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 foreign production factors and a sufficient statistic to solve the model in change is introduced. The elasticity of substitution between domestic labor and foreign factors 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

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1 Introduction

There is growing evidence that the labor share in developed countries has been declining in recent decades, raising concerns among policymakers about rising income inequality between workers and owners of capital. Several explanations have been proposed for this phenomenon, including distortions in technological change and rising markups. However, among the many potential mechanisms that could underlie technological change, there is little causal evidence for any particular one. In this paper, we examine the effect of increased multinational enterprise (MNE) activity on the labor share of their home country.

Our analysis uses novel causal evidence derived from a natural experiment resulting from the 2011 floods in Thailand. The floods caused a significant negative productivity shock to Japanese subsidiaries in Thailand, where parent firms in Japan typically outsource production. We show that Japanese MNEs with subsidiaries in the flooded areas experienced different post-flood trends in foreign and domestic activities, such as employment and capital demand, compared to other MNEs in Thailand not located in the flooded areas. Our evidence suggests that affected MNEs partially offset the negative impact on their overseas operations by hiring domestic workers to perform labor-intensive tasks.

A unique feature of the 2011 Thai floods is that many of the affected firms are foreign subsidiaries of Japanese MNEs. We match datasets from all Japanese MNEs and use detailed information on subsidiary locations, foreign operations, home-country employment, and fixed assets. The floods had a long-lasting impact on the activities of MNEs in the affected regions, with our event study regression indicating a decline in foreign and home labor compensation and operating surplus for affected Japanese MNEs relative to Japanese

MNEs with subsidiaries in Thailand that were not affected by the floods. Moreover, the flood-induced decline in fixed assets in Japan was larger than the decline in employment in Japan because the decline in employment in Thailand was partially offset by labor-intensive activities at home that compensated for the weakened foreign activities. This result suggests that labor is more substitutable than capital in the foreign operations of MNEs.

We use the model of heterogeneous offshoring firms with multiple inputs in the production function to interpret the empirical results and to formalize the idea of international factor substitution. The production function is characterized by a nested CES: The top nest is capital, labor composites, and materials, and the bottom nest is the labor composite function, which combines domestic and foreign labor. In addition, factor prices, which are endogenously determined by factor market clearing conditions in general equilibrium, are key variables driving the labor share. Finally, we use the model to conduct the counterfactual analysis to shed light on the role of the decline in Japan's labor share in the 1990s and 2000s.

The model has two mechanisms through which the aggregate labor share of firms is affected: a within-firm effect and a between-firm effect. If labor is more substitutable for foreign factors of production than capital, the productivity growth of the foreign factor will reduce the demand for labor relative to capital and thus depress the relative wage (the within-firm effect). Moreover, such foreign factor productivity growth disproportionately benefits already offshoring firms, which tend to have low labor shares in the data. Therefore, in constructing the aggregate labor share, the weight of already offshoring firms increases, which reduces the aggregate labor share (the between-firm effect).

To solve this model, we propose a sufficient statistics approach. We express equilibrium conditions in terms of the change from before to after shocks and make explicit the dependence of equilibrium conditions on observed expenditure shares rather than on unknown parameters. Because our model has heterogeneous firms, such expenditure shares include cost savings from offshoring for the firm at the productivity threshold. We proxy the unobserved cost-saving term with the model-implied measure of the offshorer's cost share.

To estimate the elasticities of substitution, we derive the relative factor demand equations and run the IV-2SLS using the Thai floods. Our central estimate for the substitutability between domestic labor and foreign factors is 1.28, suggesting the gross substitutability between domestic and foreign labor, given our nested CES production function.

We find that Thailand's productivity growth explains a 0.6 percentage point reduction in Japan's aggregate corporate labor share between 1995 and 2007. A decomposition of this labor share decline demonstrates that Thai factor productivity growth increased labor share inequality across firms because MNEs with an already low labor share further reduced their labor share by substituting foreign factors of production for domestic labor.

This paper contributes to two distinct but related bodies of literature. First, we provide a novel mechanism to explain the recent trend of declining labor shares in high-income countries. A growing body of work has explored this phenomenon since it was documented in an influential paper by Karabarbounis and Neiman (2013).[1] For example, Elsby et al. (2013) emphasizes the offshoring of labor-intensive activities across supply chains, and similarly, Oberfield and Raval (2021) emphasizes the role of technology, including offshoring and au-

[1]Other 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), labor market concentration (Gouin-Bonenfant et al., 2018; Berger et al., 2019), and intermediate price fluctuations (Castro-Vincenzi and Kleinman, 2024). Castro-Vincenzi and Kleinman (2024) examines the impact of intermediate inputs on the labor share, and the current study extends this by using a natural experiment and heterogeneous firm model to examine the role of foreign factors rather than intermediate inputs.

tomation. We extend this perspective by arguing that the deepening of global value chains, represented by intensified MNE operations, plays a role in reducing the labor share.

In recent studies, Sun (2020) and Leone (2023) highlight the role of MNEs in driving labor share. Based on different capital intensities between foreign affiliates and domestic firms, Sun (2020) develops a non-factor-neutral technology model that describes changes in labor share in developing countries that receive FDI from other countries.[2] Leone (2023) shows that firms acquired by multinationals reduce their labor share as they increase their use of robots. We complement these studies in two ways. First, we provide causal evidence on the effect of firms' intensified foreign activities on domestic factor employment based on a natural experiment and estimate the elasticity of factor substitution. Second, we use these estimates to explain the implications of the decline in the labor share in Japan, a country that invests more abroad than it attracts investment from abroad.

Our second contribution is to the literature on the impact of MNEs on the home labor market by providing evidence from natural experimental variation. experimental variation. Previous studies have examined the impact of foreign production on the source country labor market,[3] but the paucity of exogenous variation has often led to weak causal evidence. Exceptions include the work of Kovak et al. (2021), who exploit variation due to 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

[2]The main mechanism through which labor share is affected differs between a multinational production (MP) model of Sun (2020) and our offshoring model. In an MP model, capital-intensive firms in developed countries move capital-intensive production tasks to a foreign host country (production site), thereby increasing the labor share at home. In contrast, the offshoring model predicts that foreign inputs directly substitute labor more than capital, reducing the domestic labor share.

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

spillovers of the Tohoku earthquake on US manufacturing firms. We complement this evidence by drawing on another natural experiment, the impact of the 2011 Thai floods on Japanese MNEs. Moreover, while previous studies have primarily focused on the impact on employment and the labor market in the home country, they have overlooked the impact on capital demand. However, it is crucial to examine both the capital market and the labor market when discussing the corporate labor share.

Furthermore, Castro-Vincenzi (2023) empirically shows the response of global automobile production to increased climate risks and 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 firm and aggregate labor shares in the long run, conditional on the changes in firm behavior.

2 Empirical Evidence

2.1 Data Source

The first 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). The BSJBSA provides a comprehensive array of firm-level variables including the firm's physical address, the number of employees categorized by divisions and regular/non-regular workers, product-level sales data, cost breakdowns by type, import and export values by region, outsourcing activities, and balance-sheet information such as operating surplus and the value of fixed assets.[4] The survey covers the years 1995-2016. 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 obtain information on foreign subsidiaries, we 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. We use information from the Subsidiary file, which documents data about all child and grandchild foreign subsidiaries of each headquarter (HQ) firm. The survey items consist of the country of subsidiary location, employment, and sales (disaggregated by destination, such as Japan, non-Japan Asia, Europe, and North America), but do not contain information on capital stock in the subsidiary. We drop subsidiaries located in tax-haven countries, following the definition provided by Gravelle (2015).

As location in the BSOBA is available only at the country level, we enhance the information with street-level addresses from the Orbis dataset by Bureau van Dijk. Using the HQ firm name, location, and phone number, we 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. A firm is classified as multinational if and only if it appears in the BSOBA Headquarters File in the BSJBSA each year. More data details are described in Appendix A.6.

[4]The operating surplus is the sales net of the cost of sales and selling general and administrative expenses (SG&A). The SG&A includes the depreciation expense. Accounting variables in the BSJBSA are based on a single accounting rather than a consolidated accounting, so they do not encompass repatriated profits and returns to capital abroad.

First Look at MNEs and Labor Shares Figure 1 shows a simple trend highlighting the role of MNEs in the declining labor share. MNE's HQ sales as a share of total firm sales increase over the period, while the labor share of MNEs (solid line) shows both a lower labor share and a faster declining labor share than non-MNEs (dashed line) over the period.[5]

MNEs in Thailand and the Rest of the World Figure 2 shows the sales and sales productivity distribution between Japanese MNEs operating in Thailand and those who do not. Overall, the productivity of the former is higher than the latter. It motivates our choice of the parameter restrictions in the model section, which implies the pecking order of source countries as in Antras et al. (2017).

Patterns of the Firm-level Labor Share in Japan Following Rognlie (2018), we define the firm-level labor share by the net labor share

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

where $(wl)_{it}$ is the labor compensation of firm i in year t, and $(os)_{it}$ is the operating surplus.[6] This approach mitigates concerns about the mixed income of self-employed individuals and capital depreciation but requires a careful interpretation of the operating surplus, which will be discussed in the model section. It is known that this measure of corporate labor

[5]Similar conclusions can be drawn from comparisons between MNEs with and without offshoring and between MNEs with and without subsidiaries in Thailand, as reported in Appendix A.1. Cross-country evidence also points to the negative correlation between the change in the labor share and outward MNE intensity, as shown in Appendix A.2.

[6]The operating surplus depends on profits and markups, which are not directly tied to our proposed mechanism, the offshoring of the labor-intensive task. However, we believe that the influence of markups in our context is minor as the aggregate markups remained constant in Japan during our sample period of 1995-2007. the This is pointed out by Nakamura and Ohashi (2019) and in our Appendix A.5.

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.[7] Similarly, the aggregate labor share S_t^L is defined by $\sum_i (wl)_{it} / \sum_i [(wl)_{it} + (os)_{it}]$. Figure 3 shows the distribution of the firm-level labor share across different firm sizes. It reveals that (i) there is a negative relationship between labor share and firm size, and (ii) the slope of this relationship steepens in a later year. 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 (Autor et al., 2020).[8]

Consistent with this fact, the labor share is lower for MNEs, which are on average larger, as shown in Appendix A.1. These observations guide us to link globalization and intensified MNE activities to the decline in labor share. In the next section, we examine this hypothesis using our natural experiment, the 2011 Thailand Floods.

2.2 Responses of Japanese MNEs to the 2011 Thailand Floods

This subsection gives an overview of the 2011 Thailand Floods and Japanese MNEs reaction to it. Full details can be found in Appendix B.1.

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

[7] Consequently, comparisons of labor shares should not be made between different measures but only across periods for a given measure. However, in our sample period, the net and gross labor shares move in the same direction. Further details of different labor share measures are discussed in Appendix A.3.

[8] We also find that the significant share of the labor share decline happened within firm, rather than the compositional effect, in Appendix A.4.

(AP hereafter) provinces, which are home to seven industrial estates. 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 inventories, these companies were particularly vulnerable to the shock (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), or 13.6% of the 2010 Thai GDP.

Building upon the arguments put forth by Benguria and Taylor (2019) that the floods primarily impacted the production side rather than the demand side, Thailand experienced a decline in exports but not imports following the floods, as shown in Appendix B.2. Although the direct inundation period lasted only one year, the business-weakening effects of the floods were long-lasting.[9] 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.

[9]See Appendix B.3 for details. Firms possibly updated 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).

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.[10] Therefore, we control for potential cross-country differences by using the variation across geographic regions within Thailand. Figure 4 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.[11]

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

[10]A few MNEs 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). A sensitivity analysis of dropping these firms in Appendix B.5 confirms that our main results are qualitatively unaffected by this consideration.

[11]Not only subsidiaries but also headquarters are balanced between the treated and control groups, where the status is defined by the cutoff employment share in the flooded region in the world subsidiary employment. See Appendix B.1 for details.

sample of Japanese subsidiaries in Thailand:

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

where s indicates subsidiary, j indicates the industry of subsidiary, t is the 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 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 operations. Additionally, we study the adjustment at the intensive margin by analyzing log variables (investment, employment, and sales) conditional on continuing operation.

The results are presented in Figure 5. 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.[12] In contrast, panel (b) does 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.

[12] We interpret the weaker effects in the long run as the spillover to the control-group firms. See Appendix B.8 for the details.

We also observed employment response conditional on operating is not significant. These additional results are reported in Appendix B.4.

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 B.4.

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 a mean of 0.166, a median of 0.091, and a 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.[13] Our primary interest lies in the coefficient β_τ^H, which captures the within-HQ firm effect of the floods for each year. Figure 6 presents the estimates of β_τ^H for various outcome variables. 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 6a. 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. The effect is mostly explained by the employment reduction in the subsidiaries in the flooded regions (Appendix B.5).

To investigate international spillover effects, we examine Japanese HQs' intra-firm trade values from Thailand and all foreign countries in panel 6b. We find a decrease in imports by affected HQs, indicating the negative effects of the flood shock across borders.[14]

Consistent with these findings, we observe negative effects on domestic factor employment. Panel 6c shows the response of log labor compensation and operating surplus 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 increase in the labor-to-capital ratio and the labor share at the firm level, as confirmed in the panel 6d. These results, together with the observed decline in imports,

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

[14]Appendices B.5 and B.6 explore potential effects on the substitution of production in third countries, but little conclusive evidence is found.

suggest a reshoring of labor-intensive activities from abroad to the home country.[15]

Quantitatively, 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.[16] 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 offshoring of labor-intensive tasks, 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 B.5 and B.7 elaborate on these additional analyses.

Overall, we find that as firms face severe damage from the floods, the negative effects

[15] 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.

[16] 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.

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.

3 Model

We consider a heterogeneous firm 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.[17] To

[17]The purpose of including multiple industries in the model is twofold: First, labor intensities, and thus labor shares, differ across industries. Second, as we argue in Section 3.2, reallocation across industries under

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. In J, capital $\bar{K}_J$ and labor $\bar{L}_J$ are supplied inelastically, while there is inelastic Thai factor supply $\bar{X}_T$. We do not specify the household income and preferences at this point since it is not necessary to examine the effects on the labor share. We will revisit this point in the welfare analysis.

Production. There are producers of sectoral goods and producers of intermediate varieties headquartered in country J. The sectoral goods producers 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 $\underline{\psi}_j$.[18] Conditional on the subsidiary location choice, each firm hires production factors of capital, labor, and foreign production factors from competitive factor markets with factor prices (w_J, r_J, p_T^x).[19] Firms also choose the foreign subsidiary location in $c = T, R$ and produces with production

heterogeneous markups makes profit as a potentially important margin for the labor share.

[18] 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, which will be illustrated in equation (21).

[19] The capital rental rate r_J is net of the depreciation, to make the theory and data consistent. Therefore, the income concept is in this paper is net income, not gross income.

function

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

where k is the HQ capital, $h \equiv h(l, x_T, x_R)$ are labor-intensive tasks specified below, m is the intermediate input, including the imported inputs from other firms, and $\sigma \geq 0$ is the sectoral elasticity of substitution between capital and labor-intensive tasks, and $\alpha_j^k, \alpha_j^h \in (0,1)$ capture the input shares that exogenously affect the firm-level labor share.[20] The tasks are performed internationally and determined by

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

where l is the home-country labor, x_c the offshore factors from subsidiaries in $c = T, R$, and $\lambda > 1$ the elasticity of substitution between these factors.[21] Here, a_c is 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.[22] We will study comparative statics of these productivities caused by floods (negative productivity shock) or globalization (positive productivity shock).[23] 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 the country c in the unit of labor.

[20] 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.

[21] Adachi (2023) shows that a task-based framework combined with Fréchet distribution implies the same unit cost function as equation (6).

[22] 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.

[23] Appendix C.2 argues the plausibility and innocuousness of this interpretation in contrast to capital destruction.

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

$$s^L(\psi) = \frac{w_J(l(\psi) + f(\psi))}{w_J(l(\psi) + f(\psi)) + r_J k(\psi) + \pi(\psi)}, \tag{7}$$

where $\pi(\psi)$ is the profit and $f(\psi)$ is the total labor employed for fixed costs for firm ψ that varies by the offshoring strategy. The idea is that the operating profit in the data includes not only return to capital but also profit. 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

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

Equilibrium. Country T's representative producer uses factor 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 the Model Assumptions

The Small-Open Assumption. While the small-open assumption may seem restrictive, it does not pertain to all Japanese international trade but only to the much smaller fraction of MNE activities worldwide. Moreover, the small-open assumption helps us greatly simplify the analysis by eliminating the feedback effects of activities in J and T on global prices. In 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.

