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Synergy or Anergy?
Foreign acquisition and firm productivity in Japan*

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Abstract

Cross-border mergers and acquisitions (M&A) are a prominent mode of foreign direct investment. However, there remains mixed and inconclusive evidence for the impact of foreign acquisition on acquired domestic firms. This paper contributes to the literature by employing a staggered difference-in-differences approach to address the timing variation in foreign acquisitions and constructing a novel panel dataset on Japanese firms that precisely captures the post-acquisition period for acquired firms. The results show statistically insignificant estimates for the aggregate effects of foreign acquisition on the post-acquisition productivity, suggesting neither productivity gains nor adverse effects for acquired firms. Even after accounting for general acquisition effects, foreign ownership changes have no influence on post-acquisition productivity. By contrast, canonical two-way fixed effects regressions yield significantly positive estimates, highlighting the need for methodological refinement in the literature to address heterogeneous treatment effects of foreign acquisition.

Keywords: M&A, acquisition, foreign firms, productivity, Japan
JEL classification: F14, F21, F23

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1. Introduction

The global value of foreign direct investment (FDI) inward positions reached 41.1 trillion US dollars at the end of 2023.[1] The potential contribution of multinational firms to host economies has motivated policy instruments to promote inward FDI. Among entry modes, mergers and acquisitions (M&A) serve as a prominent channel through which multinational firms establish foreign subsidiaries. A large literature examines the impact of foreign acquisition on acquired domestic firms, but existing evidence remains mixed and inconclusive. For instance, positive post-acquisition effects are found in countries such as Indonesia, Turkey, Spain and the U.S. (Arnold and Javorcik, 2009; Bircan, 2019; Chen, 2011; Guadalupe et al., 2012). In contrast, more heterogeneous or conflicting results are reported within the same countries—China (Wang and Wang, 2015; Kamal, 2015; Liu et al., 2017), India (Stiebale and Vencappa, 2018; Srivastava, 2023), Japan (Fukao et al., 2005; Fukuda, 2020), the U.K. (Conyon et al., 2002; Girma and Görg, 2007; Schiffbauer et al., 2017), and the European countries (Damijan et al., 2015; Gregori et al., 2024; Fons-Rosen et al., 2021). The mixed findings underscore the need for further research to understand the post-acquisition performance of acquired firms and to inform policy strategies for inward FDI.

In this paper, I revisit this question by extending literature in several ways. First, I adopt a staggered difference-in-differences (DiD) approach developed by Callaway and Sant'Anna (2021). By accounting for the staggered timing of foreign acquisitions, I apply a new empirical approach to estimating the impact of foreign acquisition on the productivity of acquired firms. Second, I construct a novel panel dataset on Japanese firms that precisely captures the post-acquisition period for acquired firms plausibly under managerial control by foreign firms. This dataset provides a critical foundation for estimating the post-acquisition effect on the acquired firms. Third, I provide alternative explanations for the effects of M&A transactions and suggest both synergy and anergy effects on acquired domestic firms. The interplay of these opposing influences helps to understand the mixed findings in prior research. The first and second contributions are further clarified in the following.

A staggered DiD approach is crucial for causal inference in my setting. In a standard empirical approach, the causal effect of foreign acquisition on the outcome of acquired firms is a difference between their observed post-acquisition outcome and counterfactual outcome. Since the latter is never observed, it is typically approximated by the observed outcome of domestic firms that are never acquired by foreign firms. A causal parameter of foreign acquisition effects has been commonly estimated by a DiD regression model with propensity-score matching. However, recent advances in econometrics highlight that the OLS estimate of the DiD regression may not represent a reasonable causal parameter for the average treatment effect on the treated

[1] IMF Coordinated Direct Investment Survey in January 2025.

(ATT) when treatment effects are heterogeneous across either time or units (Borusyak et al., 2024; de Chaisemartin and D'Haultfoeuille, 2020; Goodman-Bacon, 2021). Although the staggered timing of M&A transactions is common, this econometric issue has not been adequately addressed in the related literature.

To account for heterogeneous treatment effects, I adopt an estimation approach by Callaway and Sant'Anna (2021). Their method allows me to generalize the ATT for multiple treatment groups and time periods by defining the group-time average treatment effects for firms of a particular acquisition timing at a particular time period. The group-time average treatment effects are a causal parameter of interest and thus identified for all pairs of acquisition time and time period. Given that the parallel trends assumption in a DiD approach may not hold unconditionally, a doubly robust estimator by Sant'Anna and Zhao (2020) is employed to relax the parallel trends assumption by conditioning on a rich array of firm-level pre-treatment covariates: sales, employment, wage, asset, export, import, R&D, and patent ownership. Finally, I compute aggregate ATT estimates by the weighted average of the group-time average treatment effects and examine the event-time effects of foreign acquisitions on the post-acquisition productivity of acquired domestic firms.

A new dataset on Japanese firms with information on foreign acquisitions is also a key contribution to the literature. Although post-acquisition performance has been commonly evaluated during the period immediately following a foreign acquisition, a relevant post-period should be the entire time period during which foreign firms acquire equity stakes in domestic firms, assume effective managerial control, and potentially divest or exit the acquired firms subsequently following the initial acquisition. This issue has been overlooked because prior studies commonly identify foreign acquisitions either directly by M&A transaction databases or indirectly by changes in equity ownership percentages held by foreign entities: a common threshold is more than 50% of foreign capital share, as majority ownership generally confers voting rights over strategic corporate decisions such as board appointments. However, this approach has several limitations. First, equity shareholding and managerial control do not necessarily align because ownership stakes may not directly translate into operational influences. Second, foreign capital can partly include passive portfolio investment by overseas institutional investors. Third, M&A transactions provide little direct information on the period in which acquired domestic firms are effectively managed by foreign acquirers subsequently following the acquisition, making it difficult to assess the long-run effects.

To fill this gap, I use the Survey of Trends on Business Activities of Foreign Affiliates (SFA) by the Japanese Ministry of Economy, Trade, and Industry. The survey was annually conducted for the enterprises that meet the criteria: (i) foreign investors own more than one-third of the company's shares or equity holdings, (ii) combined direct and indirect ownership exceeds one-

third, and (iii) the largest foreign investor holds at least 10% ownership.[2] The survey asks foreign affiliates about their entry year and mode in the Japanese market—whether M&A was the reason why foreign investors' shareholding exceeds the one-third threshold. It also collects information on their operation status, including dissolution and withdrawal. These features allow me to build clean panel data on the entry, duration, and exit of acquired domestic firms that are effectively managed by foreign firms. Furthermore, I construct firm-level panel data by merging the SFA with the Basic Survey of Japanese Business Structure and Activities (SJB). The final dataset gives a sample of domestic firms that are never acquired by foreign firms during the period 2001-2019, providing a clean control group for causal inference.

Main results are summarized as follows. First, a staggered DiD method shows that aggregate ATT estimates of foreign acquisition effects are not statistically significant. This result suggests that foreign acquisitions do not have a causal impact on the post-acquisition productivity of acquired domestic firms—neither generating productivity gains nor exerting detrimental impacts. A plausible interpretation is that both synergy and anergy effects may coexist following a foreign acquisition, and these opposing influences may offset one another. Second, canonical two-way fixed effects (TWFE) regressions show the significantly positive estimates of foreign acquisition effects. This finding is in stark contrast to the results from the staggered DiD method. Given that the previous empirical approach essentially relies on a variant of TWFE regression for identification, these findings point to a critical need for methodological refinement to account for heterogeneous treatment effects in prior studies. Third, I disentangle the effect of foreign ownership from general acquisition effects by using plausibly domestic acquisitions as a control group. I also account for timing heterogeneity between foreign and domestic acquisitions by constructing a matched sample with the same acquisition timing. The results show that a change in ownership from domestic to foreign parent firms has no significant impact on post-acquisition productivity.[3]

I examine whether the insignificant effect of foreign acquisition on acquired firms is robust to alternative specifications. First, I use alternative methods to estimate production function including Ackerberg et al. (2015), Levinsohn and Petrin (2003), and Wooldridge (2009). Second, I compute wild bootstrap standard errors in a staggered DiD method as suggested by Callaway and Sant'Anna (2021). Third, I explore heterogeneity in the ATT across various dimensions, including industrial sectors (manufacturing vs. services) and the origin country of acquiring firms

[2] Under the Japan's Companies Act, a shareholder with more than 33.4% of a company's shares is granted a blocking minority, a right to veto key corporate decisions. This implies that the shareholder has the authority to unilaterally block the passage of special resolutions at the general shareholders' meeting.

[3] Consistent with the results, Wang and Wang (2015) find that foreign acquisitions do not improve the post-acquisition productivity of acquired firms as compared with domestic acquisitions in China.

