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Intra-firm Networks during the COVID-19 Pandemic[+]

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Abstract

This study empirically investigates how the severity of the COVID-19 pandemic, as measured by mobility restriction measures, affected the quarterly performance of Japanese overseas affiliates, mainly from the perspective of sales, spanning from 2020 to 2022. In particular, we highlight the role of intra-firm networks, specifically the presence of nearby affiliates within the same parent company, in mitigating the adverse effects of COVID-19. Our major findings can be summarized as follows. First, the negative impact of local mobility-restricting measures was much larger for total sales and investment than for employment, especially during the initial phase of the pandemic. Although the negative effect was significantly larger for total sales, it took a longer time for investment to recover. Second, on average, affiliates with sibling affiliates in the same region did not necessarily play a role in mitigating the adverse effects and experienced a greater negative effect from local restriction measures in some cases. Third, such a negative effect was much smaller or disappeared for affiliates with sibling affiliates that are located in nearby countries experiencing less restrictive measures, particularly in the initial period of the shock.

Keywords: Intra-firm networks; COVID-19; Japanese multinationals
JEL classification: F15; F53

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1. Introduction

The global pandemic of the early 2020s, the COVID-19 pandemic, has prompted the reconsideration of the importance of resilience and robustness of global value chains (GVCs).[1] We have experienced massive supply shocks on GVCs several times, including the Great East Japan Earthquake and Thai flooding in 2011. These shocks in a limited geographical area propagated worldwide via supply chains and disrupted GVCs. After experiencing these shocks, global companies or multinational enterprises (MNEs) strengthened the resilience and robustness of their GVCs. Nevertheless, we again observed a serious disruption in GVCs during the COVID-19 pandemic. For example, according to an interview survey by the Japan External Trade Organization, the decrease or delay in the export of materials or inputs from China has decreased production in the Association of Southeast Asian Nations (ASEAN) countries, resulting in a reduction of their exports to Japan.

Against this backdrop, numerous studies have investigated the effects of the pandemic on firm-level GVCs. Most studies show the negative effect of COVID-19 cases or lockdown measures on sales of firms and their overseas affiliates (e.g., Cerdeiro and Komaromi, 2022; Zhang, 2021). Furthermore, the literature has investigated how stockpiling or supplier/customer diversification can mitigate this negative effect. The results of stockpiling are mixed. Lafrongne-Joussier et al. (2022) focused on the impact of sourcing Chinese input on French firms. Their major finding was that firms with relatively high inventories are better able to absorb supply shocks. Similarly, using firm-level data from Japan, Zhang and Doan (2023) demonstrated that importers holding large inventories tended to have more sales after the pandemic. In contrast, Cajal-Grossi et al. (2023) employed customs data from multiple garment-exporting countries and showed that total imports declined less for garment buyers with smaller inventories by adopting just-in-time inventory systems.

The results of supplier/customer diversification are also mixed. On the one hand, Lin et al. (2021) found that in China, firms with more suppliers or more customers increased profitability during the recovery period of the pandemic. Using transaction-level data from Kenya, Chacha et al. (2024) found that diversified domestic supply chains helped firms mitigate the impact of the pandemic and recover more strongly. Todo et al. (2023) collected firm-level data from Asia and found that firms with diversified customers and suppliers were resilient, mitigating damage from supply chain disruptions through partner substitution. On the other hand, Cajal-Grossi et al. (2023) found in their study of the garment sector in Bangladesh, Ethiopia, India, Indonesia, Pakistan, and Vietnam that total imports declined less for garment buyers with fewer suppliers. Khanna et al. (2022) used firm-to-firm transaction data from India to show that buyers with fewer available suppliers are less

[1] Resilience can be defined as the ability to return to normal operations over a reasonable period of time, whereas robustness refers to the ability to maintain operations during a crisis (Miroudot, 2020).

likely to break transaction links. Lafrongne-Joussier et al. (2022) found that in French firms sourcing inputs from China, the ex-ante geographic diversification of inputs does not seem to mitigate the impact of the shock.

Although the effects of mitigating factors remain controversial, this study highlights the role of intra-firm networks in mitigating the adverse effects of the COVID-19 pandemic. We use quarterly data from overseas affiliates of Japanese MNEs in the manufacturing sector from the first quarter of 2019 to the fourth quarter of 2022. Using this dataset, we empirically investigate how the severity of COVID-19, as measured by mobility restriction measures, in their host countries, affects their performance indicators, including total sales, local sales, exports to Japan, and exports to third countries. In particular, we examine the role of intra-firm networks, specifically the presence of nearby affiliates within the same parent company or sibling affiliates, in mitigating the adverse effects of the COVID-19 pandemic in host countries, for example, through their alternative production or flexible input supply. Although this intra-firm network effect may overlap with the above-mentioned effect of supplier/customer diversification, changes in intra-firm transactions will be more flexible than those in inter-firm transactions (i.e., arm's-length transactions).