The Single-Factor Assumption in T and R. 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 the 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 do 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, detailed data regarding factor demands from firms that are not offshore subsidiaries are needed, which is challenging to acquire. Thirdly, mapping between the flood event and theory would be difficult with the multiple factors in foreign countries as it is not clear if the flood shock affects employment or capital formation in Thailand.

The Nested CES Production Functions (5) and (6). The CES function with capital, labor-intensive tasks, and intermediate inputs is standard in the most recent literature of production functions (Doraszelski and Jaumandreu, 2018; Zhang, 2019; 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. In contrast, Boehm et al. (2018) assume a Cobb-Douglas mix of capital and labor with a more flexible substitution pattern with the foreign factors 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 tasks.

Our nested CES implies that if $\lambda > \sigma$, firm-level labor share $s^L(\psi)$ is decreasing in a_c ($c \in \{T, R\}$) since labor is a relative substitute of foreign factors to capital. This is consistent with the observation that operations in foreign subsidiaries are labor intensive and that MNE capital is often headquarter-intensive.[24] The nesting structure also implies an independence of the irrelevant alternatives (IIA) restriction: the relative demand in the same nest is not affected by the shock to the factor in a different nest. We test the model prediction in Appendix C.1, which supports our choice of the nest.

Export Platform and Uncertainty. First, we model global production in the offshoring model where HQ firms outsource tasks 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.

[24] In the BSJBSA data, the average HQ share of MNEs is 39.6%, while that of non-MNEs is only 19.2%. The structure that the outsourced tasks are direct substitutes of (low-skill) labor is also found in Hummels et al. (2014). We study the implication of the substitution of labor with intermediate inputs in Appendix C.8.

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 shown to be minor compared to the effect of reallocation between demand for labor and capital in Appendix E.2.

3.3 Characterization

The offshore subsidiary decision can be summarized by productivity thresholds $\psi_{c,j}$, $c \in \{T, R\}$. Motivated by the sales distribution across T and R, we impose a parameter restriction such that

$$\psi_{T,j} > \psi_{R,j}. \tag{9}$$

Given this restriction, the entry choice of firms is made among $d = 00$ (non-offshoring), $d = 01$ (R-offshoring), and $d = 11$ (R- and T-offshoring), so we rewrite the productivity thresholds as $\psi_{01,j}$ (the threshold between $d = 00$ and $d = 01$) and $\psi_{11,j}$ (the threshold between $d = 01$ and $d = 11$), and a firm's decision d is called an offshoring strategy hereafter.

Firm ψ's marginal cost can be written as

$$c_{d,j}(\psi) = \frac{\tilde{c}_{d,j}}{\psi},\ \tilde{c}_{d,j} \equiv \left[\alpha_j^k (r_J)^{1-\sigma} + \alpha_j^h \left(p_d^h\right)^{1-\sigma} + \left(1 - \alpha_j^k - \alpha_j^h\right)(p^m)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{10}$$

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

$$p^h_{d,j} = \begin{cases} \left(1-\beta^T_j-\beta^R_j\right)^{\frac{1}{1-\lambda}} w_J & \text{if } d=00 \\ \left[\left(1-\beta^T_j-\beta^R_j\right) w_J^{1-\lambda}+\beta^R_j\left(\frac{p^x_R}{a_R}\right)^{1-\lambda}\right]^{\frac{1}{1-\lambda}} & \text{if } d=01 \\ \left[\left(1-\beta^T_j-\beta^R_j\right) w_J^{1-\lambda}+\beta^R_j\left(\frac{p^x_R}{a_R}\right)^{1-\lambda}+\beta^T_j\left(\frac{p^x_T}{a_T}\right)^{1-\lambda}\right]^{\frac{1}{1-\lambda}} & \text{if } d=11 \end{cases} \cdot \tag{11}$$

Firm ψ's entry decision is given by the cutoffs $\psi_{d,j}$. For instance, the threshold $\psi_{11,j}$ can be derived by equating profit gain by entering T to the fixed cost, $\pi_{11,j}\left(\psi_{11,j}\right)-\pi_{01,j}\left(\psi_{11,j}\right)= w_J f_T$, or

$$\psi_{11,j} = \left(\frac{w_J f_T}{\tilde{\varepsilon}_j P_j^{\varepsilon_j-1} Q_j}\right)^{\frac{1}{\varepsilon_j-1}} CS_{11,j}, \tag{12}$$

where

$$CS_{11,j} \equiv \left[\left(\tilde{c}_{11,j}\right)^{1-\varepsilon_j}-\left(\tilde{c}_{01,j}\right)^{1-\varepsilon_j}\right]^{\frac{1}{1-\varepsilon_j}} \tag{13}$$

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 $p_{d^*,j}\left(\psi\right)=\frac{\varepsilon_j}{\varepsilon_j-1} c_{d^*,j}\left(\psi\right)$. With this strategy, firm-level factor demand functions can be derived from the CES formulation

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

$$p^h_{d^*} h_{d^*,j}\left(\psi\right) = \left(\frac{p^h_{d^*,j}}{c_{d^*,j}\left(\psi\right)}\right)^{1-\sigma}\left(\frac{p_{d^*,j}\left(\psi\right)}{P_j}\right)^{1-\varepsilon_j} P_j Q_j, \tag{15}$$

$$w_J l_{d^*,j}(\psi) = \left(\frac{w_J}{p^h_{d^*,j}}\right)^{1-\lambda} p^h_{d^*} h_{d^*,j}(\psi), \tag{16}$$

and

$$p^x_T x_{T,d^*,j}(\psi) = \left(\frac{p^x_T/a_T}{p^h_{d^*,j}}\right)^{1-\lambda} p^h_{d^*} h_{d^*,j}(\psi). \tag{17}$$

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 Sufficient Statistics with Heterogeneous Firms and Offshoring

To solve these equilibrium conditions, we follow and extend 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 hat algebra to work.

For brevity, we hereafter discuss the change in aggregate capital demand $\hat{K}^D$.[25] We have

$$\hat{K}^D = \sum_j \varsigma_j \hat{\tilde{C}}_j^K, \text{ where } \varsigma_j = \frac{r_J K_j}{\sum_k r_J K_k}. \tag{18}$$

Here, ς_j is the sectoral capital cost share, and $\hat{\tilde{C}}_j^K$ is the change in the term of capital cost relative to the unit cost averaged across offshoring strategies. This term is given by, with slight abuse of notation,

$$\hat{\tilde{C}}_j^K = (\hat{r}_J)^{-\sigma} \sum_{d \in \{00,01,11\}} \xi_{d,j}^K \left(\hat{\tilde{c}}_{d,j}\right)^{\sigma - \varepsilon_j} \hat{s}_{d,j}, \text{ where } \xi_{d,j}^K = \frac{\int_{\psi \in d} r_J k_j(\psi)\, dG_j(\psi)}{r_J K_j}. \tag{19}$$

Here, $\xi_{d,j}^K$ is the capital cost share of firms with entry decision d in sector j, and $\hat{s}_{d,j}$ is the change in the profitability share of firms with entry decision d. Formally, the profitability share is defined by

$$s_{d,j} \equiv (\Gamma_j)^{-1} \int_{\psi \in d}^{\infty} (\psi)^{-(\sigma - \varepsilon_j)} dg_j(\psi), \ \Gamma_j \equiv \int_{\underline{\psi}}^{\infty} (\psi)^{-(\sigma - \varepsilon_j)} \mathrm{d}g_j(\psi) \tag{20}$$

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. Proof of equations (18) and (19) and derivation of the productivity-controlled cost change $\hat{\tilde{c}}_{d,j}$ are given in Appendix C.3.

Using the Pareto distribution assumption, we can show that $\hat{s}_{d,j}$ depends on the change

[25] Derivations for the changes in labor demand $\hat{L}^D$ and Thailand factor demand $\hat{X}_T^D$ are similar and are provided in Appendix C.3, equations (C.8) and (C.9).

in the cost-saving (13), denoted as $\hat{CS}_{d,j}$. For example, when $d = 11$,[26]

$$\hat{s}_{11,j} = \left(\hat{\psi}_{11,j}\right)^{-(\theta_j-(\varepsilon_j-\sigma))} = (\hat{w}_J)^{\frac{-\theta_j-\left(\varepsilon_j-\sigma\right)}{\varepsilon_j-1}} \left(\hat{CS}_{11,j}\right)^{-\theta_j-(\varepsilon_j-\sigma)}, \tag{21}$$

where the last equality holds from equation (12). To sidestep the difficulty that $\hat{CS}_{11,j}$ is a counterfactual term that is hard to measure, we propose the following sufficient statistics approach. First, CES implies that the sectoral cost ratio, or $CR_{11,j} \equiv (\tilde{c}_{11,j}/\tilde{c}_{01,j})^{1-\varepsilon_j} - 1$, can be written as follows:[27]

$$CR_{11,j} = \left[(1-\kappa_{01,j}) + \kappa_{01,j}\left(1-\varpi_{11,j}\right)^{-\frac{1-\sigma}{1-\lambda}}\right]^{\frac{1-\varepsilon_j}{1-\sigma}} - 1 \tag{22}$$

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

$$\hat{CS}_{11,j} = \hat{\tilde{c}}_{01,j}\left(\frac{CR'_{11,j}}{CR_{11,j}}\right)^{\frac{1}{1-\varepsilon_j}}, \tag{23}$$

[26]Proof is given in Appendix C.4.
[27]Proof is given in Appendix C.5.

where $CR_{11,j}$ and $CR'_{11,j}$ are both derived from data before and after the change.[28] We can derive similar expressions of equation (21) for other entry strategies $d = 00, 01$, which are shown in Appendix C.3.

The intuition for this sufficient statistics is that, in the key expression of (22), 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 tasks in sector j (hence high $\kappa_{01,j}$), and if the factors in Thailand among labor-intensive tasks (hence high $\varpi_{11,j}$) are intensively used in firms offshoring in Thailand, then the optimal factor demands imply that the cost ratio between investing and not investing in Thailand is large. The nested CES production function provides a specific one-to-one relationship of this type shown in equation (22). Therefore, we can measure counterfactual cost savings by model-implied observed cost shares.

4 Estimation

To solve the equilibrium conditions, we need a set of parameters $(\theta_j, \varepsilon_j, \sigma, \lambda)$. We calibrate θ_j using the tail distribution of sales and ϵ_j using the sectoral average markups. Second, we estimate the remaining substitution parameters λ and σ. [29]

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

[29]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 model structure needed to solve for the general equilibrium.

4.1 Calibrating Sectoral Parameters

First, we fit the Pareto shape parameter θ_j to the sectoral tail sales distribution. Following Eaton et al. (2011), we consider $\ln\left(x_j^q\right) = a_j - (\theta_j)^{-1}\ln(1-q)$, where q is the percentile, a_j is the sector-specific intercept, and x_j^q is the q-th percentile of sales in sector j. We use sample firms with $q > 0.99$ for each sector, as the top tail follows a Pareto distribution, and apply the correction to the OLS estimation proposed by Gabaix and Ibragimov (2011). Second, we obtain the demand elasticity ε_j with respect to sectoral average markups. We compute markups for each firm by dividing sales by the sum of costs associated with production: labor compensation, capital costs, and purchases of intermediate goods. Further calibration details can be found in the Appendix D.1. These parameters are calibrated at the three-digit level in the manufacturing sector, as shown in table 1. The calibrated parameters satisfy the constraints of the Pareto shape parameter $\theta_j > \varepsilon_j - \sigma$ for all j, so the power averages are well defined.

4.2 Estimating the Elasticity of Substitution

We bring the relative demand functions to the log-linear estimation function and apply the Thai flood shock as an IV to identify the key substitution elasticities λ and σ. We start with equations (15) and (17). These equations imply the following relative demand equation for each firm:

$$\frac{w_J l}{r_J k} = \frac{\left(\frac{w_J}{p^h}\right)^{1-\lambda}\left(\frac{p^h}{c_{d,j}}\right)^{1-\sigma}}{\left(\frac{r_J}{c_{d,j}}\right)^{1-\sigma}} = \frac{w_J^{1-\lambda}\left(p^h\right)^{\lambda-\sigma}}{r_J^{1-\sigma}}, \tag{24}$$

which implies that the labor share is a positive function of the Thai flood shock if $\lambda > \sigma$ and the Thai flood shock increases the effective cost of the labor-intensive task, p^h. We consider the regression of the following difference-in-difference model for the sample of firms investing in Thailand in each industry j:

$$\ln\left(\frac{w_J l}{r_J k}\right)_{it} = \alpha_i + \alpha_{jt} + \beta \hat{a}_{T,it} + \epsilon_{it}, \tag{25}$$

$$\text{where} \qquad \hat{a}_{T,it} \equiv -Z_i \mathbf{1}\{t \geq 2012\} \qquad \text{and} \qquad Z_i = \frac{l_{i,2011}^{flooded}}{l_{i,2011}^{world}}. \tag{26}$$

Here, α_i is the firm fixed effect, and α_{jt} is the prefecture year fixed effect, which captures the general equilibrium effect that is constant across firms in each location and year. The explanatory variable $\hat{a}_{T,it}$ is the magnitude of the productivity shock, measured by the interaction of Z_i and the time dummy after the floods. In this regression, the inequality condition $\lambda > \sigma$ is equivalent to $0 < \lambda - \sigma = \beta$.

Next, we consider the following relative demand from the nested CES production function:

$$\frac{w_J l}{p_T^x x_T} = \left(\frac{w_J}{p_T^x}\right)^{1-\lambda}, \tag{27}$$

which shows the relative demand for domestic labor and Thai inputs, both of which are in the lower nest. Therefore, the relative demand is independent of the upper nest elasticity, σ. We fit equation (27) to the data by running the regression

$$\ln\left(\frac{w_J l}{p_T^x x_T}\right)_{it} = \tilde{\alpha}_i + \tilde{\alpha}_{jt} + \tilde{\beta} \hat{a}_{T,it} + \tilde{\epsilon}_{it}, \tag{28}$$

and estimate $\lambda = 1 - \tilde{\beta}$. With this value plugged in, we estimate the value of σ from the condition $0 < \beta$.

4.3 Estimation Results

Table 2 shows the results of the estimation. Column 1 shows the effect of the Thai floods on the ratio of Japanese employment-to-Thai value added, while column 2 shows the effect on the ratio of Japanese employment-to-Japanese capital stock. Consistent with the results in section 2.2, we find a significantly negative effect for column 1 and a significantly positive effect for column 2. These estimates imply $\lambda = 1.28$ and $\sigma = 1.14$. This result indicates that foreign factors of production and Japanese labor are substitutes. Thus, the increase in the factor-increasing productivity shock in Thailand implies a larger decrease in labor demand than in capital demand, thereby reducing the firm-level labor share in Japan.

Appendix D.2 confirms the robustness with respect to the definition of shock intensity Z_i and control groups. Estimation results by industry are presented in Appendix D.3.

5 Quantitative Exercises

5.1 Model Fit

In this subsection, we conduct a simulation to test whether the estimated model can predict firms' responses to the Thai floods. First, we simulate the same number of firms for each sector j as observed in 2011 and randomly select those affected by the flood shock based on the observed share of firms in the flooded provinces. This procedure reflects our identification assumption that the flood damage was concentrated in these two provinces and is as good as random. Second, the selected firms are hit with a productivity shock $\hat{a}_T = 0.1$.[30] Finally, we solve the model using the sufficient statistics approach to obtain the changes in equilibrium factor prices $(\hat{r}_J, \hat{w}_J, \hat{x}_T)$ and the model-predicted change in employment $\hat{l}(\omega)$ and capital $\hat{k}(\omega)$, and regress $\hat{l}(\omega)$ and capital $\hat{k}(\omega)$ on the AP dummy and the industry fixed effect. We compute the demand for capital in the data by multiplying the asset value by the long-run return on capital.

The results are shown in Table 3. We consider the fit of domestic employment, capital, sales, and value-added variables to the observed reaction to the Thai floods. Even though none of these is a directly targeted moment, the model prediction closely tracks the actual empirical pattern. The difference between the model and the data is not statistically significant. We can also confirm that the flood shock reduced labor demand less than capital demand, which is consistent with the prediction that labor and foreign factors are relative substitutes.

