Multinational Production and Corporate Labor Share*

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Abstract

This study examines how multinational enterprises (MNEs) affect labor share in their home countries, using the 2011 Thailand Floods as a natural experiment. The disaster disrupted Japanese MNEs, slightly reducing labor demand and significantly lowering capital demand in Japan. A general equilibrium model with offshore inputs and an extended hat algebra solution method are introduced. The elasticity of substitution between domestic labor and offshore inputs is estimated using a two-stage least squares regression, with an instrumental variable from the flood's impact. Results indicate that higher foreign productivity boosts capital demand over labor in Japan, reducing corporate labor share by 1.4%.

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

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

1 Introduction

A growing body of evidence suggests that labor share has been decreasing in developed countries over recent decades, raising concerns among policymakers about widening in-

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come 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 many potential mechanisms that could underlie technological changes, 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.

Our analysis uses novel causal evidence derived from a natural experiment resulting from the 2011 Thailand Floods. The floods caused a significant negative productivity shock to Japanese subsidiary firms in Thailand, where parent firms in Japan typically offshore their production. We demonstrate that Japanese MNEs with subsidiaries in the flooded areas experienced differing trends after the floods in foreign and home-country activities, such as employment and capital demand, compared to other MNEs in Thailand not in the flooded areas. 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 offshoring firms that combine home-country labor, home-country capital, and foreign factors. 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.

To motivate our analysis, we show a simple trend plot highlighting the role of MNEs in the declining labor share in Figure 1. 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. A unique feature of this event is that many firms affected by the floods are foreign subsidiaries of Japanese MNEs. 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

[1] Appendix A.1 also shows similar comparisons between MNEs with and without offshoring and between MNEs with and without subsidiaries in Thailand. Appendix A.2 shows additional motivational evidence from cross-country variation in the labor share change and outward MNE intensities.

floods had a long-lasting impact on activities of MNEs in the affected regions, with our event-study regression indicating a decline in foreign and home labor compensation and operating surplus among affected Japanese MNEs compared to Japanese MNEs with subsidiaries in Thailand that were not affected by the floods. This result is consistent with complementarity within an MNE that a negative productivity shock in one location spills over to other locations, a reminiscent of the scale effect mechanism in models of offshoring.

Moreover, we find that the floods-induced reduction in fixed assets in Japan 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. This result suggests that labor is more substitutable than capital in the foreign operations of MNEs.

We interpret these empirical findings using a general equilibrium model of heterogeneous offshoring firms with multiple inputs. Factor prices, which are endogenously determined by factor market-clearing conditions, are key variables driving labor share. The model has two mechanisms through which the aggregate corporate labor share is affected: a within-firm effect and a between-firm effect. If labor is more substitutable with foreign inputs than capital, the productivity growth of the foreign factor decreases the demand for labor relative to capital and thus pressures the relative wage downwards (within-firm effect). Moreover, such a foreign factor productivity growth disproportionately benefits already offshoring firms, which tend to be low labor share in the data. Therefore, when constructing aggregate labor share, already offshoring firms' weight increases, which reduces the aggregate labor share (between-firm effect).

To solve this model, we extend a "hat algebra" method, which expresses equilibrium conditions in terms of the change from before shocks to after shocks and makes explicit the dependence of equilibrium conditions on observed expenditure shares rather than unknown parameters. However, because our model has heterogeneous firms, such expenditure shares include cost saving by offshoring of the firm at the productivity cutoff. Since we cannot observe a firm both offshoring and not offshoring simultaneously, the standard hat algebra is inapplicable. Our solution to this problem 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. We show that the 2SLS estimator is the ratio of the indirect employment effect of the foreign productivity shock through the change in the cost index and the sum of this indirect effect and the direct substitution effect. This relationship provides a restriction for the target 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 Cobb-Douglas function 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 show that foreign productivity growths implied from data explains a 1.4 percentage point reduction in the aggregate corporate labor share in Japan between 1995 and 2007.[2] We also perform a decomposition exercise of this labor share decline and discover that the 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 substituting home-country labor with foreign inputs.

This paper makes contributions to four distinct but related 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).[3] 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. We extend this perspective by arguing that the deepening of global value chains, represented by intensified MNE operations, play a role in reducing labor share.

In recent studies, Sun (2020) and Leone (2023) delineate 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. Leone (2023) uses Spanish manufacutring firm data to show that firms acquired by MNEs reduce labor shares with increased adoption of robots. We complement these studies in two

[2]We chose this period because after 2007, the growth of MNE activities has slowed down, and labor share decline has been weaker than before in our data. Consistently, when we perform the analysis with the period extended to 2016, the estimated effect of intensified MNE activities in foreign countries on domestic labor share is qualitatively similar to the baseline.

[3]Mechanisms proposed in the literature include automation (e.g., Acemoglu and Restrepo, 2019), participation in global value chains (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.

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,[4] but the paucity of exogenous variation has often led to weak causal evidence. Exceptions include 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. Boehm et al. (2018) also studies the international spillover of the Tohoku earthquake on the US manufacturing firms. We supplement these pieces of 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 employment and labor market, they overlooked the impact on capital demand. It is crucial, however, to examine the capital market as well as the labor market when discussing corporate labor share.

Furthermore, Castro-Vincenzi (2023) studies global car production under increased climate risks. He empirically shows the global plant production's reaction to flood shocks and explicitly models climate uncertainty in a multi-country export platform setup. Since our model does not incorporate risks, it does not address why Japanese firms' behavior changed after the shock. Instead, our primary interest in this paper is the effect of foreign productivity on corporate and aggregate labor share in the long run, conditional on the changes in firm behavior.

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 facilitates the discussion of the equilibrium adjustment of firm global strategy and factor prices, which critically affect the firm-level and aggregate labor shares.

[4] 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).

Lastly, our paper is related to the literature on solving trade models using hat algebra. Since Dekle et al. (2007) proposed the method, it has become popular in solving quantitative trade models, 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, equilibrium expressions of ratios between before and after the shock 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 (≈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 obvious outliers such as mistakes in digits but still include potential effects of very large MNEs in the analysis, 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.[5] 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 Following recent discussions in the measurement of corporate labor share (Bridgman, 2018; Rognlie, 2018), we define the firm-level labor share by

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

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 of other labor share measures and comparison with our constructed measure are discussed in Appendix A.4. Using equation (1), the aggregate labor share S_t^L is defined by $\sum_i (wl)_{it} / \sum_i [(wl)_{it} + (os)_{it}]$.

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

Figure 2 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). Appendix A.5 shows more decomposition results of the corporate labor share changes in Japan during the sample period.

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, the denominator of our measure includes a markup component in the operating surplus that is not directly tied to 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.6, markups remained constant in Japan during our sample period of 1995-2007. Furthermore, we demonstrate in Appendix A.4 that the decrease in Japanese aggregate labor share during this period is robust across alternative measures. Although these analyses do not fully preclude the influence of markups, these findings motivate us to examine the cause of labor share decline other than 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.[6] These estates housed about 800 companies, including 450 Japanese subsidiaries, many of which operated in the automobile and electronics industries and manufactured parts used in later stages of global production. Having embraced the "just-in-time" production model with minimal invento-

[6]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.

ries, 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.7 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.[7] 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).

Our sample contains 658 Japanese MNEs in Thailand in 2011. Among them, 89 have at least one subsidiary in the flooded regions. In 2011, there were 1,526 subsidiaries in Thailand, 148 of which were located in flooded regions. The majority of the subsidiaries in the inundated regions and non-inundated regions in Thailand are the automotive and electronics industries, as shown in the distribution in Appendix A.9.

Balancing Checks. To ensure that there are no systematic differences between MNEs with subsidiaries located in the flooded regions and those without, we examined firm characteristics. The treated group is defined as subsidiaries operating in the AP provinces in 2011, while the control group consists of subsidiaries located in other regions of Thailand during the same period.[8] Therefore, we control for potential cross-country differences by using the variation across geographic regions within Thailand. Figure 3 presents the results of these balancing checks, with the left panel comparing the distributions of shares of the number of firms at the 4-digit industry level 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.

[7]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).

[8]Some headquarter firms own subsidiaries both in the flooded and non-flooded regions in Thailand. In this case, firms may easily substitute production between these regions (Castro-Vincenzi, 2023). We conduct sensitivity analysis by dropping these firms in Appendix , confirming that our main results are qualitatively unchanged.

We also performed the similar balancing check for the headquarter level analysis. To do so, we categorize headquarters by the share of employment in the flooded region in the overall employment in the MNE group below and above 20%. The industry and size distribution are fairly balanced, as in the case of the subsidiary-level balancing check. See Appendix Figure A.9 for details.

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 sample of Japanese subsidiaries in Thailand:

$$y_{st} = \alpha_s^S + \alpha_{jt}^S + \sum_{\tau \neq 2011} \beta_\tau^S \times (flooded_s \mathbf{1}\{t = \tau\}) + X_{st}\gamma^S + \varepsilon_{st}^S, \tag{2}$$

where s indicates subsidiary, j indicates the industry of 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 of the interaction of the pre-flood linear trend with the floods indicator. We include the subsidiary fixed effect and industry-year fixed effect to control for the unobserved and constant firm heterogeneity and sector-year level shocks. We estimate this equation using a the set 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 stopping operation. 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. In contrast, panel (b) do not show significant sales responses for firms that are operating, suggesting that the negative effects of the floods primarily affected the extensive margin. We have also found a substantial positive response in investment among firms in the operating treatment group, which could indicate reinvestment efforts to restore damaged properties. We also observed employment response conditional on operating is not significant. These additional results are reported in Appendix A.10.

It is worth mentioning that MNEs tend to have multiple plants in multiple locations. One of the reasons for this is to mitigate the climate risks by substituting production in case of extreme climate events (Castro-Vincenzi, 2023). In our sample of 658 MNEs that owned subsidiaries in Thailand in 2011, 26 had subsidiaries in flooded and non-flooded regions. We have checked that the influence of such MNEs is minimal in our regression. We have also assessed various sample selection criteria, including whole and partial ownership. These robustness check results are reported in Appendix A.10.

Headquarter (HQ)-level Analysis. Next, we examine the cross-border effects on Japanese HQ firms. For this analysis, we select HQ firms that have subsidiaries in Thailand. We consider the following event-study specification:

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

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 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_{jt}^H is the industry-year fixed effect; and ε_{it}^H is the error term. The shock intensity measure Z_i has the mean of 0.166, the median of 0.091, and the standard deviation of 0.191 for the sample. In the HQ-level analysis, the control variables X_{it} are the pre-flood linear trend and 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.[9] 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 significant reduction in employment in foreign countries for MNEs with flooded subsidiaries in panel 5a. The effect is stronger and more persistent in Thai employment. This observation reflects the country's response "to avoid potential supply chain disruptions" in the future (Nikkei Asian Review, December 2, 2014). We have also confirmed that the effect is mostly explained by the employment reduction in the subsidiaries in the flooded regions in Appendix A.11.

To investigate international spillover effects, we examine the Japanese HQ's intra-firm trade values from Thailand and all foreign countries in panel 5b. We find a decrease in imports by affected HQs, indicating the negative effects of the flood shock across borders. Appendices A.11 and A.12 explore potential effects on the substitution of production in third countries, but little conclusive evidence is found.

Consistent with these findings, we observe negative effects on home-country factor employment. Panel 5c shows the response of log labor compensation and operating surplus

[9] We follow Carvalho et al. (2021) to flag the firms affected by the earthquake directly and indirectly through the supply chain.

in Japan, and we find that both measures are negatively affected in firms severely affected by the floods. Importantly, the point estimates for operating surplus are larger in absolute value than those for labor compensation. Not surprisingly, the weaker negative employment effects imply an increased labor share at the firm level, as confirmed in panel 5d. These findings, along with the observed reduction in imports, suggest a reshoring of labor-intensive inputs from the foreign country to the home country.[10]

Quantitatlvely, the point estimates in these figures imply that increasing the Thailand operation intensity Z_i by one standard deviation (0.191) decreases Thai employment by 10.96%, total foreign employment by 2.06%, intra-firm import from Thailand by 3.44%, total foreign import by 1.91%, labor compensation by 0.17%, operating surplus by 0.81%, and increases the firm-level labor share by 0.44 percentage points in five years after the floods.

Since the operating surplus measure includes profits rather than capital demand, we also check the use of fixed assets as an outcome variable and confirm that this does not affect the result.[11] This finding indicates that the increase in the labor share of firms affected by the Thailand floods is not solely attributed to a decrease in profit but also to a reduction in capital demand. Next, to further support the hypothesis of offshore labor-intensive inputs, we examined the effect on non-regular worker employment. In the Japanese employment institution, these workers perform relatively low-skilled tasks and can be hired and fired flexibly (Yokoyama et al., 2021). Furthermore, we 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 offshore subsidiaries. Appendices A.11 and A.13 elaborate 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 employment, offshore imports, home-country labor compensation and operating surplus. 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.

[10]We have also explored the role of credit constraints in these results since flooded firms need to fund increased investment to remedy the flood damage. We proxy the credit constraints by the liquid assets and credit score variable provided by the TSR, but no conclusive evidence is found. We suspect that most of the MNEs are productive and well credited, leading to the credit constraint inframarginal, or the proxy quality is poor. Exploring this dimension is left for future research.

[11]The tangible asset measure is taken from the BSJBSA, which only targets domestic assets. Therefore, mechanical effects due to destroyed assets in Thailand by the floods are not included in this robustness analysis.

3 Model

We consider a heterogeneous firms model of offshore subsidiaries to study the home-country labor share effect of multinational activities. 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 industries indexed by j and three countries $c \in \{J, T, R\}$ where J stands for Japan, T for Thailand, and R for the Rest of the World. Each country produces sectoral goods j. To focus on the role of foreign factors, we assume no factor mobility between countries and free trade, implying that the sectoral price index P_j is equalized between countries. We assume sectoral price index P_j and factor prices in R as given to producers in J and T, so that J and T are small-open. 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. By contrast, we allow activities of firms in J to affect the factor market in T and, therefore, influence the factor prices in T, motivated by the significant presence of Japanese MNEs in the flooded regions of Thailand. In J, capital $\bar{K}_J$ and labor $\bar{L}_J$ are supplied inelastically, while there is inelastic factor supply $\bar{X}_c$ in $c = T, R$. We do not specify household income and preferences at this point as 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 one factor in countries T and R, it does not address labor share implications for countries other than country J, the country where headquarters of MNEs are located in our data. While the model can naturally accommodate multiple factors in foreign countries, we intentionally adopt a single factor assumption for three 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. Thirdly, mapping between the floods event and theory would be difficult with the multiple factors in foreign countries as it is not clear if the floods shock affects the employment or capital formation in Thailand.