The study closest to ours is that of Liang (2024). He used the same data as ours and investigated similar issues. In particular, he examined the role of intra-firm network effects using the interaction term between the severity of COVID-19 in an affiliate's locating country and the number of its sibling affiliates in the world. However, there are two crucial differences between his study and ours. First, we examine the existence of sibling affiliates only in the same region where the concerned affiliate is located, not in the world, because inter-regional input-output relations are not so strong in Japanese overseas affiliates.[2] Second, we consider the difference in the severity of COVID-19 between the concerned affiliate's location and its sibling affiliates' location. Sibling affiliates may not be helpful if their locations impose more restrictive mobility measures. Our analysis aims to provide more realistic and detailed insights into the role of intra-firm networks in Japanese MNEs.

This study contributes to the literature on the effects of the COVID-19 pandemic on GVCs. In addition to the above-mentioned firm-level studies, some examine this issue at an industry or product level (Ando and Hayakawa, 2022; Bas et al., 2024; Hayakawa and Mukunoki, 2021; Kejžar et al., 2022; Meier and Pinto, 2024).[3] There are also simulation studies on the propagation of COVID-19 shocks along GVCs (Bonadio et al., 2021; Eppinger et al., 2020; Inoue and Todo, 2020). More generally, such propagation of shocks has also been investigated in other contexts, including the Great East Japan Earthquake in 2011 (Carvalho et al., 2016; Boehm et al., 2019), US natural disasters (Barrot and Sauvagnat, 2016), Turkish

[2] See Table A1 in the Appendix.

[3] Hayakawa and Mukunoki (2021), for instance, demonstrated that the largest negative impacts of COVID-19 in the former half of 2020 were from supply chain effects, which is denoted as the negative effect on trade of downstream products caused by a negative supply shock in the supplier countries of upstream inputs in machinery industries.

tax on import transactions (Demir et al., 2024), and the 2014 Russia-Ukraine crisis (Korovkin and Makarin, 2022).[4]

Our findings can be summarized as follows: First, the negative impact of local mobility restriction measures was much larger for total sales and investments than for employment. The notable difference is that, while the negative effect was significantly larger for total sales, it took a longer time for investment to recover. In contrast, Japanese firms basically maintained employment in their affiliates abroad. Second, local mobility restriction measures negatively affected total sales, especially during the initial phase, that is, the initial short period of the pandemic. Among sales by destinations, local sales experienced the most significant decline. Third, on average, affiliates with sibling affiliates in the same region did not necessarily play a role in mitigating adverse effects and experienced a greater negative effect from local restriction measures than those without in some cases. Fourth, this negative impact is much smaller or disappears when sibling affiliates are located in nearby countries with fewer restrictive measures, particularly during the initial short period of the shock. In other words, affiliates with sibling affiliates located in nearby countries experiencing fewer restrictive measures than those in their own countries may mitigate the negative impact on production, for instance, by switching input sources from local entities to sibling affiliates. Fifth, in the initial short period of the pandemic, Japanese overseas affiliates experienced a negative supply chain effect through local and/or foreign purchases, which is denoted as the negative effect on the production and sales of downstream products caused by the difficulty in purchasing upstream inputs locally and/or from foreign countries due to restrictive measures.

The remainder of this paper is organized as follows: Section 2 provides an overview of Japanese overseas affiliates and mobility restrictions. After providing our empirical framework in Section 3, we present estimation results in Section 4. Finally, Section 5 concludes the paper.

2. Overview of Japanese Overseas Affiliates and Mobility Restrictions

This review examines the trends in COVID-19 severity in terms of local mobility restriction measures in East Asia, North America, and Europe[5], where Japanese overseas affiliates are located, from the first quarter of 2020 (2020Q1) to the fourth quarter of 2022 (2022Q4). The local mobility restriction index is drawn from the Oxford COVID-19

[4] See Carvalho and Tahbaz-Salehi (2019) for the literature review.

[5] East Asia includes China, Hong Kong, South Korea, Taiwan, and six ASEAN countries (Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam); North America covers the United States and Canada; and Europe includes European Union countries (countries in the euro area, Czech Republic, Hungary, Poland, and Romania, and Sweden), Norway, Russia, Switzerland, Turkey, and United Kingdom.

Government Response Tracker (OxCGRT) (Hale et al., 2020). This measure is available on a daily basis. For our quarterly analysis, we take a simple average of daily indicators at the quarterly level. In our study, it takes a value from zero to one, which is converted from the original index ranging between 0 and 100, with a larger value indicating greater restriction. We also provide an overview of Japanese overseas affiliates' performance, for which quarterly data are obtained from the Quarterly Survey of Overseas Subsidiaries (QSQS) conducted by the Ministry of Economy, Trade and Industry, Japan.[6] This survey focuses on manufacturing affiliates.