(the U.S., European, and Asian firms). These results show that foreign acquisition does not have a significant impact on the post-acquisition productivity of acquired firms. Additionally, I examine other outcome variables, including sales, cost of sales, wages, administrative costs, asset, and employment. The results show that foreign acquisition does not affect these outcomes.

This paper relates to recent empirical work that addresses the staggered timing of foreign acquisition.[4] By accounting for selection bias with propensity score matching and inverse probability weighting, Gregori et al. (2024) argue that the use of propensity score matching should satisfy the assumption that the coefficient from a DiD regression model can be interpreted as a weighted average causal effect of the treatment (Athey and Imbens, 2022). Görg and Lehr (2024) adopt the event study estimator developed by Sun and Abraham (2021) to address dynamic and heterogeneous effects of foreign acquisitions. This approach estimates cohort-time interactions in a regression model and aggregates the relevant coefficients over relative time to acquisition. Meanwhile, this paper adopts the approach by Callaway and Sant'Anna (2021) and allows for the conditional parallel trends via a doubly robust estimator.

Among the extensive body of literature, this paper closely relates to prior studies using Japanese data. Fukao et al. (2005) use firm-level panel data from the SJB and define foreign ownership solely based on foreign capital share. Their results show the significantly positive impact of foreign acquisitions on the productivity of acquired firms. Fukuda (2020) uses the SPEEDA global M&A data and the NEEDS database to construct firm-level panel data. Foreign acquisitions are measured by M&A transactions in which 50% or more of equity in Japanese companies are acquired by foreign companies. By combining propensity score matching with a DiD regression, the results show no significant effect of foreign acquisition on labor productivity. As compared with these studies, this paper improves panel data on foreign acquisitions and employs a staggered DiD approach.

The rest of this paper is organized as follows. Section 2 presents a conceptual framework to understand the impact of M&A transactions by foreign firms on acquired domestic firms. Section 3 discusses a prior empirical approach for causal inference to highlight a staggered DiD approach on this topic. Section 4 describes firm-level panel data with foreign acquisitions in Japan. Section 5 shows the estimation results and robustness checks. Finally, section 6 concludes.

2. Conceptual Framework

This section presents a conceptual framework to understand the impact of foreign acquisition on the productivity of acquired firms. A starting point is a fundamental reason for firms to make direct investment in a foreign market. In general, firms face a different competitive environment in the foreign market from that in a home market for cross-country differences in market

[4] For a review of related literature, see Tőkés (2021).

competition, business practices, government regulation, and language and culture. These differences impose significant costs on them to do business in the foreign market as compared to local firms. To offset these disadvantages, they should possess firm-specific advantages in management, production, and innovation, including superior production technology, valuable patent, managerial know-how, corporate brand, and distributional networks. These intangible assets allow them to compete with the local firms and play a key role in FDI decisions (Dunning, 1981; Markusen, 2002; Helpman et al., 2004). Upon the decision to make FDI, they select from alternative entry modes such as greenfield investment, joint ventures, and acquisition of existing domestic firms. This study focuses on the latter, wherein a foreign firm acquires ownership from a domestic parent firm and assumes long-term managerial control of the acquired domestic firm.[5]

When foreign firms gain control over the management of domestic firms that they purchase, such acquisitions can produce both synergy and anergy effects on acquired firms. These effects result from complex interactions involving management practices and organization transformations, and they jointly influence the post-acquisition productivity of the acquired firms. Several mechanisms can enable the acquired domestic firms to realize the synergy effects of foreign acquisition. For instance, foreign parent firms can transfer a variety of tangible and intangible assets to the acquired firms, such as managerial expertise, advanced production technology, capital, and skilled workers. Intangible assets may also include patents, licenses, and product brands (Bircan, 2019; Tőkés, 2021; Gregori et al, 2024). These assets contribute to the acquired firm's competitive advantages in production and innovation (Guadalupe et al., 2012). Moreover, foreign acquirers may introduce superior management practices including corporate strategy, human resources, marketing, and finance. They may also implement organizational restructuring and optimize supply chains. These changes in managerial and organizational structures under foreign ownership can produce the synergy effects of foreign acquisition and enhance the post-acquisition productivity of the acquired firms.

It should be highlighted that the mechanisms underlying synergy effects are not necessarily exclusive to foreign acquisition. They can also apply to domestic acquisitions, where other domestic parent firms gain control over the management of domestic firms. When domestic acquirers possess superior tangible and intangible assets, domestic acquisition may also involve a transfer of these assets to acquired firms and consequently enhance the post-acquisition productivity of the acquired firms (Bertrand and Zitouna, 2008; Conyon et al. 2002). However, foreign acquisition can be more conductive to the transfer of superior tangible and intangible assets as compared to domestic acquisition. The reason is that domestic acquiring firms typically face lower entry barriers in the domestic market and thus may not systematically possess greater amount of superior tangible and intangible assets such as proprietary technologies, global brand,

[5] See, for instance, Harris and Robinson (2002) for discussions on the reasons for foreign acquisition.

and advanced management practices for technology transfers (Chen, 2011). This distinction between foreign and domestic acquirers partly motivates my analysis to focus on the impact of foreign acquisitions.

Second, the synergy effects discussed above may not materialize in acquired domestic firms under foreign ownership for several reasons. When foreign parent firms attempt to transfer their managerial practices and production technology to acquired domestic firms, their firm-specific knowledge may not be complementary with that in the acquired firms, limiting the effectiveness of knowledge and technology transfers. Incompatibility of managerial and technological systems between acquiring and acquired firms can prevent the transfer of tangible and intangible assets from foreign parent firms to the acquired firms, limiting the realization of intended synergies. Additionally, the transfer of foreign practices in management and production entails significant adjustment costs such as managerial relearning and worker retraining. Large adjustment costs may discourage the acquired firms from fully absorbing these changes brought by foreign parent firms. These barriers hinder the effective utilization of superior intangible assets provided by the foreign parent, thereby reducing productivity gains for the acquired firms after foreign acquisition.

Third, acquired firms may experience anergy effects of foreign acquisition for various reasons, as widely discussed in the M&A literature (Balsvik and Haller, 2020; Siegel and Simons, 2010; Li, 2013; Tőkés, 2021; Tuch and O'Sullivan, 2007). When the anergy effects outweigh the potential synergies, foreign acquisition can have an adverse impact on the productivity of the acquired firms (Gregori et al, 2024). For instance, corporate culture and managerial practices may be largely different between acquiring foreign and acquired domestic firms, and the adverse effect stems from the misalignment between corporate culture and management practices. An attempt to transplant foreign cultural norms and management styles can spark frictions at both management and worker levels, potentially undermining employee morale and motivation. Concerns about drastic organizational restructuring and job security under foreign ownership may further exacerbate employee dissatisfaction, possibly leading to the departure of key managers and skilled workers from acquired firms. Additionally, consumers may respond unfavorably to a shift from familiar domestic brands to international brands, perceiving it as a decline in product quality or an increase in prices. Such consumer reactions can lead to lower customer loyalty and a decline in customer retention, leading to an adverse influencing on the post-acquisition performance.

Taken together, these discussions highlight that foreign acquisition can produce both synergy and anergy effects on acquired domestic firms. However, these opposing influences may not necessarily materialize during the post-acquisition period for a variety of theoretical reasons and firm-specific contexts. If synergy effects outweigh anergy effects, acquired firms are likely to experience productivity improvements following foreign acquisition. On the other hand, if anergy

effects dominate synergy effects, they may face productivity declines. Additionally, if these effects offset one another, the overall net impact of foreign acquisition may be neutral, suggesting that it is difficult to observe a clear change in the post-acquisition productivity of acquired firms. Thus, the impact of foreign acquisition on firm productivity remains an empirical question.

3. Empirical Strategy

This paper aims to examine whether a change in ownership change from domestic to foreign parent firms has a causal impact on the post-acquisition productivity of acquired domestic firms. To this end, I start to review prior empirical approaches for estimating the impact of foreign acquisition and identify key econometric issues unexplored in prior studies. These discussions highlight the importance of employing a staggered DiD approach in my setting.

A starting point for causal inference is to define the causal effect of foreign acquisition on the outcome of acquired firms, which is measured by the difference between their observed post-acquisition productivity and counterfactual productivity. The counterfactual productivity refers to the level of productivity that the acquired firms would have exhibited had they not been acquired by foreign parent firms. Because this counterfactual outcome is never observed, a lack of counterfactual data is a key empirical challenge in identifying the causal effect of foreign acquisition (Girma and Görg, 2007). In this respect, prior studies commonly approximate this unobserved counterfactual outcome by using the observed outcome of domestic firms that have not been acquired by foreign investors (Arnold and Javorcik, 2009).

