs with several large economies (India in 2003, the US in 2004, Australia and Japan in 2005), and ASEAN as an association also made some major internal and external FTAs in which Thailand participated. The internal FTA became effective in 1993, and by 2003, internal tariffs were driven down to below five percent. Among the external ASEAN FTAs with other large economies is one established with China in 2003. Due to active international liberation by Thailand from the 1980s through the early 2000s, we do not find extensive large-scale globalization

Figure A.4: Markup Estimates



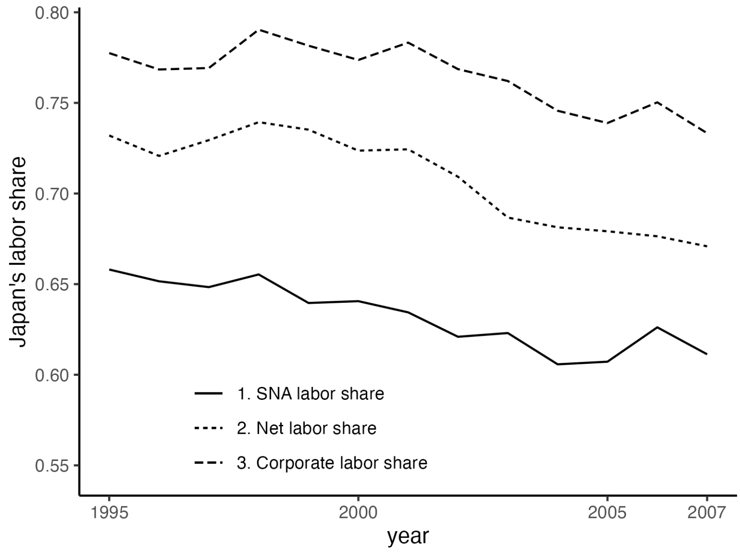
Note: Authors' calculation based on De Loecker and Eeckhout (2017) using 1995-2016 data from the Basic Survey on Japanese Business Structure and Activities (BSJBSA). The variable input cost is the sum of labor compensation and intermediate purchases. The output elasticity is estimated by the Olley and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

in the international economic policy sphere between 2007 and 2016, with several exceptions including the ASEAN-South Korea FTA that reduced the tariff between South Korea and Thailand in 2010 and the Chile-Thailand FTA that became effective in 2015. The pattern of gross trade trends in Figure A.6 are consistent with this history, showing that the drivers behind the changes in trade trends are external business cycles (e.g., the global great recession since 2008) or political upheaval (e.g., a coup d'état in 2014) rather than large shifts in trade policy.

A.7 Overview of Japanese Subsidiaries in Thailand

In this section, using the datasets described above, we show some statistics about production in the flooded region. First, to understand the industry clustering patterns in detail, Figure A.7 shows the distribution by industry of the Japanese subsidiaries in the flooded regions in terms of sales and number in 2011. As mentioned earlier, the largest industry that was affected by the floods was Transportation Equipment, which includes automobiles, as measured both in total sales and the number of local subsidiaries. In total sales, Electronics is a far distant second, while Others and Chemicals are next in terms of number of subsidiaries. The difference between Transportation Equipment and other industries is less dramatic when measured by the number of subsidiaries rather than by total sales, partly because of the high unit value of Transportation Equipment.

Figure A.5: Alternative Labor Share Measures

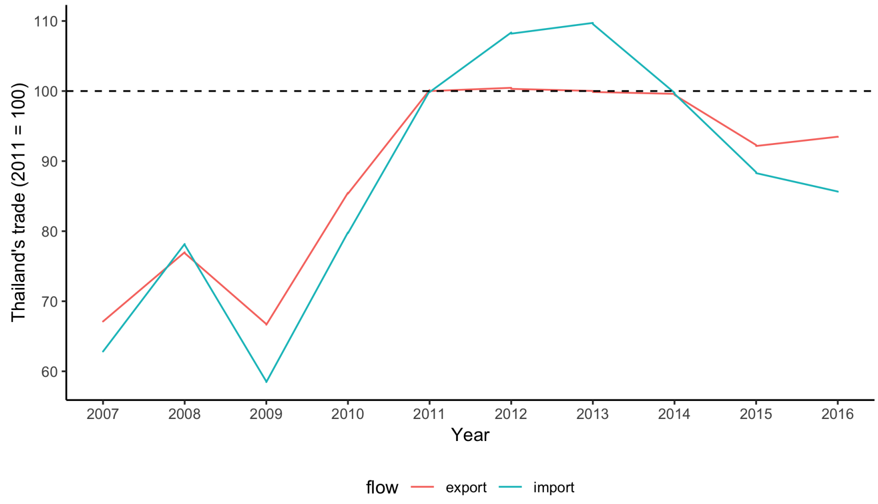


Note: Several labor share measures in Japan from 1995 to 2007 are shown. Taken from the 2015 Japan Industrial Productivity (JIP) Database administered by the Research Institute of Economy, Trade and Industry (RIETI), the JIP labor share is calculated as the share of nominal labor cost in nominal value-added of JIP market economies (Fukao and Perugini, 2021). Net labor share is the fraction of nominal employee compensations over nominal national income, taken 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 System of National Accounts (SNA), as wages and salaries divided by the sum of wages and salaries and net operating surplus.