Production in Country J. There are producers of sectoral goods and producers of intermediate varieties in country J, with producers of sectoral goods aggregating intermediate varieties by

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

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 $\underline{\psi}_j$.[12] 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 foreign subsidiary location in $c = T, R$ and produces with production function

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

where k is the headquarter capital, $h \equiv h(l, x_T, x_R)$ are labor-intensive inputs specified below, m are intermediate inputs, and $\sigma_j \geq 0$ is the sectoral elasticity of substitution between capital and labor-intensive inputs, and $\alpha_j^k, \alpha_j^h \in (0,1)$ capture the input shares that exogenously affect the firm-level labor share.[13] The tasks are performed internationally and determined by

$$h(l, x_T, x_R) \equiv \left[\left(1 - \beta_j^T - \beta_j^R \right) l^{\frac{\lambda - 1}{\lambda}} + \beta_j^T \left(a_T x_T \right)^{\frac{\lambda - 1}{\lambda}} + \beta_j^R \left(a_R x_R \right)^{\frac{\lambda - 1}{\lambda}} \right]^{\frac{\lambda}{\lambda - 1}}, \tag{6}$$

where l is the home-country labor input, x_c the offshore inputs from subsidiaries in $c = T, R$, and $\lambda > 1$ the elasticity of substitution between these factors.[14] Here, a_c is an exogenous productivity of country $c = T, R$, which can represent factor productivity in foreign country c from country J, or (lack of) barriers to firms headquartered in J to operate in c.[15] We will

[12] Most of the derivations do not depend on the Pareto assumption. This assumption is useful when connecting the shift in the offshorer's share to the productivity cutoff, as illustrated later in equation (19).

[13] 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 the role of foreign offshoring.

[14] 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 (6).

[15] 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.

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_c^M) if they enter and offshore in country c.

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

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

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

$$S^L = \frac{w_J \bar{L}_J}{w_J \bar{L}_J + r_J \bar{K}_J + \Pi}. \tag{7}$$

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 Discussions of Model Assumptions

We mention the feature of our model assumptions, comparison with other setting in the literature, and the reason for our choice in the following.

The Nested CES Production Functions (5) and (6). First, the CES function with capital, labor-intensive inputs 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. By contrast, Boehm et al. (2018) assume a Cobb-Douglas mix of capital and labor with a more flexible substitution pattern with the foreign inputs than our setting. Since we aim to derive labor share implication of foreign productivity within a firm, we depart from their setting and assume the CES between capital and labor-intensive inputs. Second, our nested CES implies that if $\lambda > \sigma_j$, firm-level labor share $s^L(\psi)$ is decreasing in a_c $(c \in \{T, R\})$ 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).[16] 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).

Export Platform and Uncertainty. First, we model global production in the offshoring model where headquarters firms use inputs from foreign countries since the purpose of many firms having foreign subsidiaries is offshoring in our data. However, this excludes other purpose of foreign investment, like export platforms Tintelnot (2017). In the case of export platforms, firms may substitute productions with more ease than offshoring, implying a larger impact on the domestic economy than our model predicts. Second, unlike Castro-Vincenzi (2023), we do not explicitly model the uncertainty in the model because the primary purpose is not to study the effect of uncertainty but the impact of foreign productivity on the domestic labor share. However, since firms have incentives to set up multiple plants with inefficiently small sizes under uncertainty to buffer the shock, we acknowledge that our model may overstate the response to the shock of the floods. We leave these extensions for future work.

Monopolistic Competition. 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 and sectoral differences in demand elasticity ε_j. The magnitude of the labor share change due to this mechanism is minor compared to the effect of reallocation between demand for labor and capital. We derive how to compute this component in Appendix B.4.

3.3 Characterization

The offshore subsidiary decision can be summarized by productivity thresholds $\psi_{c,j}$, $c \in \{T, R\}$. To simplify the model, we impose a parameter restriction such that

$$\psi_{T,j} > \psi_{R,j}. \tag{8}$$

This restriction is 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. It implies the pecking order of source countries as in Antras et al. (2017). Given this restriction, the entry choice of firms is made among $d = 00$ (non-offshoring), $d = 01$ (R-offshoring), and $d = 11$

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

(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 labor-intensive inputs 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, $\pi_{11,j}\left(\psi_{11,j}\right) - \pi_{01}\left(\psi_{11,j}\right) = f_T$, 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

$$CS_{11,j} \equiv \left[\left(\tilde{c}_{11,j}\right)^{1-\varepsilon_j} - \left(\tilde{c}_{01,j}\right)^{1-\varepsilon_j}\right]^{\frac{1}{1-\varepsilon_j}} \tag{12}$$

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

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

$$p_{d^*}^h h_{d^*,j}(\psi) = \left(\frac{p_{d^*,j}^h}{c_{d^*,j}(\psi)}\right)^{1-\sigma_j} \left(\frac{p_{d^*,j}(\psi)}{P_j}\right)^{1-\varepsilon_j} P_j Q_j, \tag{14}$$

$$w_J l_{d^*,j}(\psi) = \left(\frac{w_J}{p^h_{d^*,j}}\right)^{1-\lambda} p^h_{d^*} h_{d^*,j}(\psi), \tag{15}$$

and

$$p^x_T x_{T,d^*,j}(\psi) = \left(\frac{p^x_T / a_T}{p^h_{d^*,j}}\right)^{1-\lambda} p^h_{d^*} h_{d^*,j}(\psi). \tag{16}$$

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 $X^D_T + (p^x_T/a_T)^{-\gamma} = \bar{X}_T$.

3.4 Extensive Margin Hat Algebra

To solve these equilibrium conditions, we follow the "hat algebra" approach (Dekle et al., 2007), allowing us to sidestep explicitly estimating unobserved objects such as input share parameters by using directly observed input shares. 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. Furthermore, in the data, we assign the MNE status of 11 if the firm has a subsidiary in Thailand, 01 if the firm has a subsidiary in the Rest of the World but not in Thailand, and 00 otherwise. This assignment enables us to sort all firms into each of three offshoring strategies and rationalize observed shares in the baseline equilibrium, a prerequisite for the exact hat algebra to work.

For brevity, we hereafter discuss the change in aggregate capital demand $\hat{K}^D$. Derivations for the changes in labor demand $\hat{L}^D$ and Thailand factor demand $\hat{X}^D_T$ are similar and are provided in Appendix B.2. In the same appendix, we show that

$$\hat{K}^D = \sum_j \varsigma_j \hat{\bar{C}}^K_j, \text{ where } \varsigma_j = \frac{r_J K_j}{\sum_k r_J K_k}. \tag{17}$$

Here, ς_j is the sectoral capital cost share, and $\hat{\bar{C}}^K_j$ is the change in the average relative cost term for capital demand given by, with slight abuse of notation,

$$\hat{\bar{C}}^K_j = (\hat{r}_J)^{-\sigma_j} \sum_{d \in \{00,01,11\}} \xi^K_{d,j} \left(\hat{\bar{c}}_{d,j}\right)^{\sigma_j - \varepsilon_j} \hat{s}_{d,j}, \text{ where } \xi^K_{d,j} = \frac{\int_{\psi \in d} r_J k_j(\psi)\, dG_j(\psi)}{r_J K_j}. \tag{18}$$

Here, $\xi^K_{d,j}$ 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 $\hat{\bar{c}}_{d,j}$ 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.

Using the Pareto distribution assumption, we can show that $\hat{s}_{d,j}$ depends on the change in the cost-saving (12), denoted as $\hat{CS}_{d,j}$. For example, when $d = 11$,

$$\hat{s}_{11,j} = \left(\hat{\psi}_{11,j}\right)^{-\left(\theta_j - \left(\varepsilon_j - \sigma_j\right)\right)} = \left(\hat{CS}_{11,j}\right)^{-\theta_j - \left(\varepsilon_j - \sigma_j\right)}, \tag{19}$$

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

$$CR_{11,j} = \left[\left(1 - \kappa_{01,j}\right) + \kappa_{01,j}\left(1 - \varpi_{11,j}\right)^{-\frac{1-\sigma_j}{1-\lambda}}\right]^{\frac{1-\varepsilon_j}{1-\sigma_j}} - 1 \tag{20}$$

where

$$\kappa^h_{01,j} = \frac{\int_{\psi_{01,j}}^{\psi_{11,j}} p^h_{01,j} h_{01,j}(\psi)\, dG_j(\psi)}{\int_{\psi_{01,j}}^{\psi_{11,j}} c_{01,j} q_{01,j}(\psi)\, dG_j(\psi)} \text{ and } \varpi_{11,j} = \frac{\int_{\psi_{11,j}}^{\infty} p^x_T x_{T,j}(\psi)\, dG_j(\psi)}{\int_{\psi_{11,j}}^{\infty} p^h_{11,j} h_{11,j}(\psi)\, dG_j(\psi)}$$

are, respectively, the cost share of the labor-intensive input for firms with entry decision $d = 01$ and the cost share of the factor in Thailand among labor-intensive 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

$$\hat{CS}_{11,j} = \hat{\tilde{c}}_{01,j}\left(\frac{CR'_{11,j}}{CR_{11,j}}\right)^{\frac{1}{1-\varepsilon_j}}, \tag{21}$$

where $\hat{\tilde{c}}_{01,j}$ can be derived from standard hat algebra shown in Appendix B.2, and $CR_{11,j}$ and $CR'_{11,j}$ are both derived from data before and after the change.[17] We can derive similar expressions of equation (19) 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 (20), 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 labor-intensive inputs in sector j (hence high $\kappa_{01,j}$), and if the factors in Thailand among labor-intensive inputs (hence high $\varpi_{11,j}$) are in-

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

tensively 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 (20). 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 $\ln\left(x_j^q\right) = a_j - \left(\theta_j\right)^{-1} \ln\left(1-q\right)$, where q stands for percentile, a_j for the sector-specific intercept, and x_j^q for q-th percentile sales in sector j. We use sample firms with $q > 0.99$ for each sector as the top tail 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 the elasticity between capital and labor-intensive input 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.14. These parameters are calibrated at 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. Since we use the Thailand flood shock that hits firms operating in Thailand differently, we make explicit the dependence of Thailand productivity term on firm indicator i. So we write $d\ln a_{T,i}$. Starting with factor demand functions (15) and (16), we decompose the effect of the Thailand productivity shock $d\ln a_{T,i}$ into two distinct components: an individual-firm (i) component and a general equilibrium component, as follows.

$$d\ln l_{i,d^*,j} = -\varpi_j\left[\left(\lambda-\sigma_j\right)+\kappa_j\left(\sigma_j-\varepsilon_j\right)\right]d\ln a_{T,i}+D^l_{d^*,j}, \tag{22}$$

$$d\ln x^T_{i,d^*,j}\left(\psi\right) = \lambda d\ln a_{T,i}-\varpi_j\left[\left(\lambda-\sigma_j\right)+\kappa_j\left(\sigma_j-\varepsilon_j\right)\right]d\ln a_{T,i}+D^T_{d^*,j} \tag{23}$$

where ϖ_j is the factor cost share in T among labor-intensive inputs h, and κ_j is the labor-intensive input share in each industry j, with slight abuse of notation. $D^l_{d^*,j}$ and $D^T_{d^*,j}$ are general equilibrium effects constant across firms and specific to offshoring strategy (d^*) and industry (j) that arises from changes in prices. 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 (22) and (23) reveals the underlying logic for identification. Two effects stand out. On the one hand, the employment effect $d\ln l_{i,d^*,j}$ solely depends on the inflated cost index, revealing an "indirect effect" that occurs because the productivity change in Thailand affects labor demand through the cost index of labor-intensive inputs, $p^h_{d^*}$, in labor demand equation (15) and the unit cost index $c_{d^*,j}\left(\psi\right)$ in the demand equation for labor-intensive inputs (14). This effect is linked to λ through the elasticity of the change in labor demand with respect to the change in the price index of labor-intensive inputs.

On the other hand, the Thailand factor demand $d\ln x^T_{i,d^*,j}$ is derived from not only the indirect effect but also a direct substitution effect; Productivity in Thailand $a_{T,i}$ affects not only $c_{d^*,j}\left(\psi\right)$ but also $a_{T,i}$ in the effective Thailand factor price directly, as in (16). 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 put firm index i and year t for all variables. 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 (3). We regard the change in the IV as a negative productivity shock as argued in Section 2.2, and formulate $dZ_{it} = -kd \ln a_{T,i}$ for some unknown positive constant k that relates the empirical measure dZ_{it} and the theoretical productivity reduction $d \ln a_{T,i}$ for those affected by the floods. Therefore, we assume that the flood shock hits all firms proportionally to the share of employment in the flooded region after 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 (22) and (23) across all firms and industries and taking the ratio, we have

$$\frac{E\left[d \ln \tilde{l}_{it} / d\tilde{Z}_{it}\right]}{E\left[d \ln \tilde{x}^T_{it} / d\tilde{Z}_{it}\right]} = \frac{\Xi(\lambda)}{\Xi(\lambda) - \lambda}, \tag{24}$$

where $\Xi(\lambda) = \sum_j (1 - \varsigma_j)\varpi_j \left[(\lambda - \sigma_j) + \kappa_j (\sigma_j - \varepsilon_j)\right]$ summarizes the indirect effect across firms. Note that the unknown constant k cancels out in the numerator and denominator of equation (24), 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 (22) and (23). Using (24), we can identify the EoS λ in the RHS since the LHS of (24) is estimable and all the other terms in the RHS are observed.