To estimate the causal impact of foreign acquisition, DiD estimation is a standard econometric approach since the work of Conyon et al. (2002) and Harris and Robinson (2002). Following the previous work (Bircan, 2019; Gregori et al. 2024; Guadalupe et al., 2012; Stiebale and Vencappa, 2018; Wang and Wang, 2015), my benchmark is to estimate a two-way fixed effects (TWFE) model for firm *i* and year *t*:

$$Y_{it} = \alpha + \beta FA_{it} + \gamma_i + \delta_t + \varepsilon_{it} \quad (1)$$

where Y_{it} is the outcome of firm *i*; FA_{it} takes on unity for firm *i* acquired by foreign investors in post-acquisition years, and zero otherwise. Note that FA_{it} is defined to take missing values for firm *i* in the years following divestment by foreign firms. This definition ensures that the coefficient β captures a change in the outcome for firm *i* following foreign acquisition, exclusive of divestment effects by foreign parent firms such as a change in ownership from foreign to domestic parent firms and the exit of the acquired firms.[6] γ_i and δ_t are firm-level and year-level fixed effects, respectively. Finally, ε_{it} is an error term.

The estimated coefficient $\hat{\beta}$ from the ordinary least squares (OLS) estimation of equation

[6] For instance, Bircan (2019) and Stiebale and Vencappa (2018) define the acquisition variable to take on unity in all post-acquisition periods.

(1) can be interpreted as the average acquisition effect on the acquired firms under three assumptions: parallel trends, no anticipation, and independent sampling (Roth et al., 2023). The no-anticipation assumption implies that outcome in acquired domestic firms was not affected by the upcoming acquisition in years prior to foreign acquisition—a condition largely taken for granted in prior work. Meanwhile, the parallel trends assumption suggests that the average change in outcome for acquired and unacquired domestic firms would have followed similar trajectories over time in the absence of foreign acquisition. Previous research has highlighted that the parallel trends assumption may be violated due to non-random sample selection of acquired domestic firms (Girma and Görg, 2007; Arnold and Javorcik, 2009). To clarify the nature of selection bias, it should be underscored that the DiD framework accounts for selection bias stemming from time-invariant firm characteristics that affect the level of outcome. Yet, the parallel trends assumption suggests that the selection bias must be the same in pre- and post-acquisition periods (Roth et al., 2023). A key threat to this assumption arises if acquired domestic firms exhibit differential outcome trends compared to their unacquired counterparts. To this end, the existing literature addresses this selection issue by combining a matching estimator with DiD estimation; for instance, propensity score matching is used to align treatment and control firms based on pre-acquisition characteristics and mitigate differential trends in outcomes stemming from different firm characteristics. While balancing is not necessary for identification, it strengthens the plausibility of the parallel trends assumption for causal inference.

However, recent advances in the econometrics of DiD estimation highlight a fundamental econometric issue in OLS estimation of equation (1) when treatment timing is staggered; for instance, the timing of foreign acquisition is different across foreign investors. Specifically, the OLS coefficient $\hat{\beta}$ from a two-way fixed effects regression model may not represent a reasonable causal parameter for the ATT when treatment effects are heterogeneous across either time or units (Borusyak et al., 2024; de Chaisemartin and D'Haultfoeuille, 2020; Goodman-Bacon, 2021). In the context of this study, such heterogeneity is plausible, as the effect of foreign acquisition on acquired firms may differ by acquisition year. For instance, foreign acquisitions in later periods may produce stronger synergy effects if foreign investors learn from earlier cases and more selectively target domestic firms with preferable conditions, thereby leading to preferable synergies. Although staggered treatment timing is common in related empirical research on foreign acquisition, this econometric issue is not adequately addressed in the literature.[7]

To address heterogeneous treatment effects, I adopt an estimation design developed by Callaway and Sant'Anna (2021). Under the potential outcomes framework, $Y_{i,t}(0)$ is firm i's

[7] Görg and Lehr (2024) employs the event study estimator developed by Sun and Abraham (2021) to examine the effect of foreign acquisition. A key difference from this paper is that they assume unconditional parallel trends.

untreated potential outcome at time *t* if they are not acquired by foreign firms throughout time period $\mathcal{T}$. Denote G_g as a binary variable that takes on unity if a firm is first acquired by foreign firms in time *g*. For $g = 2, \cdots, \mathcal{T}$, $Y_{i,t}(g)$ is the potential outcome that firms *i* would experience at time *t* if they were first acquired by foreign firms in time *g*. To generalize the ATT for multiple treatment groups and time periods, the group-time average treatment effects are defined for firms of a particular group *g* at a particular time *t*:

$$ATT(g,t) = \mathbb{E}\left[Y_{i,t}(g) - Y_{i,t}(0) | G_g = 1\right] \quad (2)$$

where $ATT(g,t)$ is causal parameter of interest. For example, $ATT(2010{,}2013)$ is the average treatment effect in 2013 for domestic firms that are acquired by foreign firms in 2010. Under the no-anticipation and parallel trends assumptions in a staggered setting, $ATT(g,t)$ is identified by comparing the average change in outcome between periods $g-1$ and t for domestic firms acquired at time *g* to that for a comparison group of unacquired domestic firms. In baseline, the comparison group consists of domestic firms that are never acquired by foreign firms during an examination period.

As discussed above, the parallel trends assumption may not hold in observational data on foreign acquisitions for potential time-varying confounding factors across acquired and unacquired domestic firms. To address this issue in a staggered setting, I employ a doubly robust method by Sant'Anna and Zhao (2020) and relax the parallel trends assumption by conditioning on a rich array of firm-level pre-treatment covariates, X_i. Denote a propensity score for the conditional likelihood of foreign acquisition given covariates, $p(X_i) = P(FA_i = 1|X_i)$. By combining regression adjustment and inverse probability weighting methods, the doubly robust estimator identifies the ATT as follows:

$$ATT(g,t) = \mathbb{E}\left[\frac{FA_i}{\mathbb{E}[FA_i]} - \frac{\frac{(1-FA_i)p(X_i)}{1-p(X_i)}}{\mathbb{E}\left[\frac{(1-FA_i)p(X_i)}{1-p(X_i)}\right]}\right]\kappa(g,t) \quad (3)$$

where $\kappa(g,t) = \left[\left(Y_{i,t} - Y_{i,g-1}\right) - \mathbb{E}\left(Y_{i,t} - Y_{i,g-1}|FA_i = 0, X_i\right)\right]$. The advantage of the doubly robust method is that it is valid if either the outcome model or the propensity score model is correctly specified. In my analysis, the pre-treatment covariates include sales, employment, wage, asset, and dummy variables on export, import, R&D, and patent ownership.

Given that my sample consists of many acquired domestic firms across acquisition timing over long periods, it is not reasonable to report $\widehat{ATT}(g,t)$ for all pairs of acquisition time *g* and time period *t*. Callaway and Sant'Anna (2021) show that the aggregate ATT estimates are computed by the weighted average of the estimates $\widehat{ATT}(g,t)$ for relevant group-time average treatment effects. As an event study parameter is of main interest, I compute the average of the treatment effects for *l* periods after foreign acquisition across different acquired domestic firms:

$$ATT(l) = \sum_{g} w_g ATT(g, g+l) \tag{4}$$

where w_g is the weights based on the relative frequencies of acquired firms in the overall treated population.

Finally, there are at least two qualifications in my empirical strategy. First, it is difficult to remove completely time-varying confounding bias from the causal impact of foreign acquisition—a common issue to analyze observational data on foreign acquisition. If acquired firms experience unobserved shocks following foreign acquisition, their productivity may be affected by other effects unrelated to foreign acquisition. The estimated impact of foreign acquisition could pick up partly unobserved time-varying confounding factors that may systematically occur in acquired firms during a post-acquisition period. Second, the potential outcomes framework assumes that there is no interference between units. In my study, foreign acquisitions should have no real effective influence on the outcome for the control group of non-acquired domestic firms: they should receive no horizontal and vertical spillover effects of foreign acquisitions. In this respect, my control group consists of a large number of domestic firms in a competitive market, excluding the oligopolistic markets such as the utility sector. As compared with developing economies, there is no strong evidence of FDI spillovers in the case of Japan. Thus, there is no strong concern about a possible violation of this assumption.[8]

4. Data Description

Firm-level panel data are constructed from two datasets: the Survey of Trends in Business Activities of Foreign Affiliates (SFA) and the Basic Survey of Japanese Business Structure and Activities (SJB) by the Japanese Ministry of Economy, Trade, and Industry (METI). As my sample of foreign acquisitions is based on the SFA, the sample coverage depends on the definition of foreign affiliates in the SFA and the difference in the survey designs between the SFA and SJB. To clarify these issues, this section describes details of the SFA and their linkages with the SJB.