A.8 The Floods and Aggregate Trends

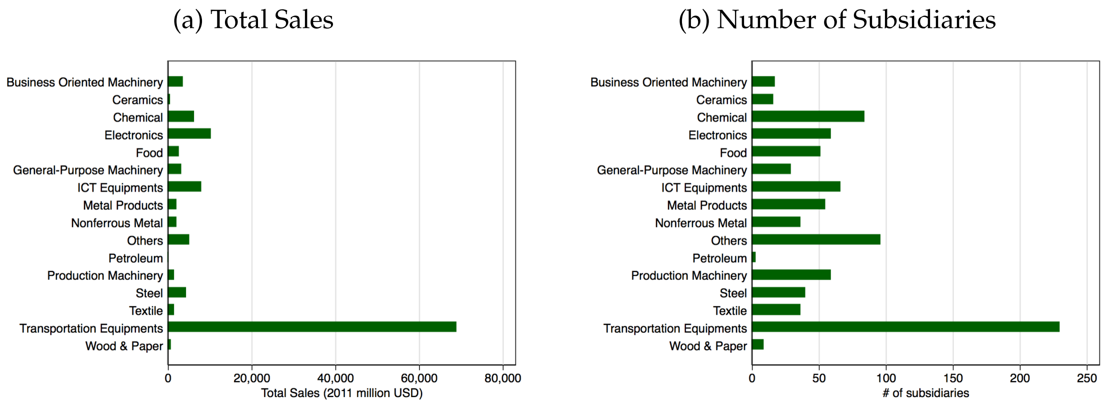
Here, we show the aggregate statistics of Japanese MNEs in our dataset as described in Section 2.1. The top two panels of Figure A.8 show the normalized trend of total employment (Panel A.8a) and the number of subsidiaries (Panel A.8b) in flooded regions (the solid line) versus the rest of the world excluding Japan (the dashed line). Focusing on first on Panels a and b, we notice that, by both measures, the ROW trend is increasing over the sample period, indicating that more firms are becoming MNEs and hiring foreign workers. Second, the trend in the flooded regions is broken in 2011, the year of the floods, after having experienced an increasing trend before 2011 similar to or even more rapid than ROW. The *persistence* of this decline is also noteworthy. Even though the floods were short-lived and the immediate recovery was over in most regions by early 2012, the decreasing trend of both total employment and number 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 future floods, they "move[d] to avoid potential supply chain disruptions" (Nikkei Asian Review, 2014). Our estimate of the long-run elasticity is due to these findings.

Figure A.6: Trend of Thailand's Trade



Note: The figure shows Thailand export and import trends taken from COMTRADE data. The trend is normalized to 100 in 2011.

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



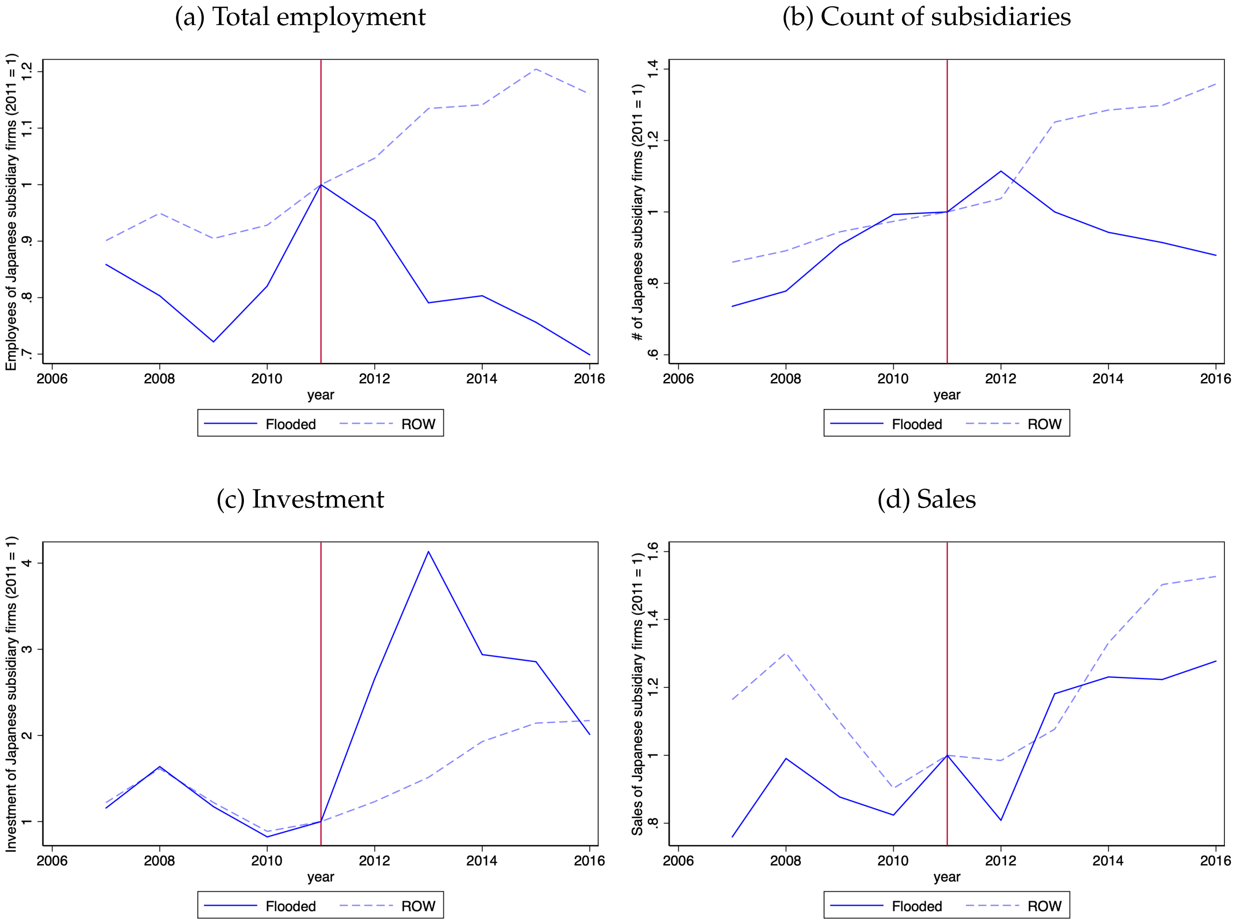
Note: The figure shows the distribution by industry of the Japanese subsidiaries in the flooded areas (*Ayutthaya* and *Pathum Thani* Provinces) by total sales (Panel A.7a) and number of subsidiaries (Panel A.7b).