Implementation: Two-Stage Least Square (2SLS) Regression. The LHS of (24) tells us the relative average size of the reaction of domestic employment to the foreign flood shock to that of foreign inputs. This observation motivates us to use the two-stage least square (2SLS), where the first stage is to regress the foreign inputs on the foreign shock, and the second stage is to regress the domestic employment on the foreign shock. In fact, the 2SLS estimator is a consistent estimator of the LHS of (24). In addition, we will also account for the general equilibrium effects $D^l_{d^*,j}$ and $D^T_{d^*,j}$ in (22) and (23). To formalize these ideas, we consider the following two-way fixed-effect 2SLS regression:

$$\ln(l_{it}) = a_i + a_{jt} + b \ln\left(x^T_{it}\right) + e_{it}, \tag{25}$$

where l_{it} is employment in Japan, x_{it}^T is factor input 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 (24), 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.15. Note that equation (24) 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 input 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 $p_T^x/a_{T,i}$ specific to firms through the productivity term $a_{T,i}$. This implies that our identification method does not require assumptions about labor markets such as how local labor markets are delineated or imperfectly competitive.

4.3 Estimation Results

Table 2 shows the estimation results of regression equation (25). 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 (24) 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.16 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.17.

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 (25), 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 the cost index is mitigated by the direct substitution effect.

5.2 Quantifying the Effect 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 (15) and (16). For instance, in Appendix B.3, we show that the Thailand factor productivity term can be backed up by

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

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, an increase in the foreign factor producitivity is a biased shock to the foreign factor. In other words, 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 employment in country c 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 (26) to the data is not straightforward. Therefore, we perform hat algebra to obtain

$$\hat{a}_T = \frac{\frac{\hat{p}_T^x}{w_J}\left(\widehat{\frac{\overline{p_T^x x_T}}{w_J L}}\right)_{11}}{\hat{\bar{p}}_{11}}. \tag{27}$$

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

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

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

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

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 $\hat{a}_R = 2.92$.[18]

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, in an analogy to (7), 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

[18] These values are broadly consistent with the aggregate statistics of offshoring. The growth rate of imports from Thailand and from the rest of the world from 1995 to 2007 was 276% and 238% (8.1% and 6.9% per annum), respectively.

with endogenous threshold change $\hat{\psi}_{d,j}$ provides the effect of selection. In Appendix B.4, we show how to compute the change in group-specific labor shares such as $\hat{S}^L_d$.

The simulation results are shown in Figure 6, 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 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 $c = J$. To close the model, we assume an auxiliary sector so that the economy level trade balances before and after the shock. 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 $c = J$ and $\left(r_J K + w_J L + \hat{p}_T^x X_T + p_R^x X_R\right)$, where X_c is the aggregate factor demand in country $c \in \{T, R\}$. 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.

References

Acemoglu, D. and Restrepo, P. (2019). Automation and new tasks: How technology displaces and reinstates labor. Technical report, National Bureau of Economic Research.

Adachi, D. (2023). Robots and wage polarization: The effects of robot capital by occupations. Technical report, Mimeo.

Antras, P., Fort, T. C., and Tintelnot, F. (2017). The margins of global sourcing: theory and evidence from us firms. *American Economic Review*, 107(9):2514–64.

Arkolakis, C. (2010). Market penetration costs and the new consumers margin in international trade. *Journal of Political Economy*, 118(6):1151–1199.

Autor, D., Dorn, D., Katz, L. F., Patterson, C., and Van Reenen, J. (2017). Concentrating on the fall of the labor share. *American Economic Review*, 107(5):180–85.

Autor, D., Dorn, D., Katz, L. F., Patterson, C., and Van Reenen, J. (2020). The fall of the labor share and the rise of superstar firms. *The Quarterly Journal of Economics*, 135(2):645–709.

Barkai, S. (2017). Declining labor and capital shares. *University of Chicago*.

Benguria, F. and Taylor, A. M. (2019). After the panic: Are financial crises demand or supply shocks? evidence from international trade. Working Paper 25790, National Bureau of Economic Research.

Berger, D. W., Herkenhoff, K. F., and Mongey, S. (2019). Labor market power. Technical report, National Bureau of Economic Research.

Blaum, J., Lelarge, C., and Peters, M. (2018). The gains from input trade with heterogeneous importers. *American Economic Journal: Macroeconomics*, 10(4):77–127.

Boehm, C. E., Flaaen, A., and Pandalai-Nayar, N. (2018). Input linkages and the transmission of shocks: Firm-level evidence from the 2011 tōhoku earthquake. *Review of Economics and Statistics*, (00).

Boehm, C. E., Flaaen, A., and Pandalai-Nayar, N. (2020). Multinationals, offshoring, and the decline of us manufacturing. *Journal of International Economics*, 127:103391.

Bridgman, B. (2018). Is labor's loss capital's gain? gross versus net labor shares. *Macroeconomic Dynamics*, 22(08):2070–2087.

Carr, D. L., Markusen, J. R., and Maskus, K. E. (2001). Estimating the knowledge-capital model of the multinational enterprise. *American Economic Review*, 91(3):693–708.

Carvalho, V. M., Nirei, M., Saito, Y. U., and Tahbaz-Salehi, A. (2021). Supply chain disruptions: Evidence from the great east japan earthquake. *The Quarterly Journal of Economics*, 136(2):1255–1321.

Castro-Vincenzi, J. (2023). Climate hazards and resilience in the global car industry. Technical report, Technical report, Working Paper.

Castro-Vincenzi, J. M. and Kleinman, B. (2022). Intermediate input prices and the labor share. *Unpublished manuscript, Princeton University*.

Costinot, A. and Rodríguez-Clare, A. (2014). Trade theory with numbers: Quantifying the consequences of globalization. *Handbook of international economics*, 4:197–261.

De Loecker, J. and Eeckhout, J. (2017). The rise of market power and the macroeconomic implications. Technical report, National Bureau of Economic Research.

De Loecker, J. and Eeckhout, J. (2018). Global market power. Technical report, National Bureau of Economic Research.

Dekle, R., Eaton, J., and Kortum, S. (2007). Unbalanced trade. *American Economic Review*, 97(2):351–355.

Desai, M. A., Foley, C. F., and Hines, J. R. (2009). Domestic effects of the foreign activities of us multinationals. *American Economic Journal: Economic Policy*, 1(1):181–203.

Doraszelski, U. and Jaumandreu, J. (2018). Measuring the bias of technological change. *Journal of Political Economy*, 126(3):1027 – 1084.

Eaton, J., Kortum, S., and Kramarz, F. (2011). An anatomy of international trade: Evidence from french firms. *Econometrica*, 79(5):1453–1498.

Ebenstein, A., Harrison, A., McMillan, M., and Phillips, S. (2014). Estimating the impact of trade and offshoring on american workers using the current population surveys. *The Review of Economics and Statistics*, 96(4):581–595.

Eden, M. and Gaggl, P. (2018). On the welfare implications of automation. *Review of Economic Dynamics*, 29:15–43.

Elsby, M. W., Hobijn, B., and Şahin, A. (2013). The decline of the us labor share. *Brookings Papers on Economic Activity*, 2013(2):1–63.

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

Forslid, R. and Sanctuary, M. (2022). Climate risks and global value chains: The impact of the 2011 thailand flood on swedish firms.

Fukao, K. and Perugini, C. (2021). The long-run dynamics of the labor share in japan. *Review of Income and Wealth*, 67(2):445–480.

Gabaix, X. and Ibragimov, R. (2011). Rank- 1/2: a simple way to improve the ols estimation of tail exponents. *Journal of Business & Economic Statistics*, 29(1):24–39.

Gandhi, A., Navarro, S., and Rivers, D. A. (2020). On the identification of gross output production functions. *Journal of Political Economy*, 128(8):2973–3016.

Gouin-Bonenfant, E. et al. (2018). Productivity dispersion, between-firm competition and the labor share.

Gravelle, J. G. (2015). Tax havens: International tax avoidance and evasion.

Grieco, P. L., Li, S., and Zhang, H. (2016). Production function estimation with unobserved input price dispersion. *International Economic Review*, 57(2):665–690.

Grossman, G. M. and Rossi-Hansberg, E. (2008). Trading tasks: A simple theory of offshoring. *American Economic Review*, 98(5):1978–97.

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

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

Harrigan, J., Reshef, A., and Toubal, F. (2021). Techies, trade, and skill-biased productivity.

Harrigan, J., Reshef, A., and Toubal, F. (2023). Techies and firm level productivity. Technical report, National Bureau of Economic Research.

Harrison, A. and McMillan, M. (2011). Offshoring jobs? multinationals and us manufacturing employment. *Review of Economics and Statistics*, 93(3):857–875.

Hubmer, J. (2023). The race between preferences and technology. *Econometrica*, 91(1):227–261.

Hummels, D., Jørgensen, R., Munch, J., and Xiang, C. (2014). The wage effects of offshoring: Evidence from danish matched worker-firm data. *American Economic Review*, 104(6):1597–1629.

Karabarbounis, L. and Neiman, B. (2013). The global decline of the labor share. *The Quarterly Journal of Economics*, 129(1):61–103.

Kehrig, M. and Vincent, N. (2021). The micro-level anatomy of the labor share decline. *The Quarterly Journal of Economics*, 136(2):1031–1087.

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

Leone, F. (2023). Multinationals, robots, and the labor share. *Available at SSRN 4334330*.

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

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

Muendler, M.-A. and Becker, S. O. (2010). Margins of multinational labor substitution. *The American Economic Review*, 100(5):1999–2030.

Nakamura, T. and Ohashi, H. (2019). *Linkage of markups through transaction*. RIETI.

Oberfield, E. and Raval, D. (2021). Micro data and macro technology. *Econometrica*.

Olley, G. S. and Pakes, A. (1996). The dynamics of productivity in the telecommunications equipment industry. *Econometrica*.

Ottaviano, G. I. and Peri, G. (2012). Rethinking the effect of immigration on wages. *Journal of the European Economic Association*, 10(1):152–197.

Pierce, J. R. and Schott, P. K. (2016). The surprisingly swift decline of us manufacturing employment. *American Economic Review*, 106(7):1632–62.

Reshef, A. and Santoni, G. (2023). Are your labor shares set in beijing? the view through the lens of global value chains. *European Economic Review*.

Rognlie, M. (2018). Comment on" accounting for factorless income". In *NBER Macroeconomics Annual 2018, volume 33*. University of Chicago Press.

Simon, H. A. and Bonini, C. P. (1958). The size distribution of business firms. *The American Economic Review*, 48(4):607–617.

Steinberg, J. et al. (2017). Brexit and the macroeconomic impact of trade policy uncertainty. In *2017 Meeting Papers*, number 216. Society for Economic Dynamics.

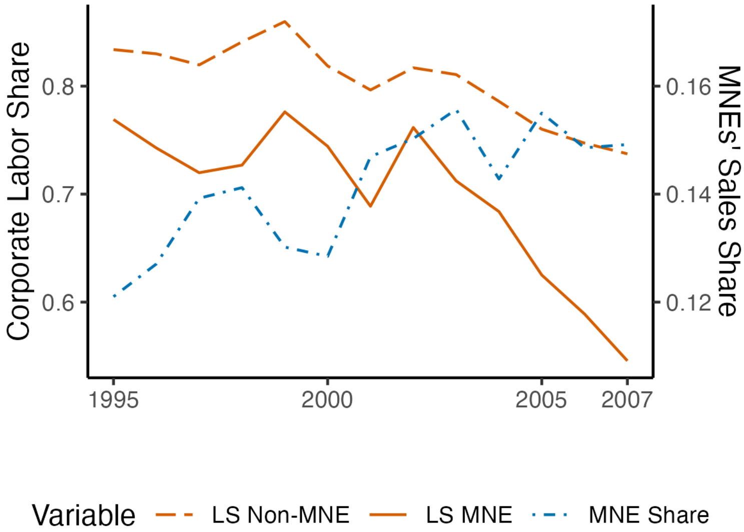
Sun, C. (2020). Multinational production with non-neutral technologies. *Journal of International Economics*, 123:103294.

Tintelnot, F. (2017). Global production with export platforms. *The Quarterly Journal of Economics*, 132(1):157–209.

Yokoyama, I., Higa, K., and Kawaguchi, D. (2021). Employment adjustments of regular and non-regular workers to exogenous shocks: evidence from exchange-rate fluctuation. *ILR Review*, 74(2):470–510.

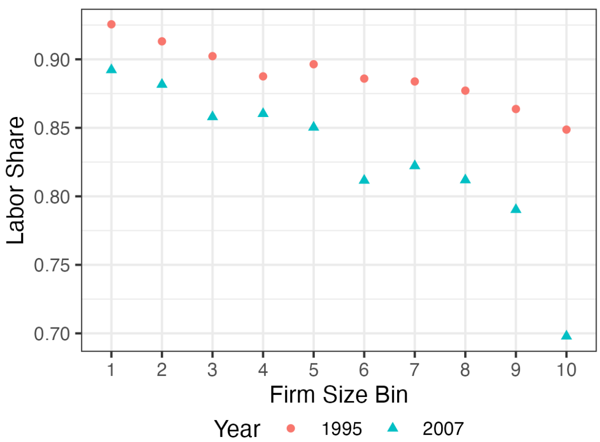
Zhang, H. (2019). Non-neutral technology, firm heterogeneity, and labor demand. *Journal of Development Economics*, 140:145–168.