4.1. The Survey of Trends in Business Activities of Foreign Affiliates

The SFA is an approved statistical survey conducted annually by the Japanese METI since 1967 under the Statistics Act. It was discontinued in the fiscal year 2020, and the latest available data on foreign affiliates in Japan are collected in the fiscal year 2019. The survey covers the enterprises that meet the following conditions as of March 31 in each fiscal year: (i) foreign investors own more than one-third of the company's shares or equity holdings, (ii) a subsidiary company owned by another domestic company in which foreign investors hold more than one-

[8] This assumption may likely be violated if foreign acquisitions produce spillover effects on non-acquired domestic firms and the affected domestic firms are used as the matched control group.

third of shares or equity—a direct and indirect combined ownership exceeding one-third, and (iii) under the above conditions, the largest foreign investor holds at least 10% ownership. A foreign investor here refers to non-resident individuals, corporations established under foreign laws, and corporations headquartered abroad. Following the definition of the SFA, I can clearly identify companies in the Japanese market that come effectively under the managerial control of foreign-capital enterprises. In other words, I can clearly exclude domestic companies in which foreign investors hold substantial equity stakes for portfolio investment purposes.

Among local subsidiaries of foreign companies in the Japanese market, this study focuses on Japanese firms acquired or merged with foreign-affiliated enterprises. To identify the target firms, I use a survey question on the reason why foreign investors' shareholding exceeds one-third of the company's shares. In this question, four response options are given: (i) independent new establishment, i.e., greenfield investment; (ii) joint-venture new establishment, where foreign investor's shareholding exceeded one-third at the time of joint venture formation; (iii) merger or acquisition (M&A), and (iv) other reasons. Specifically, the M&A case indicates that a domestic company's foreign ownership was initially below one-third and foreign investors' shareholding surpassed the threshold for M&A; this also includes cases where foreign investors increased their stake through share purchases or additional capital injections. For analysis, I extract the foreign firms that answered M&A as their response to this question.

Data on target firms acquired by foreign investors are constructed as follows. I extract the sample of foreign acquisitions from the SFA data for 2002-2019: data on the above question were available only from 2002. The year of foreign acquisition is determined by the year of entry into the Japanese market reported by foreign investors. Additionally, the survey asks a question on the operation status of foreign-affiliate firms; one of response options is dissolution, withdrawal, and decline in foreign ownership ratio. Answers to this question are used to identify the target firms in operation and the timing when foreign investors divest from their acquired firms. Thus, I can precisely define the post-acquisition timing of acquired firms in terms of entry and exit by foreign investors. These features are advantageous in estimating the post-acquisition effects as compared with M&A transaction datasets used in the related literature because the latter do not provide detailed information on the operational status and the withdrawal of foreign acquirers in post-acquisition periods.

4.2. Linking to the Basic Survey of Japanese Business Structure and Activities

Data on foreign acquisitions are linked to firm-level panel dataset in the SJB, which is a fundamental statistical survey conducted annually by the METI under the Statistics Act to collect information on corporate activities and provide essential data for policy formulation. The SJB is a nationwide survey on individual firms in Japan. For instance, the 2021 results show that there

were 36,294 surveyed firms, and the response rate was 86.0%. Firms are legally required to respond to the questionnaire under the Statistics Act, ensuring high data reliability. The survey coverage includes the firms with more than 50 employees or capital of 30 million yen or more in manufacturing, mining, commerce, and other service industries.

I use the corporate identification number to link firm data between the SFA and SJB. Each entity including registered corporations, government agencies, local municipalities, and unincorporated associations is assigned a unique corporate identification number. By matching corporate identification numbers between the SFA and SJB, I could identify the same firms across these datasets. However, information on the corporate identification number was not available in older periods. If only corporate identification number is used to link firms, I would not be able to identify the foreign-affiliated firms that merged or acquired Japanese firms in earlier years but later exited the market. For this reason, I extract a group of foreign-affiliated firms that are not matched with the corporate identification number and manually match these firms between the SFA and SJB. Specifically, they are linked if the company name is matched in both datasets.

A difference in the survey design is a key challenge in linking foreign firms between the SFA and SJB. While the SFA surveys firms in which foreign investors hold more than one-third of shares, the SJB surveys the firms with more than 50 employees or capital of 30 million yen or more. If a foreign-affiliated enterprise acquires a Japanese company with less than 50 employees or capital under 30 million yen, the acquired firm is surveyed in the SFA but excluded from the SJB. As a result, smaller Japanese firms acquired by foreign investors are systematically excluded from the constructed dataset. To check this issue, Appendix Table 1 shows the number of foreign acquisitions across survey datasets, which classify foreign acquisitions in the SFA in terms of the threshold of 50 employees. During the period 2001-2019, a total of 773 foreign-affiliated firms entered the Japanese market through M&A. Among them, 383 firms had less than 50 employees and thus could not be matched with individual firm records in the SJB. In this respect, this analysis excludes small and micro firms acquired by foreign investors, and estimation results must be interpreted with care. Meanwhile, the remaining 390 firms had 50 or more employees, which could be matched with individual firm records in the SJB. By matching firms with corporate identification numbers and company names, 237 foreign acquisitions were matched between these datasets. Among the connectable foreign acquisitions, approximately 60.7% of firms were accurately identified.

After matching acquired firms by foreign investors, I use the rest of sample firms as a control group: firms that are never acquired by foreign investors during the examination period. However, possibly inaccurate information in corporate identification numbers or company names could make some acquired firms unmatched between the SFA and SJB. To mitigate the risk that these firms are mistakenly used as a control group, I exclude the remaining firms with the foreign

ownership ratio of 30% or more.

4.3. Firm-level Variables

A key outcome variable is total factor productivity (TFP) at the firm level. Assuming a Cobb-Douglas production function for firm *i* and time *t*, value-added output is a function of productivity, labor input, and capital input. Nominal value added is total sales minus total cost of sales and selling, general and administrative expenses plus wage payments and depreciation. Labor input is measured by the number of full-time employees. Capital input is proxied by the value of fixed tangible asset. Nominal value added is divided by output deflators at the industry level to measure real value added. Capital is divided by the deflator of manufacturing gross fixed capital formation. As data on firm-level prices are not available, I compute revenue TFP in this study.[9] Specifically, firm-level revenue TFP is calculated by estimating the production function across industries following Ackerberg et al. (2015).[10] A proxy for the unobserved productivity level is measured by the sum of advertising and transport costs divided by input deflator at the industry level. To mitigate the influence of outliers, I winsorize the TFP estimates at the 1st and 99th percentiles in each industry. For a robustness check, I compute the TFP following the method in Levinsohn and Petrin (2003).[11] In the following, I denote TFP by Ackerberg et al. (2015) as ACF TFP and TFP by Levinsohn and Petrin (2003) as LP TFP.

All firm-level data used in productivity estimation are taken from the SJB, and data on deflators come from the Japan Industrial Productivity Database 2023. Other variables used in staggered DiD include total asset, export values, import values, the value of in-house R&D expenses, and patent ownership. The data are taken from the SJB. Additionally, I use the data on the presence of a parent company in the SJB to define domestic acquisitions.

5. Estimation Results

This section starts to describe the sample used in estimation.[12] Figure 1 shows the annual number of foreign acquisitions across two aggregate industries—manufacturing and services—during the period 1996-2019. The timing of these acquisitions varies considerably across years, averaging approximately 10 acquisitions per year. Foreign acquisitions occur in both industries, with no discernible difference in the timing between these industries. Given that acquired firms

[9] Bircan (2019) and Stiebale and Vencappa (2018) estimate the effect of foreign acquisition on physical productivity of acquired firms in Turkish and Indian manufacturing industries, respectively.
[10] See Rovigatti and Mollisi (2018) for a review of estimation methods and econometric issues.
[11] The results are largely unchanged when the production function is estimated by the method in Wooldridge (2009). The results are available upon request.
[12] I exclude the following from the sample: (i) primary, mining, utilities, finance, insurance, and real estate sectors; (ii) sectors with no foreign acquisition during a sample period, and (iii) domestic firms acquired by foreign firms before 1995.

can experience varying degrees of synergy and anergy effects, it is crucial to account for heterogeneous timing in foreign acquisitions. Additionally, Table 1 presents the summary statistics of the sample for treatment and control groups. A simple comparison of sample means reveals that acquired domestic firms tend to show higher productivity, larger sales, and a higher likelihood of engaging in foreign trade and innovative activities.

---Figure 1 & Table 1 here---

5.1. Main Results

Columns (1) and (3) of Table 2 report the results of the TWFE model using ACF and LP TFP measures, respectively. In both columns, the coefficient of foreign acquisition is significant and positive. These findings have been commonly interpreted as suggesting that foreign acquisition improves the post-acquisition productivity of acquired firms. The estimated productivity gains are 6.6% in column (1) and 7.3% in column (2). For comparison, Bircan (2019) estimates 8.5% productivity gains for Turkish domestic plants acquired by foreign firms, suggesting that the TWFE estimates alight with prior empirical findings. However, these estimates may mask underlying heterogeneity in the impact of foreign acquisition across acquisition timing and sample years.[13] To avoid potentially misleading conclusions, it is crucial to employ a staggered DiD method.