5.2 Measuring the Foreign Productivity Increase

We use the estimated model to assess the role of MNEs in reducing the corporate labor share in Japan from 1995 to 2007.[31] Since we are estimating the model with the Thai floods, we perform this exercise using only Thai productivity growth $\hat{a}_T$, holding RoW productivity a_R fixed.

[30] We confirm robustness with respect to this shock size in Appendix E.1.

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

First, we invert the relative demand functions (16) and (17) to get:[32]

$$a_T = \frac{\frac{p_T^x}{w_J}\left(\overline{\frac{p_T^x x_T}{w_J L}}\right)_{11}}{\bar{p}_{11}} \qquad \text{or} \qquad \hat{a}_T = \frac{\hat{\frac{p_T^x}{w_J}}\left(\hat{\overline{\frac{p_T^x x_T}{w_J L}}}\right)_{11}}{\hat{\bar{p}}_{11}}. \tag{29}$$

where $\left(\overline{\frac{p_T^x x_T}{w_J L}}\right)_{11} \equiv \sum_j E\left[\left(\frac{p_T^x x_{T,d^*,j}(\psi)}{w_J l_{d^*,j}(\psi)}\right)^{\frac{1}{\lambda-1}} |d^* = 11\right]$ 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 entry into T is. This equation shows that a_T is high when (i) the relative T factor price p_T^x / w_J is high, (ii) the average of the relative T factor demand conditional on the factor elasticity $\left(\overline{\frac{p_T^x x_T}{w_J L}}\right)_{11}$ is high, or (iii) entry into Thailand is selective and $\bar{p}_{11}$ is low. Since our estimated λ is greater than one, an increase in foreign factor productivity is a foreign-factor biased shock. We proxy the firm-level T factor demand $x_T(\psi)$ by total employment in country c and the T factor price p_T^x by total compensation divided by the size of employment.

Applying a similar idea to the sufficient statistics approach introduced above, we can measure (29) in the data. The change in average Thailand relative factor demand is measured by[33]

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

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 the share of ψ in the relative factor demand in T, and $\chi_j \equiv \frac{(1-G_j(\psi_{11,j}))}{\sum_j (1-G_j(\psi_{11,j}))}$ is the share of firms entering in T in sector j.

[32] The proof is given in Appendix C.6.
[33] The proof is given in Appendix C.6.

The change in selection in T is summarized in $\hat{\bar{p}}_{11} = \sum_j \chi_j \left(\left(\hat{c}_{01,j} \right) \left(CR'_{11,j} / CR_{11,j} \right)^{\frac{1}{1-\varepsilon_j}} \right)^{-\theta_j}$, where $\hat{c}_{01,j}$ can be measured by changes in labor costs 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. Using the above method, we obtain $\hat{a}_T = 2.36$.[34]

5.3 Quantifying the Labor Share Effect

Using this productivity growth estimate, we will derive the impact on the aggregate labor share across firms' different offshoring strategies, S_d^L. For example, in analogy to (8), the labor share of Thai investors is given by

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

Our sufficient statistics approach also provides a natural way to control for the effect of selection in our model-based decomposition exercise. To do this, we first solve the model using the sufficient statistics approach for the selection-fixed (SF) factor price changes $\left(\hat{r}_J^{SF}, \hat{w}_J^{SF}, \hat{p}_T^{x,SF} \right)$, setting $\hat{\psi}_{d,j} = 1$ for all d and j exogenously. This means that there is no change in the foreign entry threshold, so the resulting solution gives 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 the labor share measures with the selection fixed prices. Such a change gives the counterfactual change in the labor share in the absence of the entry/exit decision. Therefore, the difference between the baseline decomposition results

[34] This value is broadly consistent with aggregate statistics on offshoring. The growth rate of imports from Thailand and from the rest of the world from 1995 to 2007 was 276% (8.1% annually), respectively.

with the endogenous threshold change $\hat{\psi}_{d,j}$ provides the effect of selection.[35]

The simulation results are shown in figure 7. On the left, the baseline simulation shows that the overall decline in the labor share is 0.6 percentage points, explaining 5.2% of the observed decline between 1995 and 2007. When we fix the changes in the extensive margin, we find that the decline in the labor share is only 0.3 percentage points. This implies that about half of the change in the labor share is due to the change in the labor share within firms, and the rest is due to the change in selection.

The remaining part of the panel 7a shows that the baseline labor shares are dramatically different when the aggregate change is decomposed into offshoring types. The baseline difference in the labor share between non-MNEs and MNEs in Thailand is 7.7 percentage points. This substantial difference in the baseline labor share is widened by Thai factor productivity growth; the labor share of non-MNEs increases by 2.4 percentage points, but the labor share of MNEs in Thailand decreases by 7.7 percentage points. Thus, the intensified MNE activities widened 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; the labor share of non-MNEs increases by 3.4 percentage points relative to the baseline, while the labor share of Thai MNEs decreases by as much as 10.9 percentage points. This result shows that the selection mechanism mitigates the inequality. Namely, a marginal firm that shifts from a RoW MNE to a Thai MNE has a relatively high labor share among Thai MNEs. Therefore, its inclusion as a Thai MNE increases the overall labor share of Thai MNEs.

Finally, panel 7b shows the impact of the labor share across firm size deciles and confirms

[35] We show how to compute the change in group-specific labor shares such as $\hat{S}^L_d$ in Appendix C.7.

that the foreign productivity shock contributes to the reduction in the labor share across firm sizes. In particular, we find that the reduction in the labor share is larger for larger firms, revealing both the substitution of foreign for domestic labor demand by already multinational firms and the extensive-margin effect of the relative reduction in labor demand as more firms become multinational. The data support this view, but show even more pronounced heterogeneity in labor share reductions across firm sizes.

5.4 Welfare

Finally, we briefly discuss the welfare implications 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 net domestic product (NDP) in our economy as $\widehat{NDP}_J = (\widehat{r_J K + w_J L}) = 4.0\%$. Since our model has MNEs that claim income in foreign countries, we can also think about another welfare measure: NNI. 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 NNI is also 4.9%, which can be obtained by assuming that all generated income is claimed by $c = J$ and $(\widehat{r_J K + w_J L + p_T^x X_T + p_R^x X_R})$, where X_c is the aggregate factor demand in country $c \in \{T, R\}$.

Looking into each factor, we find that the real labor income in Japan increased much more mildly, by 3.6%, and the real capital income increased by 6.6%, revealing a greatly heterogeneous impact between labor and capital. Taking these results together, while MNE activities reduced aggregate home-country corporate labor share, it has a positive effect on welfare, mainly due to the increased marginal productivities of home-country capital.

6 Conclusion

In this paper, we examined the impact of increased utilization of foreign factors by multinational enterprises (MNEs) on corporate labor share in the home country. We began by conducting a decomposition analysis of the Japanese corporate labor share to investigate the factors contributing to its decline. Additionally, we estimated the effect of the major floods in Thailand in 2011 and, based on these findings, we developed a heterogeneous firms model of production, incorporating foreign factor employment using a nested CES production function. By treating the flood shock as an instrumental variable, we then estimated a crucial substitution elasticity between foreign factors and home-country labor, finding that they are gross substitutes. From the estimated model, we found that the increase in foreign factor productivity accounted for a 1.4 percentage point decline in the corporate labor share in Japan from 1995 to 2007.

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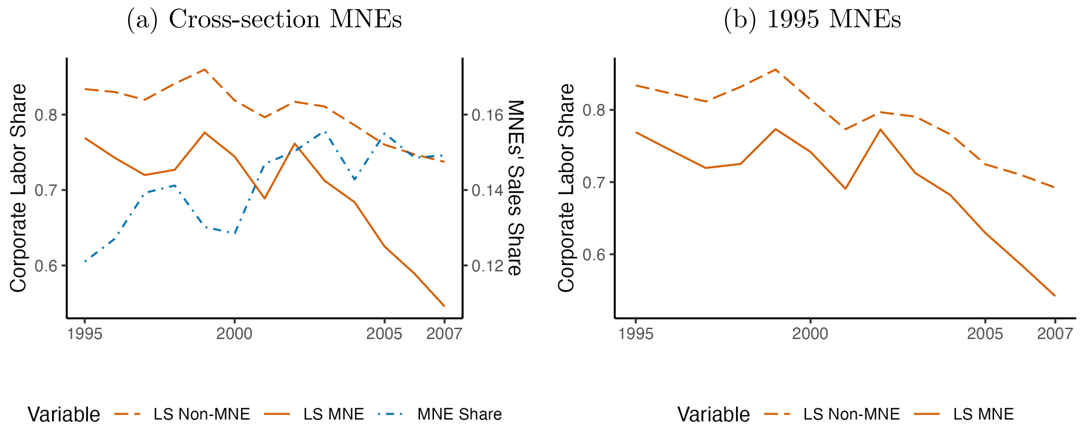
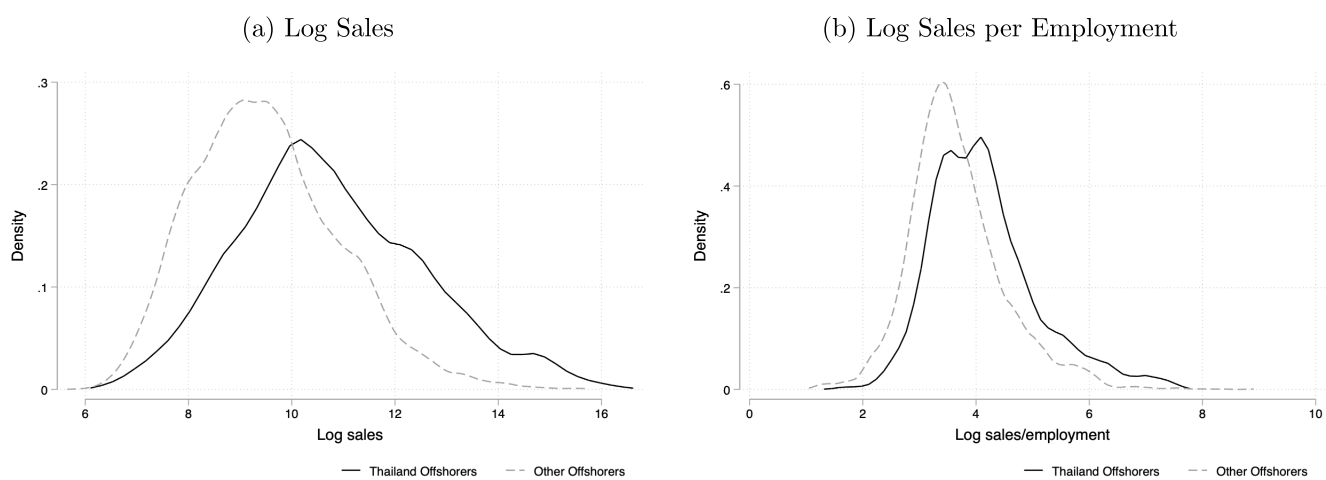
7 Figures and Tables

Figure 1: Labor Shares of MNEs and Non-MNEs



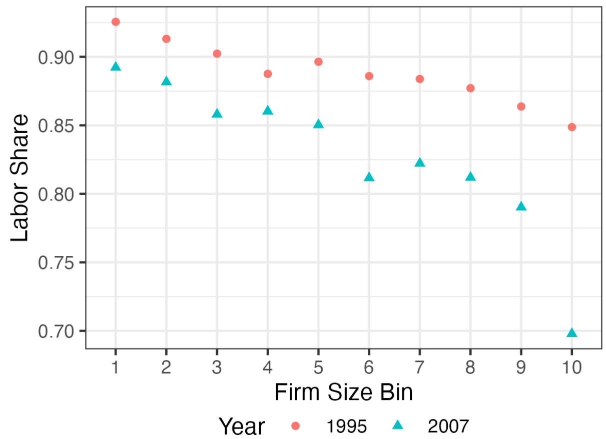
Note: The figures show trends in the labor share of multinational enterprises (MNEs) and non-MNEs (left axis) and in the sales share of MNEs (right axis). The left panel uses the definition of MNEs in each year, while the right panel uses the MNE status fixed in 1995, the base year. For each firm, the corporate labor share is calculated as total labor compensation divided by the sum of total labor compensation and operating surplus.

Figure 2: Thai Investors Sales Distribution vis-a-vis Other MNEs



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

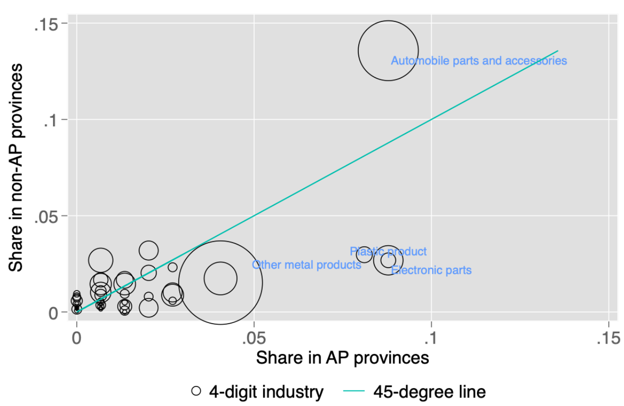
Figure 3: Firm Size and Labor Share



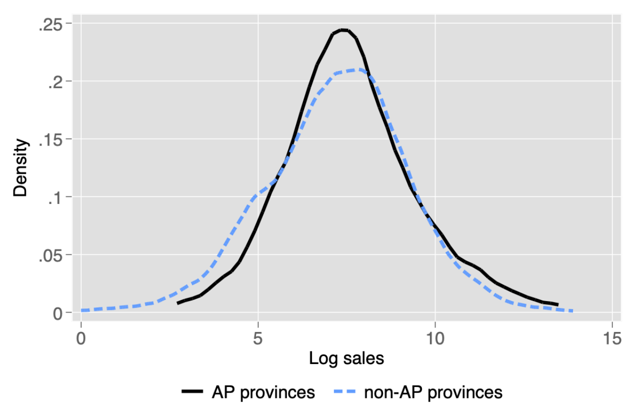
Note: The figure plots evolution of the distribution of the corporate labor share measure defined in equation (1) by firm-size deciles from 1995 to 2007.