Turning next to the bottom of Figure A.8, we see the trends for investment (Panel A.8c) and sales (Panel A.8d). Interestingly, the trends for investment in the flooded region and the rest of the world follow a parallel path before the floods, but this pattern breaks sharply after the floods, reflecting the much greater investment required to reconstruct damaged plants after the floods. In terms of sales, however, the trends in the affected region and ROW do not exhibit a parallel path before or after the floods.

A.9 Notes on the Choice of the Treatment Group

As discussed in Section A.8 and earlier in the paper, the 2011 Thailand Floods severely affected Ayutthaya and Pathum Thani provinces, so it is important to focus on these particular

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



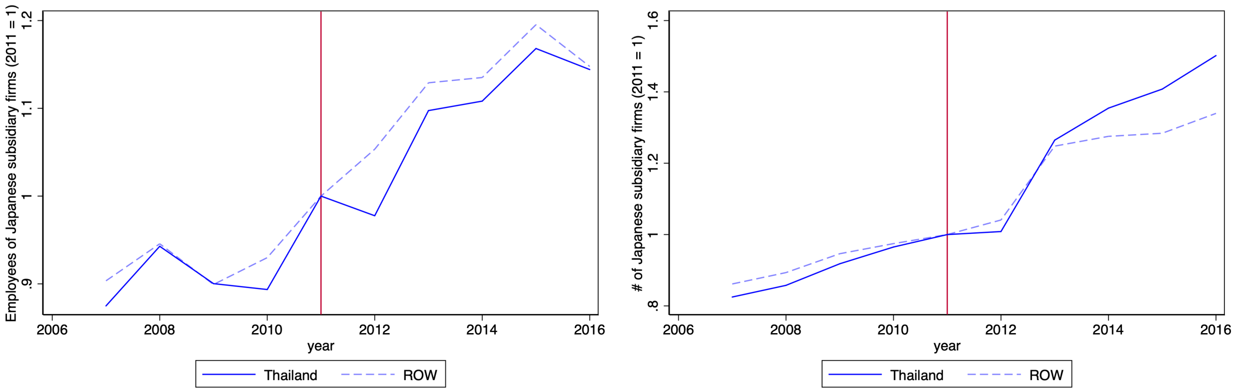
Note: The figure shows the trends of aggregate variables in flooded regions and the rest of the world, excluding Japan. In all panels, "Flooded" shows the evolution of total employment in plants located in the flooded area (*Ayutthaya* and *Pathum Thani* Provinces), and "ROW" shows plants in all other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

provinces because overall employment or numbers of subsidiaries of Japanese MNEs did not decrease in Thailand after the floods, as seen in Figure A.9. While Figure A.8 in the previous section compares the flooded provinces and non-flooded provinces in Thailand, Figure A.9 shows the trends in employment and number of subsidiaries within and outside of Thailand, and we can see that the impact of the floods is not as stark as in Figure A.8.