Figure 1: Labor Shares of MNEs and Non-MNEs



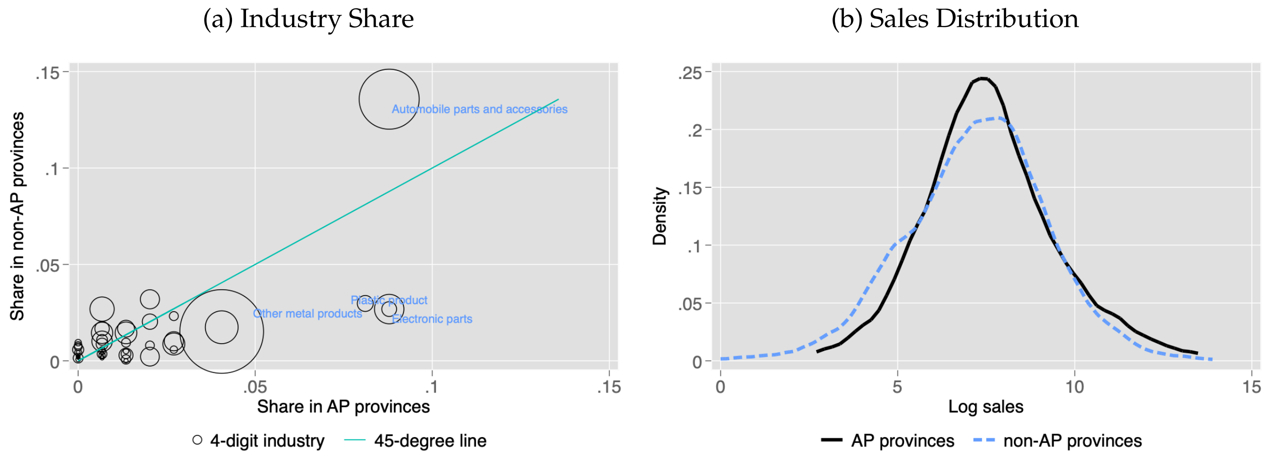
Note: The figure shows trends in the corporate labor share of multinational enterprises (MNEs) and non-MNEs (left axis) and of MNEs' sales share (right axis). For each firm, the corporate labor share is calculated as total labor compensation divided by the sum of total labor compensation and operating surplus.

Figure 2: Firm Size and Labor Share



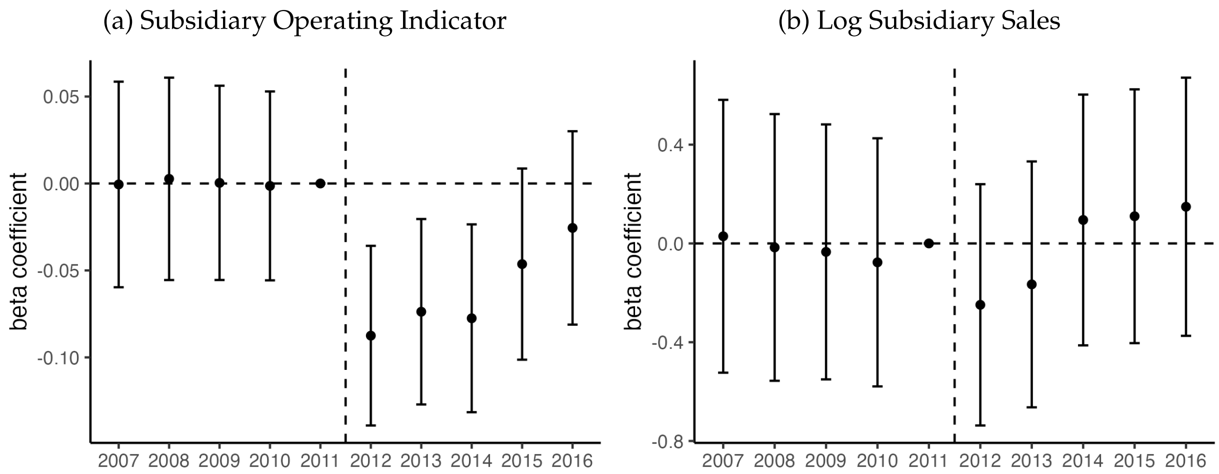
Note: The figure plots evolution of the distribution of the corporate labor share measure defined in equation (1) by firm-size deciles from 1995 to 2007.

Figure 3: Balancing Checks



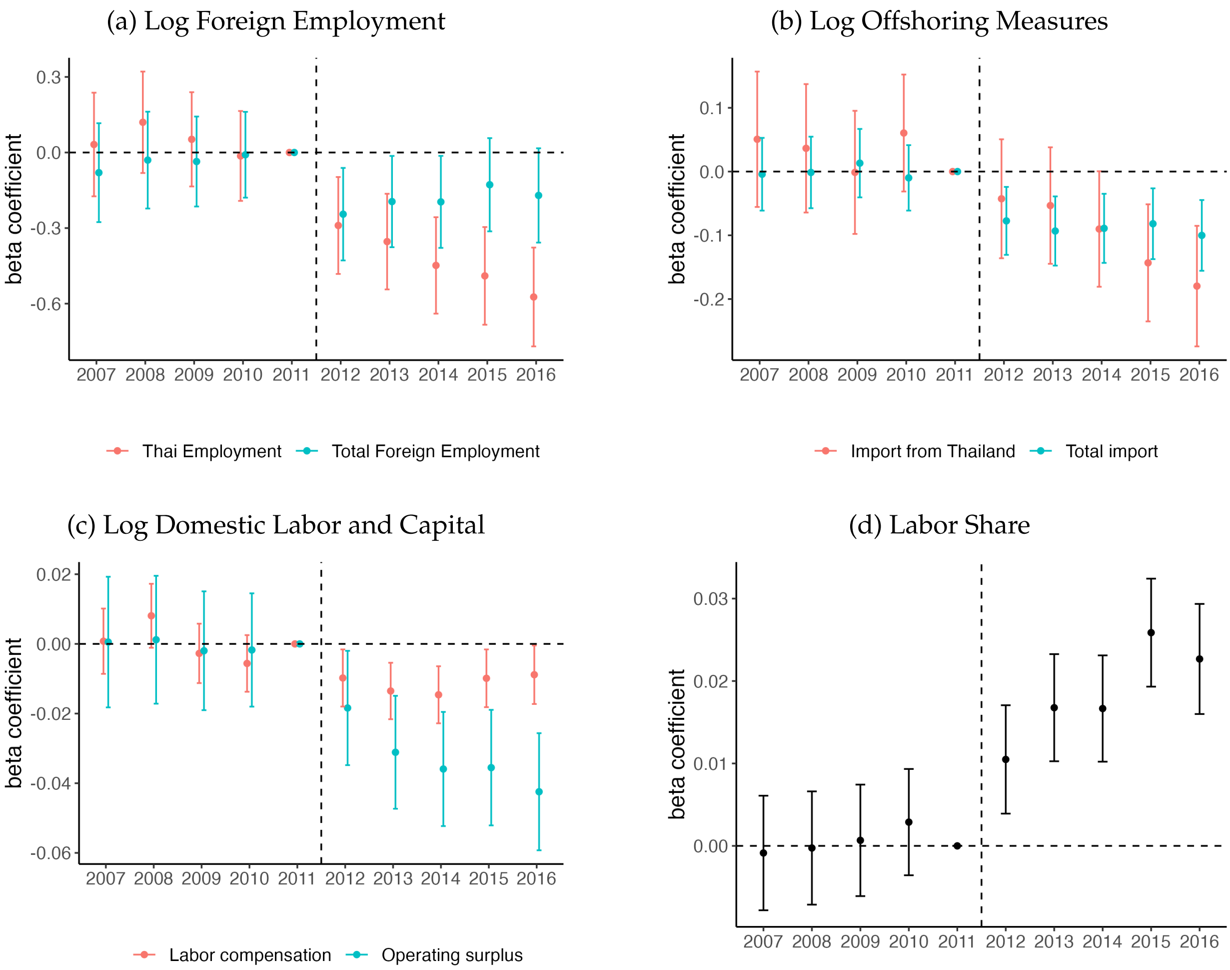
Note: The left panel shows the scatterplot of 4-digit industry shares for groups of firms in Ayutthaya and Pathum Thani (AP) provinces (treatment) in the horizontal axis and and those not in AP provinces (control) in the vertical axis. The green line shows the 45 degree line. Industry labels are shown if the industry share in AP provinces is higher than 0.05. The right panel plots the sales distributions of firms in AP provinces and not in AP provinces.

Figure 4: Event Study at the Subsidiary Level



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

Figure 5: Event Study at the Headquarter Level

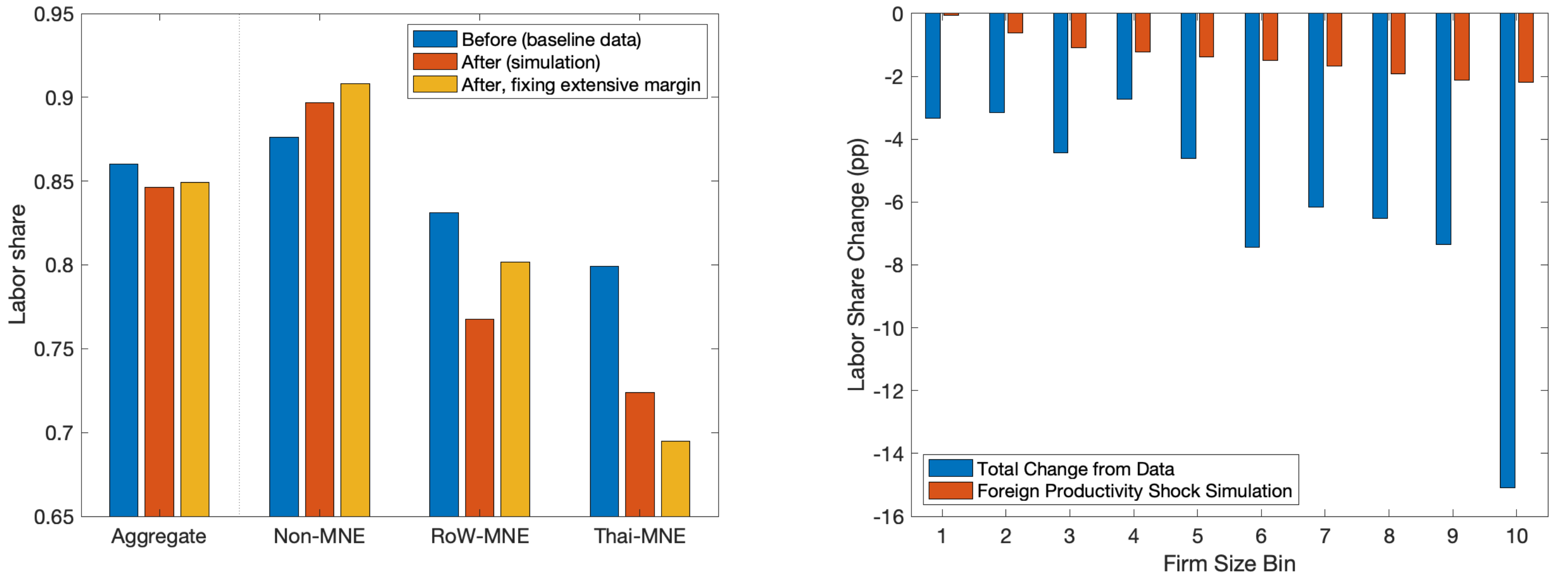


Note: The figure plots coefficient estimates of the headquarter-level event-study regression in equation (3). As the outcome variable, panel (a) takes log Thai employment and total foreign employment (both including the flooded regions), panel (b) takes the log value of intra-firm import to the Japanese parent firm from Thailand and all foreign countries, panel (c) takes log home-country labor compensation and operating surplus, and panel (d) takes the firm-level labor share defined in equation (1). Standard errors are cluster-robust at the firm level, and bars indicate 95 percent confidence intervals.

Figure 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.

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 4), and σ_j is the sectoral elasticity of substitution between capital and labor-intensive inputs (see equation 5).

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

	(1)	(2)	(3)	(4)	(5)
		Measures of factor usage in Thailand, $x_{i,t}^{T}$			
VARIABLES	$\ln l_{it}^{JPN}$	$\ln l_{it}^{THA}$	$\ln VA_{it}^{THA}$	$\ln sales_{it}^{THA}$	$\ln trade_{it}^{THA\rightarrow JPN}$
Panel A: The Effects of the Thailand Floods					
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)
Implied elasticity λ		1.40	1.45	1.26	1.17
Observations	5,563	5,563	5,460	5,503	3,993

Note: Panel A presents the effects of variable Z_{it}, 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 MNE 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 activity measures on Japanese employment, as outlined in equation (25). From the 2SLS estimates, the elasticity of substitution between labor and foreign inputs, λ, is implied by solving equation (24). Standard errors are clustered at both the firm and industry-year levels and are shown in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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

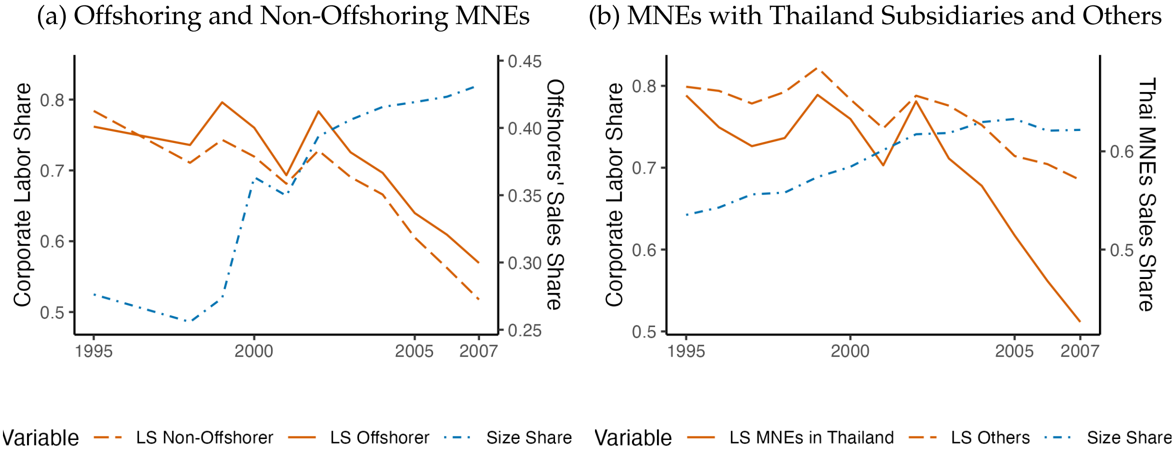
Online Appendix

A Empirical Appendix

A.1 More Labor Share Trends

Since our model features offshoring with MNE operations in Thailand, this section presents the results of a simple decomposition analysis comparing offshoring MNEs (firms that import from their subsidiary) and non-offshoring MNEs (Figure A.1a). We also check the systematic differences in labor share trends between MNEs with subsidiaries in Thailand and MNEs without Thai subsidiaries (Figure A.1b).