Figure 4: Balancing Checks

(a) Industry Share

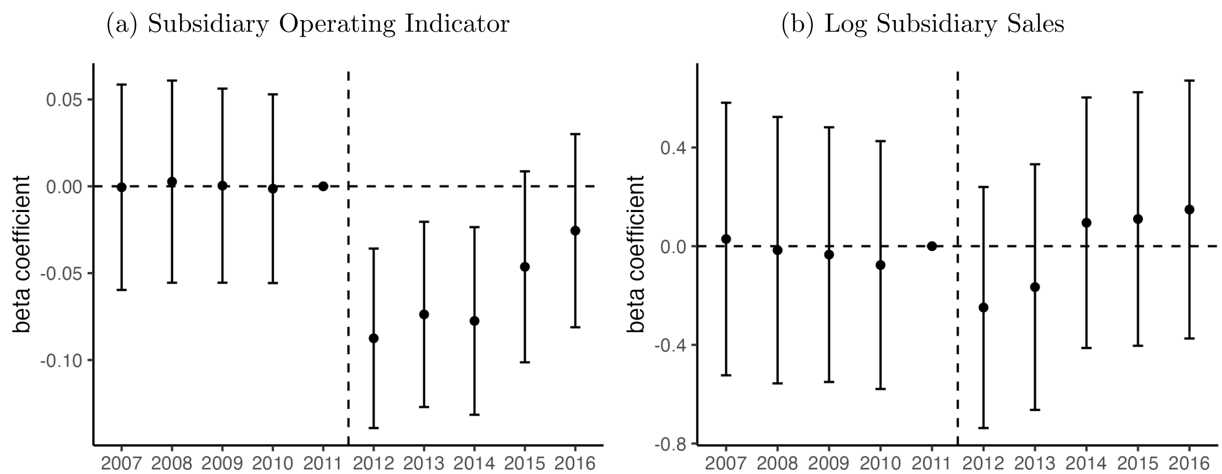


(b) Sales Distribution



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

Figure 5: Event Study at the Subsidiary Level



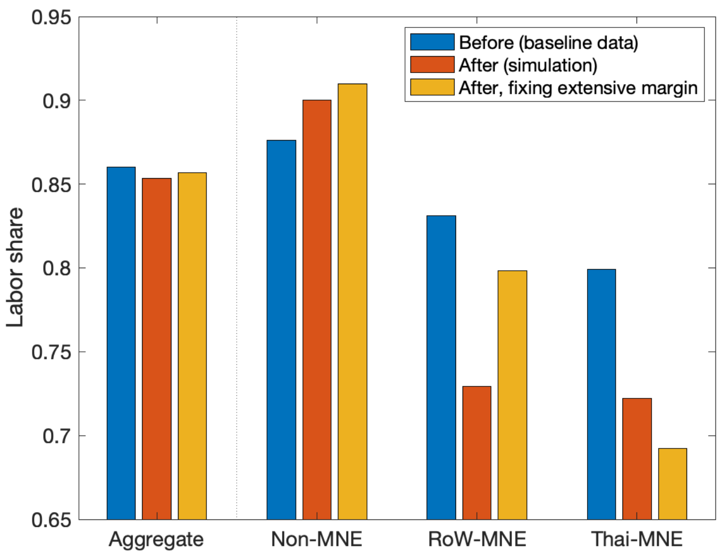
Note: The figure plots coefficient estimates of subsidiary-level event-study regression in equation (2). Panel (a) takes the operating indicator as the outcome variable for the sample of firms that operated throughout 2007-2011, and panel (b) takes log sales of the firms operating in each year. Standard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

Figure 6: Event Study at the Headquarter Level

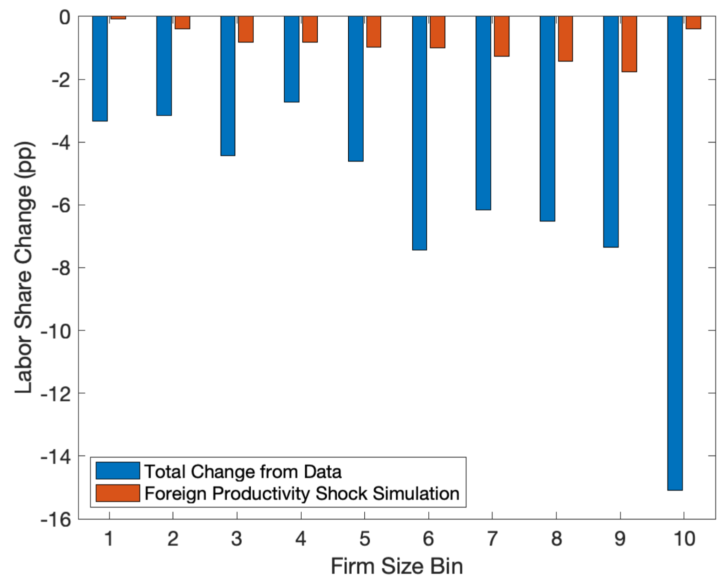
Note: The figure plots coefficient estimates of the headquarter-level event-study regression in equation (3). As the outcome variable, panel (a) takes log Thai employment and total foreign employment (both including the flooded regions), panel (b) takes the log value of intra-firm import to the Japanese 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 7: The Role of MNEs in the Corporate Labor Share Decline

(a) By MNE Status



(b) By Firm Size



Note: The left panel shows the results of the counterfactual effect on labor shares of the Thai productivity growth. The “Aggregate” group on the left of the panel 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 the panel 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). The right panel shows the labor share implication across baseline firm-size deciles on the horizontal axis. The blue bar shows the total changes in the labor share observed from the data, and the red bar shows the implied labor share change due to the simulated Thai productivity shock.

Table 1: Sectoral Parameters

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

Note: θ_j is the shape parameter of the sectoral Pareto productivity distribution, and ε_j is the sectoral elasticity of substitution between firm outputs (see equation 4). Details of the calibration are described in section 4.1.

Table 2: The effect of Thai shock on relative factor demand

VARIABLES	(1) $\ln(l/x_T)$	(2) $\ln(l/k)$
$\hat{a}_T$	-0.283***	0.143***
	(0.0808)	(0.0517)
Observations	22,767	22,738
Firm FE	YES	YES
Location-Year FE	YES	YES
Identification	$1-\lambda$	$\lambda-\sigma$

Note: The table shows the results of the relative factor demand regression. Column 1 regresses the log domestic labor-to-Thai value added ratio on the intensity of the Thai flood shock. Column 2 regresses the log domestic labor-domestic capital ratio on the intensity of the Thai flood shock. Standard errors are clustered by industry and year. ***$p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The details are described in section 4.2.

Table 3: Model Fit Exercise

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

	Sales		Value added	
	Model	Data	Model	Data
	(1)	(2)	(3)	(4)
Shocked	-0.048^{***}	-0.044^{***}	-0.031^{***}	-0.021
	(0.002)	(0.014)	(0.002)	(0.034)
N of firms	595	595	595	595

Note: The regression coefficients of factor demand with respect to the flood shock from the model-simulated and observed data are shown. 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 capital demand regression from simulated data and observed data, respectively. The capital demand from the observed data is measured by the asset value interacted with the 5% long-run return on capital (Rognlie, 2018). In regressions (2) and (4) based on observed data, industry fixed effects are controlled for. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The details of the simulation are described in Section 5.1.

Online Appendix

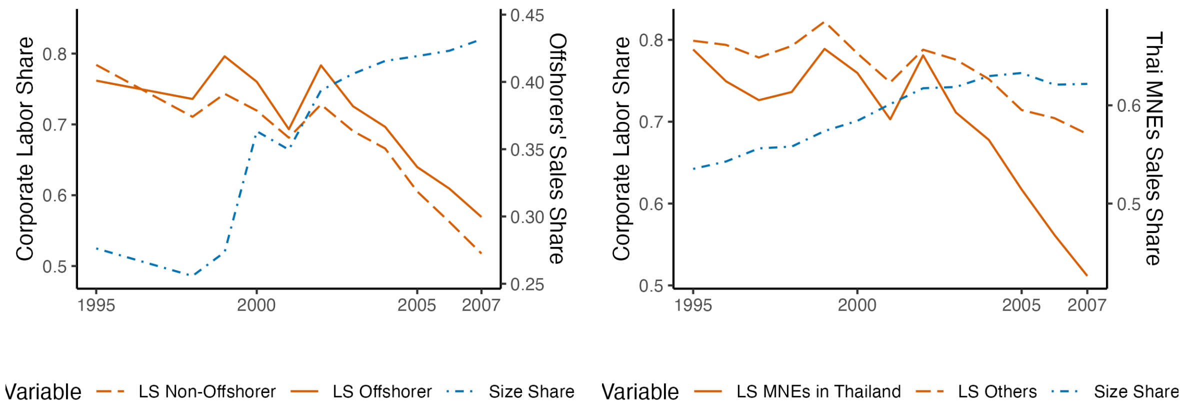
A Data Appendix

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

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



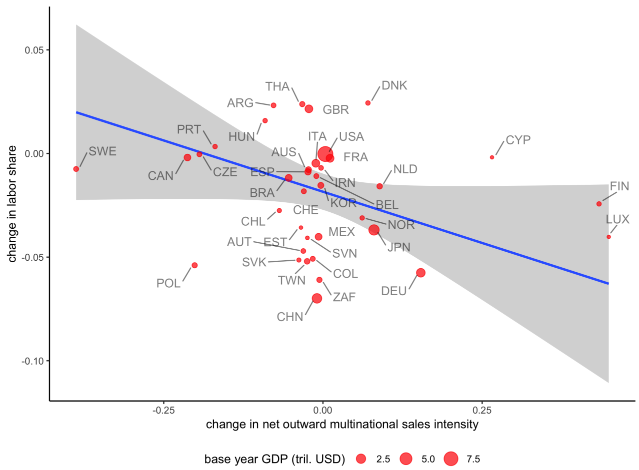
Note: The figure shows the corporate labor share trends of offshoring multinational enterprises (MNEs) and non-offshoring MNEs (Panel A.1a on the left) and of MNEs having subsidiaries in Thailand and MNEs without Thai subsidiaries (Panel A.1b on the right), in orange lines measured in the left axis, 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

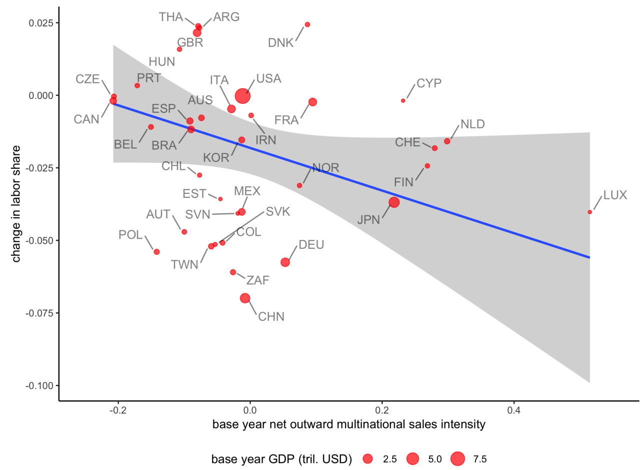
To empirically motivate our analysis, we conducted a cross-country correlation between the intensity of outward MNE activities and the change in labor shares using UNCTAD data on multinational activities. First, the level of outward multinational activities is calculated by taking the 1996-2000 average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

Figure A.2: Outward Multinational Activity and Labor Share

(a) Outward Multinational Changes



(b) Outward Multinational Levels



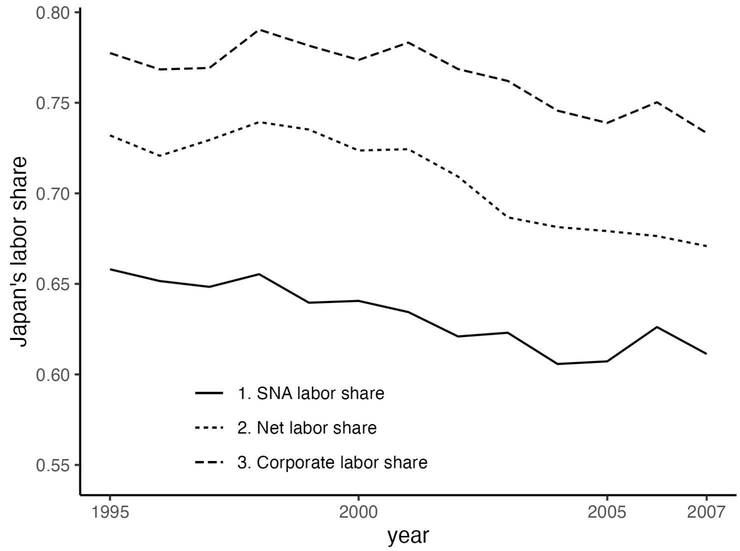
Note: Data are from Karabarbounis and Neiman (2013) and UNCTAD. In both panels a and b, the vertical axis is the change in labor share from 1991 to 2000, and fitted lines weighted by the base-year GDP are drawn with the 95 percent confidence intervals. In panel a on the left, the horizontal axis is the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

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 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.3, exhibits three measures of labor shares proposed in the literature. First, the SNA labor share, which is the total labor cost divided by GDP from the System of National Accounts, shows a decreasing trend. However, since GDP or value added contains capital depreciation, it overstates net capital

Figure A.3: 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.

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.4 Labor Share Decompositions

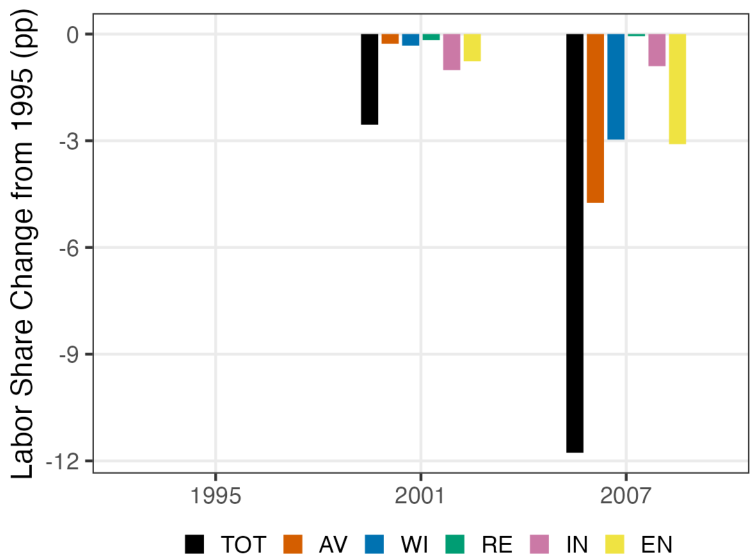
In this subsection, we consider the firm-level decomposition following Kehrig and Vincent (2021) to study the anatomy of Japanese corporate labor share decline. Fukao and Perugini (2021) take a different approach and decompose the aggregate labor share to industry-level labor shares. They report a small 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.

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

Figure A.4: 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.

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.4 shows the change in the labor share in Japan since 1995.

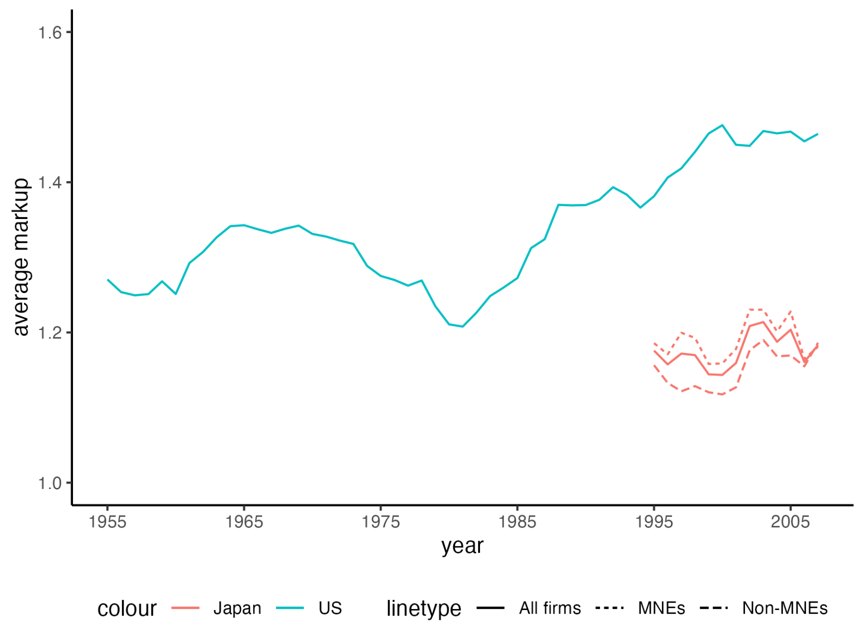
We find that (i) there has been a substantial drop in the total corporate labor share in Japan, amounting to 11-12 percentage points until 2007, and (ii) this decline can largely be attributed to a combination of the average effect, within-firm effect, interaction effect, and entry-exit effects. Specifically,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

A.5 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.5). 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.1 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 increase 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

Figure A.5: 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.

(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.6 Children and Grandchildren Firms in the BSOBA Subsidiary File

Children and grandchildren firms are defined based on the shareholding ratio. Children firms (*Kogaisha*) are foreign entities in which Japanese investors hold a total equity stake of 10% or more. Grandchildren firms (*Magogaisha*) are foreign entities that meet one of the following conditions: (i) a child firm in which the Japanese investors hold a total equity stake exceeding 50% owns more than 50% of the shares in another foreign company, or (ii) the

Table A.1: 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.

combined stake of the Japanese parent company and the subsidiary with over 50% Japanese ownership results in a majority shareholding in another foreign company.

B Empirical Analysis Appendix

B.1 More details in the 2011 Thailand Floods

Our microdata of the subsidiaries of Japanese MNEs do not include the damage variable, making it challenging to estimate the damage made to the Japanese subsidiaries. We estimate the value of damages to the Japanese subsidiaries using additional data from a survey called "RIETI Survey of Industrial Estates/Parks and Firms in Thailand on Geographic and Flood Related Information." (RIETI survey hereafter). The RIETI survey is specifically designed to measure the nature of the 2011 floods and their damages to a subsample of Japanese subsidiaries (N=314). It also contains the total assets at the time of the floods, which seems an appropriate denominator since the damage is defined as the devaluation of the asset stock in the survey. For the sample of the firms that report both the damage and total asset values (N=86), the ratio of the total damages to the total assets is 55.4%.