Figure 1 shows the mean of total sales in Japanese manufacturing affiliates indexed to the same quarter of 2019.[7] After the decline in total sales by around 15 percent in 2020Q1 and by close to 40 percent in the second quarter of 2020 (2020Q2), total sales of Japanese manufacturing affiliates abroad achieved a V-shaped recovery and returned to the pre-pandemic level by 2021. The figure also presents the mean and median of their host countries' mobility restriction measures in each quarter (*LCOVID* in the figure), showing a somewhat different picture: after they became drastically restrictive in 2020Q2 in terms of both mean and median, mobility restriction measures remained at approximately the same level for a long period. In terms of the mean, after becoming less restrictive to some extent in the third quarter of 2020 (2020Q3), the restriction levels were maintained until their gradual reduction in 2022. In terms of the median, the highly restrictive level in 2020Q2 was kept until the third quarter of 2021 (2021Q3) and then started to become less restrictive rapidly in 2022. This suggests that many countries where Japanese affiliates abroad are located removed local mobility restrictions or reduced restrictions significantly by 2022, whereas some countries still had high restrictions.

== Insert Figure 1 here ==

Figure 2 presents the additional performance indicators of Japanese manufacturing affiliates abroad during the pandemic. Panel (i) shows three types of economic activities: total sales, employment, and investment (measured by tangible fixed assets), indexed to the

[6] According to the explanation of this survey, it covers Japanese companies that met all the following criteria: all industries except finance, insurance, and real estate; companies with 100 million yen or more in capital; companies with 50 or more employees; and companies with overseas subsidiaries. This survey also targets overseas subsidiaries of the above Japanese parent companies (including overseas subsidiaries that were established during the term of the survey) that meet all of the following criteria as of the end of the surveyed quarter: manufacturing companies; companies with 50 or more employees; companies with 50% or more of their capital coming from parent companies, including both direct and indirect funds (such as funds provided via local subsidiaries).

[7] Figure A1 in the Appendix shows that for affiliates in East Asia, the decline of total sales in 2020Q2 was smaller at 30 percent than the case of the whole affiliates. The larger local mobility restriction measures for East Asia since 2021Q3 probably reflect the propagation of delta-variant COVID-19 in ASEAN countries or the COVID-19 spread in some areas of China.

same quarter of 2019.[8] The negative impact was much larger for both total sales and investment than that for employment in 2020Q2. However, there is a notable difference between total sales and investment in terms of speed of recovery.[9] It took a much longer time for investment to return to pre-pandemic levels, while total sales recovered quickly. This result may indicate that Japanese firms hesitated to expand new economic activities during the pandemic. Conversely, the median of employment is almost zero throughout the pandemic period, although the mean is slightly lower, with around a five percent decline.[10] This indicates that a large proportion of Japanese firms maintained employment in their affiliates abroad during the pandemic.

== Insert Figure 2 here ==

Looking at sales by three destinations—local, Japan, and third countries—we find that the pattern of exports to Japan is somewhat different from sales to other countries, as depicted in panel (ii). Although the negative impact in 2020Q2 was much smaller for exports to Japan (30 percent for mean and 20 percent for median) than for local sales and exports to third countries (approximately 40 percent for mean and 30 percent for median for both types of sales), it took a longer time for exports to Japan to return to the pre-pandemic level in terms of the mean. Local sales and exports to third countries returned to pre-pandemic levels by the fourth quarter of 2020 (2020Q4). However, exports to Japan finally reached the pre-pandemic level in the third quarter of 2021 (2021Q3) in terms of the mean, while they returned to that level in 2020Q4 in terms of the median, as did the other two sales. These findings may indicate that the recovery of exports to Japan by some affiliates was slow.

3. Empirical Framework

This section explains the empirical framework of the study. Our empirical analyses focus on Japanese affiliates in East Asia, North America, and Europe. As Figures 1 and 2 show, the COVID-19 pandemic negatively affected the economy. Negative impacts may be realized through demand, production, and procurement channels. This decreases consumption opportunities through stay-at-home orders, which worsen business performance and lower revenue and income. Such decreases in consumption opportunities and income result in shrinking demand. Similarly, work-from-home orders decrease factory production (Dingel and Neiman, 2020). Furthermore, infection control measures in factories,

[8] See Figure A2 in the Appendix for the corresponding figure for affiliates in East Asia. There seems to be no significant difference between the case of the whole affiliates and that of affiliates in East Asia.

[9] While Liang (2024) also examined the impact of COVID-19 on investment, he does not refer to this point.

[10] This is true for the case of Japanese manufacturing affiliates in the US as well.

such as social distancing, may lower productivity (Dutcher, 2012; Etheridge et al., 2020), which in turn results in reducing production sizes. Because other firms in the same country also decrease their production, it is challenging to procure inputs from local suppliers. The effects of demand, production, and procurement worsen the performance of Japanese overseas affiliates.

To investigate the effects of COVID-19 severity on Japanese overseas affiliates' performance, we begin with various simple specifications, which are given below.

$$\ln Y_{fyq} = \beta_1 \cdot LCOVID_{cyq} + FE_f + FE_{yq} + \epsilon_{fyq}. \quad (1)$$
$$\ln Y_{fyq} - \ln Y_{fc2019q} = \beta_2 \cdot LCOVID_{cyq} + FE_f + FE_{yq} + \epsilon_{fyq}. \quad (2)$$