Figure A.1: Alternative Simple Decomposition of Labor Shares



Note: The figure shows the corporate labor share trends of offshoring multinational enterprises (MNEs) and non-offshoring MNEs (Panel A.1a on the left) and of MNEs having subsidiaries in Thailand and MNEs without Thai subsidiaries (Panel A.1b on the right), in orange lines measured in the left axis, as well as size share measures for each figure in blue lines measured in the right axis. Offshorers are defined as firms that import from their subsidiary. Corporate labor share is calculated as the fraction of total labor compensation over the sum of total labor compensation and operating surplus. 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

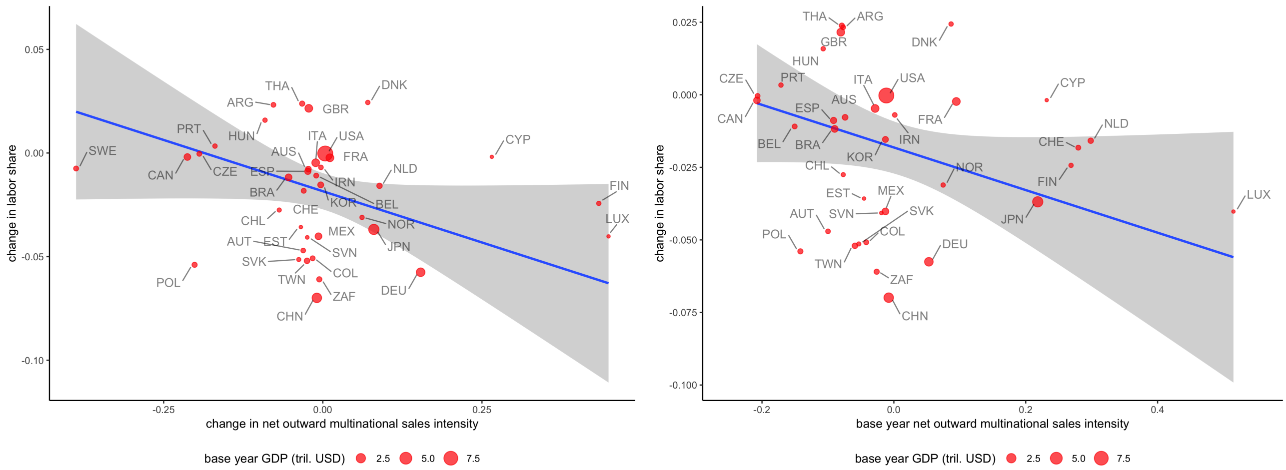
To empirically motivate our analysis, we conducted a cross-country correlation between the intensity of outward MNE activities and the change in labor shares using UNCTAD data on multinational activities. First, the level of outward multinational activities is calculated by taking the 1996-2000 average 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.

Figure A.2: Outward Multinational Activity and Labor Share

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



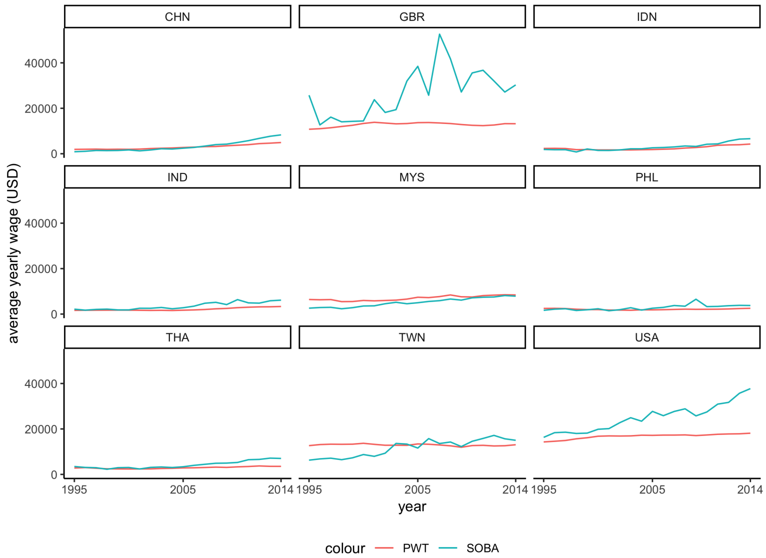
Note: Data are from Karabarbounis and Neiman (2013) and UNCTAD. In both panels a and b, the vertical axis is the change in labor share from 1991 to 2000, and fitted lines weighted by the base-year GDP are drawn with the 95 percent confidence intervals. In panel a on the left, the horizontal axis is the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

Thus, a wage difference emerges if Japanese-parented subsidiaries hire a different mix of 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 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.4, 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.

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.

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.

A.5 Labor Share Decompositions

In this subsection, we consider the firm-level decomposition following Kehrig and Vincent (2021) to study the anatomy of Japanese corporate labor share decline. Fukao and Perugini (2021) take a different approach and decompose the aggregate labor share to industry-level labor shares. They report a small contribution of markup trends to the decline of labor share, consistent with our paper, and find that the labor share decline concentrates in low-knowledge-intensive sectors. However, their data are aggregated at the industry level, where the industry codes are not directly comparable to the ISIC-based codes we use. Therefore, they are not suitable for studying firm-level phenomena such as MNEs.

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.

Using our firm-level measure of corporate labor share, we decompose the change in the aggregate labor share since $t_0 \equiv 1995$ as follows:

$$\Delta S_t^L \equiv S_t^L - S_{t_0}^L = AV_t + WI_t + RE_t + IN_t + EN_t, \tag{A.1}$$

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

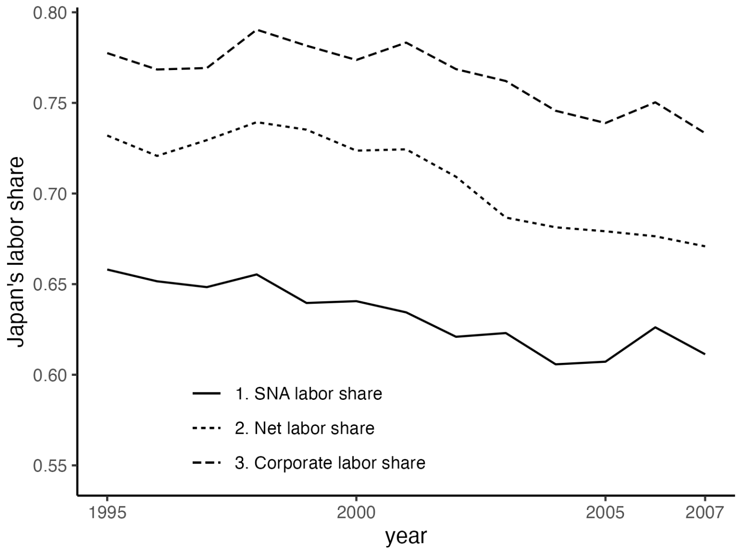
$$WI_t = \sum_{i \in \Omega_t \cap \Omega_{t_0}} \omega_{it_0} \Delta \left(ls\right)_{it}, \; RE_t = \sum_{i \in \Omega_t \cap \Omega_{t_0}} \left(ls\right)_{it_0} \Delta\omega_{it}, \; IN_t = \sum_{i \in \Omega_t \cap \Omega_{t_0}} \Delta\omega_{it} \Delta \left(ls\right)_{it},$$

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

Figure A.5 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

Figure A.4: Alternative Labor Share Measures



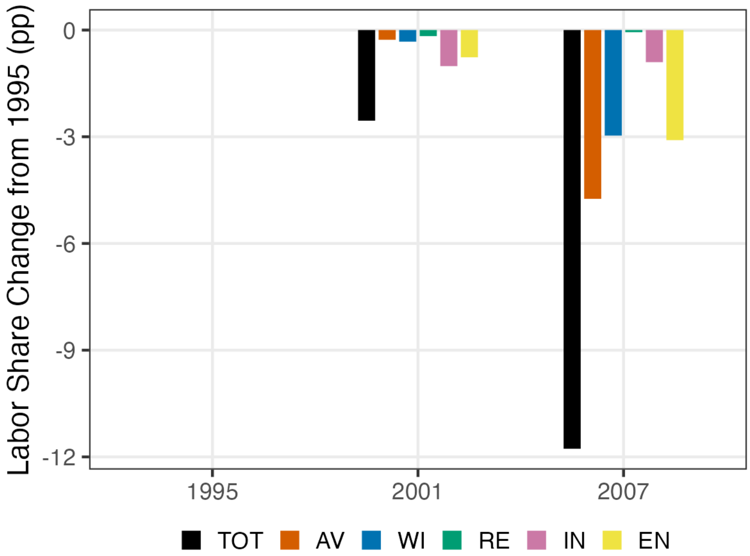
Note: Several labor share measures in Japan from 1995 to 2007 are shown. Taken from the 2015 Japan Industrial Productivity (JIP) Database administered by the Research Institute of Economy, Trade and Industry (RIETI), the JIP labor share is calculated as the share of nominal labor cost in nominal value-added 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.

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.

A.6 Markup Trend in Japan

This section discusses another possible explanation for the observed decrease in labor share (De Loecker and Eeckhout, 2017; Autor et al., 2020), namely, a surge in market power. Using a parsimonious but versatile method to back out the markups from firm- or plant-level data, De Loecker and Eeckhout, 2017 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, we find a considerably smaller increase in markups relative to the US (Figure A.6). We also study the markup trends between MNEs and non-MNEs, finding little evidence about the divergence of markups between MNEs and non-MNEs. Furthermore, Table A.2 shows the markup trend for industries of electrical machinery, electronics, and transportation machinery, where Japanese MNEs tend to operate. Although we observe a modest markup increase for the electronics industry, strong evidence of overall markup in-

Figure A.5: Decomposition of the Firm-level Change in Labor Share



Note: The figure plots the decomposition of corporate labor shares based on equation (A.1). "TOT" stands for the total effects and equals the sum of all effects, "WI" for the within-firm effect, "RE" for the reallocation effect, "IN" for the interaction effect, and "EN" for the entry-exit effect, explained in the main text.

crease is not found in these industries. The trends for other industries are also examined, but few significant patterns are detected.

The relatively small increase in the Japanese markup aligns with the previous literature (De Loecker and Eeckhout, 2018; Nakamura and Ohashi, 2019), and motivates us to examine a more direct factor substitution theory raised in the main text. However, we acknowledge that the reduction in the labor share in Japan is also smaller than that in the US (Karabarbounis and Neiman, 2013), so our trend analysis does not preclude the influence of the markup change on the labor share trend in Japan.

A.7 Thailand Gross Export and Import Trends

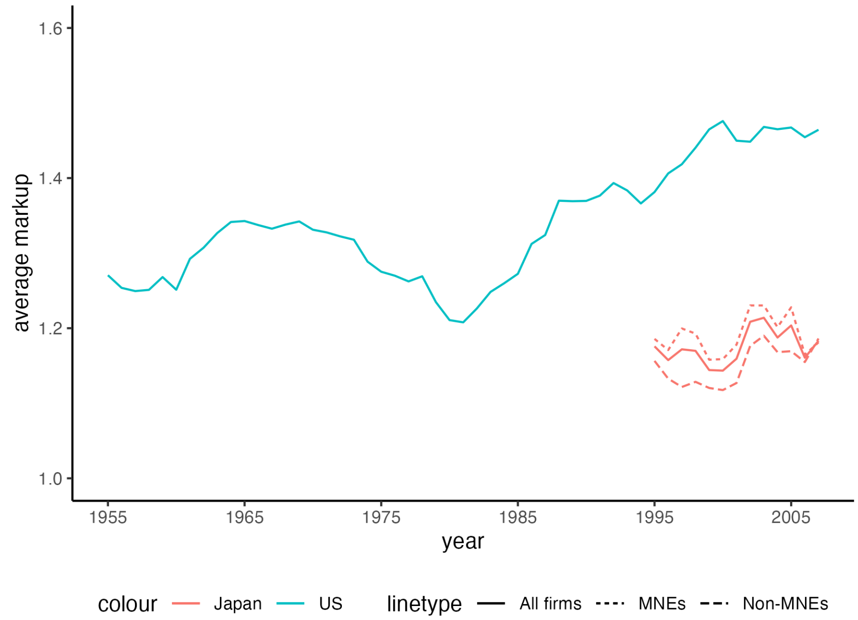
Figure A.7 shows the trends of Thailand's exports and imports, using data from UN Comtrade. Recalling that 2011 was the year of the floods, we see that Thai export and import trends were roughly parallel before the floods, but this pattern was broken when the floods caused exports to flatline until 2014 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.

Table A.2: Markup Trend for Selected Industries

	28 Electrical	29 Electronics	31 Transportation
1995	1.313	1.159	0.967
1996	1.169	1.179	0.979
1997	1.112	1.218	0.979
1998	1.099	1.25	0.975
1999	1.099	1.138	0.947
2000	1.145	1.189	0.975
2001	1.168	1.126	0.956
2002	1.169	1.223	1.005
2003	1.249	1.173	1.008
2004	1.233	1.186	0.967
2005	1.259	1.209	1.052
2006	1.313	1.203	1.01
2007	1.337	1.285	1.039

Note: Markup estimates based on De Loecker and Eeckhout (2017) using 1995-2016 data from the Basic Survey on Japanese Business Structure and Activities (BSJBSA) and the Basic Survey of Oversea Business Activities (BSOBA) are shown by selected sectors, 28 Electrical machinery, 29 Electronics, and 31 Transportation machinery. 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.