The flooded area and the locations of the inundated industrial clusters can be found in `http://thoughtleadership.aonbenfield.com/Documents/20120314_impact_forecasting_thailand_flood_event_recap.pdf` (accessed on May 23, 2022).

Table B.2 shows the cross-country industry distribution of Japanese subsidiaries in the BSOBA data.

Table B.3 shows the sales distribution by industry of the Japanese subsidiaries in Thai-

Table B.2: Subsidiary industry distribution (%)

		N			Sales		
	Industry	THA	Asia	RoW	THA	Asia	RoW
1	Food	5.29	4.61	6.37	2.07	2.89	2.93
2	Textile	4.41	6.12	1.96	1.34	1.08	0.61
3	Wood & paper	0.88	1.65	1.59	0.37	0.33	1.03
4	Chemicals	10.24	11.29	13.80	4.53	7.38	10.11
5	Petroleum	0.33	0.39	0.53	0.10	0.22	0.49
6	Celamics	2.20	2.80	2.04	0.46	1.45	1.66
7	Steel	4.19	3.06	3.06	2.98	3.47	1.41
8	Non-ferrous metal	4.63	3.36	2.29	2.30	2.47	0.88
9	Metal products	5.62	5.14	2.61	1.35	0.97	0.30
10	General machinery	3.08	3.22	3.92	1.67	2.05	2.01
11	Construction machinery	6.06	5.96	6.08	0.83	2.20	2.29
12	Industrial machinery	2.09	3.32	4.37	3.82	3.27	1.57
13	Electircal machinery	7.05	7.16	5.06	9.06	8.12	4.24
14	Electronics	7.49	14.09	8.70	5.80	20.76	10.32
15	Transportation machinery	25.77	15.23	27.19	59.27	39.57	52.62
16	Other manufacturing	10.68	12.59	10.41	4.05	3.78	7.52

Note: Japanese subsidiaries' industry distributions across the 2-digit manufacturing industries in 2010 are shown. Asia is the set of Asian countries except for Thailand. N indicates the number of subsidiaries. Cells show row probabilities and sum up to 100 when summed across rows.

land 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.

We performed a similar balancing check for the HQ-level analysis as the one in Section 2.2. 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 Figure B.6 for the detail.

Table B.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).

B.2 Thailand Gross Export and Import Trends

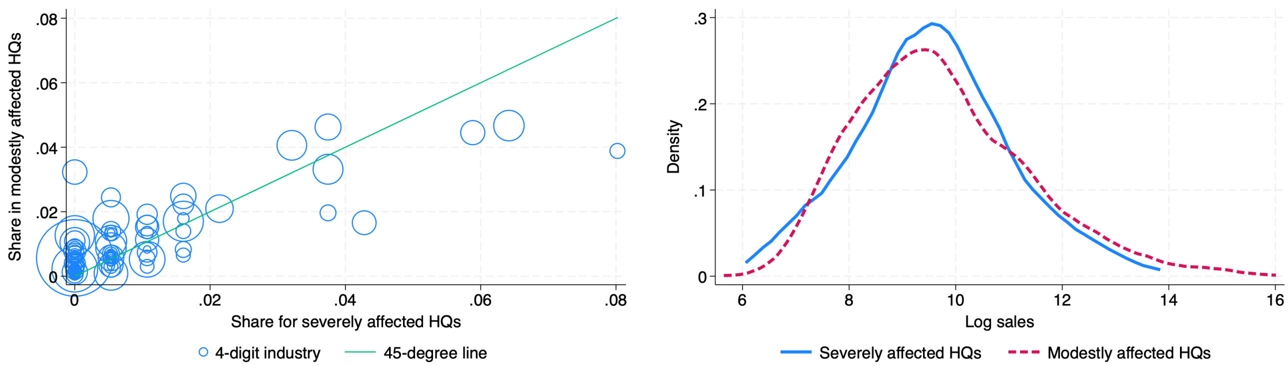
Figure B.7 shows the trends of Thailand's exports and imports, using data from UN Comtrade. Recalling that 2011 was the year of the floods, we see that Thai export and import trends were roughly parallel before the floods, but this pattern was broken as the export trend became flat after the floods until 2014 while imports continued to rise for several years. This observation is consistent with our interpretation that the flood shock heavily impacted the supply side of the economy, given that several large-scale manufacturing industrial parks were inundated. This is also consistent with Benguria and Taylor (2019), who discuss a method for identifying demand and supply shocks from gross export and import data during financial crises. They find that "firm-deleveraging shocks are mainly supply shocks and contract exports," while imports are left largely unchanged.

To provide context that the trends in Thailand's international trade were due to exoge-

Figure B.6: Balancing Checks at the headquarter level

(a) Industry Share

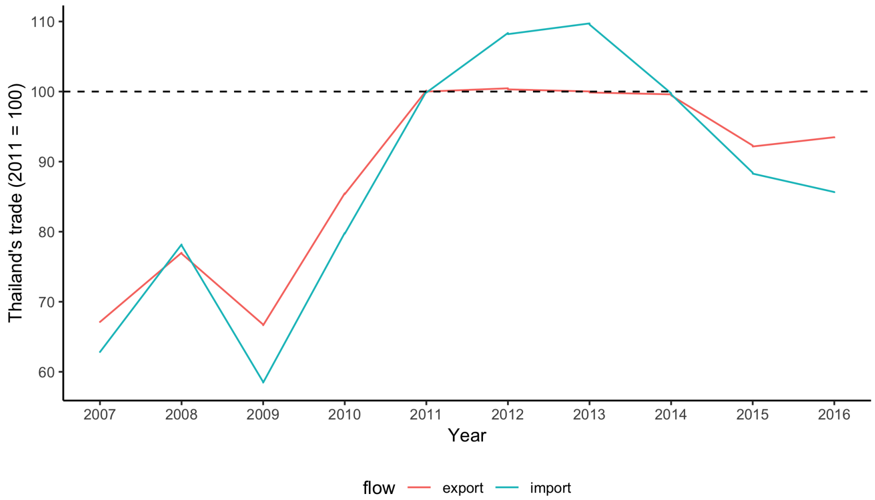
(b) Sales Distribution



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.

nous 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 particularly 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

Figure B.7: Trend of Thailand's Trade



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

Thailand in 2010 and the Chile-Thailand FTA that became effective in 2015. The pattern of gross trade trends in Figure B.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 policy.

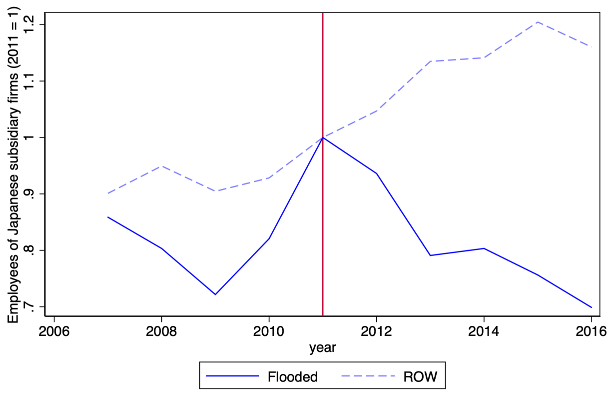
B.3 The Floods and Aggregate Trends

Here, we show the aggregate statistics of Japanese MNEs in our dataset as described in Section 2.1. The top two panels of Figure B.8 show the normalized trend of total employment (Panel B.8a) and the number of subsidiaries (Panel B.8b) in flooded regions (the solid line) versus the rest of the world excluding Japan (the dashed line).

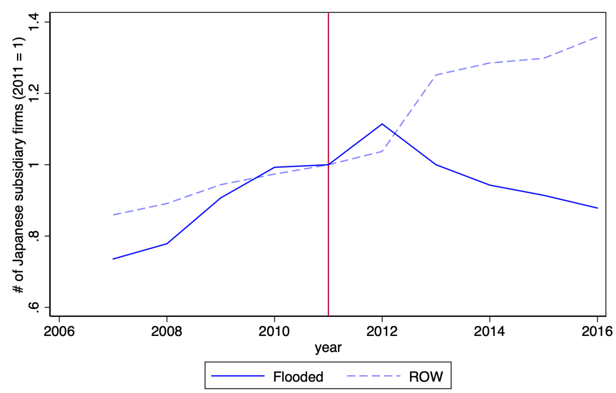
Focusing on first on Panels a and b, we notice that, by both measures, the ROW trend is increasing over the sample period, indicating that more firms are becoming MNEs and

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

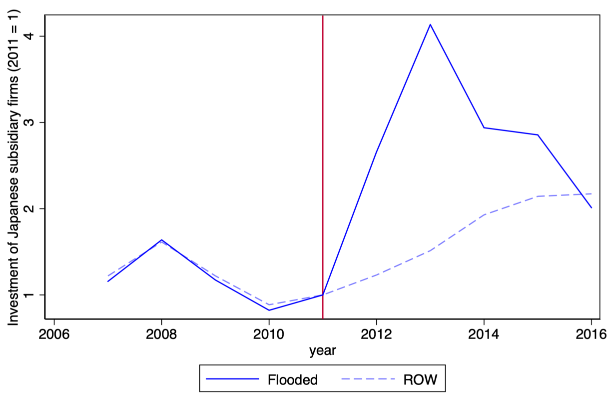
(a) Total employment



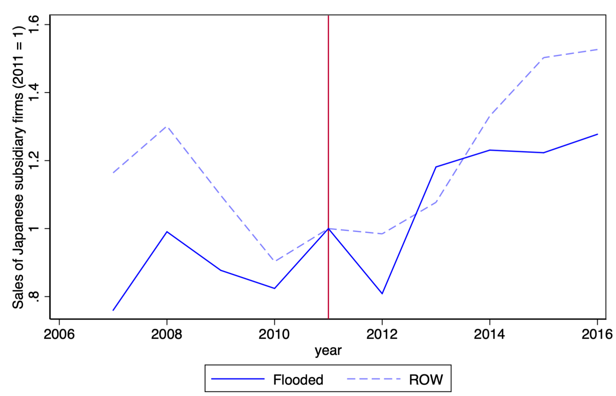
(b) Number of subsidiaries



(c) Investment



(d) Sales



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 B.8a shows the trend of total employment, Panel B.8b shows the number of subsidiaries, Panel B.8c shows investment, and Panel B.8d shows sales by subsidiaries.

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

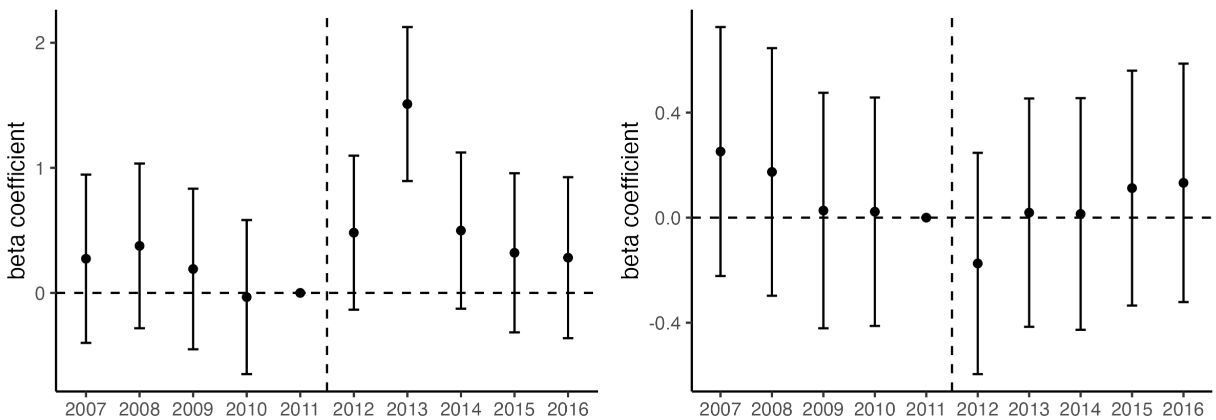
B.4 Additional Analysis for the Subsidiary-level Event Study

Figure B.9 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

Figure B.9: 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.

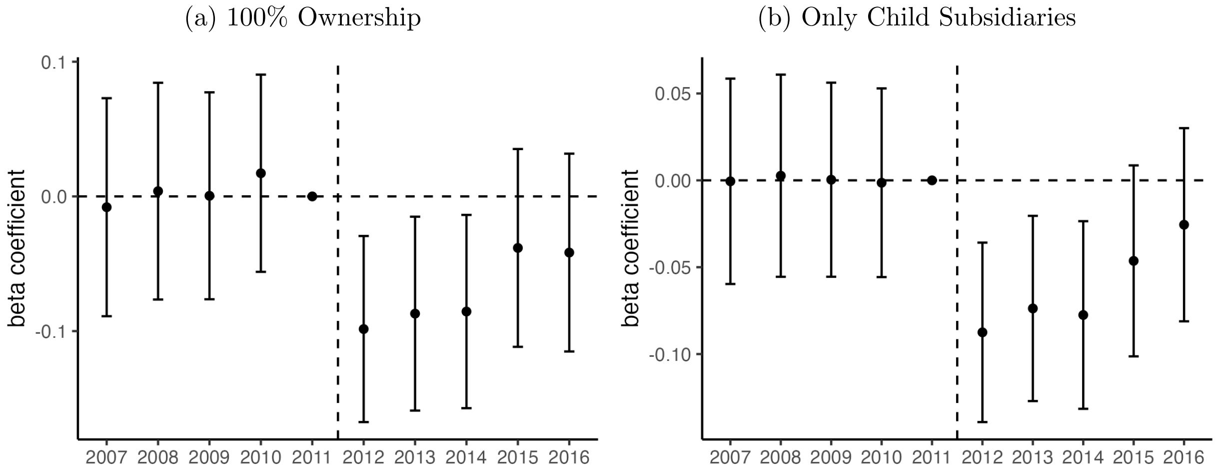
this definition, foreign production is not limited to greenfield investments, which are new operations set up in foreign locations, but also includes the acquisition of foreign companies such as through mergers and acquisitions (M&A).

Figure B.10 shows the result of regression equation 2 with selected samples. Panel B.10a shows the result with the sample of Thailand subsidiaries of Japanese MNEs with 100% ownership. Panel B.10b 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.

B.5 Additional Analysis for the Headquarter-level Event Study

First, we decompose the impact on foreign employment shown in Figure 6a into Thai employment in the flooded regions (panel B.11a), Thai employment in non-flooded regions (panel B.11b), and foreign non-Thai employment (panel B.11c). Consistent with the strong

Figure B.10: Event Study of Subsidiary Operating Indicator

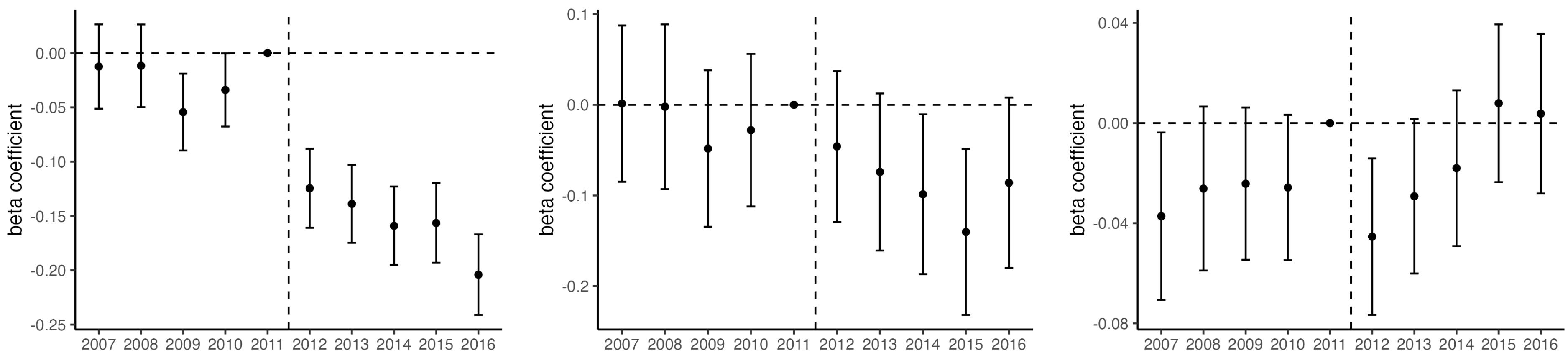


Note: The figure plots coefficient estimates of subsidiary-level event-study regression in equation (2) with the operating indicator as the outcome variable for the balanced panel of firms that operated throughout 2007-2011. In panel (a), the sample is the set of Thailand subsidiaries of Japanese MNEs 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.

negative impact on the flooded regions, we find a large and persistent negative effect only in panel B.11a. 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 B.11b and B.11c.