Y_{fyq} includes either total sales, the number of employees, or investment in affiliate f (in country c) in quarter q of year y. $LCOVID_{cyq}$ is the index of mobility restriction measures in country c in quarter q of year y. These two models quantify the effect of the local mobility restriction on affiliates' performance or its change. FE_f and FE_{yq} are affiliate fixed effects and year-quarter fixed effects, respectively. ϵ_{fyq} is an error term. We also examine the effect of changes in the restriction by estimating the following:

$$\ln Y_{fyq} = \beta_3 \cdot \left(LCOVID_{cyq} - LCOVID_{cy,q-1}\right) + FE_f + FE_{yq} + \epsilon_{fyq}. \quad (3)$$
$$\ln Y_{fyq} - \ln Y_{fc2019q} = \beta_4 \cdot \left(LCOVID_{cyq} - LCOVID_{cy,q-1}\right) + FE_f + FE_{yq} + \epsilon_{fyq}. \quad (4)$$

Next, we extend Equation (1) to investigate the effects of intra-firm networks on sales of Japanese overseas affiliates. In the following analyses, we focus on the effects on sales, including total sales, local sales, exports to Japan, and exports to third countries. The extended model is as follows:

$$\ln Y_{fyq} = \gamma_1 \cdot LCOVID_{cyq} + \gamma_2 \cdot Network_{fyq} + \gamma_3 \cdot LCOVID_{cyq} \cdot Network_{fyq} + FE_f + FE_{yq} + \epsilon_{fyq}. \quad (5)$$

This model includes a network variable, $Network_{fyq}$, and its interaction term with $LCOVID_{cyq}$. This network variable is a dummy variable that takes a value of one if the parent firm of the concerned affiliate has foreign affiliates in other countries of the same region and zero if it does not.[11] Although we introduce a non-interacting version of this variable, we

[11] Liang (2024) uses the number of its sibling affiliates in the world as the network variable, as mentioned in Section 1. However, the number of foreign affiliates is likely to be related to the firm size; large-sized firms tend to have a larger number of foreign affiliates. Thus, the network variable based on the number of sibling affiliates may directly capture the firm size. Moreover, if we use the number of sibling affiliates, it is difficult to differentiate mobility restrictiveness among countries with those affiliates as we will do. Thus, we create the network variable as a dummy variable rather than the one based on the number of affiliates.

do not examine it much because the existence of affiliates is almost time-invariant in our short study period, and most of its variation is controlled by affiliate fixed effects.

However, certain issues exist with this network variable. First, the network variable indicates the existence of sibling affiliates. Our data do not reveal whether the concerned affiliate has transactions with affiliates of the same parent firm in other countries of the same region, or where the concerned affiliates are located in supply chains. We could create some indices, such as the upstreamness index proposed by Antras et al. (2012), using input-output tables; however, we avoid using data defined in the largely aggregated industry classification. Moreover, we could use intra-firm transaction data available from the annual data. However, such intra-firm transaction data are not available every year. In addition, the sample size is significantly reduced when quarterly data are matched with annual data. Thus, we use our network variable, which can be constructed from only quarterly data without matching two databases. Second, we cannot capture some cases of the network when quarterly data are missing, even if the concerned affiliate actually has sibling affiliates nearby according to the annual data, partly because the targeted firms and affiliates are different in these two surveys as explained later. In this case, the network effect could be underestimated. Despite these shortcomings, the possibility of intra-firm transactions is high when sibling affiliates are nearby. Furthermore, this variable allows us to examine the role of intra-firm networks in further detail, as explained below. Therefore, we use this network variable in this study.

The model specified in Equation (5) investigates how the nearby existence of sibling affiliates changes the effects of local restrictive measures on affiliates' performance. Suppose an affiliate *a* in country *A*. This affiliate has a sibling affiliate *b* in country *B within the same region*. This model examines how the effect of COVID-19 in country *A* on affiliate *a*'s sales differs based on the existence of sibling affiliate *b* in country *B*. We consider these differences in the aforementioned three channels (i.e., demand, production, and procurement) separately. As discussed below, this has both positive and negative effects.

The first is how the decrease in demand in country *A* due to the severity of COVID-19 could be mitigated by the existence of sibling affiliate *b* in country *B*. If affiliates tend to engage in the international division of labor among affiliates within the same parent firm and sell their products to nearby sibling affiliates, the decrease in demand in country *A* does not change affiliate *a*'s sales because its main customers are in country *B*. In this case, the negative effect of COVID-19 through the demand channel will be smaller for affiliates with their sibling affiliates nearby than for those without.

Second, on the one hand, affiliates may share best practices to mitigate productivity loss during the pandemic within an MNE. This information sharing will minimize the negative effects of COVID-19 on production. On the other hand, owing to the productivity decrease caused by the severity of COVID-19, affiliate *a* may request sibling affiliate *b* to produce products on behalf of affiliate *a*, which leads to a greater decrease in affiliate *a*'s sales. Another possibility is that when firms have to judge the balance between maintaining

production and securing workers' health in facing the worsening severity of COVID-19, they may adjust the volume of intra-firm transactions more flexibly on a priority basis than that of arm's-length transactions. Since the short-run adjustment costs of intra-firm transactions are lower because arm's-length transactions cannot be recovered easily once they are disconnected by a shock (e.g., Todo et al., 2023), firms will reduce intra-firm sales more, compared with arm's-length sales, when they are forced to reduce production due to the severity of COVID-19. In short, intrafirm networks will have both decreasing and increasing effects on sales through the production channel.