---Table 2 here---

Columns (2) and (4) of Table 2 show the aggregate ATT estimates for the impact of foreign acquisition on the post-acquisition productivity of acquired firms, with asymptotic-theory standard errors. The estimates are 0.32 and 0.36, respectively, indicating potential productivity gains of approximately 38% and 43% for acquired domestic firms—substantially larger estimates in size than those suggested by the TWFE model. However, the aggregate ATT estimates have large standard errors and are not statistically significant. These results highlight that the TWFE and staggered DiD approaches may yield different conclusions regarding the causal impact of foreign acquisition. A key implication is that much of the existing literature has yet to fully incorporate recently developed staggered DiD methods, leaving room for further empirical improvements to better capture heterogeneous treatment effects across acquired firms over time.

Figure 2 shows the staggered DiD estimates of event-time effects of foreign acquisition on the ACF TFP of acquired firms, with 95% confidence bands. The pre-acquisition coefficients capture year-over-year productivity changes prior to acquisition and serve as a diagnostic for the parallel trends and no-anticipation assumptions underlying causal inference. These coefficients

[13] Appendix Table 2 shows the aggregate ATT estimates by acquisition timing (cohort) and calendar year, suggesting the heterogeneous impacts of foreign acquisition on the post-acquisition productivity across cohorts and calendar periods.

are generally close to zero, with their 95% confidence bands including zero. These results indicate no systematic difference in pre-acquisition productivity trends between acquired and never-acquired firms, providing support for the validity of the identifying assumptions required to interpret the ATT estimates as causal effects. Additionally, the post-acquisition coefficients reflect productivity changes relative to the fixed pre-treatment year $g-1$. The estimated effects are close to zero immediately after foreign acquisition and become positive and large in size during the second and third years, consistent with the idea that synergy effects of foreign acquisition are realized after restructuring by foreign investors. However, these post-acquisition coefficients are not statistically significant across post-acquisition years, suggesting that the evidence does not directly support the positive causal impact.

---Figure 2 here---

For a robustness check of the results in Figure 2, I compute wild bootstrap standard errors as suggested by Callaway and Sant'Anna (2021). Appendix Figure 1 shows the event-time effects of foreign acquisition on the ACF TFP of acquired firms, with 95% confidence bands. Consistent with the result in Figure 2, there is no sign of differential pre-acquisition productivity trends, and the post-acquisition coefficients remain statistically insignificant across all post-acquisition years. To further check the sensitivity of the results to the choice of productivity estimation methods, I examine the event-time effects using the LP TFP and present these estimates in Appendix Figure 2. Consistent with the previous results, there is no apparent violation of the identifying assumptions for causal inference. However, the post-acquisition coefficients remain statistically insignificant across post-acquisition years. Taken together, these robustness checks reinforce the conclusion that there is not strong evidence of a causal impact of foreign acquisition on the productivity of acquired firms.

5.2. Heterogeneous Impacts on Acquired Firms

The aggregate ATT estimates of foreign acquisition effects may have masked possible heterogeneity in treatment effects across acquired firms. To explore this heterogeneity across various dimensions, I estimate the group-time ATT of foreign acquisition using the ACF TFP separately for acquired firms in manufacturing and service sectors. I then average the estimated event-time effects during the 0-5 year period following acquisition. Figure 3 shows the post-acquisition treatment effects with 95% confidence bands. The aggregate ATT estimates are close to zero for both sectors, and the corresponding confidence bands include zero. This suggests that foreign acquisition has little effect on the post-acquisition productivity of acquired firms in both sectors.

---Figure 3 here---

Second, I estimate the group-time ATT of foreign acquisition on the ACF TFP of acquired

firms separately across the origin country of acquiring firms: U.S., European, and Asian firms.[14] To isolate the effect of U.S. acquisitions, for example, I apply a staggered DiD approach to a subsample that excludes all acquisitions by non-U.S. firms. For consistency, the same control group is used across estimations by the origin of acquiring firms. Figure 3 shows that the aggregate ATT estimates for U.S. and European acquirers are close to zero, with 95% confidence bands encompassing zero. Although the aggregate ATT estimate for Asian acquirers is negative and lower than those for U.S. and European acquirers, its confidence band also includes zero. Thus, there is no evidence of heterogeneity in post-acquisition effects based on the origin of these acquiring firms.

Finally, I assess the effect of foreign acquisition on other outcomes of acquired firms. For each outcome, I estimate the group-time ATT of foreign acquisition and report the average of estimated event-time effects during the 0-5 year period following acquisition, with 95% confidence bands. The corresponding variable used as an outcome in these estimations is excluded from the pre-treatment covariates used in the doubly robust estimator. The aggregate ATT estimates are positive for sales, cost of sales, and wages, while estimates for administrative costs, asset, and employment are close to zero. However, the confidence bands for these outcomes include zero, suggesting that foreign acquisition does not exert a significant influence on these outcomes among acquired firms.

5.3. Domestic Acquisitions as a Control Group

My analysis up to this point has compared domestic firms acquired by foreign firms with other domestic firms that are not acquired by foreign firms, aiming to identify the overall net effects of foreign acquisition on post-acquisition productivity. While the aggregate ATT estimates reflect these overall effects, they do not disentangle whether the estimated impact is driven by a shift in ownership to foreign parent firms or by general acquisition effects related to M&A deals such as restructuring. To identify the primary source of foreign acquisition effects, it is crucial to distinguish between general acquisition and foreign ownership effects (Arnold and Javorcik, 2009; Chen, 2011; Wang and Wang, 2015).

In the baseline specification, the control group consists of domestic firms that are never acquired by foreign firms. To further isolate the foreign ownership effects from general acquisition effects, I construct the control group to include only domestic firms that are acquired by other domestic firms. In this task, the SJB dataset is used to identify domestic firms with less than 10% ownership, in which their parent firms changed at least once during an examination

[14] The European origins include Austria, Belgium, Switzerland, Germany, Denmark, Spain, France, the U.K., Greece, Ireland, Italy, Luxembourg, Netherlands, and Sweden. Asian origins include China, Hong Kong, Korea, Singapore, Thailand, and Taiwan.

period (Fukao et al., 2005). These firms should experience ownership changes between domestic parent firms, thereby capturing general M&A-related acquisition effects without the influence of foreign ownership. By comparing outcomes between foreign and domestic acquisitions, this approach helps to disentangle the general acquisition effects from the foreign ownership effects.

As the SJB dataset provides information on changes in parent firms only for the period 2010-2019, I restrict the analysis of foreign acquisition effects to this sample window. Figure 4 shows the group-time ATT of foreign acquisition using the ACF TFP and reports the average event-time effects during the 0-5 year period following acquisition, with 95% confidence bands. The aggregate ATT estimate is close to zero, and its confidence band includes zero, indicating no statistically significant impact. One concern in this estimation is the potential mismatch in the timing of M&A deals between foreign and domestic acquisitions, making it difficult to precisely define the post-acquisition period. To this end, I construct a subsample in which foreign and domestic acquisitions occur in the same calendar years, and estimate event-time effects separately for each acquisition year during the period 2010-2014. Figure 4 shows that the aggregate ATT estimate remains close to zero after accounting for timing differences. These results suggest that a shift in ownership from domestic to foreign parent firms does not significantly affect the post-acquisition productivity of acquired domestic firms.

---Figure 4 here---

6. Conclusion

A large and growing body of research examines the impact of foreign acquisition on the performance of acquired domestic firms. However, formal empirical evidence remains mixed and inconclusive. This paper revisits the question by addressing two key limitations in the previous literature. First, I adopt a staggered DiD approach by Callaway and Sant'Anna (2021) to account for variation in acquisition timing across firms. Second, I construct a novel panel dataset on Japanese firms that enables precise identification of the post-acquisition period for acquired domestic firms plausibly subject to managerial control by foreign firms. This approach allows for a more credible estimation of foreign acquisition effects by aligning treatment timing and firm-level dynamics.

The empirical analysis suggests that foreign acquisitions do not have a causal impact on the post-acquisition productivity of acquired domestic firms. This finding can be interpreted as reflecting the coexistence of synergy and anergy effects following foreign acquisition—where potential gains from foreign managerial practices are offset by integration frictions or misalignments. These opposing influences may lead to a net effect that is statistically indistinguishable from zero. The results further confirm that a shift in ownership from domestic to foreign parent firms does not significantly improve post-acquisition productivity after isolating the effect of foreign ownership from general acquisition effects. Additionally, the canonical

TWFE regression yields significantly positive estimates of foreign acquisition effects, which stand in stark contrast to the results obtained using the staggered DiD method. This discrepancy highlights the risk of biased inference when treatment effects vary across firms over time—a limitation inherent in the TWFE framework under staggered adoption. From a methodological standpoint, these findings underscore the importance of adopting more flexible estimation strategies that explicitly account for heterogeneous acquisition timing and allow for heterogeneity in the foreign acquisition effects across cohorts. In this respect, the staggered DiD method offers a more credible framework, and applying this approach to prior empirical studies may provide further insights into the existing evidence of foreign acquisition effects.