Figure B.11: 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

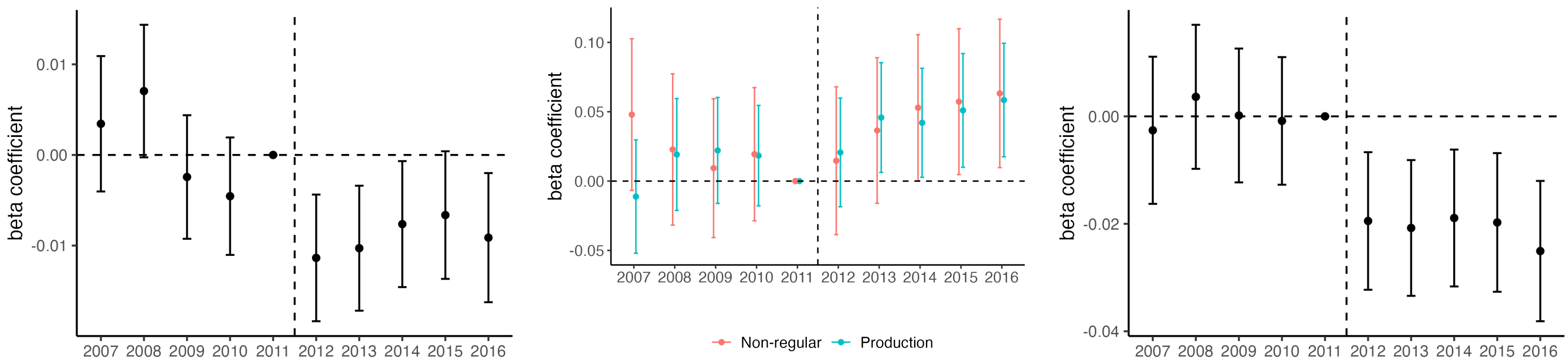


Note: The figure plots coefficient estimates of headquarter-level event-study regression in equation (3). As an outcome variable, panel (a) takes the log foreign non-Thai employment, panel (b) takes log Thai employment in non-flooded regions, and panel (c) takes log Thai employment in the flooded regions. 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, we consider total employment and non-regular/production workers. In Japan, non-regular workers include part-time, contract, and temp workers dispatched from temporary employment agencies, and their number is growing rapidly (Morikawa, 2010). Overall, they are a type of worker with flexible labor arrangements that can be adjusted by firms with relative ease. For capital, we use fixed assets. Figure B.12 shows the result and confirms the main results in Figures 6 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 B.12: 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.

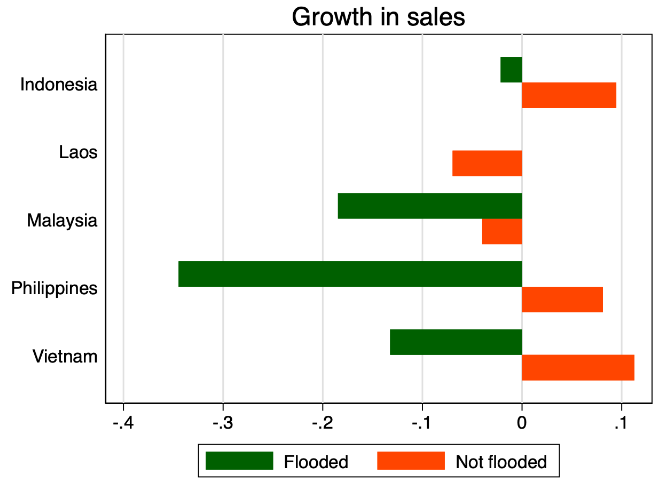
Notably, panel B.12b presents a view consistent with the hypothesis of flexible labor adjustment after the shock of the Thai flood, as non-regular workers increased after the floods and offshore activities weakened. Therefore, firms affected by the floods may have reacted by substituting foreign workers with non-regular domestic Japanese workers. Furthermore, panel B.12c shows that the effect on fixed assets is as negative and significant.

B.6 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 B.13 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 B.14a shows that imports from Asia (excluding Thailand) networks decline after the floods. Panel B.14b 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 B.14c and B.14d show the results, and we do not find any positive substitution effect from the flooded regions

Figure B.13: Sales Comparison between Firms in Thailand and Those Not, 2011



to non-flooded third countries. These findings indicate that there are not strong production substitution to third country in our context.

B.7 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 6 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

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

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 B.15 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 B.16 shows the result, which confirms that the qualitative conclusions are unchanged by the sample restriction from the main analysis.

B.8 Comparison between Thai and other Southeast Asian Subsidiaries

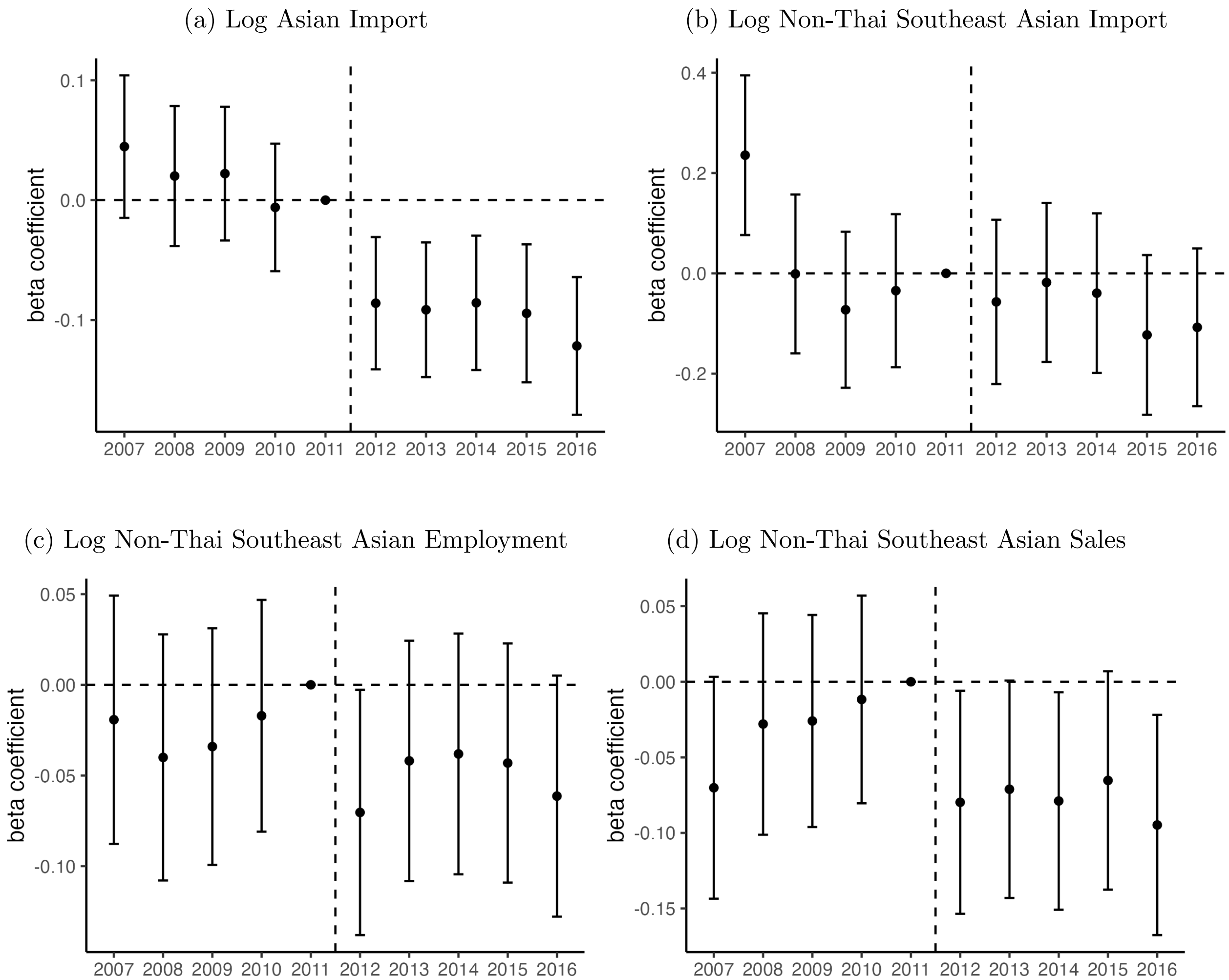
The event-study evidence in this paper may give the impression that the flood is a transitory shock to operations in Thailand. We point out that the long-run insignificance result is due not only to the temporary nature of the shock and recovery from the shock but also to "catch-up" in the control group in the long run. Detailed arguments follow.

We hypothesize that only the directly flooded firms (firms located in Ayutthaya and Pathum Thani provinces, or "AP" provinces) responded immediately by ceasing operations. Although the firms in the non-flooded regions of Thailand do not respond immediately, they also cease operations or leave Thailand in the long run, possibly due to the loss of business relationships with the firms in the flooded regions. In this case, the difference in the operating status between the flooded (treatment group) and non-flooded (control group) firms will eventually be smaller in the long run, even though the flood had persistent negative effects. We think this view is more realistic because we find the long-run persistent effect at the headquarters level (Figure 5 in the original manuscript; Figure 6), especially for the effect on Thai employment (Figure 6a).

To test this hypothesis directly, we compare affiliates in Thailand with non-Thai but somewhat comparable firms. We consider two alternative designs. In the first design, the treatment group consists of affiliates in AP provinces. In the second design, the treatment group is the set of affiliates in non-AP Thailand. In both designs, the control group consists of firms in other Southeast Asian (SEA) countries (Myanmar, Malaysia, Indonesia, Philippines, Cambodia, and Laos). We exclude Singapore from the list of SEA countries because the Singaporean economy is significantly different from the rest of the SEA countries, and the investment motives of Japanese MNEs are significantly different.

Figure B.17 shows the result. As we hypothesized, we found that the negative effect on subsidiaries in AP relative to non-Thai subsidiaries persists until 2016, and there is also a negative effect only in the long run for non-AP subsidiaries. Therefore, the overall effect on MNEs operating in Thailand is persistent at the subsidiary level. However, we find some violations of the parallel trend assumption (year 2010), which may reflect the country-level differences in economic structure between Thailand and other SEAs that affect the different trends of Japanese subsidiaries' operating strategy.

Figure B.14: Analysis of Third-country Effects



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.

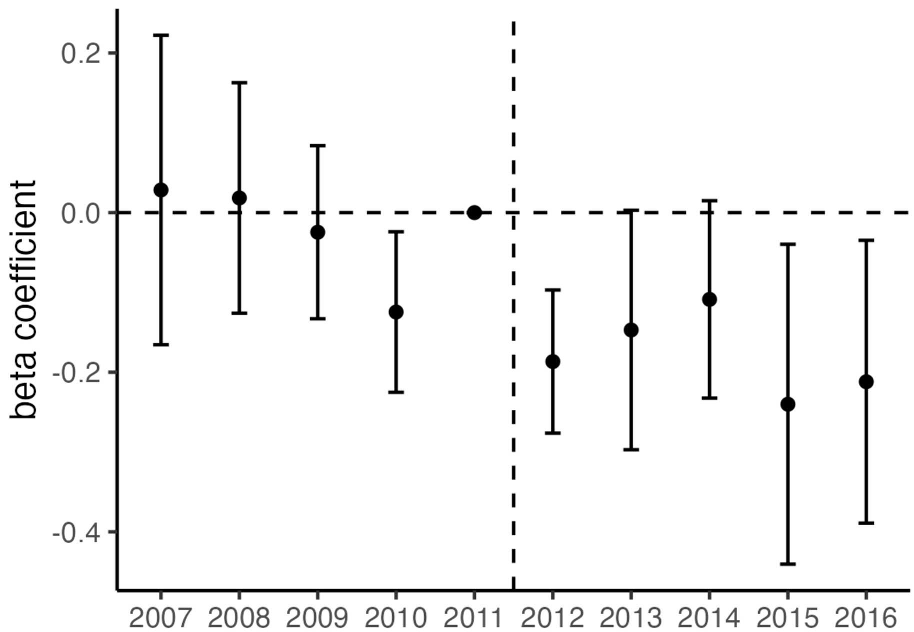
Figure B.15: Event Study at the Headquarter Level using Alternative Shock Variable

Note: The figure plots coefficient estimates of the headquarter-level event-study regression in equation (3), but using an alternative shock measure defined in (B.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 B.16: Headquarter-Level Event Study without Firms in Both Flooded and Non-Flooded Regions

Note: The figure plots coefficient estimates of the headquarter-level event-study regression in equation (3). Unlike Figure 6, 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.

Figure B.17: Thai versus Southeast Asia event-study results



Note: The figure plots the coefficient estimates of the event-study log-employment regression at the subsidiary level in equation (2). The treatment group is subsidiaries located in Thailand, and the control group is subsidiaries located in other Southeast Asian countries (Myanmar, Malaysia, Indonesia, Philippines, Cambodia, and Laos). Standard errors are cluster-robust at the firm level, and bars indicate 95 percent confidence intervals.

C Theory Appendix

C.1 Testing the Restriction of the Nested CES

Consider the shock to a_T measured by the Thai floods. Due to the independence of irrelevant alternatives (IIA) property of the CES functions, the Thai flood shock in the lower nest does not affect the (irrelevant) relative demand in the upper nest. In our case, it should not affect the relative capital-material demand, so

$$\frac{d\ln\frac{k}{m}}{d\ln a_T} = 0. \tag{C.1}$$

We also have another restriction that the relative demand for inputs within the same nest should not be affected by the shock in the same nest. In our case, the relative domestic employment to foreign inputs is not a function of the Thai shock, so

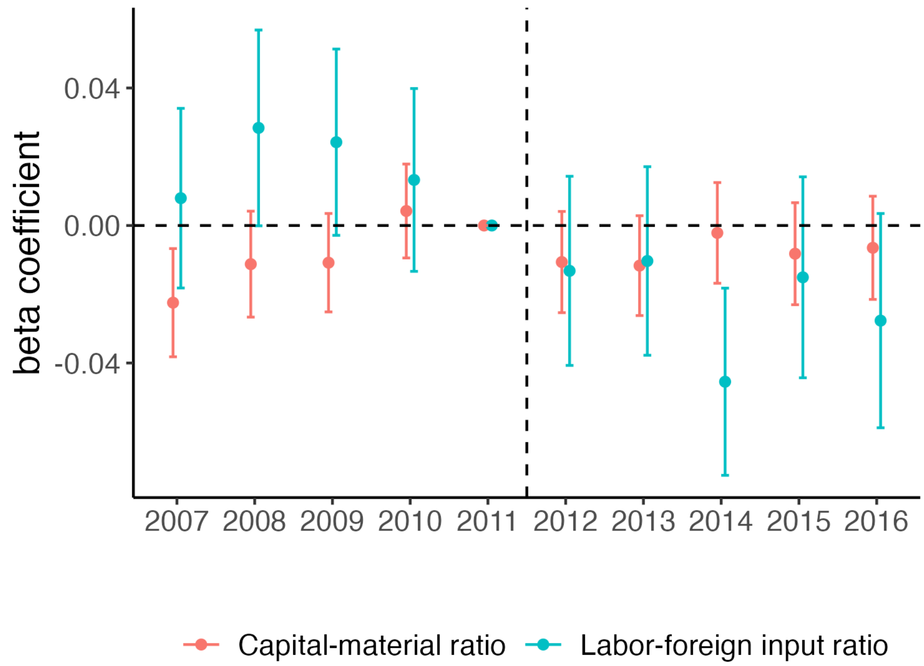
$$\frac{d\ln\frac{l}{x_R}}{d\ln a_T} = 0. \tag{C.2}$$

To check whether these restrictions are consistent with the data, we regress the following difference-in-difference model with the long difference on the sample of firms investing in Thailand in each industry j:

$$\ln y_{it} = \alpha_i + \alpha_{jt} + \sum_{\tau\neq 2011} \beta_\tau \times \left(Z_i \mathbf{1}\left\{t=\tau\right\}\right) + \epsilon_{it},$$

$$\text{where } Z_i = \frac{l^{flooded}_{i,2011}}{l^{world}_{i,2011}},$$

Figure C.1: Testing the bundling assumption



Note: The figure shows the dynamic difference-in-difference coefficients of the Thai flood shock. The pink bars show the estimates for the capital-to-material ratio, and the blue bars show those for the labor-to-foreign (non-Thai) input ratio.

where y_i is either k/m from (C.1) or l/x_R from (C.2), α_i is the firm fixed effect, $\gamma_{j,t}$ is the industry year fixed effect that captures the general equilibrium effect that is constant across firms in each industry and year, and β is the coefficient of the Thai flood shock. The variable Z_i measures the magnitude of the Thai flood shock for firm i. In this regression, the conditions in (C.1) and (C.2) are equivalent to $\beta_\tau = 0$ for $\tau > 2011$.