A.10 Mechanisms and Robustness Checks

In this section, we consider other possible mechanisms and robustness checks of our model. Figure A.10 shows the regression results of equation 3 with alternative outcome variables. Panels A.10a, A.10b, and Panel A.10c show the results using the total number of foreign subsidiaries, subsidiaries in Thailand, and log Thailand employment, respectively. Consistent with the subsidiary-level results in Figure 4, there are sizable negative effects on the num-

Figure A.9: Trends of Japanese MNEs, Thailand versus ROW

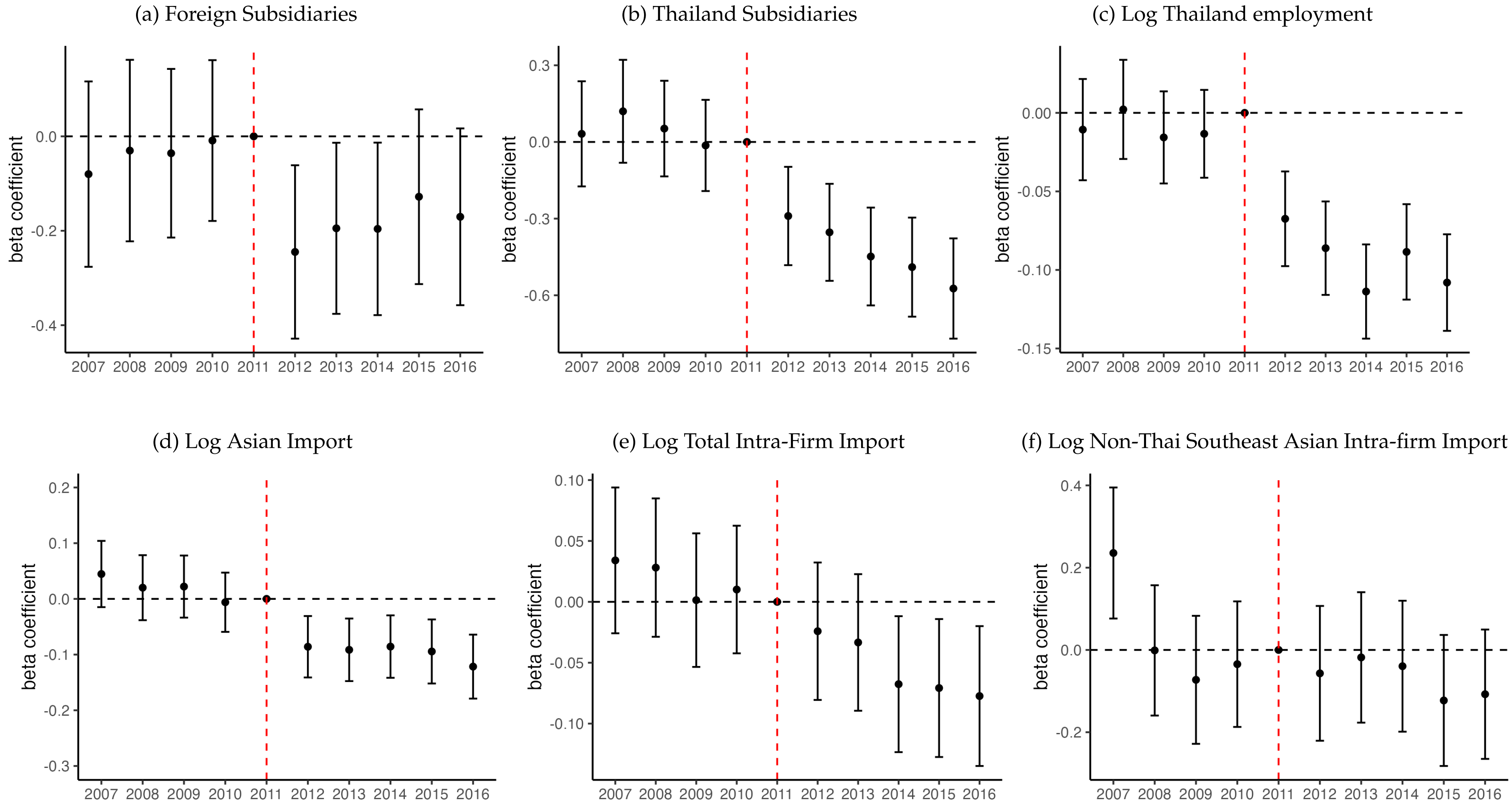


(a) Total employment (b) Count of subsidiaries

Note: The figure shows the trends of aggregate variables in Thailand and the rest of the world, excluding Japan. In all panels, "Thailand" shows the evolution of total employment in plants located in Thailand, and "ROW" shows that of 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 number of subsidiaries.

ber of operating subsidiaries and employment. Additionally, Panels A.10d and A.10e show that imports from Asia and intra-firm networks decline after the floods, which confirms the result from Figure 5b.

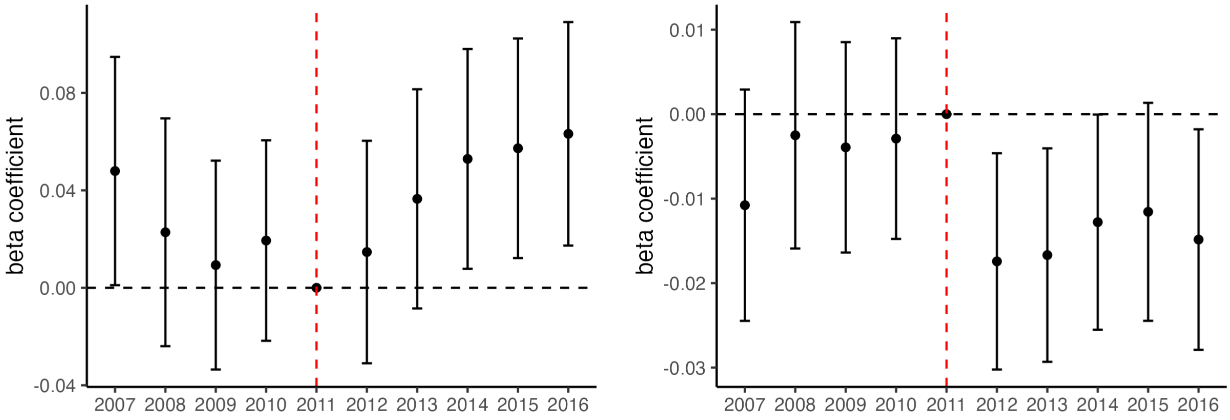
Figure A.10: More Evidence of The Effects of the Thailand Floods on Headquarters