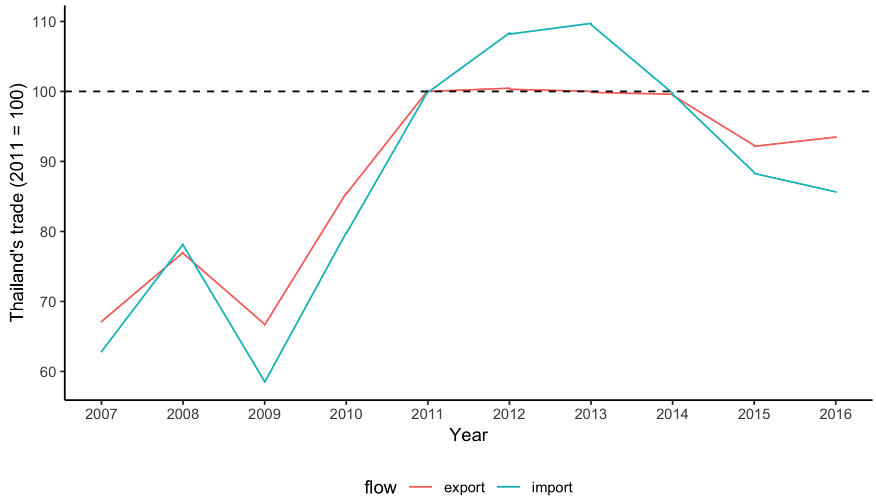
Figure A.6: Markup Estimates



Note: The figure plots the markup trends in the US and Japan. The US trend is based on estimates from De Loecker and Eeckhout (2017). The Japanese trend is based on the method of De Loecker and Eeckhout (2017) applying 1995-2016 data from the Basic Survey on Japanese Business Structure and Activities (BSJBSA) and the Basic Survey of Oversea Business Activities (BSOBA). The variable input cost is the sum of labor compensation and intermediate purchases. The output elasticity is estimated using the method of Olley and Pakes (1996) for each JSIC 3-digit industry.

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 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.7 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

Figure A.7: 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.

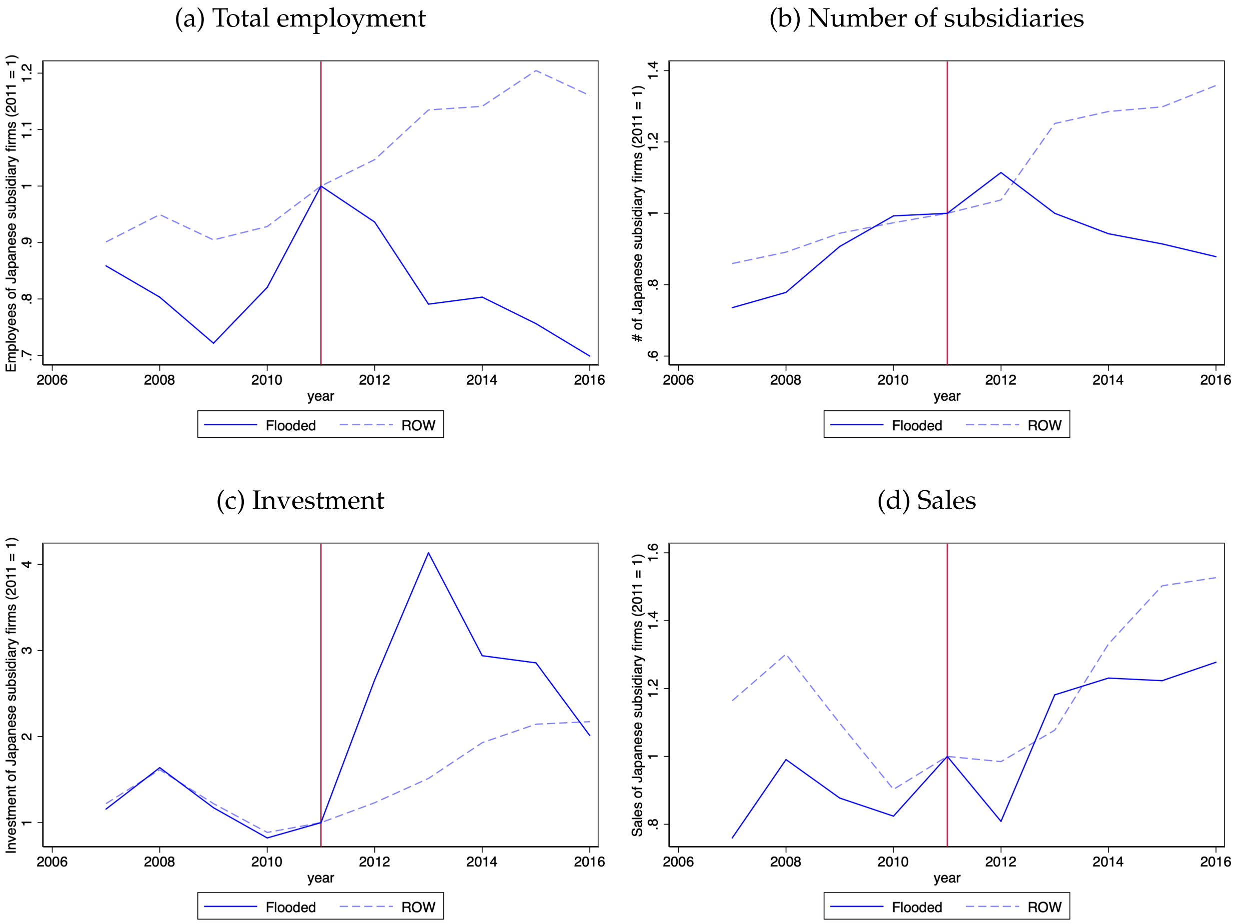
policy.

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.

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

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.

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 Sales Distribution of Japanese Subsidiaries in Thailand

Table A.3 shows the sales distribution by industry of the Japanese subsidiaries in Thailand in 2011. As mentioned in the main text, the largest industry was Transportation Equipment, which includes automobiles, followed by industrial machinery in the flooded areas and electronics in other areas.

Table A.3: Industrial sales distribution of Japanese Subsidiaries in Thailand

Subsidiary industry	Ayutthaya/Pathum Thani	Other location
Food	2780	236940
Textile	2210	67344
Chemicals	11830	732891
Ceramics	11395	140444
Steel	19134	221748
Non-ferrous metal	26320	182440
Metal products	57946	65886
General machinery	83495	187224
Construction machinery	24022	234474
Industrial machinery	245293	179186
Electircal machinery	221209	417909
Electronics	210758	1113570
Transportation machinery	871216	3954838
Other manufacturing	37868	432350

Note: The table shows the sales distribution by industry of the Japanese subsidiaries in the flooded areas (Ayutthaya and Pathum Thani provinces) and other areas in Thailand in 2011 (before the floods).

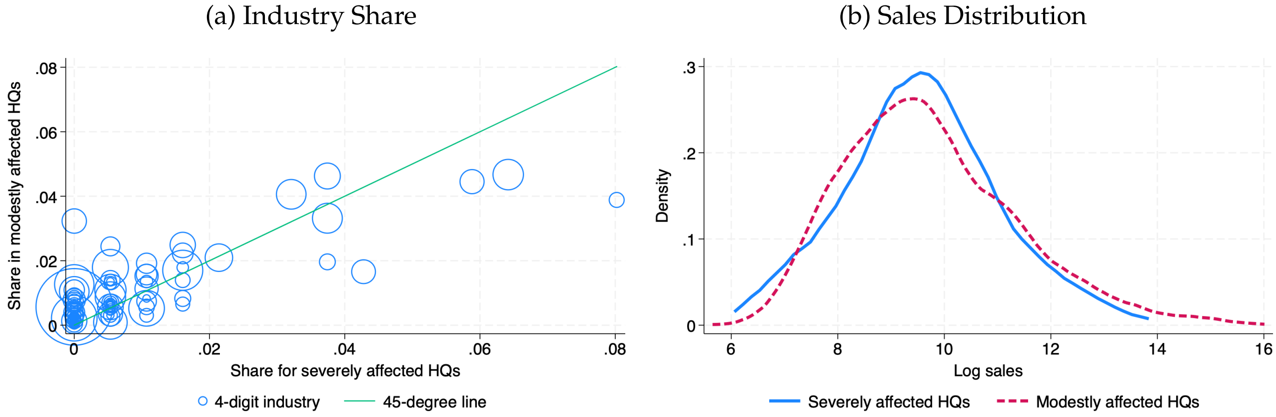
A.10 Additional Analysis for the Subsidiary-level Event Study

Figure A.10 shows the subsidiary-level event study using subsidiary investment and employment variables.

Furthermore, 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.11 shows the result of regression equation 2 with selected samples. Panel A.11a shows the result with the sample of Thailand subsidiaries of Japanese MNEs with 100% ownership. Panel A.11b 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 2 is driven by both wholly-owned subsidiaries and child subsidiaries.

Figure A.9: Balancing Checks at the headquarter level



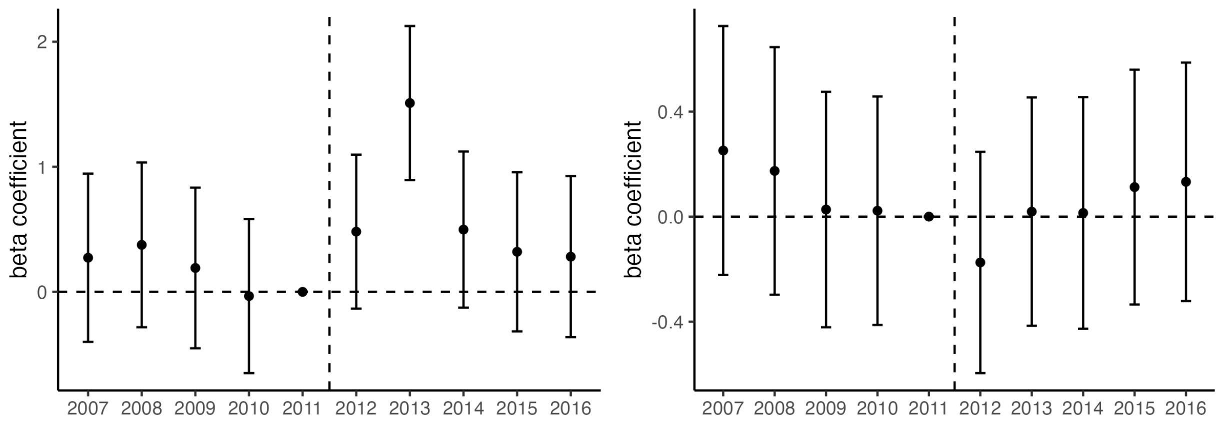
Note: The left panel compares the distributions of shares of the number of firms at the 4-digit industry level between severely affected and modestly affected groups. The severely affected group is defined by those headquarters whose employment share in the flooded regions of Thailand in 2011 before the flood is higher than the 20%, while the modestly affected group is lower than 20%. The green line shows the 45-degree line. The right panel plots the sales distributions of headquarters between the above-median and below-median groups.

A.11 Additional Analysis for the Headquarter-level Event Study

First, we decompose the impact on foreign employment shown in Figure 5a into Thai employment in the flooded regions (panel A.12a), Thai employment in non-flooded regions (panel A.12b), and foreign non-Thai employment (panel A.12c). Consistent with the strong negative impact on the flooded regions, we find a large and persistent negative effect only in panel A.12a. We also find moderate evidence of short-run spill-over effects on employment in other regions (non-Thai and non-flooded regions in Thailand) with substitution in the longer run in panels A.12b and A.12c.

Figure A.10: More Outcome Variables for the Subsidiary-level Event Study

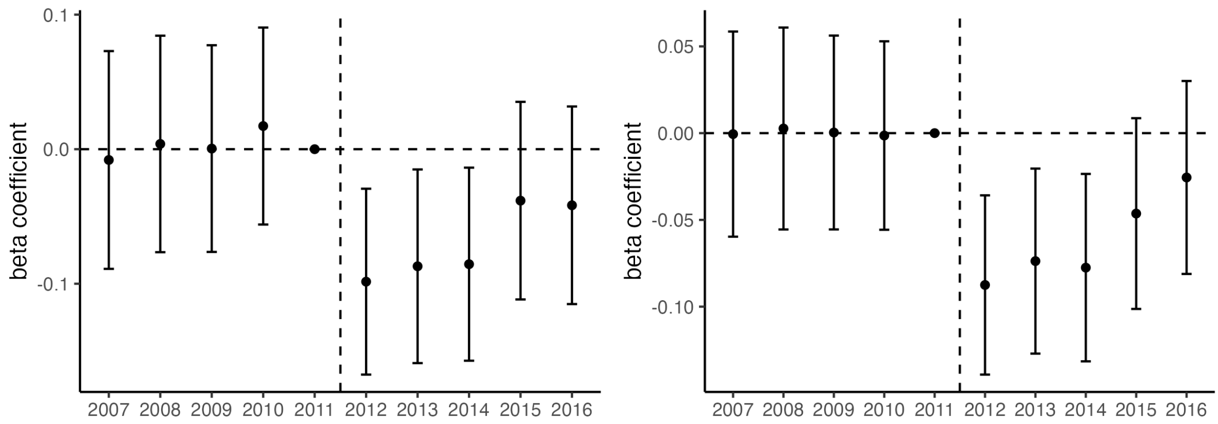
(a) Log Subsidiary Investment (b) Log Subsidiary Employment



Note: The figure plots coefficient estimates of subsidiary-level event-study regression in equation (2). Panel (a) takes log investment, and panel (b) takes log employment, both 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.