I conclude this section by discussing some remaining issues. First, my analysis relies on the SJB dataset that covers firms with more than 50 employees or capital of 30 million yen or more. As small firms below this threshold are not excluded, the impact of foreign acquisition on small Japanese firms is unexplored. Second, data limitations on firm-level activities make it difficult to estimate physical productivity; foreign acquisitions may yield different impacts on physical productivity compared to revenue-based productivity. Third, the empirical analysis is conducted at the firm-level and thus does not address whether foreign acquired plants—rather than entire firms—exhibit distinct outcomes in post-acquisition productivity. Finally, an unexplored question is whether post-acquisition outcomes vary by the types of M&A transactions and foreign investors. These issues are left for future research.

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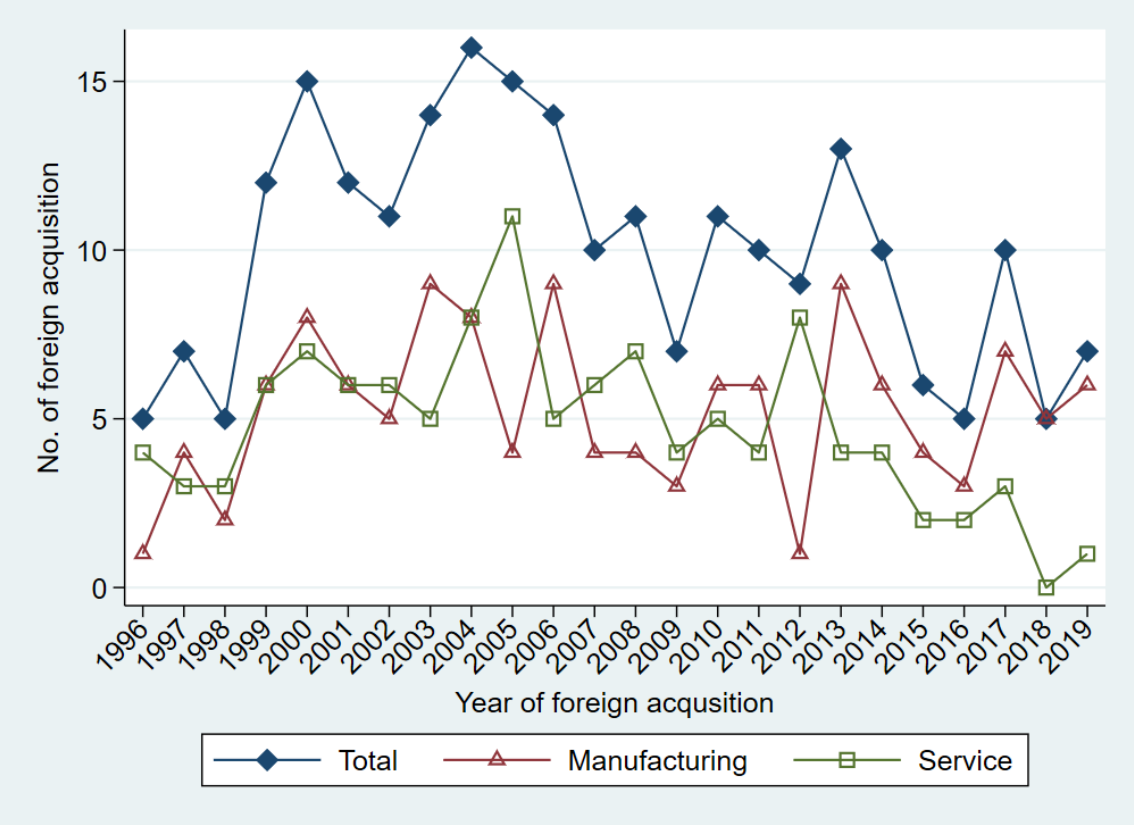
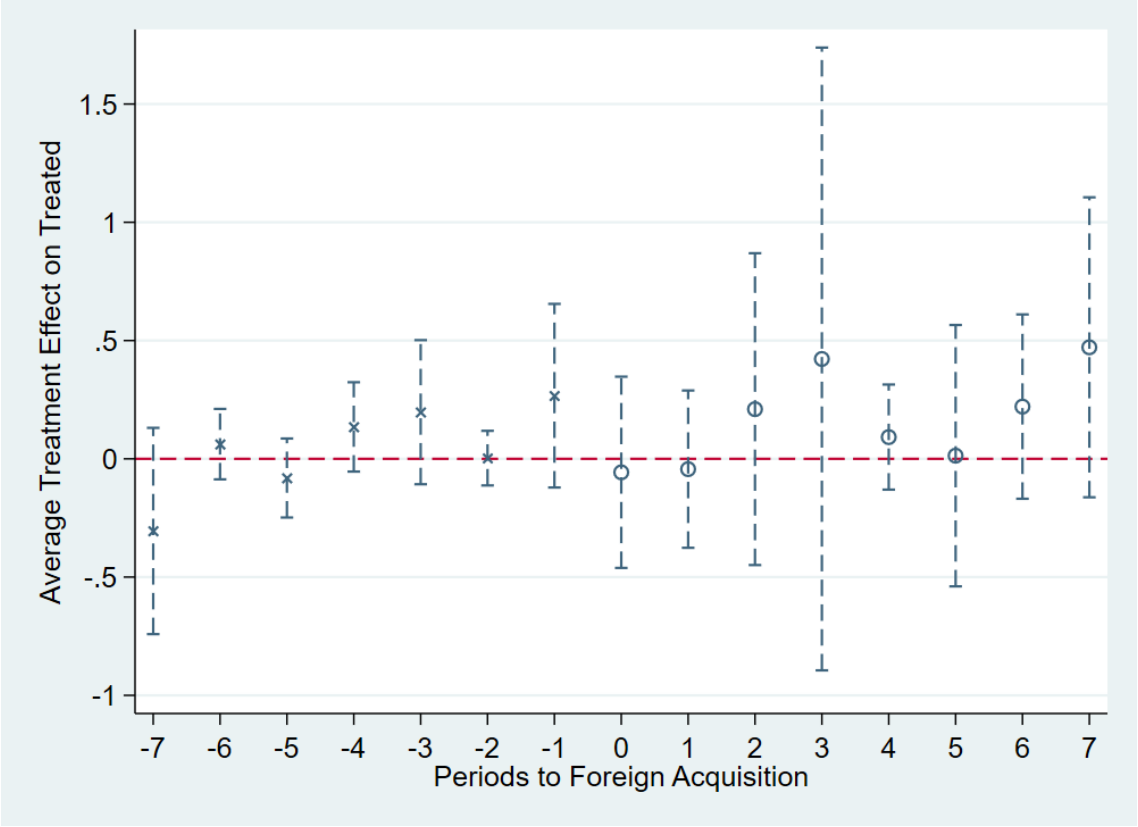
Figure 1. Foreign Acquisition by Year and Industry



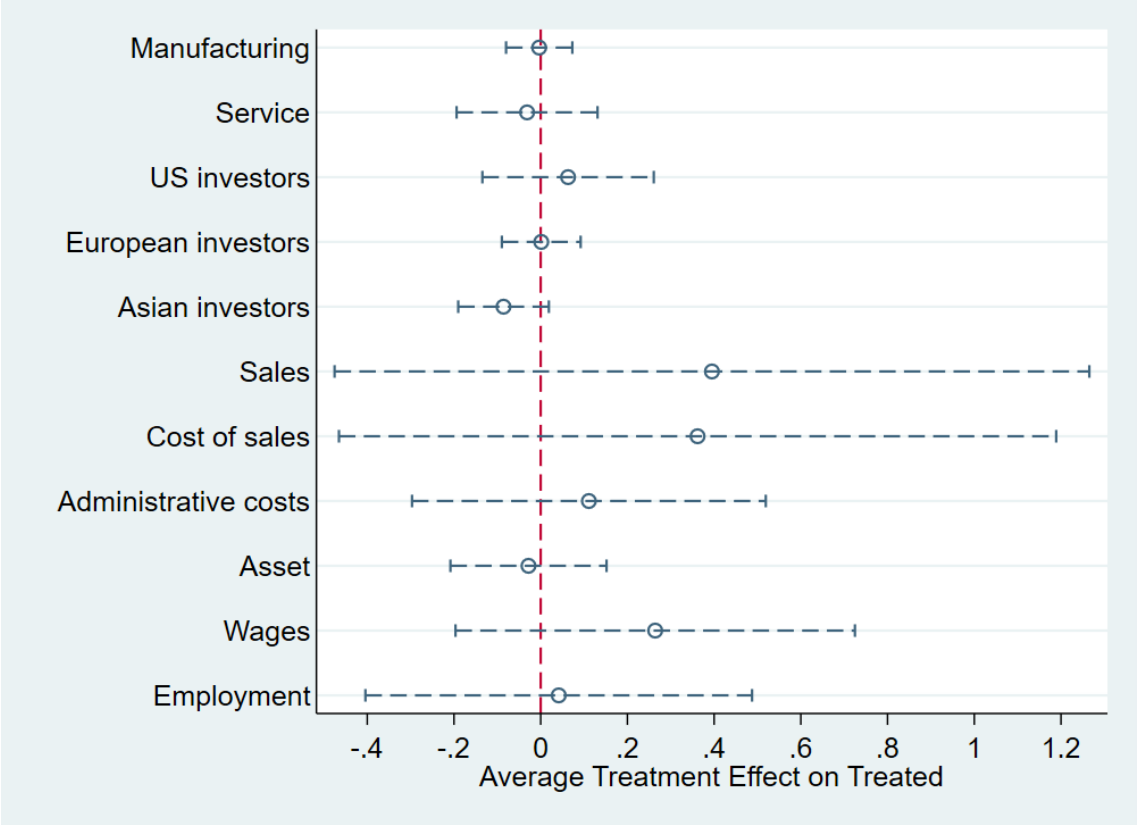
Source: Survey of Trends in Business Activities of Foreign Affiliates by METI.