Third, as in the demand channel above, if affiliate a procures inputs from sibling affiliate b in country B, the severity of COVID-19 in country A does not change affiliate a's procurement. However, if affiliate a was sourcing local inputs, it may be able to switch the source of procurement from local firms to sibling affiliate b relatively easily, because the short-run adjustment costs of intra-firm transactions are lower than those of arm's-length transactions. In this case, the negative effect via the procurement channel will be smaller for affiliates with sibling affiliates nearby than for those without. In contrast, as in the above production channel, when firms have to judge the balance between maintaining production and securing workers' health in facing the severity of COVID-19, they may reduce intra-firm purchases and production while keeping arm's-length purchases. Thus, as in the case of the production channel, intrafirm networks could have both decreasing and increasing effects on sales through the procurement channel for affiliates with sibling affiliates nearby than those without.

Although Model (5) investigates the role of sibling affiliates, it may depend on whether those affiliates are in countries with less restrictive measures than in the country of the concerned affiliate. For example, the aforementioned input switching would be possible if sibling affiliates were in countries with fewer restrictive measures.[12] To examine this hypothesis, we add another interaction term of the network variable, $Network\ Low_{fyq}$, to Equation (5), as follows:

$$\ln Y_{fyq} = \gamma_1 \cdot LCOVID_{cyq} + \gamma_2 \cdot Network_{fyq} + \gamma_3 \cdot LCOVID_{cyq} \cdot Network_{fyq} + \gamma_4 \cdot LCOVID_{cyq} \cdot Network\ Low_{fyq} + FE_f + FE_{yq} + \epsilon_{fyq}. \quad (6)$$

This newly added network variable is a dummy variable that takes the value of one (zero) if the parent firm of the concerned affiliate has (does not have) other affiliate(s) in surrounding countries of the same region, and the minimum level of mobility restriction measures in those countries is lower than in the concerned affiliate's locating country.

[12] Another possible case would be that the decrease in demand in the country of the concerned affiliate, due to the severity of COVID-19, could be partially substituted by the increase in the sales to sibling affiliates when those affiliates are in countries with less restrictive measures to mitigate the negative effect of COVID-19 on production, considering the benefit as an MNE.

Finally, we control for the effect of mobility restriction measures in input source countries. Specifically, Equation (6) is extended as

$$\ln Y_{fyq} = \gamma_1 \cdot LCOVID_{cyq} + \gamma_2 \cdot LCOVID_{cyq} \cdot LInput_{f2019} + \gamma_3 \cdot FInpCOVID_{fcyq} + \gamma_4 \cdot Network_{fyq} + \gamma_5 \cdot LCOVID_{cyq} \cdot Network_{fyq} + \gamma_6 \cdot LCOVID_{cyq} \cdot Network\ Low_{fyq} + FE_f + FE_{yq} + \epsilon_{fyq}. \quad (7)$$

In this specification, the local mobility restriction measure interacts with the share of local inputs out of total inputs of affiliate *f* in 2019 ($LInput_{f2019}$). The coefficient for this interaction term indicates how the effect of local mobility restriction differs depending on the local input share. Affiliates with a higher local input share will experience a greater loss of inputs through more restrictive measures in their host countries, resulting in decreased sales.

$FInpCOVID_{fcyq}$ captures the mobility restriction measures in foreign input source countries, which is computed as follows.

$$FInpCOVID_{fyq} \equiv \sum\nolimits_{r \in R} \left(\frac{Input^r_{f2019}}{\sum_{k \in R} Input^k_{f2019}} \right) COVID_{ryq}.$$

The set of R consists of four regions: East Asia, Japan, North America, and Europe. $Input^r_{f2019}$ represents the total import value of inputs from region *r* for 2019. $COVID_{ryq}$ is the mobility restriction in region *r*, of which the details are explained below. Note that both $Input^r_{f2019}$ and $COVID_{fryq}$ do not include figures in the country of affiliate *f*. In short, this measure is the weighted average of mobility restriction measures in foreign countries using their input shares as weights. Its coefficient indicates the effects of foreign mobility restriction measures on sales. More restrictive measures in input source countries abroad will worsen the performance of Japanese affiliates.

All models are estimated using the ordinary least squares (OLS) method. The main data sources are the same as those described in the previous section, that is OxCGRT and QSQS. As specified above, our empirical analyses are conducted at a quarterly level. Considering that the impact of local mobility restriction measures on performance may differ depending on the timing since the pandemic started, we use three analytical periods: the entire period from 2020Q1 to 2022Q4 (expressed as 2020–2022), the initial year of the pandemic from 2020Q1 to 2020Q4 (expressed as 2020), and the initial short period of the pandemic from 2020Q1 to 2020Q2 (expressed as 2020Q1Q2). We restrict Japanese overseas affiliates to manufacturing affiliates.