Figure A.11: Event Study of Subsidiary Operating Indicator

(a) 100% Ownership (b) Only Child Subsidiaries



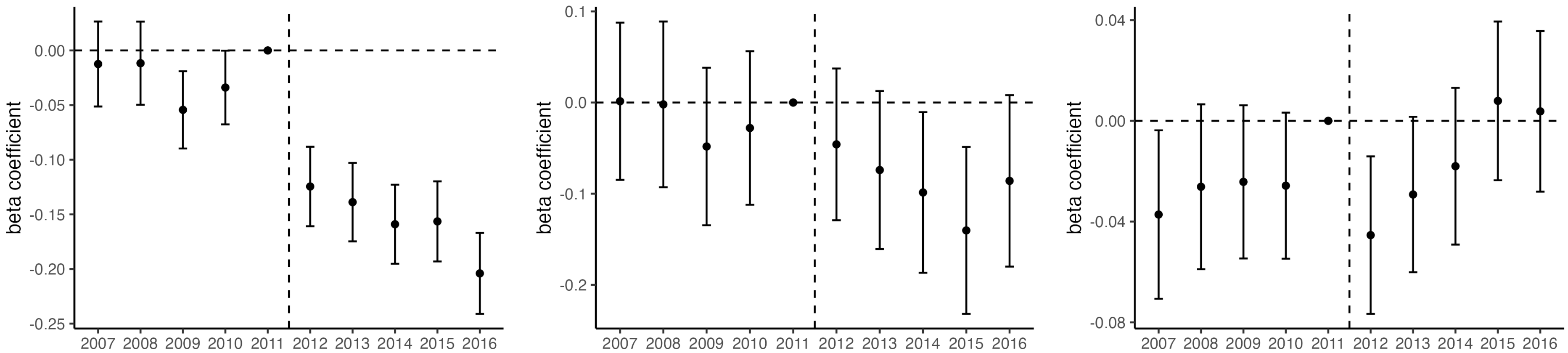
Note: The figure plots coefficient estimates of subsidiary-level event-study regression in equation (2) with the operating indicator as the outcome variable for the balanced panel of firms that operated throughout 2007-2011. In panel (a), the sample is the set of Thailand subsidiaries of Japanese MNEs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

Figure A.12: Decomposition of the Thailand Flood Effects on Foreign Employment

(a) Thai Employment in Flooded Regions

(b) Thai Employment in Non-flooded Regions

(c) Foreign non-Thai employment

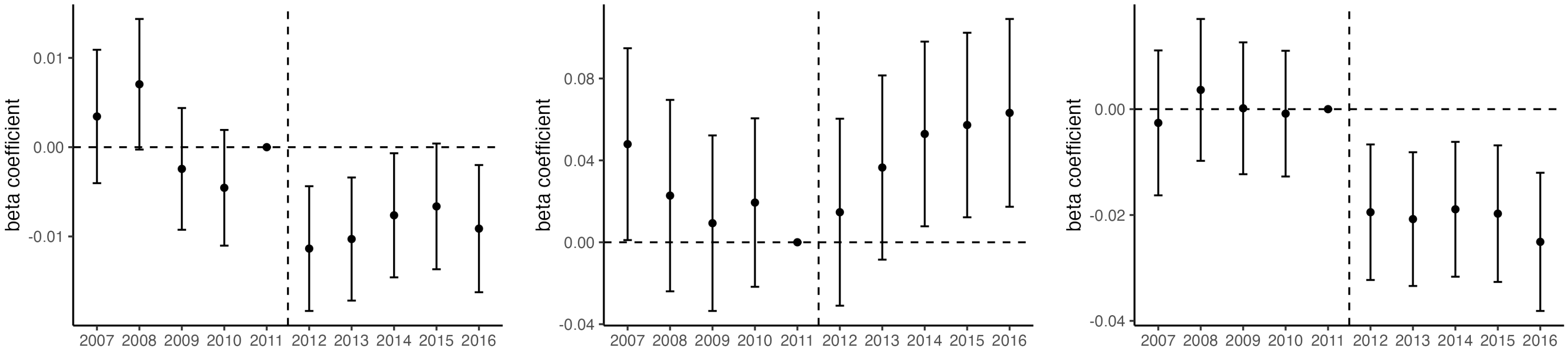


Note: The figure plots coefficient estimates of headquarter-level event-study regression in equation (3). As an outcome variable, panel (a) takes the log foreign non-Thai employment, panel (b) takes log Thai employment in non-flooded regions, and panel (c) takes log Thai employment in the flooded regions.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

Second, we consider other measures of labor and capital demand in Japan. For employment measure, we consider the total employment and non-regular employment. 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. For capital measure, we use fixed assets. Figure A.13 shows the result and confirms main results in Figures 5 qualitatively: both labor compensation and operating surplus fell after the floods differentially for those who were severely affected by the floods, with a greater negative impact on the operating surplus.

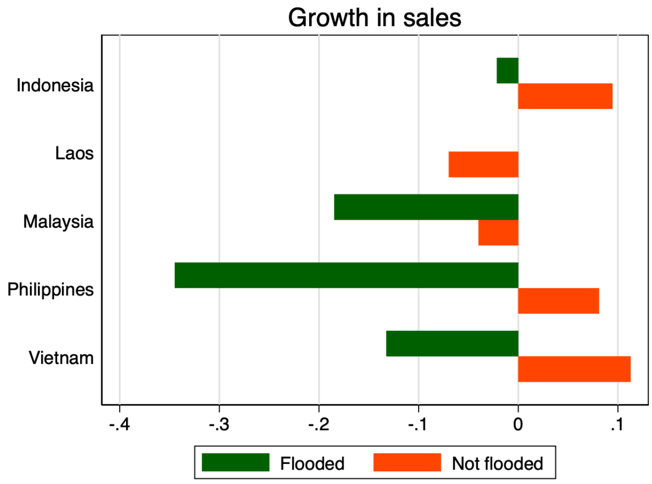
Figure A.13: Alternative Measures of Labor and Capital Demand

(a) Log Employment (b) Log Non-regular Employment (c) Log Fixed Asset



Note: The figure plots coefficient estimates of headquarter-level event-study regression in equation (3). As outcome variables, panel (a) takes log total Japanese employment, panel (b) takes log total Japanese employment in the non-regular contract, and panel (c) takes log fixed assets. Standard errors are cluster-robust at the firm level, and the bars indicate the 95 percent confidence intervals.

Figure A.14: Sales Growth of Firms in Thailand and Not in 2011



Notably, panel A.13b presents a view consistent with the hypothesis of flexible labor adjustment after the foreign floods shock, 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.13c shows that the effect on fixed assets is as negative and significant.

A.12 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 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.

We also check the third-country substitution using the event study specification (3). Panel A.15a shows that imports from Asia (excluding Thailand) networks decline after the floods. Panel A.15b shows that the effect on non-Thai Southeast Asian import does not react strongly after the floods. We also construct the outcome variable of log total employment and sales of subsidiaries in non-Thailand Southeast Asian countries. Panels and show the results, and we do not find any positive substitution effect from the flooded regions to non-flooded third countries. These findings indicate that there are not strong production substitution to third country in our context.

A.13 Robustness checks

Since our model considers vertical multinational production where the foreign factors provide added value to the global production process, our main regression results in Figure 5 should also hold with the MNEs that have subsidiaries that sell their products to the Japanese headquarters (HQ). In the data, however, most subsidiaries in Thailand trade with their Japanese HQ. Nonetheless, to confirm that our findings are driven by firms exporting back to Japan, we define an alternative shock variable by

$$Z_i^{ALT} \equiv \frac{l_{i,2011}^{\text{flooded, exporting to HQ}}}{l_{i,2011}^{world}}, \tag{A.2}$$

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.16 shows the result of event study specification (3) with this alternative shock variable and various outcome variables. As expected, the results barely changes from our main findings, confirming the robustness of our specification.

Lastly, in our sample of 658 MNEs that owned subsidiaries in Thailand in 2011, 26 of them had subsidiaries in both the flooded and non-flooded regions. Such MNEs may substitute production within Thailand more easily than those who have subsidiaries only in the flooded region. To explore the sensitivity of our results to these MNEs, we conduct the analysis with the data where these firms are dropped. Table A.17 shows the result, which confirms that the qualitative conclusions are unchanged by the sample restriction from the main analysis.

A.14 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 (13) and (14) 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

$$\ln\left(\frac{rk}{wl}\right)_i = b_{0,j} + b_1 \ln\left(w_{\text{city}(i)}\right) + X_i b_2 + e_i, \tag{A.3}$$

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.3) 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.3). 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.15 The Delta Method

By inverting equation (24), we have

$$\lambda = \frac{\Xi b - \Xi}{\left(1 - \bar{s}^{T|h}_{11}\right) b + \bar{s}^{T|h}_{11}},$$

where b is the estimate of (24), $\Xi = \sum_j (1-\varsigma_j)\varpi_{11,j}\left[-\sigma_j + \left(\sigma_j - \varepsilon_j\right)\kappa^h_j\right]$, and $\bar{s}^{T|h}_{11} \equiv \sum_j (1-\varsigma_j)\varpi_{11,j}$. Applying the continuous mapping theorem and central limit theorem to this ex-

Table A.4: Robustness Checks for Regression (25)

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
Implied elasticity λ	1.32	1.62	0.84	1.07

Note: The table presents regression results of equation (25) 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 observations, and columns 3 and 4 use the balanced panel as indicated by "Balanced panel" in the bottom 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, 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. The elasticity of substitution between labor and foreign inputs, λ, is implied by solving equation (24). Standard errors are clustered at the firm and industry-year level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

pression, we have the asymptotic standard error of λ given by

$$\sigma_\lambda^2 = \frac{\Xi\left(\left(1-\bar{s}_{11}^{T|h}\right)b+\bar{s}_{11}^{T|h}\right)-\left(\Xi b-\Xi\right)\left(1-\bar{s}_{11}^{T|h}\right)}{\left[\left(1-\bar{s}_{11}^{T|h}\right)b+\bar{s}_{11}^{T|h}\right]^2}\sigma_b^2,$$

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 for λ, 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.16 Robustness Checks for the Extensive Margin Shock

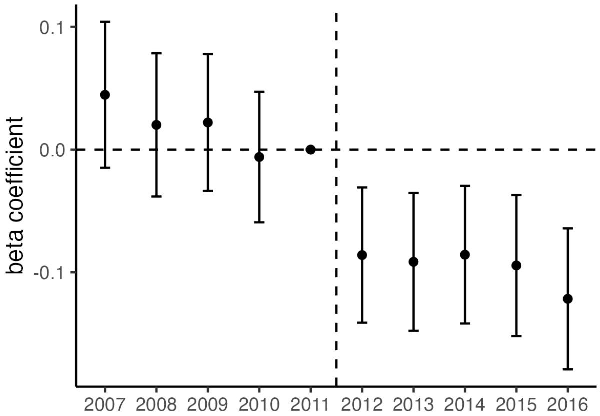
In this section, we investigate the impact of the flood shock at an extensive margin. Specifically, we define an MNE as affected by the floods if and only if it was operating and employing more than one person in the flooded region. The extensive-margin flood shock is given by $Z_{it}^{EXT} = \mathbf{1}\left\{l_{i,2011}^{flooded} > 0 \cap t \geq 2012\right\}$, where, again, $l_{i,2011}^{flooded}$ is MNE i's employment in the flooded region in 2011. We also examine if the results are sensitive to if the panel is unbalanced or balanced. The regression results are shown in Table A.4, and they are qualitatively consistent with those in Table 2. This result alleviates concerns that Thai investors may be on a different trend than the remaining firms in Japan, thereby validating the use of the estimated elasticity of substitution for the quantitative analysis.

A.17 Estimation Results of Equation (25) by Industry

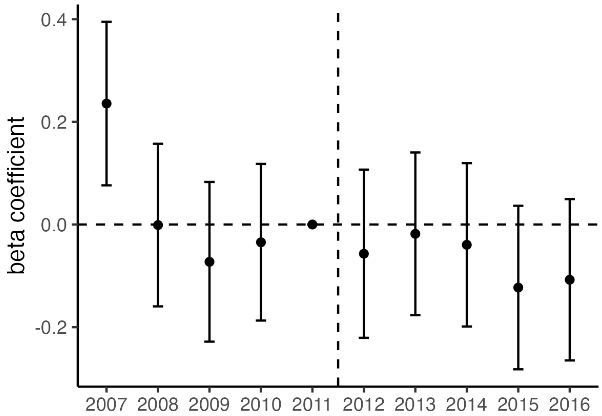
We examine the suitability of the constant factor substitution elasticity λ across different sectors in our model by analyzing the 2SLS regression coefficients across various sub-sectors. The regression results of equation (25) for each industry are displayed in Table A.5. Panel A presents the first-stage 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.