Figure C.1 shows the result. Overall, the Thai flood shock measure does not have a strong effect on the two outcome variables. We do find marginally significant pretrends during the period of the global financial crisis. In addition, 2014 witnessed regional conflicts in the South China Sea, which may have affected the incentives of Japanese MNEs to reduce investment and activities in China.

C.2 On the interpretation of the shock of the Thai floods

Are the floods negative productivity shocks or capital destruction? Unfortunately, the BSOBA data do not contain rich accounting variables for foreign affiliates. Therefore, it is difficult to measure capital destruction in a standard way, which is why we use the foreign factor as an input for each country rather than labor and capital (and possibly other factors). Nevertheless, we report the following theoretical observations and additional empirical analysis.

When floods cause capital destruction and reduce the capital stock, the marginal product of labor (MPL) falls. In an extreme case, plant operations must cease and the MPL is zero. Moreover, in our nested CES framework for MNEs, the production function has diminishing returns to scale with respect to Thai inputs when other inputs are fixed. Thus, the negative productivity shock to the Thai input is equivalent to the capital destruction that triggers the MPL reduction.

Moreover, in the quantitative section, we backed out the size of the foreign productivity shock from total foreign sales growth (equation 29), independent of the value of the capital stock. Had we observed foreign capital destruction in the data and included foreign capital in the model, we could have calibrated both the negative productivity shock and capital destruction. However, because we match the total sales moment, the calibrated shock and destruction would imply the same quantitative results as those of the negative productivity shock measured in our main specification where there is only the productivity shock.

C.3 Derivation of Equations (18) and (19)

In this section, we derive equation (18) 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

$$K^D_{00,j} = \int_{\underline{\psi}_j}^{\psi_{01,j}} \left((r_J)^{-\sigma} \left(c_{00,j}(\psi)\right)^{\sigma-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j(\psi), \tag{C.3}$$

$$K^D_{01,j} = \int_{\psi_{01,j}}^{\psi_{11,j}} \left((r_J)^{-\sigma} \left(c_{01,j}(\psi)\right)^{\sigma-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j(\psi), \tag{C.4}$$

$$K^D_{11,j} = \int_{\psi_{11,j}}^{\infty} \left((r_J)^{-\sigma} \left(c_{11,j}(\psi)\right)^{\sigma-\varepsilon_j} \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j \right) dG_j(\psi). \tag{C.5}$$

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

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

Second, equations (C.3), (C.4), and (C.5) imply

$$K_j^D = \bar{C}_j^K \left(\frac{\varepsilon_j}{\varepsilon_j - 1}\right)^{1-\varepsilon_j} P_j^{\varepsilon_j - 1} Q_j, \tag{C.6}$$

where $\bar{C}_j^K$ is the term of capital cost relative to the unit cost averaged across offshoring strategies, given by

$$\bar{C}_j^K \equiv (r_J)^{-\sigma} \left(\int_{\underline{\psi}_j}^{\psi_{01,j}} (c_{00,j}(\psi))^{\sigma-\varepsilon_j} dG_j(\psi) \right.$$
$$\left. + \int_{\psi_{01,j}}^{\psi_{11,j}} (c_{01,j}(\psi))^{\sigma-\varepsilon_j} dG_j(\psi) + \int_{\psi_{11,j}}^{\infty} (c_{11,j}(\psi))^{\sigma-\varepsilon_j} dG_j(\psi) \right). \tag{C.7}$$

Finally, taking the new-to-old ratio of equation (C.6) proves equation (18).

To derive equation (19), substituting unit cost expression (10) in equation (C.7), we have

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

Taking the new-to-old ratio yields equation (19). Accordingly, the aggregate labor demands for the three groups of offshoring strategy are

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

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

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

and similarly for the Thailand factor demand,

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

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

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

Hence, using a similar method, we have

$$\hat{L}^D=\sum_j\varsigma_j^L\hat{L}_j^D,\ \hat{L}_j^D=\left(\hat{w}_J\right)^{-\lambda}\hat{\tilde{C}}_j^L,\ \hat{\tilde{C}}_j^L=\sum_{d\in\{00,01,11\}}\xi_{d,j}^L\left(\hat{p}_{d,j}^h\right)^{\lambda-\sigma}\left(\hat{\tilde{c}}_{d,j}\right)^{\sigma-\varepsilon_j}\hat{s}_{d,j}\tag{C.8}$$

$$\hat{X}_T^D=\sum_j\varsigma_j^{X_T}\hat{X}_{T,j}^D,\ \hat{X}_{T,j}^D=\left(\frac{\hat{p}_T^x}{\hat{a}_T}\right)^{-\lambda}\hat{\tilde{C}}_j^{X_T},\ \hat{\tilde{C}}_j^{X_T}=\sum_{d\in\{00,01,11\}}\xi_{d,j}^{X_T}\left(\hat{p}_{d,j}^h\right)^{\lambda-\sigma}\left(\hat{\tilde{c}}_{d,j}\right)^{\sigma-\varepsilon_j}\hat{s}_{d,j},\tag{C.9}$$

where

$$\varsigma_j^L=\frac{w_JL_j}{\sum_k w_JL_k},\ \xi_{d,j}^L\equiv\frac{w_JL_{d,j}}{w_JL_j},\ \varsigma_j^{X_T}=\frac{p_T^xX_{T,j}}{\sum_k p_T^xX_{T,k}},\ \xi_{d,j}^{X_T}\equiv\frac{p_T^xX_{T,d,j}}{p_T^xX_{T,j}},$$

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

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

$$\begin{aligned}\hat{\tilde{c}}_{d,j} &= \left(\frac{\alpha_j^k \left(r'_J\right)^{1-\sigma} + \alpha_j^h \left(p_{d,j}^{h\prime}\right)^{1-\sigma} + \left(1-\alpha_j^k-\alpha_j^h\right)\left(p_j^m\right)^{1-\sigma}}{\alpha_j^k \left(r_J\right)^{1-\sigma} + \alpha_j^h \left(p_{d,j}^{h}\right)^{1-\sigma} + \left(1-\alpha_j^k-\alpha_j^h\right)\left(p_j^m\right)^{1-\sigma}} \right)^{\frac{1}{1-\sigma}} \\ &= \left(s_{d,j}^K \left(\hat{r}_J\right)^{1-\sigma} + s_{d,j}^H \left(\hat{p}_{d,j}^h\right)^{1-\sigma} + \left(1 - s_{d,j}^K - s_{d,j}^H\right)\right)^{\frac{1}{1-\sigma}}, \end{aligned} \tag{C.10}$$

where

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

and

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

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

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

where

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

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

and

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

C.4 Derivation of (21)

To show the first equality, observe the definition (20). In case of $d = 11$, this becomes

$$s_{11,j} = \left(\Gamma_j\right)^{-1}\int_{\psi_{11,j}}^{\infty}\left(\psi\right)^{-(\sigma-\varepsilon_j)}dg_j\left(\psi\right) = \left(\Gamma_j\right)^{-1}\left(\psi_{11,j}\right)^{-(\theta_j-(\sigma-\varepsilon_j))}.$$

Hence, in terms of change,

$$\hat{s}_{11,j} = \left(\hat{\psi}_{11,j}\right)^{-(\theta_j-(\sigma-\varepsilon_j))}.$$

The second equality follows immediately from the threshold condition (12), with the assumption that price index P_j and quantity index Q_j does not change because of the small-open assumption.

C.5 Derivation of (22)

$$\begin{aligned}
CR_{11,j} &\equiv \left(\frac{c_{11,j}}{c_{01,j}}\right)^{1-\varepsilon_j} - 1\\
&= \left(\frac{\alpha_j^k\left(r_J\right)^{1-\sigma}+\alpha_j^h\left(p_{11,j}^h\right)^{1-\sigma}+\left(1-\alpha_j^k-\alpha_j^h\right)\left(p_j^m\right)^{1-\sigma}}{\alpha_j^k\left(r_J\right)^{1-\sigma}+\alpha_j^h\left(p_{00,j}^h\right)^{1-\sigma}+\left(1-\alpha_j^k-\alpha_j^h\right)\left(p_j^m\right)^{1-\sigma}}\right)^{\frac{1-\varepsilon_j}{1-\sigma}} - 1\\
&= \left[\left(1-s_{01}^h\right)+s_{01}^h\left(\frac{p_{11,j}^h}{p_{01,j}^h}\right)^{1-\sigma}\right]^{\frac{1-\varepsilon_j}{1-\sigma}} - 1,
\end{aligned}$$

where

$$\frac{p^h_{11,j}}{p^h_{01,j}} = \left(\frac{w_J^{1-\lambda} + \left(\frac{p^m_T}{a_T}\right)^{1-\lambda} + \left(\frac{p^m_R}{a_R}\right)^{1-\lambda} + \left(p^m_j\right)^{1-\lambda}}{w_J^{1-\lambda} + \left(\frac{p^m_R}{a_R}\right)^{1-\lambda} + \left(p^m_j\right)^{1-\lambda}}\right)^{\frac{1}{1-\lambda}}$$

$$= \left(\frac{w_J^{1-\lambda} + \left(\frac{p^m_R}{a_R}\right)^{1-\lambda} + \left(p^m_j\right)^{1-\lambda}}{w_J^{1-\lambda} + \left(\frac{p^m_T}{a_T}\right)^{1-\lambda} + \left(\frac{p^m_R}{a_R}\right)^{1-\lambda} + \left(p^m_j\right)^{1-\lambda}}\right)^{-\frac{1}{1-\lambda}}$$

$$= \left(1 - \underbrace{\frac{\left(\frac{p^m_T}{a_T}\right)^{1-\lambda}}{w_J^{1-\lambda} + \left(\frac{p^m_T}{a_T}\right)^{1-\lambda} + \left(\frac{p^m_R}{a_R}\right)^{1-\lambda} + \left(p^m_j\right)^{1-\lambda}}}_{\equiv s^{T|h}_{11,j}}\right)^{-\frac{1}{1-\lambda}}.$$

combining these,

$$CR_{11,j} = \left[\left(1 - s^h_{01}\right) + s^h_{01}\left(1 - s^{T|h}_{11,j}\right)^{-\frac{1-\sigma}{1-\lambda}}\right]^{\frac{1-\varepsilon_j}{1-\sigma}} - 1$$

C.6 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 (16) and (17) for $d = 11$, we have

$$\frac{w_J l_{11,j}(\psi)}{p^x_T x_{11,j}(\psi)} = \left(\frac{w_J}{p^m_T / a_T}\right)^{1-\lambda}$$

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

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

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

which is equation (29).

Next, taking the change of expression (29), we have

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

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

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

where

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

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

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

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

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

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

Hence, we have

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

Furthermore, we have

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

where the threshold change can be obtained in the same way in equation (23).

C.7 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

$$S_g^L \equiv \left(\frac{w_J L_g}{w_J L_g + r_J K_g + \Pi_g} \right), \tag{C.11}$$

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 $S_g^{L|C} \equiv w_J L_g / (w_J L_g + r_J K_g)$ 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

$$\hat{S}_g^X = \sum_j \bar{S}_{g,j}^C \frac{\hat{X}_{g,j}^J}{\hat{X}_g^J}, \;\; \bar{S}_{g,j}^C = \frac{\frac{\varepsilon_j - 1}{\varepsilon_j} X_{g,j}^J}{\sum_k \frac{\varepsilon_k - 1}{\varepsilon_k} X_{g,k}^J}, \tag{C.12}$$

$$\hat{X}^J_{g,j} = \frac{\varepsilon_j}{\varepsilon_j - 1} S^L_{g,j} \hat{w}_J \hat{L}_{g,j} + \left(1 - \frac{\varepsilon_j}{\varepsilon_j - 1} S^L_{g,j}\right) \hat{r}_J \hat{K}_{g,j}, \tag{C.13}$$

and

$$\begin{aligned}
\hat{K}_{g,j} = & \left(\hat{r}_J\right)^{-\sigma} \left(\hat{c}_{00,j}\right)^{\sigma-\varepsilon_j} \left(1 - \left(S^K_{01,j|g} + S^K_{11,j|g}\right) \left(\hat{\psi}_{01,j}\right)^{-(\theta_j - (\varepsilon_j - \sigma))}\right) \\
& + \left(\hat{r}_J\right)^{-\sigma} \left(\hat{c}_{01,j}\right)^{\sigma-\varepsilon_j} \left[\left(S^K_{01,j|g} + S^K_{11,j|g}\right) \left(\hat{\psi}_{01,j}\right)^{-(\theta_j - (\varepsilon_j - \sigma))} \right. \\
& \left. \quad - S^K_{11,j|g} \left(\hat{\psi}_{11,j}\right)^{-(\theta_j - (\varepsilon_j - \sigma))}\right] \\
& + \left(\hat{r}_J\right)^{-\sigma} \left(\hat{c}_{11,j}\right)^{\sigma-\varepsilon_j} S^K_{11,j|g} \left(\hat{\psi}_{11,j}\right)^{-(\theta_j - (\varepsilon_j - \sigma))},
\end{aligned} \tag{C.14}$$

$$\begin{aligned}
\hat{L}_{g,j} = & \left(\hat{w}_J\right)^{-\lambda} \left(\hat{p}^{m,P}_{00,j}\right)^{\lambda-\sigma} \left(\hat{c}_{00,j}\right)^{\sigma-\varepsilon_j} \left(1 - \left(S^L_{01|j,g} + S^L_{11|j,g}\right) \left(\hat{\psi}_{01,j}\right)^{-(\theta_j - (\varepsilon_j - \sigma))}\right) \\
& + \left(\hat{w}_J\right)^{-\lambda} \left(\hat{p}^{m,P}_{01,j}\right)^{\lambda-\sigma} \left(\hat{c}_{01,j}\right)^{\sigma-\varepsilon_j} \left[\left(S^L_{01|j,g} + S^L_{11|j,g}\right) \left(\hat{\psi}_{01,j}\right)^{-(\theta_j - (\varepsilon_j - \sigma))} \right. \\
& \left. \quad - S^L_{11|j,g} \left(\hat{\psi}_{11,j}\right)^{-(\theta_j - (\varepsilon_j - \sigma))}\right] \\
& + \left(\hat{w}_J\right)^{-\lambda} \left(\hat{p}^{m,P}_{11,j}\right)^{\lambda-\sigma} \left(\hat{c}_{11,j}\right)^{\sigma-\varepsilon_j} S^L_{11|j,g} \left(\hat{\psi}_{11,j}\right)^{-(\theta_j - (\varepsilon_j - \sigma))}
\end{aligned} \tag{C.15}$$

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

$$S^L_{d|j,g} = \frac{\int_{i\in\{d,j,g\}} w_J l_i di}{\int_{i\in\{j,g\}} w_J l_i di}, \;\; S^K_{d,j|g} = \frac{\int_{i\in\{d,j,g\}} r_J k_i di}{\int_{i\in\{j,g\}} r_J k_i di}, \tag{C.16}$$

the threshold change for $d = 11$, $\hat{\psi}_{11,j}$, is given in equations (21) and (23), and $\hat{\psi}_{01,j}$ is given analogously.

Proof. Using equation (C.11), we have

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

Taking the new-old ratio, it is immediate that $\hat{S}_g^L = \hat{S}_g^{L|C} \widehat{\left[\sum_j \left(w_J L_{g,j} + r_J K_{g,j}\right) / X_{g,j}^J\right]}$. Therefore, it remains to be shown that $\widehat{\left[\sum_j \left(w_J L_{g,j} + r_J K_{g,j}\right) / X_{g,j}^J\right]} = \hat{S}_g^X$. For this purpose, we will derive equations (C.12), (C.13), (C.14), (C.15), and (C.16). First, fix an industry j. Then we have

$$X_{g,j} = \frac{\varepsilon_j}{\varepsilon_j - 1} \left(w_J L_{g,j} + r_J K_{g,j}\right) \tag{C.17}$$

since we fix the industry, and the markup rate is constant within the industry due 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

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

which completes the proof of equation (C.12).