Note: The figure plots coefficient estimates of a headquarter-level event-study regression of equation (4) using different outcome variables. 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 the log total intra-firm import value, and panel (f) takes the 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 a headquarter-level event-study regression in equation (4). Panel (a) takes the number of Thailand subsidiaries as the outcome variable, 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.

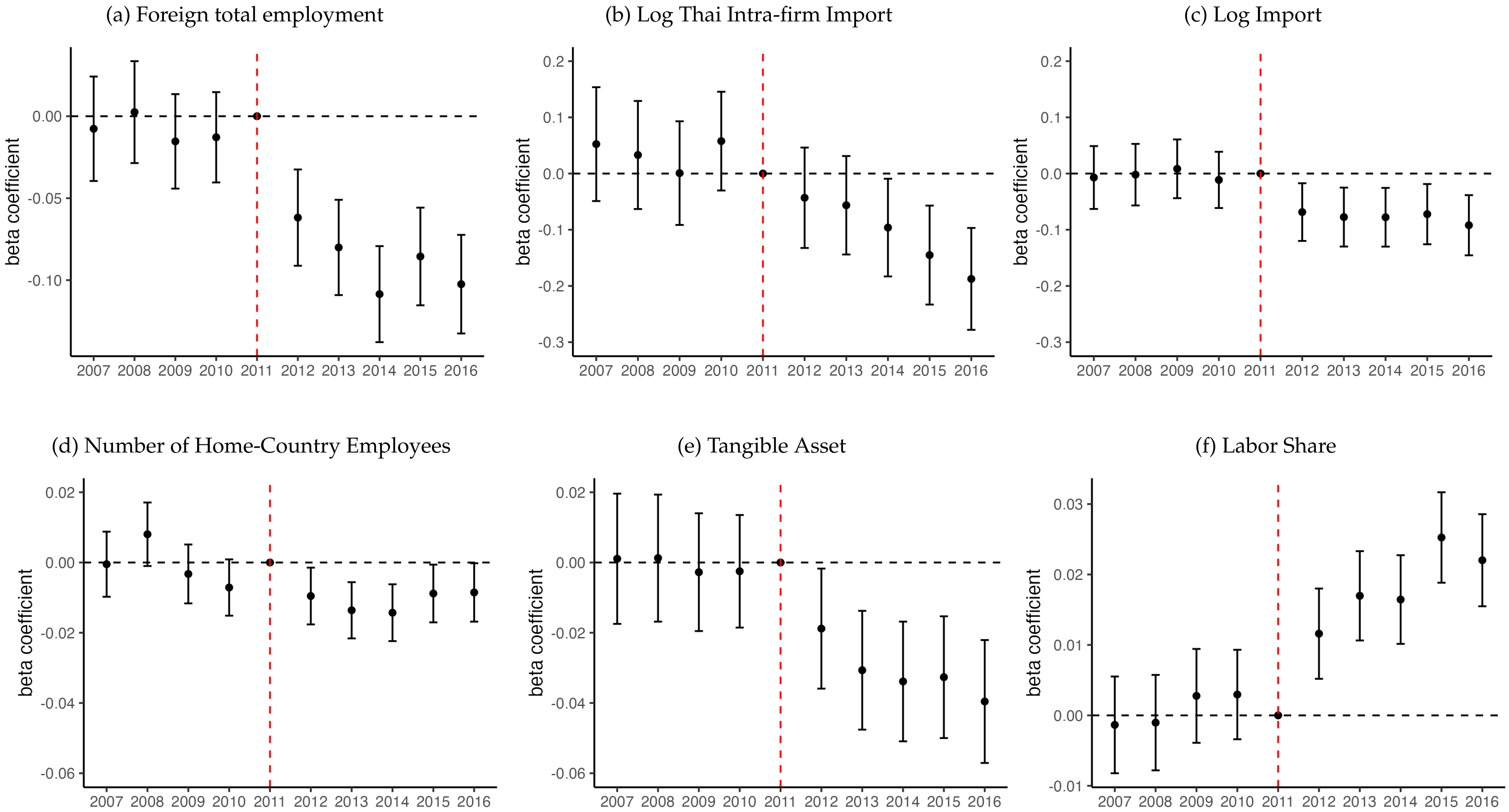
Next, we consider work status, as the weaker effect on employment than on capital demand suggested in Figure 5 could potentially be partly explained by an increase in non-regular workers. In Japan, non-regular workers include part-time, contract, and temp workers dispatched from temporary employment agencies, and their number is growing rapidly (Morikawa, 2010). Overall, they are a type of worker with flexible labor arrangements that can be adjusted by firms with relative ease. Panel A.11a presents a view consistent with this hypothesis, as non-regular workers increased after the floods and offshore activities weakened. Therefore, firms affected by the floods may have reacted by substituting foreign workers with non-regular domestic Japanese workers. Furthermore, Panel A.11b shows that the effect on fixed asset is as negative as that on tangible assets as seen in Figure 5e.