$LInput_{f2019}$ and $Input^r_{f2019}$ are constructed using data from the 2019 Basic Survey on Overseas Business Activities (BSOBA). The BSOBA is an annual version of the QSQS that includes more detailed information on overseas affiliates. [13] The computation of

[13] The targeted firms in BSOBA are those, in industries other than finance, insurance, and real estate, with overseas affiliates as of the end of March every year. Overseas affiliates here include both foreign

$FInpCOVID_{fcyq}$ is slightly complicated. $Input^{r}_{f2019}$ and $COVID_{fryq}$ are defined at a regional level (i.e., East Asia, Japan, North America, and Europe). The data on $Input^{r}_{f2019}$ can be obtained from the BSOBA.[14] In contrast, when constructing $COVID_{ryq}$, we need to aggregate country-level indicators at the regional level. We take their weighted average using the share of country c's imports from each country in the region out of total imports from the region as a weight. The trade data are obtained from the BACI database managed by the CEPII. Furthermore, we use weights specific to the industry to which affiliate f belongs (four-digit level). Notably, the matched sample of two databases (QSOS and BSOBA) is reduced to approximately one-third of the sample set using only QSOS.[15]

4. Empirical Results

Table 1 summarizes the estimation results of Equations (1)−(4). It provides several interesting findings for sales. First, local mobility restriction measures have a negative impact on all types of sales—that is, total sales, local sales, exports to Japan, and exports to third countries—regardless of the dependent and independent variables. Sales tend to decline when local mobility restriction measures are more restrictive. Second, the negative effect is the largest for 2020Q1Q2, followed by 2020 and 2020–2022 in this order. This result indicates that the negative impact was large in the initial year of the pandemic, particularly in the initial short period, although the negative effect of mobility restriction measures exists throughout the entire period. Third, local sales had the largest negative effect among sales by destinations. This is likely because local regulations must have influenced local sales not only through the supply side but also through demand side factors. The patterns of exports to Japan and those to third countries tend to be similar, but the negative effect is the smallest for exports to Japan in the initial short period of the pandemic among three types of sales in all four specifications.[16]

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affiliates whose Japanese ownership is 10 percent or more and affiliates with an ownership ratio of over 50 percent by foreign affiliates with a Japanese ownership ratio of over 50 percent. On the other hand, the targeted firms in QSQS are those in industries other than finance, insurance, and real estate, with capital of 100 million yen or more, employment of 50 or over, and overseas affiliates that are manufacturing affiliates with employment of 50 or more and Japanese ownership ratio in total of 50 percent or more as of the end of each quarter. Both surveys are approved statistics surveys, not designated statistics surveys.

[14] More precisely, the BSOBA reports input values from "Asia," which includes not only East Asian countries but also other Asian countries, such as South Asian countries. However, those input values from Asia mainly consist of those from East Asia in our study observations because of few inputs from other Asian countries in Japanese affiliates in East Asia, North America, and Europe.

[15] Basic statistics are available in Table A2 in the Appendix.

[16] When the sample is divided into two groups based on the employment size of affiliates, larger affiliates and smaller affiliates, the negative effect was greater for larger affiliates than for smaller affiliates in most cases, regardless of whether total sales or sales by destinations. See Table A3 in the Appendix.

== Table 1 ==

The results for employment and investment are as follows: as shown in the table, the negative impact of local mobility restriction measures on employment exists but is quite small. Even during the initial phase of the pandemic, when the impacts were slightly larger than the entire first year or full period, the negative effect on employment was very small, unlike in the case of sales. This finding suggests that Japanese affiliates abroad rarely reduced employment during the pandemic. Investment in tangible fixed assets tends to reduce when local mobility restriction measures are restrictive, and such negative impacts are much larger than in the case of employment but smaller than in the case of sales.

The estimation results of Equation (5) for total sales are reported in the upper panel of Table 2. As specified in Equation (5), we control for affiliate fixed effects and year-quarter fixed effects in Columns (I), (III), and (V). In the other columns, we further control for country-year-quarter fixed effects and industry-year-quarter fixed effects, which play important roles in controlling for confounding factors defined at these levels. Industry is defined at the four-digit level. The coefficient for the interaction term between the local restriction measure and network variable is statistically insignificant in all columns. As discussed in the previous section, there could be positive (e.g., switching input sources) and negative effects (e.g., alternative production by sibling affiliates) of the network, that is, the existence of sibling affiliates nearby. Our insignificant results may indicate that these two opposing effects offset each other on average. Thus, the existence of sibling affiliates nearby does not necessarily play a role in mitigating the adverse effects of the local restriction measure.

== Table 2 ==

The estimation results of Equation (6) for total sales are reported in the lower panel of Table 2. Some specifications in the initial year of the pandemic show significant results for the network variables. Specifically, the interaction term of $Network_{fyq}$ is significantly negative, whereas that of $Network\ Low_{fyq}$ is positive and statistically significant. Nevertheless, the absolute value of the former coefficient is slightly larger than that of the latter. These results imply that the existence of sibling affiliates in the same region yields a larger negative impact of the local restriction measure in some cases, compared with the case without those affiliates, regardless of whether they are located in countries with less or more restrictive measures; however, such a negative impact is much smaller when they are located in countries with less restrictive measures than the measures in the country of the concerned affiliate. The negative impact almost disappears for these affiliates during the initial short period of the shock.