Next, using equation (C.17), we have

$$
\begin{aligned}
\hat{X}_{g,j} &= (w_J L_{g,j} \hat{+} r_J K_{g,j}) \\
&= \frac{w_J L_{g,j}}{w_J L_{g,j} + r_J K_{g,j}}\hat{w}_J \hat{L}_{g,j} + \frac{r_J K_{g,j}}{w_J L_{g,j} + r_J K_{g,j}}\hat{r}_J \hat{K}_{g,j}.
\end{aligned}
\tag{C.18}
$$

Note that

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

and $\frac{r_J K_{g,j}}{w_J L_{g,j}+r_J K_{g,j}} = 1 - S^L_{g,j}\frac{\varepsilon_j}{\varepsilon_j-1}$ likewise. Substituting these equations in equation (C.18) completes the proof of equation (C.13).

Finally, deriving equations (C.14) (C.15), and (C.16) is analogous to the one in Appendix C.3, with conditions on group g added in each derivation there. $\square$

C.8 Extension: Labor-substituting intermediate input

We consider an alternative nested structure where imported inputs can displace labor like offshored tasks:

$$
\begin{aligned}
q_j &= \psi \left[(\alpha_j^k)^{\frac{1}{\sigma}} k^{\frac{\sigma-1}{\sigma}} + (\alpha_j^h)^{\frac{1}{\sigma}} h^{\frac{\sigma-1}{\sigma}} \right] \\
h\left(l, x_T, x_R, m\right) &\equiv \left[\left(\beta_j^l\right)^{\frac{1}{\lambda}} l^{\frac{\lambda-1}{\lambda}} + (\beta_j^T)^{\frac{1}{\lambda}} \left(a_T x_T\right)^{\frac{\lambda-1}{\lambda}} + (\beta_j^R)^{\frac{1}{\lambda}} \left(a_R x_R\right)^{\frac{\lambda-1}{\lambda}} + \left(\beta_j^m\right)^{\frac{1}{\lambda}} m^{\frac{\lambda-1}{\lambda}} \right]^{\frac{\lambda}{\lambda-1}},
\end{aligned}
$$

A key parameter here is the elasticity of substitution between labor-intensive inputs, λ. If we use our central estimate of $\lambda = 1.4 > 1$, imported and offshored inputs are substitutable, thus the reduction in the price of imported inputs would also substitute labor, which is reminiscent of the mechanism between firm-level importing and employment in Hummels et al. (2014).

We can then formalize the interaction effect of the offshored and imported inputs. Imagine comparing the following two scenarios. In the first scenario, we fix the price of imported inputs and only change the foreign productivity, like our main analysis. In the second scenario, we reduce the import price as well as increase foreign productivity. Compared to scenario 1, scenario 2 features a *weaker* effect of MNEs because some of the increased MNE activities are substituted by cheaper foreign inputs.

This insight will be applied in a production function with a different nest structure. In such a case, the parameter that matters is still the substitutability between foreign outsourced inputs and imported inputs. As long as these inputs are substitutes, we believe that the additional mechanism the referee suggested will counteract our focused mechanism.

D Structural Estimation Appendix

D.1 Calibration Details of the Top Nest Elasticity

We consider estimating the elasticity between capital-intensive and labor-intensive tasks σ_j by fitting the relative demand for capital with respect to the 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). That is, we 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 (14) and (15) for non-offshorers $d^* = 00$ imply

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

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

$$\ln\left(\frac{rk}{wl}\right)_i = b_{0,j} + b_1 \ln\left(w_{\text{city}(i)}\right) + X_i b_2 + e_i, \tag{D.19}$$

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 (D.19) 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 (D.19). 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.

Table D.1: Robustness Checks for Regression (**??**)

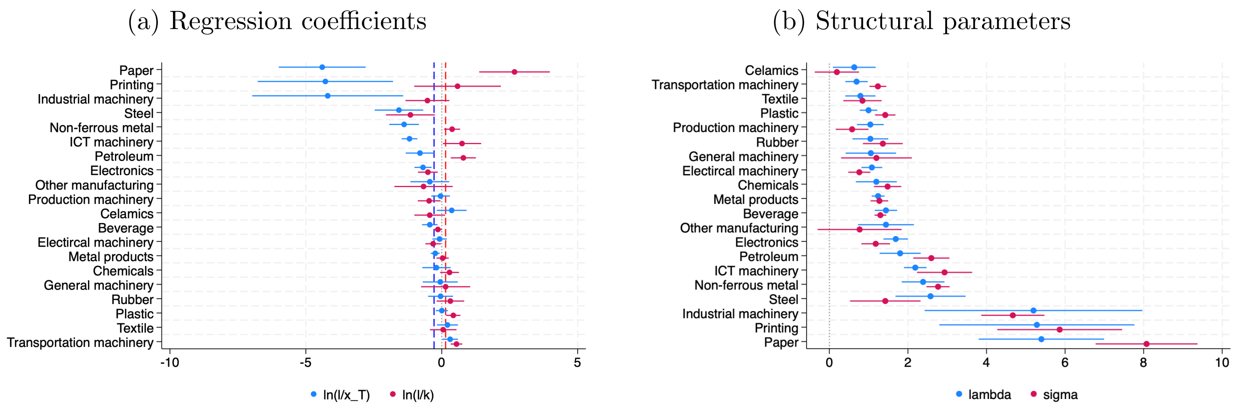
VARIABLES	(1) $\ln l_{it}^{JPN}$	(2) $\ln l_{it}^{JPN}$	(3) $\ln l_{it}^{JPN}$	(4) $\ln l_{it}^{JPN}$
shock	-0.0497***	-0.172***	-0.0490***	-0.249***
	(0.0126)	(0.0667)	(0.0139)	(0.0774)
Observations	185,703	185,703	91,690	91,690
Shock measure	Extensive	Intensive	Extensive	Intensive
Balanced panel?			YES	YES
Implied elasticity λ	1.32	1.62	0.84	1.07

Note: The table presents regression results of equation (**??**) 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 factors, λ, is implied by solving equation (**??**). Standard errors are clustered at the firm and industry-year level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

D.2 Robustness Checks with the Thai Shock at the Extensive Margin

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 D.1, and they are qualitatively consistent with those in Table **??**. 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.

Figure D.2: Sector-specific estimates



Note: The figure shows the result of the sectoral structural estimation of the CES parameters. The left panel shows the regression coefficients of the log relative domestic employment to foreign input (blue dots) and the log relative domestic employment to domestic capital (red dots) with respect to the Thai flood shock, specified in equation (26). Industries are sorted by the values of the blue dots. The blue and red dashed lines indicate -0.283 and 0.143, respectively, which are the industry-average estimates obtained in table **??**. Standard errors are clustered by 3-digit industry and year. The right panel shows the implied structural parameters, λ and σ, sorted by the point estimate of λ. $^{***}p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

D.3 Elasticity of Substitution heterogeneous across industries

It is technically possible to identify the EoS in (5) (σ_j) and (6) (λ_j) by interacting the shock variable with industries. In practice, however, the sample size of firms in the Thai flood analysis is too small to identify the industry-specific coefficients sharply. Figure D.2a shows the results, which show a large variation in the sector-specific estimates, centered around the averages found in table **??**. In addition, some industries violate the Pareto aggregation restriction that $\lambda - \sigma$ must be small enough for the integral to be well-defined.

E Counterfactual Exercise Appendix

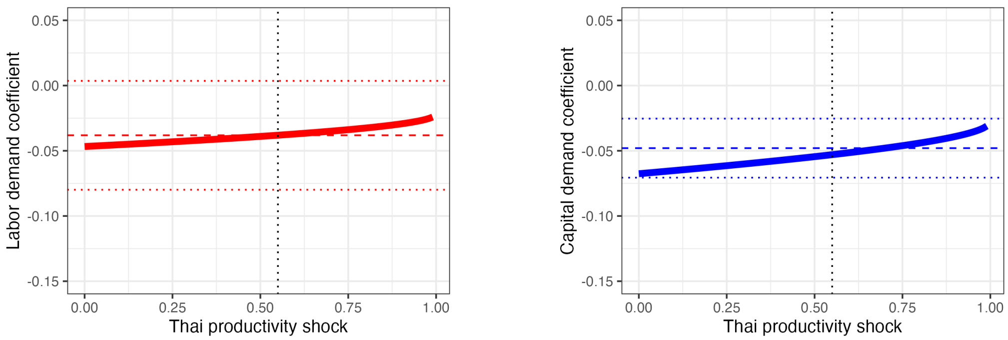
E.1 Robustness check of the model fit exercise

We analyze the sensitivity of the model fit to the size of the shock by varying the size of the shock between $\hat{a}_T = 0$, which means that Thai productivity is zero, and there is no operation in Thailand, and $\hat{a}_T = 1$, which means that Thai productivity after the floods is unchanged at all. For each value of $\hat{a}_T$, we simulate the model again and run the same specification as in the original manuscript (regressing the simulated change in labor and capital demand on the shock indicator). Figure E.3a shows the result for labor. As expected, the coefficient changes only slightly between -0.03 and -0.05, which is well within the 95% confidence interval of -0.08 and 0.00. Nevertheless, the coefficient range includes the true coefficient of -0.038 at $\hat{a}_T = 0.55$, demonstrating the successful performance of the model in predicting the important covariance moment in the data.

Turning to Figure E.3b, the result for capital is shown with the same variation in shock size (between 0 and 1) and also shows reasonably good predictive power of the estimated model. The slope of the coefficient with respect to shock size is slightly larger than the effect on labor, perhaps reflecting greater non-linearity between capital demand and the Thai shock due to the different locations in the nests of the nested CES. Nevertheless, for $\hat{a}_T = 0.55$, the simulated coefficient (-0.057) is within the confidence interval of the coefficient from the data (-0.08 and -0.03). Therefore, the agreement of the simulated moments with the capital coefficient, an unmatched data moment, is good and robust.

Figure E.3: Sensitivity analysis to the model fit exercise

(a) Labor coefficient (b) Capital coefficient



Note: The figure plots the coefficient of the regression of labor demand (panel a) and capital demand (panel b) on the Thai-flood shock indicator on the vertical axis. The horizontal axis shows the size of the simulated shock of Thai floods. The horizontal dashed line in the middle of each panel shows the point estimate from the data, which does not vary across the simulated shock size, and two dotted lines indicate 95 percent confidence intervals for the estimate. The vertical dotted line indicates the shock size $\hat{a}_T = 0.55$, or post-flood Thai productivity is 55% of the pre-flood level, at which the labor demand coefficients from the simulation and data coincide.

E.2 The Profit Share

In this subsection, we can consider the Thai flood impact on the profit share. One of the key insights of Castro-Vincenzi and Kleinman (2024) is that the calculation of labor and profit shares is nuanced in the presence of intermediate inputs, since the value-added share of total revenue varies due to price shocks. Like Castro-Vincenzi and Kleinman (2024), we consider the value-added share of profit, defined as

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

Write the firm-level total cost as $c_j(\psi) q(\psi)$. Then we have

$$s^{\pi}(\psi) = \frac{\frac{\pi(\psi)}{c_j(\psi) q(\psi)}}{\frac{w_J l(\psi) + (r_J k(\psi) + \pi(\psi))}{c_j(\psi) q(\psi)}} = \frac{\frac{\varepsilon_j}{\varepsilon_j - 1}}{1 - \upsilon_j(\psi)},$$

where $\upsilon_j(\psi)$ is the intermediate cost share

$$\upsilon_j(\psi) \equiv \frac{p^m m(\psi)}{c_j(\psi)\, q(\psi)}.$$

This expression is reminiscent of the mechanism introduced by Castro-Vincenzi and Kleinman (2024). On the one hand, under the CES demand, the profit share of total costs is constant, depending on the demand elasticity ε_j. On the other hand, the total cost share of value added is a function of the intermediate cost share $\upsilon_j(\psi)$. Note that our CES production function implies that

$$\upsilon_j(\psi) = \left(\frac{p^m}{c_j(\psi)}\right)^{1-\sigma_j}.$$

Now, consider the Thai flood shock, $-d\ln a_T$. Under the small-open assumption, we have $d\ln p^m = 0$, and the effect on total costs depends on whether the firm with productivity ψ expands into Thailand:

$$d\ln c_j(\psi) = \begin{cases} 0 & \text{if } \psi < \psi_{11,j} \\ \kappa^h_{11,j}\varpi_{11,j}\left(-d\ln a_T\right) & \text{if } \psi \geq \psi_{11,j} \end{cases},$$

where $\kappa^h_{11,j}$ and $\varpi_{11,j}$ are the cost shares of labor-intensive tasks and Thai tasks for Thai investing firms, as in the main text. Thus, the first-order effect on the profit share is given by

$$
\begin{aligned}
d \ln s^{\pi}(\psi) &= -d \ln \left(1-\upsilon_j(\psi)\right) \\
&= \frac{\upsilon_j(\psi)}{1-\upsilon_j(\psi)} d \ln \upsilon_j(\psi) \\
&= \frac{\upsilon_j(\psi)}{1-\upsilon_j(\psi)} \left(\sigma_j-1\right) d \ln c_j(\psi) \\
&= \frac{\upsilon_j(\psi)}{1-\upsilon_j(\psi)} \left(\sigma_j-1\right) \kappa_{11,j}^{h} \varpi_{11,j} \left(-d \ln a_T\right)
\end{aligned}
$$

if $\psi \geq \psi_{11,j}$, and 0 otherwise. Therefore, in our setup, the profit share effect of the Thai flood shock is a function of the following objects:

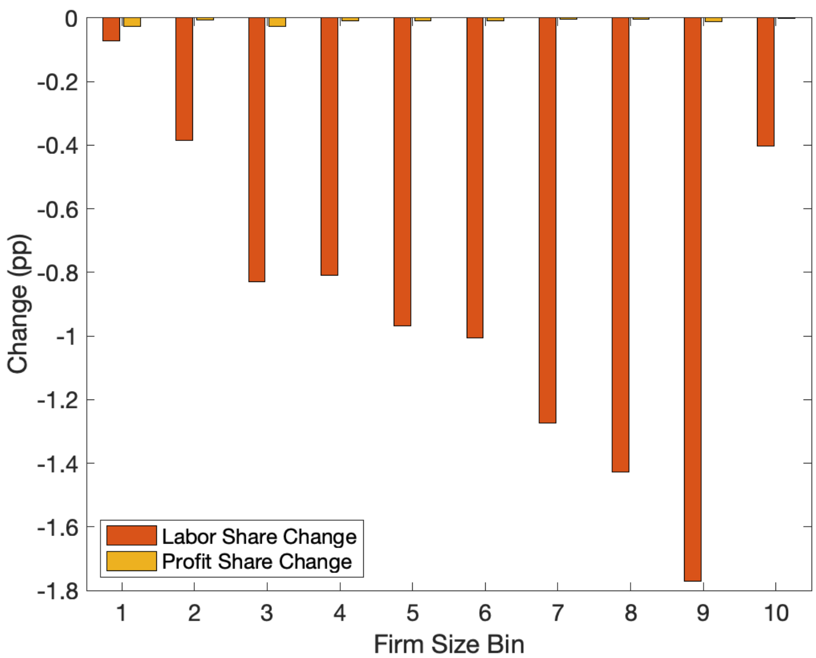
1. The intermediate cost share $\upsilon_j(\psi)$, which governs how the value-added share of total cost changes; this effect appears in Castro-Vincenzi and Kleinman (2024).

2. The elasticity of substitution for intermediate goods σ_j, which governs the responsiveness of the share of intermediate costs with respect to total unit costs.

3. The input shares of Thai investors $\kappa_{11,j}^{h}$ and $\varpi_{11,j}$, which determine the effect of the Thai shock on total unit costs.

Figure E.4 shows the profit share effect of foreign productivity growth across firm size bins. The figure follows the structure of Figure 7b, which shows a similar analysis with respect to labor shares. We find that the effect on the profit share implied by the model is much smaller than the effect on the labor share.

Figure E.4: The labor share and profit share change



Note: The figure shows the simulation result of the foreign productivity growth on the labor shares and profit shares across firm size bins.