Figure 2. Event-time Effects of Foreign Acquisition on Acquired Firms' Productivity



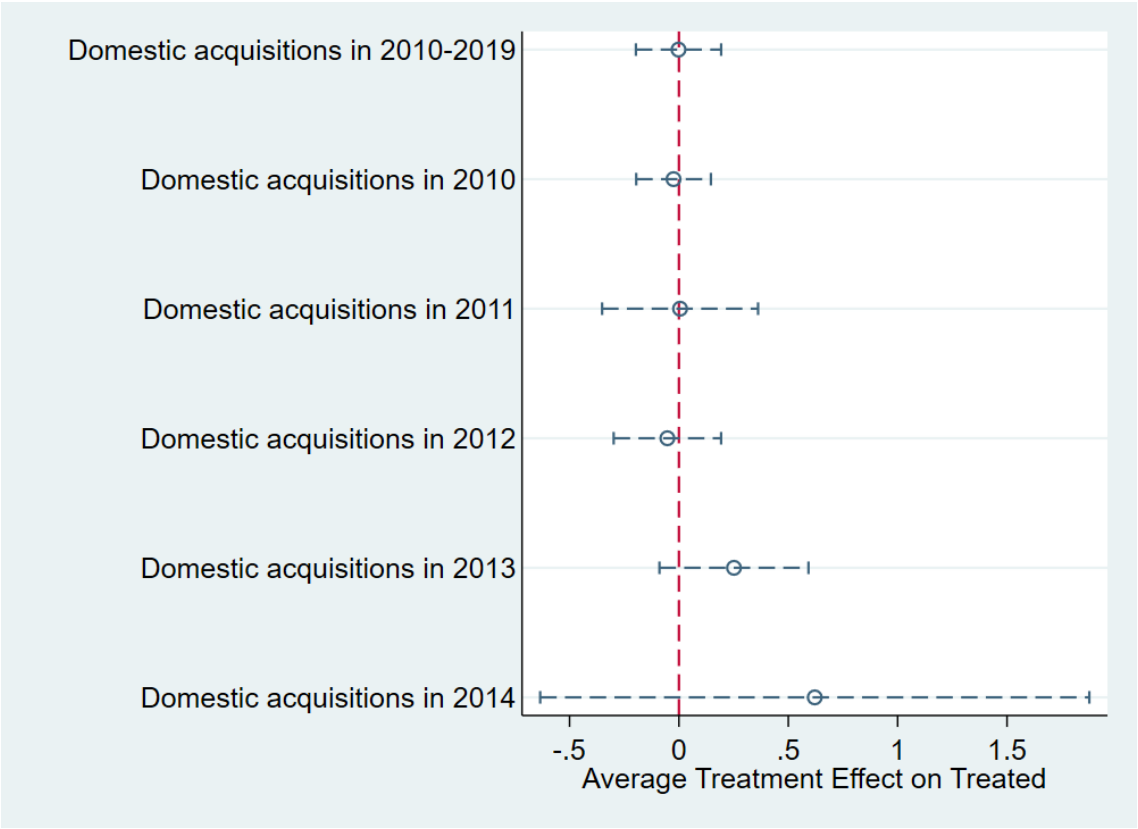
Notes: The figures plot the estimates and 95% confidence intervals of the average treatment effect on the treated using the doubly robust estimator in Callaway and Sant'Anna (2021). Productivity is estimated by the approach in Ackerberg, Caves, and Frazer (2015). Cross indicates pre-treatment periods. Hollow circle indicates post-treatment periods.

Figure 3. Post-acquisition Effects for Alternative Samples and Outcomes



Notes: The figures plot the estimates and 95% confidence intervals of the average treatment effect on the treated during the post-treatment periods 0-5 using the doubly robust estimator in Callaway and Sant'Anna (2021). Productivity is estimated by the approach in Ackerberg, Caves, and Frazer (2015).

Figure 4. Results using Domestic Acquisitions as Control



Notes: The figures plot the estimates and 95% confidence intervals of the average treatment effect on the treated during the post-treatment periods 0-5 using the doubly robust estimator in Callaway and Sant'Anna (2021). Productivity is estimated by the approach in Ackerberg, Caves, and Frazer (2015). Each row indicates the sample of domestically acquired firms used as a control group.

Table 1. Summary Statistics

	Treatment			Control		
Variable	N	Mean	Std. Dev.	N	Mean	Std. Dev.
TFP_{acf}	2,725	1.32	0.68	478,287	1.23	0.60
TFP_{lp}	2,731	0.08	0.45	478,252	0.003	0.41
ln(sale)	2,724	9.58	1.63	478,316	8.74	1.32
ln(employment)	2,724	5.97	1.39	478,316	5.30	1.04
ln(wage)	2,724	7.62	1.45	478,311	6.75	1.09
ln(asset)	2,724	9.41	1.72	478,316	8.43	1.34
Export dummy	2,724	0.49	0.50	478,316	0.23	0.42
Import dummy	2,724	0.49	0.50	478,316	0.23	0.42
R&D dummy	2,724	0.47	0.50	478,316	0.32	0.47
Patent dummy	2,724	0.35	0.48	478,316	0.22	0.42

Notes. TFP_{lp} is the log of total factor productivity estimated by the production function approach in Levinsohn and Petrin (2003). TFP_{acf} is the log of total factor productivity estimated by the approach in Ackerberg, Caves, and Frazer (2015).

Source: The Basic Survey of Japanese Business Structure and Activities by METI.