Since our model considers vertical multinational production where the foreign factors provide added value to the global production process, our main regression results in Table 5 should also hold with the MNEs that have subsidiaries that sell 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 but the numerator is number of employees in subsidiaries that are in Ayutthaya and Pathum Thani provinces and which export back to Japanese HQ. Figure A.12, which shows the result of event study specification (4) with this alternative shock variable and various outcome variables, confirms the robustness of our model to this change.

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



Note: The figure plots coefficient estimates of the headquarter-level event-study regression specified in equation (4) with the alternative shock variable defined in equation (A.1). As outcome variables, panel (a) takes log total foreign employment (including the flooded regions), panel (b) the log value of intra-firm import from Thailand to the Japanese headquarter, panel (c) the log import value, panel (d) the log home-country employment, panel (e) the log tangible asset stock, and panel (f) 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.

Lastly, we examine the possible effect of heterogeneity of 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", whereby a child subsidiary refers to a foreign corporation in which the Japanese firm owns 10% or more of the ownership stake and 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. Under this definition, foreign production is not limited to greenfield investments, which are new operations set up in foreign locations, but also includes the acquisition of foreign companies such as through mergers and acquisitions (M&A).

Figure A.13 shows the result of regression 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), confirming that our main result in Figure 3 is driven by both wholly-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 of Firms in Thailand and Not in 2011

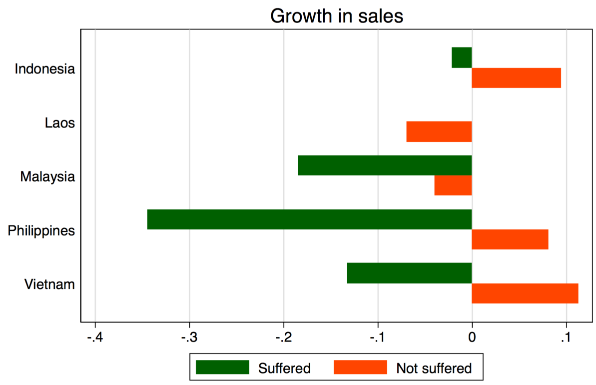
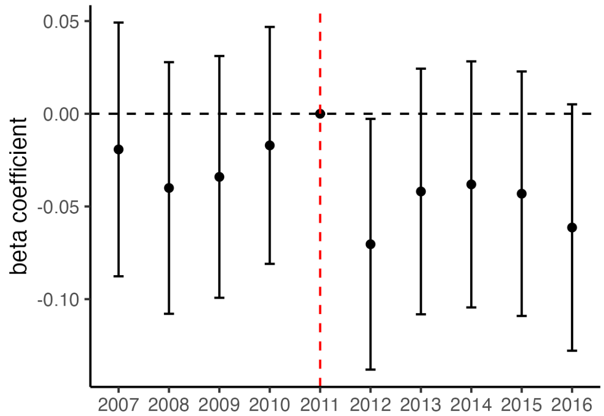
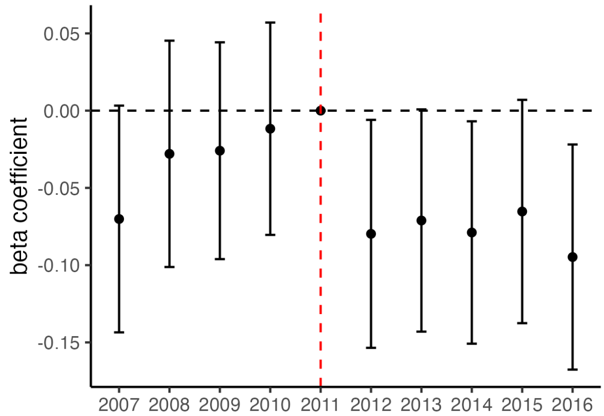


Figure A.15: Headquarter-Level Third Country Effects

(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.

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.14 illustrates 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 any third country, 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. Notably, 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, even 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) 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 a plant-level control variable, and $b_{0,j}$ is an industry-j fixed effect. The log local wage term $\ln\left(w_{\text{city}(i)}\right)$ is instrumented 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 the ten-year period prior to the analysis period, and g_j is the leave-one-municipality-out growth rate of national employment in industry j over the ten year period that preceded the analysis year taken from the Employment Status Survey (ESS). We find that wage variation across local labor markets is significant and persistent, so we interpret that the coefficient obtained by such variation provides the long-run elasticity of substitution.