On the one hand, the negative effect on the sales of affiliates with sibling affiliates in countries with more restrictive measures is due to the loss of sales opportunities. Since it is also difficult for sibling affiliates to conduct production activities due to restrictive measures, the concerned affiliate decreases its supply to those sibling affiliates and thus its sales. On the other hand, affiliates with sibling affiliates experiencing fewer restrictive measures may experience a positive effect from intra-firm networks. As the concerned affiliate can switch input sources from local entities to sibling affiliates, the decrease in production is moderated. In summary, these network variables reflect two opposing effects: one from intra-firm purchases and the other from intra-firm sales.

Similarly, Table 3 shows the results of Equation (6) for sales at three destinations: local sales, exports to Japan, and exports to third countries. The results for the interaction term of $Network\ Low_{fyq}$ for local sales and exports to Japan are similar to those for total sales (see Table 2), especially in 2020Q1Q2. Nevertheless, the interaction term of $Network_{fyq}$ is insignificant for local sales and exports to Japan. Therefore, immediately after the shock started, Japanese affiliates maintained these sales by utilizing the advantage of intra-firm networks such as switching input sources to nearby sibling affiliates. We do not observe a significant effect of intra-firm networks on exports to third countries.

== Table 3 ==

In East Asia, dense international production networks have developed covering many countries in the region, and Japanese firms are key players in the networks. Therefore, we estimate our models only for affiliates in East Asia. The results for our network-related variables, which correspond to Tables 2 and 3, are reported in Tables 4 and 5 and are similar to those for the world. Nevertheless, there are some interesting differences. Except for the case of local sales in 2020 in Table 5, which is significantly negative, all results for the interaction term of $Network_{fyq}$ are insignificant. In addition, in some specifications, the interaction term of $Network\ Low_{fyq}$ in the initial year of the pandemic (including the initial short period) is positive and statistically significant, and the sum of the coefficients for these two network variables remains positive. Thus, on average, the existence of sibling affiliates nearby does not necessarily play a role in mitigating the adverse effect of the local restriction measure. However, their existence is more likely to play a mitigating role in the case of affiliates in East Asia, compared to the case of all affiliates, when they are located in countries with less restrictive measures than the measures in the country of the concerned affiliate. This result may be partly because affiliates could enjoy the positive side of network effects more easily within dense production networks covering many countries in the region, such as switching input sources.

== Table 4 ==

== Table 5 ==

Finally, Table 6 shows the estimation results of Equation (7) for total sales by all affiliates. On the one hand, the results for network variables are qualitatively unchanged from those in the previous tables. In particular, the interaction term of $Network\ Low_{fyq}$ has significantly positive coefficients in the initial year of the pandemic, although it is insignificant when controlling for country-year and industry-year fixed effects. On the other hand, the interaction term between local restrictions and local input shares has significantly negative coefficients only during the initial period of the pandemic. During this short period, the pandemic's negative impact was greater for local input-intensive affiliates. Foreign mobility restrictions in foreign input source countries/regions have an insignificant effect in all cases of all affiliates. Thus, compared to local inputs, affiliates may find alternatives to foreign inputs. Table 7 presents the corresponding results for affiliates in East Asia. In this case, foreign mobility restrictions in foreign input source countries/regions have a significantly negative effect in the initial year (including the initial period) of the pandemic. This indicates that mobility restrictions in input source countries lead to decreased sales in East Asia through supply chains. In summary, Japanese overseas affiliates experienced the negative supply chain effect through local and/or foreign purchases during the initial period of the COVID-19 pandemic.[17]

== Table 6 ==

== Table 7 ==

5. Conclusion

This study empirically investigated how COVID-19 severity, as measured by mobility restriction measures, affected the performance indicators of Japanese overseas affiliates. In particular, we shed light on the role of intra-firm networks—that is, that of nearby other affiliates in the same parent company—in the adverse effects of the COVID-19 pandemic.

[17] To examine the sales-side effect, we estimated a variation of Equation (7), which replaces the interaction term of LCOVID with local purchase ratios (LCOVID*LInput) and FCOVID weighted by foreign purchasing ratios (FInpCOVID) by that with local sales ratios (LCOVID*LOut) and FCOVID weighted by foreign sales ratios (FOutCOVID), respectively. The results, shown in Table A4 in the Appendix, suggest that in 2020, particularly in the initial period of 2020, the negative impact of the pandemic was greater when local sales ratios were larger and also when foreign mobility restrictions in foreign sales destination countries/regions were more restrictive. For affiliates in East Asia, in particular, the effect of foreign mobility restriction measures remains throughout the whole period. Note that if we include both purchase-side and sales-side variables, the sample size is further reduced. In addition, there is a possibility of multicollinearity. Thus, we did not include variables on both sides together.