Figure A.15: Analysis of Third-country Effects

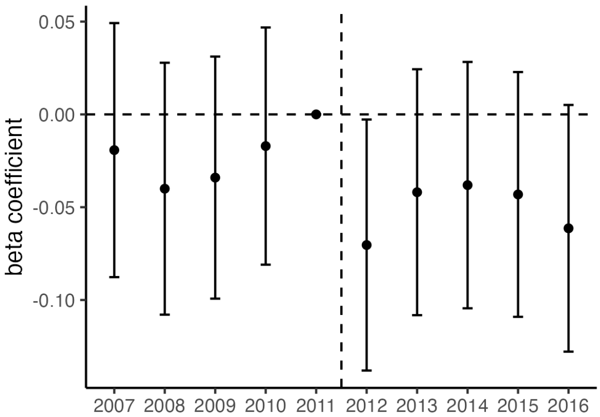
(a) Log Asian Import



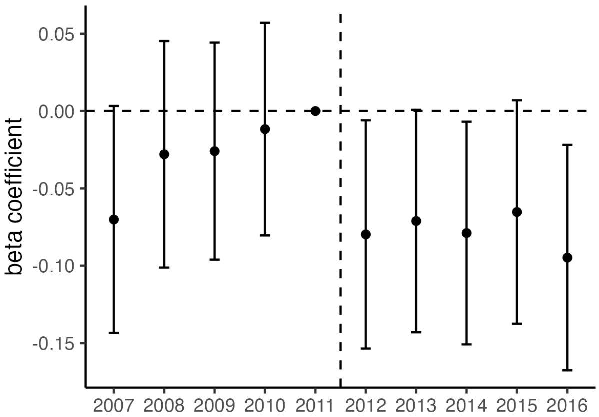
(b) Log Non-Thai Southeast Asian Import



(c) Log Non-Thai Southeast Asian Employment

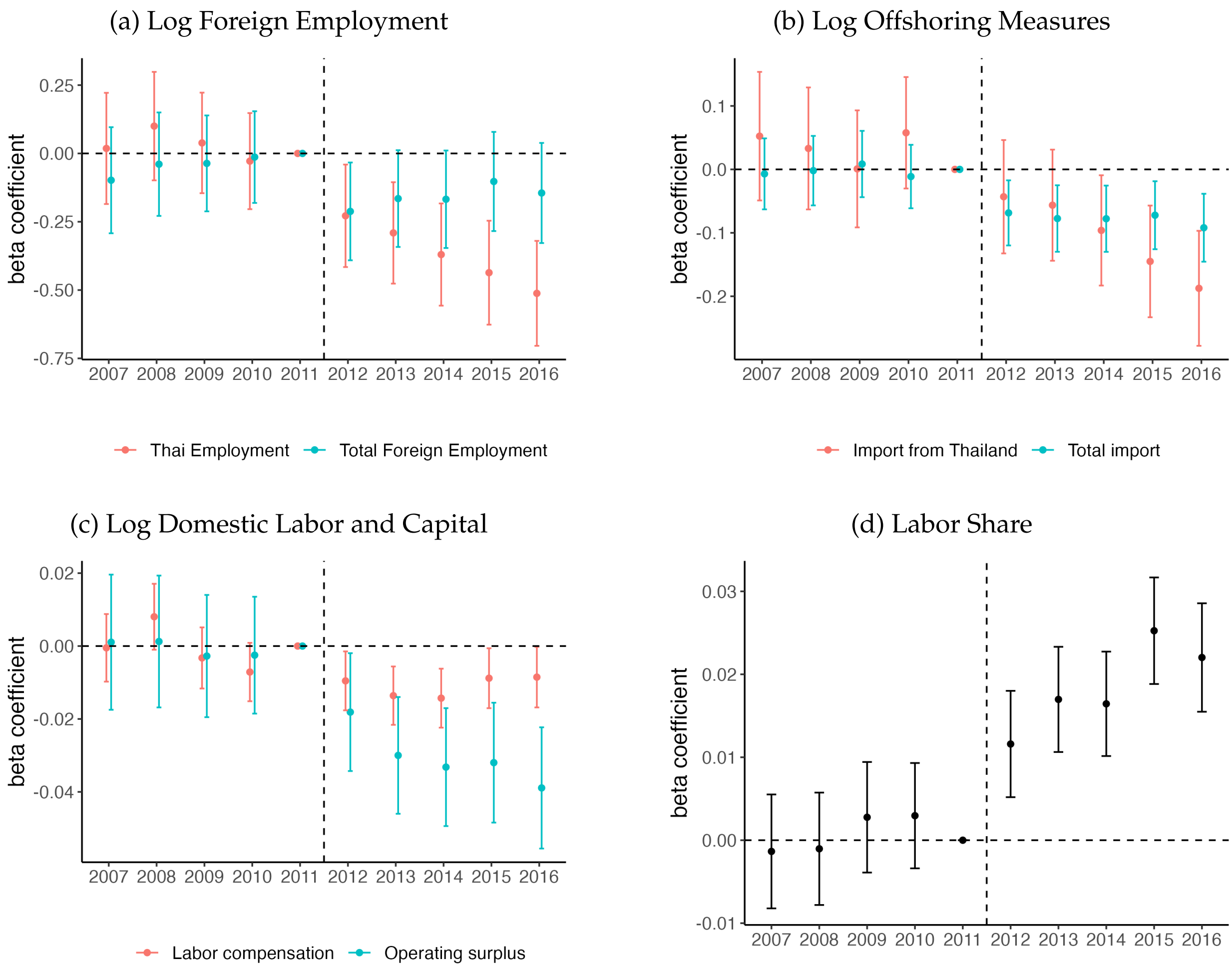


(d) Log Non-Thai Southeast Asian Sales



Note: The figure plots coefficient estimates of a headquarter-level event-study regression of equation (3) using different outcome variables. As outcome variables, panel (a) takes the log import value from Asia (excluding Thailand), panel (b) takes the log non-Thai Southeast Asian import value, panel (c) takes log total employment of subsidiaries in non-Thailand Southeastern countries, and panel (d) takes log total sales of subsidiaries in non-Thailand Southeastern countries. Standard errors are cluster-robust at the firm level, and bars indicate 95 percent confidence intervals.

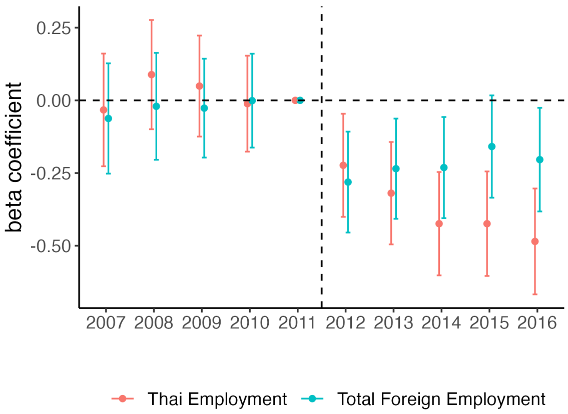
Figure A.16: Event Study at the Headquarter Level using Alternative Shock Variable



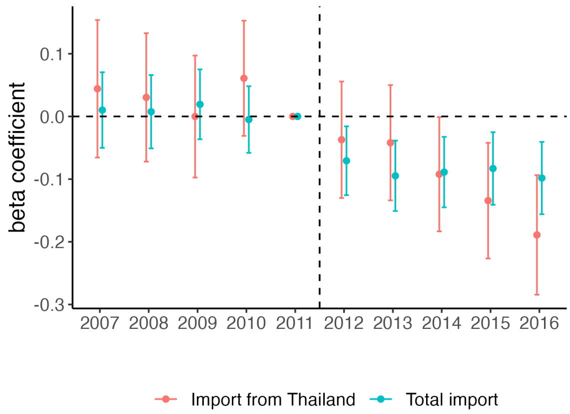
Note: The figure plots coefficient estimates of the headquarter-level event-study regression in equation (3), but using an alternative shock measure defined in (A.2). As the outcome variable, panel (a) takes log Thai employment and total foreign employment (both including the flooded regions), panel (b) takes the log value of intra-firm import to the Japanese parent firm from Thailand and all foreign countries, panel (c) takes log home-country labor compensation and operating surplus, and panel (d) takes the firm-level labor share defined in equation (1). Standard errors are cluster-robust at the firm level, and bars indicate 95 percent confidence intervals.

Figure A.17: Event Study at the Headquarter Level

(a) Log Foreign Employment

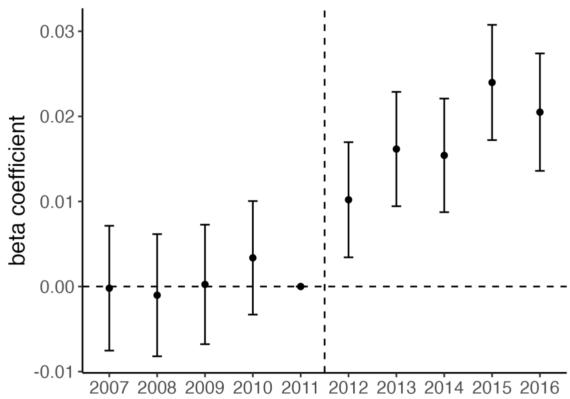


(b) Log Offshoring Measures



(c) Log Domestic Labor and Capital

(d) Labor Share



Note: The figure plots coefficient estimates of the headquarter-level event-study regression in equation (3). Unlike Figure 5, we exclude headquarter firms that have subsidiaries both in the flooded and non-flooded regions of Thailand. As the outcome variable, panel (a) takes log Thai employment and total foreign employment (both including the flooded regions), panel (b) takes the log value of intra-firm import to the Japanese parent firm from Thailand and all foreign countries, panel (c) takes log home-country labor compensation and operating surplus, and panel (d) 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.

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

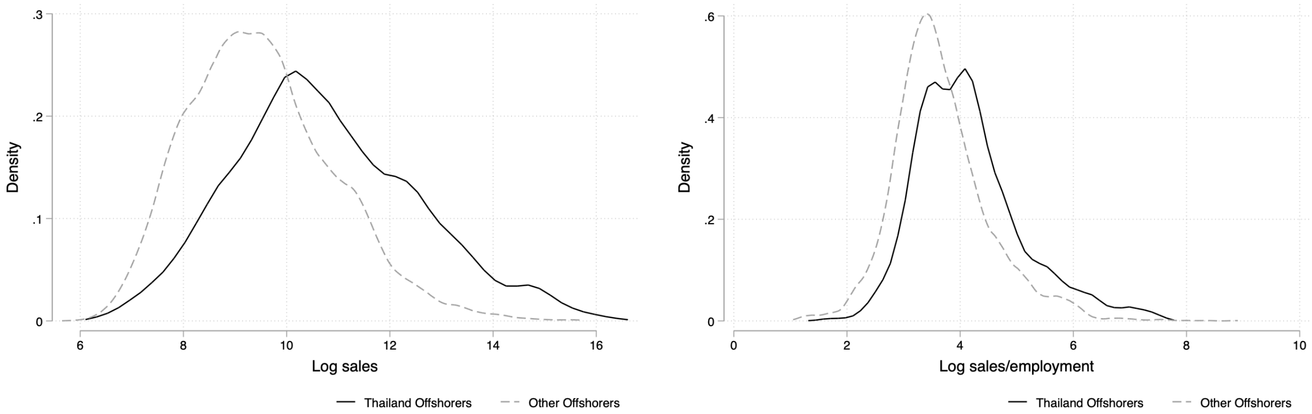
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A	1st	1st	1st	1st	1st	1st
Thai Flood Shock	-0.730***	-0.152	-1.655***	-2.223**	-0.655***	-0.303**
	(0.169)	(0.173)	(0.358)	(1.101)	(0.161)	(0.132)
Panel B	reduced	reduced	reduced	reduced	reduced	reduced
Thai Flood Shock	-0.0874**	0.000677	-0.277***	-0.172	0.120	-0.154**
	(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 (25) 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

(a) Log Sales

(b) Log Sales per Employment



Note: The figure shows the distribution of log sales (left panel) and log sales-to-employment ratio (right panel) of group of 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 (17) and (18)

In this section, we derive equation (17) 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

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

$$K_{01,j}^{D} = \int_{\psi_{01,j}}^{\psi_{11,j}} \left((r_J)^{-\sigma_j} \left(c_{01,j} (\psi) \right)^{\sigma_j - \varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1} \right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j (\psi) , \tag{B.2}$$

$$K_{11,j}^{D} = \int_{\psi_{11,j}}^{\infty} \left((r_J)^{-\sigma_j} \left(c_{11,j} (\psi) \right)^{\sigma_j - \varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1} \right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j (\psi) . \tag{B.3}$$

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

$$\hat{K}^D = \frac{\sum_j K_j^{D'}}{\sum_j K_j^D} = \sum_j \frac{K_j^D}{\sum_j K_j^D} \frac{K_j^{D'}}{K_j^D} = \sum_j \varsigma_j \hat{K}_j^D .$$

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

$$\begin{aligned} \bar{C}_j^K \equiv (r_J)^{-\sigma_j} \Bigg(& \int_{\underline{\psi}_j}^{\psi_{01,j}} \left(c_{00,j} (\psi) \right)^{\sigma_j - \varepsilon_j} dG_j (\psi) \\ & + \int_{\psi_{01,j}}^{\psi_{11,j}} \left(c_{01,j} (\psi) \right)^{\sigma_j - \varepsilon_j} dG_j (\psi) + \int_{\psi_{11,j}}^{\infty} \left(c_{11,j} (\psi) \right)^{\sigma_j - \varepsilon_j} dG_j (\psi) \Bigg) . \end{aligned} \tag{B.5}$$

Finally, taking the new-to-old ratio of equation (B.4) proves equation (17).

To derive equation (18), substituting unit cost expression (9) in equation (B.5), we have

$$\begin{aligned} \bar{C}_j^K = (r_J)^{-\sigma_j} \Bigg(& \left(\tilde{c}_{00,j} \right)^{\sigma_j - \varepsilon_j} \int_{\underline{\psi}_j}^{\psi_{01,j}} \psi^{\varepsilon_j - \sigma_j} dG_j (\psi) \\ & + \left(\tilde{c}_{01,j} \right)^{\sigma_j - \varepsilon_j} \int_{\psi_{01,j}}^{\psi_{11,j}} \psi^{\varepsilon_j - \sigma_j} dG_j (\psi) + \left(\tilde{c}_{11,j} \right)^{\sigma_j - \varepsilon_j} \int_{\psi_{11,j}}^{\infty} \psi^{\varepsilon_j - \sigma_j} dG_j (\psi) \Bigg) . \end{aligned}$$

Taking the new-to-old ratio yields equation (18). Accordingly, the aggregate labor demands for the three groups of offshoring strategy are

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

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

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

and similarly for the Thailand factor demand,

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

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

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

Hence, using a similar method, we have

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

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

where

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

and $\hat{p}^h_{d,j}$ is the change in the price index of labor-intensive inputs for offshoring strategy d in sector j that will derived below.

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

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

where

$$s^K_{d,j} \equiv \frac{\alpha^k_j \left(r_J\right)^{1-\sigma_j}}{\alpha^k_j \left(r_J\right)^{1-\sigma_j} + \alpha^h_j \left(p^h_{d,j}\right)^{1-\sigma_j} + \left(1-\alpha^k_j-\alpha^h_j\right)\left(p^m_j\right)^{1-\sigma_j}}$$

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 input 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

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

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

and

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

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_c, $c \in \{T, R\}$, 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 (15) and (16) for $d = 11$, we have

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

Rearranging, we have

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

We aggregate this expression across all offshorers in T to get

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

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

which is equation (26).

Next, taking the change of expression (26), we have

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

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

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

where

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

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

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

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

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

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

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

Hence, we have

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

Furthermore, we have

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

where the threshold change can be obtained in the same way in equation (21). This completes the derivation of equation (27).

B.4 Deriving Group-Specific Changes in Labor Shares

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

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

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

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

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

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

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

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

and

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

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

with the sector j-group g-specific MNE status d's factor shares 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* (19) *and* (21), *and* $\hat{\psi}_{01,j}$ *is given analogously.*

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

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

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

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

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

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

In terms of changes, we have

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

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

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

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

Note that

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

and $\frac{r_J K_{g,j}}{w_J L_{g,j} + r_J K_{g,j}} = 1 - S_{g,j}^L \frac{\varepsilon_j}{\varepsilon_j - 1}$ 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. □