We apply this method to obtain the factor expenditure ratio $(r_J k / w_J l)_i$ using the *Census of Manufacture* (CoM), as the plant-level data of the CoM can capture the factor use reaction to the local labor market shock more accurately than firm-level data such as the BSJBSA. Following Oberfield and Raval (2021), we measure $r_J k$ by the initial stock of tangible assets in the next year's 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, which includes three values: multiple plants, no other plants or headquarter office, no other plant but with headquarter office. We include the fixed effect for all of these values in specification (A.2). There are 1700 municipalities, which is a fine delineation of local labor markets 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, the *Basic Survey on Wage Structure* (BSWS) administered by Japan's Ministry of Health, Labour and Welfare offers 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 a high standard of the significance level, 0.1 percent.

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

In order to address a concern that our findings might be due to the control group chosen, we conducted a robustness check considering all firms in Japan instead of firms operating in Thailand and also a balanced panel of firms in Japan (Desai et al., 2009) as the control group. In this section, we also investigate the impact of the flood shock by an extensive margin. Specifically, an MNE was affected by the floods if and only if it was operating in the flooded region. Thus we define the extensive-margin flood 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 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 any concerns that Thai investors may

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: The table presents regression results of equation (24) with an alternative sample of Japanese headquarter firms and an alternative definition of the Thailand Floods IV. All columns take the log Japanese employment as the outcome variable. Columns 1 and 2 use all firms in Japan as indicated by "Full sample" in the top of the table, and columns 3 and 4 use all firms in Japan using the balanced panel as indicated by "Balanced panel" in the top of the table. The variable "shock" is the interaction term of the shock intensity and the after-the-floods indicator. Columns 1 and 3 use an extensive margin IV that interacts the dummy of employing more than one employee in the flooded region with the after-flood dummy as indicated by "Ext." (or Extensive margin) in the top of the table, while columns 2 and 4 use an intensive margin IV defined by the share of pre-flood employment share in the flooded area interacted by the after-flood dummy as indicated by "Int." (or Intensive margin) in the top of the table. Standard errors are clustered at the firm and industry-year level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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

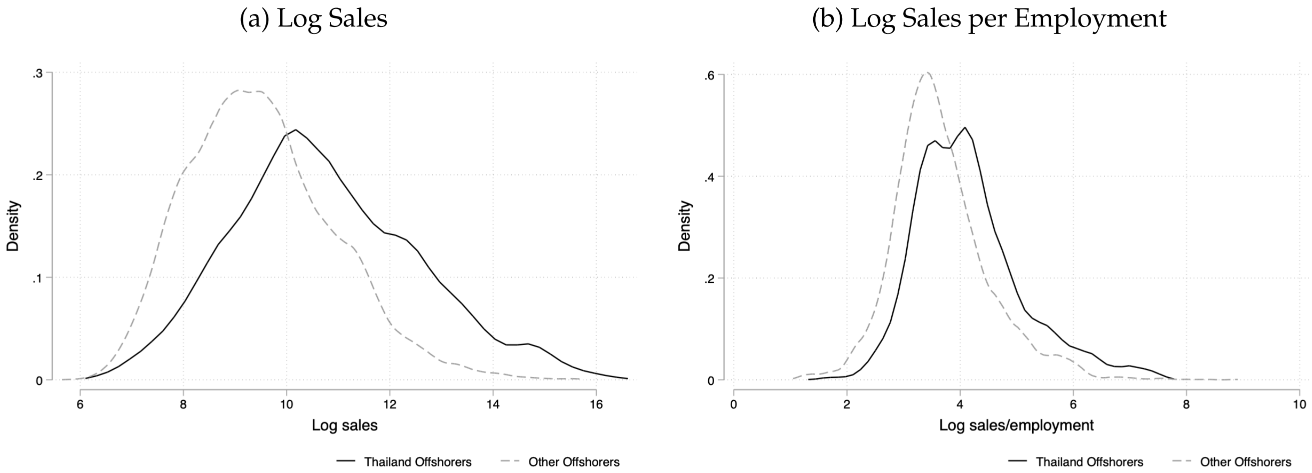
We examine the suitability of the constant factor substitution elasticity λ across different sectors in our model by analyzing the 2SLS regression coefficients across various sub-sectors. The regression results of equation (24) for each industry are displayed in Table A.3. Panel A presents the first-stage regression estimates of log Thai employment on the flood shock variable Z_{it}, Panel B displays the reduced-form regression estimates of log Japanese employment on Z_{it}, and Panel C presents the 2SLS regression estimates of log Japanese employment on log Thai employment, using Z_{it} as the IV. Consistent with the main regression, we observe significant negative estimates in both the first-stage and reduced-form regressions, which result in positive estimates in the 2SLS, specifically in the overall manufacturing sector (column 1), the metal sub-sector (column 3) and the automobile sub-sector (column 6). However, we do not observe significant coefficients in other sub-sectors, which suggests insufficient estimation power to identify sub-sector-specific coefficients using our regression sample. Therefore, in our primary structural estimation analysis, we consolidate all sub-sectors into a single regression analysis and estimate the sector-constant substitution elasticity λ.