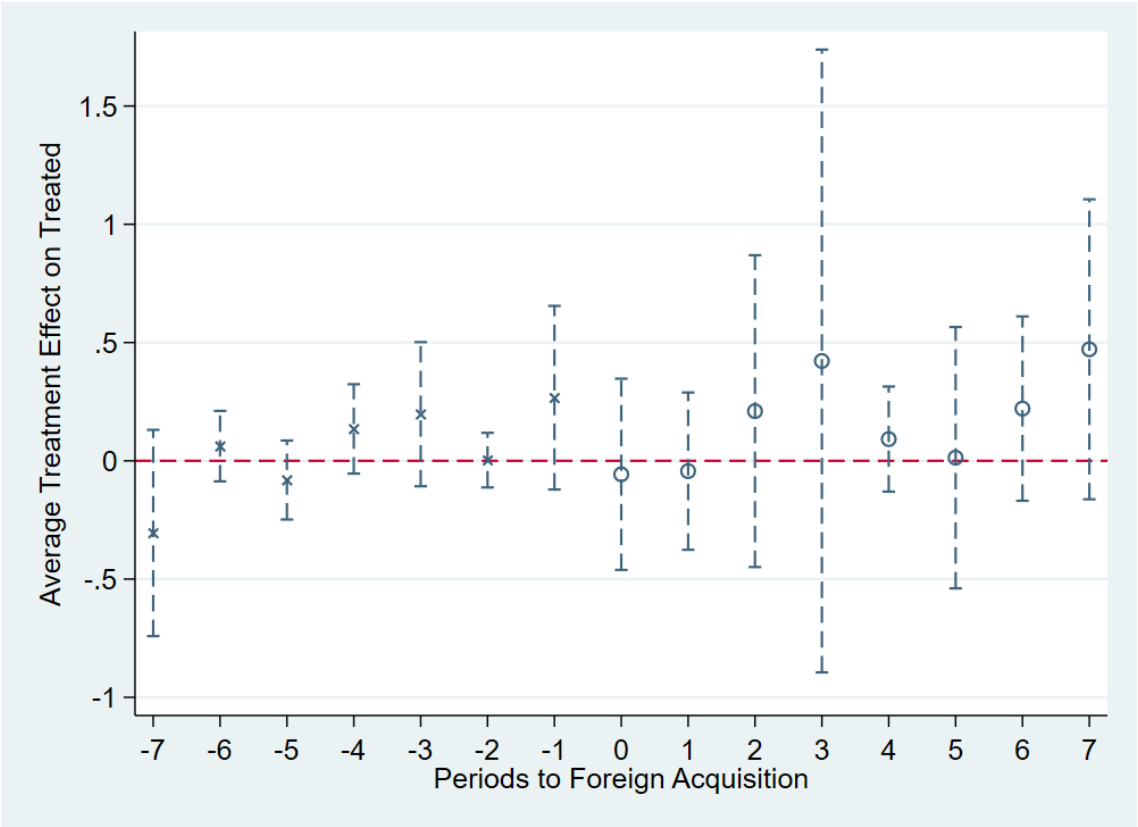
Table 2. Estimation Results

	(1)	(2)	(3)	(4)
Dependent variable	TFP_{acf}		TFP_{lp}	
Estimation	OLS	CSDiD	OLS	CSDiD
Foreign acquisition	0.064**	0.32	0.070*	0.36
	(0.034)	(0.40)	(0.031)	(0.36)
Firm fixed effect	Y		Y	
Year fixed effect	Y		Y	
No. of observations	480,984	477,681	481,040	477,638
R-squared	0.61		0.84	

Notes. OLS is two-way fixed effects estimation for panel data. CSDiD is the staggered difference-in-differences estimation by Callaway and Sant'Anna (2021) using doubly robust estimator by Sant'Anna and Zhao (2020), where covariates include sales, employment, wages, asset, and dummy variables for export, import, R&D, and patent. TFP_{lp} is the log of total factor productivity estimated by the production function approach in Levinsohn and Petrin (2003). TFP_{acf} is the log of total factor productivity estimated by the approach in Ackerberg, Caves, and Frazer (2015). Parentheses report standard errors clustered by firms for OLS and asymptotic-theory standard errors for CSDiD. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

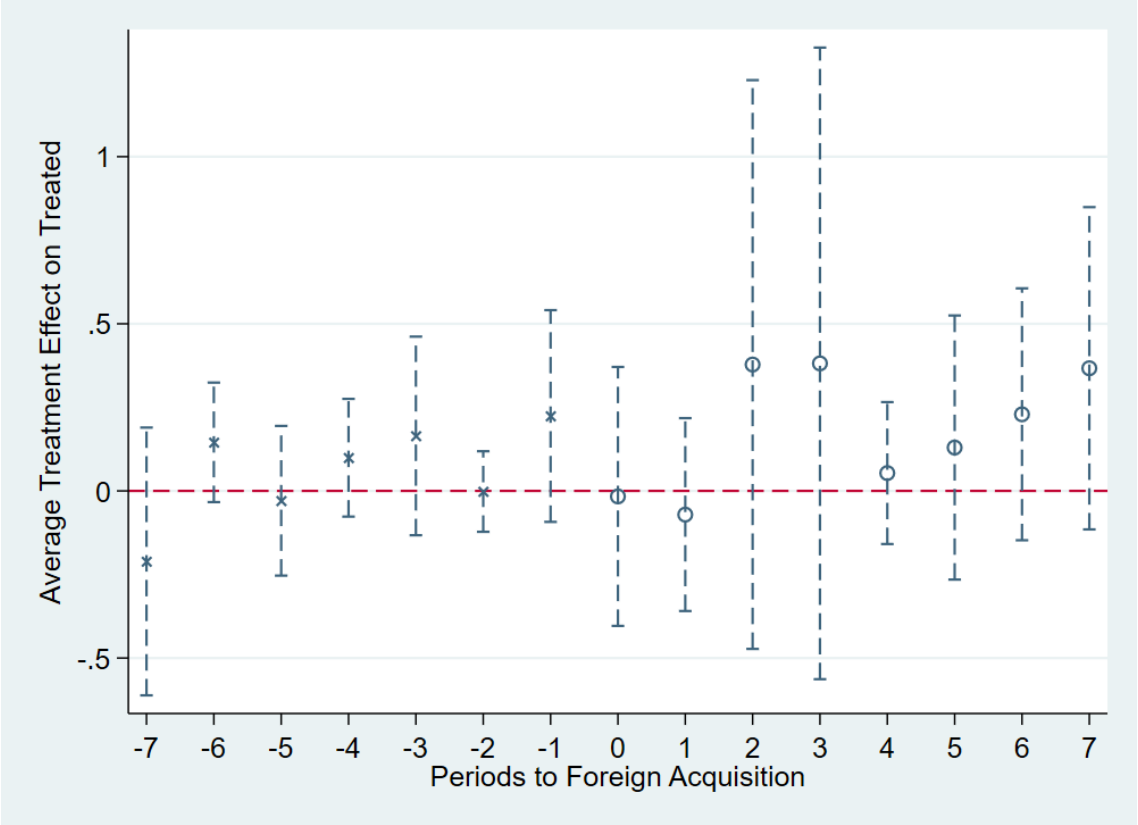
Appendix

Appendix Figure 1. The Results using Wildbootstrap Standard Errors



Notes: The figures plot the estimates and 95% confidence intervals of the average treatment effect on the treated using the doubly robust estimator in Callaway and Sant'Anna (2021). Productivity is estimated by the approach in Ackerberg, Caves, and Frazer (2015). Cross indicates pre-treatment periods. Hollow circle indicates post-treatment periods.

Appendix Figure 2. Results with Alternative Productivity Estimation



Notes: The figures plot the estimates and 95% confidence intervals of the average treatment effect on the treated using the doubly robust estimator in Callaway and Sant'Anna (2021). Productivity is estimated by the production function approach in Levinsohn and Petrin (2003). Cross indicates pre-treatment periods. Hollow circle indicates post-treatment periods.

Appendix Table 1. Foreign Acquisitions across Survey Datasets

Acquisition year	Survey of Trends in Business Activities of Foreign Affiliates		Matched foreign firms in the Basic Survey of Japanese Business Structure and Activities
	Less than 50 employees	50 or more employees	
2001	22	27	16
2002	28	20	14
2003	24	22	14
2004	26	31	20
2005	26	29	18
2006	28	29	17
2007	31	31	17
2008	20	26	14
2009	37	19	9
2010	20	28	16
2011	13	22	14
2012	21	16	10
2013	15	20	17
2014	24	17	10
2015	11	11	6
2016	12	9	7
2017	12	13	9
2018	5	8	3
2019	8	12	6
Total	383	390	237

Source. The Survey of Trends in Business Activities of Foreign Affiliates by METI.

Appendix Table 2. Estimation Results by Cohort and Calendar Year

	(1) Cohort		(2) Calendar	
Year	Coef.	Std. Err.	Coef.	Std. Err.
1997	-0.12	(0.12)	0.16*	(0.02)
1998	2.65*	(1.04)	-0.14	(0.19)
1999	0.57*	(0.09)	-0.64	(0.49)
2000	-3.90	(3.86)	-1.25	(1.81)
2001	9.41**	(4.64)	0.17	(0.49)
2002	0.04	(0.16)	0.29	(0.21)
2003	0.05	(0.30)	0.64**	(0.25)
2004	0.19	(0.49)	0.13	(0.14)
2005	-0.33	(0.47)	0.43	(0.34)
2006	0.10	(0.30)	0.48	(0.38)
2007	0.17**	(0.08)	0.29	(0.33)
2008	-2.72***	(1.64)	-0.07	(0.65)
2009	0.65	(1.31)	-0.07	(0.12)
2010	-0.14	(0.12)	0.52	(1.04)
2011	-0.02	(0.20)	-2.78	(2.52)
2012	-0.12	(0.10)	0.80	(0.66)
2013	0.07	(0.18)	0.49	(0.55)
2014	0.23	(0.38)	0.64	(0.78)
2015	21.1*	(0.05)	-0.15	(0.17)
2016	-0.12*	(0.01)	1.00	(0.71)
2017	-0.003	(0.21)	1.26	(0.80)
2018	-0.61*	(0.28)	1.01	(0.77)
2019	-0.19	(0.19)	0.96	(0.82)

Notes. The results are based on the staggered difference-in-differences estimation by Callaway and Sant'Anna (2021) using doubly robust estimator by Sant'Anna and Zhao (2020), where covariates include sales, employment, wages, asset, and dummy variables for export, import, R&D, and patent. Dependent variable is the log of total factor productivity estimated by the approach in Ackerberg, Caves, and Frazer (2015). Parentheses report asymptotic-theory standard errors. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.