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: The table presents the regression results of equation (24) with the sample of Japanese headquarter firms operating in Thailand at the industry level. In panel A, the regressor is employment in Thailand while 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



Note: The figure shows the distribution of log sales (left panel) and log sales-to-employment ratio (right panel) of group of Japanese 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 of Firms Entering Thailand and Others

Figure B.1 shows the distribution of log sales (left panel) and the log sales-to-employment ratio (right panel) of multinational firms that had subsidiaries in Thailand ("Thailand Offshorers") and those who did not ("Other Offshorers") in 2011. The distribution of Thailand Offshorers first order-stochastically dominates that of the Other Offshorers 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

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

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

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

Using these expressions, the change in the aggregate capital demand can be derived as follows. First, it can be rewritten as

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

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

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

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

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

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

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

$$L_{01,j}^{D} = \int_{\psi_{01,j}}^{\psi_{11,j}} \left((w_J)^{-\lambda} \left(p_{01,j}^{h}\right)^{\lambda-\sigma_j} \left(c_{01,j}(\psi)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j-1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j-1} Q_j \right) dG_j(\psi),$$

$$L_{11,j}^{D} = \int_{\psi_{11,j}}^{\infty} \left((w_J)^{-\lambda} \left(p_{11,j}^{h}\right)^{\lambda-\sigma_j} \left(c_{11,j}(\psi)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j-1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j-1} Q_j \right) dG_j(\psi),$$

and similarly for the Thailand factor demand,

$$X_{T,00,j}^{D} = \int_{\underline{\psi}_j}^{\psi_{01,j}} \left(\left(\frac{p_T^x}{a_T}\right)^{-\lambda} \left(p_{00,j}^{h}\right)^{\lambda-\sigma_j} \left(c_{00,j}(\psi)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j-1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j-1} Q_j \right) dG_j(\psi),$$

$$X_{T,01,j}^{D} = \int_{\psi_{01,j}}^{\psi_{11,j}} \left(\left(\frac{p_T^x}{a_T}\right)^{-\lambda} \left(p_{01,j}^{h}\right)^{\lambda-\sigma_j} \left(c_{01,j}(\psi)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j-1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j-1} Q_j \right) dG_j(\psi),$$

$$X_{T,11,j}^{D} = \int_{\psi_{11,j}}^{\infty} \left(\left(\frac{p_T^x}{a_T}\right)^{-\lambda} \left(p_{11,j}^{h}\right)^{\lambda-\sigma_j} \left(c_{11,j}(\psi)\right)^{\sigma_j-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j-1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j-1} Q_j \right) dG_j(\psi).$$

Hence, using a similar method, we have

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

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

where

$$S_j^L = \frac{w_J L_j}{\sum_k w_J L_k},\ S_{d,j}^L \equiv \frac{w_J L_{d,j}}{w_J L_j},\ S_j^{X_T} = \frac{p_T^x X_{T,j}}{\sum_k p_T^x X_{T,k}},\ S_{d,j}^{X_T} \equiv \frac{p_T^x X_{T,d,j}}{p_T^x X_{T,j}},$$

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

Finally, the derivation of $\hat{c}_{d,j}$ is standard, as follows.

$$\begin{aligned} \hat{c}_{d,j} &= \left(\frac{\alpha_j^k \left(r_J'\right)^{1-\sigma_j} + \alpha_j^h \left(p_{d,j}^{h\prime}\right)^{1-\sigma_j} + \left(1-\alpha_j^k-\alpha_j^h\right)\left(p_j^m\right)^{1-\sigma_j}}{\alpha_j^k \left(r_J\right)^{1-\sigma_j} + \alpha_j^h \left(p_{d,j}^{h}\right)^{1-\sigma_j} + \left(1-\alpha_j^k-\alpha_j^h\right)\left(p_j^m\right)^{1-\sigma_j}} \right)^{\frac{1}{1-\sigma_j}} \\ &= \left(s_{d,j}^K \left(\hat{r}_J\right)^{1-\sigma_j} + s_{d,j}^H \left(\hat{p}_{d,j}^h\right)^{1-\sigma_j} + \left(1-s_{d,j}^K-s_{d,j}^H\right) \right)^{\frac{1}{1-\sigma_j}}, \end{aligned} \tag{B.6}$$

where

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

and

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

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

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

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 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 the ratio of equations (14) and (15) for $d = 11$, we have

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

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

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

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

which is equation (25).

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

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

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

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

where

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

summarizes the sectoral relative demand share. To derive the remaining terms, we focus on the case $\psi_{11,j} > \psi'_{11,j}$ whereby 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

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

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

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

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

Hence, we have

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

Furthermore, we have

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

where the threshold change can be obtained in 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

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

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

with the sector j-group g-specific MNE status d's factor shares 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 $\hat{S}_g^L = \hat{S}_g^{L|C} \widehat{\left[\sum_j \left(w_J L_{g,j} + r_J K_{g,j}\right) / X_{g,j}^J\right]}$. Therefore, it remains to be shown that $\widehat{\left[\sum_j \left(w_J L_{g,j} + r_J K_{g,j}\right) / X_{g,j}^J\right]} = \hat{S}_g^X$. 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

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

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 added in each derivation there. □