We found that, on average, affiliates with sibling affiliates in the same region did not necessarily play a role in mitigating the adverse effects and experienced a greater negative effect from local restriction measures than those without in some cases, probably due to the more flexible adjustment of intra-firm transactions compared with arm's-length transactions through demand, production, and procurement channels. However, it was also revealed that such a negative effect is much smaller or disappears for affiliates that have sibling affiliates in countries with less restrictive measures, particularly in the initial short period of the shock. We conjecture that affiliates with sibling affiliates experiencing fewer restrictive measures may moderate the decrease in production by switching input sources from local entities to those sibling affiliates. In particular, their existence is more likely to play a mitigating role in the case of affiliates in East Asia, compared to the case of all affiliates.

Our results suggest that desirable policies may vary depending on the timing of the shock as well as the situation/status of affiliates (e.g., whether the concerned affiliate has intra-firm transactions or an intra-firm network, where the concerned affiliates are located in supply chains, and whether the concerned affiliate is involved in the network covering other affiliates located in more favorable conditions for operations when the shock occurs). Thus, it is important to establish corporate strategies and policies that support them by judging affiliate situations appropriately and to provide an environment in which firms can flexibly adjust their operations when necessary. Simultaneously, to create appropriate corporate strategies and policies, it is necessary to conduct further analyses to explicitly examine the types of transactions of overseas affiliates from the perspective of procurement or sales.

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Table 1. Estimation Results of Equations (1)–(4) by the OLS Method

	(I)		(II)		(III)		(IV)	
Dep. var.	Level		Change		Level		Change	
Indep. var.	Level		Level		Change		Change	
	Coef.	N	Coef.	N	Coef.	N	Coef.	N
A. Total sales								
2020-2022	-0.348***	55,580	-0.369***	51,972	-0.460***	55,580	-0.423***	51,972
2020	-1.029***	18,429	-0.862***	17,748	-0.628***	18,429	-0.556***	17,748
2020Q1Q2	-1.373***	9,002	-1.224***	8,722	-0.764***	9,002	-0.685***	8,722
Local sales								
2020-2022	-0.403***	50,097	-0.435***	46,413	-0.536***	50,097	-0.517***	46,413
2020	-1.226***	16,555	-1.060***	15,858	-0.731***	16,555	-0.685***	15,858
2020Q1Q2	-1.601***	8,016	-1.490***	7,720	-0.884***	8,016	-0.827***	7,720
Sales to Japan								
2020-2022	-0.187***	32,130	-0.219***	28,534	-0.250***	32,130	-0.261***	28,534
2020	-0.515***	10,398	-0.534***	9,684	-0.328***	10,398	-0.316***	9,684
2020Q1Q2	-0.712***	4,924	-0.692***	4,602	-0.402***	4,924	-0.384***	4,602
Sales to third countries								
2020-2022	-0.167***	33,632	-0.222***	30,100	-0.238***	33,632	-0.259***	30,100
2020	-0.492***	10,928	-0.450***	10,229	-0.324***	10,928	-0.335***	10,229
2020Q1Q2	-0.752***	5,196	-0.716***	4,872	-0.417***	5,196	-0.405***	4,872
B. Employment								
2020-2022	-0.0413***	56,361	-0.0414***	52,654	-0.0163***	56,361	-0.0204***	52,654
2020	-0.0397***	18,769	-0.0464**	18,033	-0.0217***	18,769	-0.0283***	18,033
2020Q1Q2	-0.0487***	9,266	-0.0604***	8,892	-0.0263***	9,266	-0.0347***	8,892
C. Investment								
2020-2022	-0.158**	31,759	-0.238**	26,100	-0.281***	31,759	-0.249***	26,100
2020	-0.797***	9,873	-0.487**	8,584	-0.361***	9,873	-0.295***	8,584
2020Q1Q2	-1.020***	4,058	-0.865***	3,510	-0.562***	4,058	-0.503***	3,510

Notes: In all specifications, we control for affiliate fixed effects and year-quarter fixed effects. Standard errors are clustered at the affiliate level.

Sources: OxCGRT and QSQS.

Table 2. Estimation Results of Equations (5) and (6) for Total Sales

	2020-2022		2020		2020Q1Q2	
	(I)	(II)	(III)	(IV)	(V)	(VI)
Equation (5)						
LCOVID	-0.328***		-1.003***		-1.337***	
	[0.0866]		[0.264]		[0.188]	
Network	0.0349	0.0287	-0.0735	-0.0985*	-0.349***	-0.316***
	[0.0579]	[0.0424]	[0.0526]	[0.0540]	[0.128]	[0.104]
LCOVID*Network	-0.0252	-0.0195	-0.0347	0.0446	-0.0459	0.0246
	[0.0380]	[0.0273]	[0.0455]	[0.0489]	[0.0493]	[0.0524]
N	55,580	55,501	18,429	18,403	9,002	8,990
Adj. R-squared	0.954	0.959	0.946	0.953	0.926	0.935
Equation (6)						
LCOVID	-0.333***		-1.043***		-1.421***	
	[0.0844]		[0.247]		[0.169]	
Network	0.0363	0.029	-0.0673	-0.0975*	-0.334**	-0.318***
	[0.0588]	[0.0424]	[0.0545]	[0.0544]	[0.139]	[0.108]
LCOVID*Network	-0.049	-0.0252	-0.149*	0.0167	-0.242**	-0.041
	[0.0510]	[0.0326]	[0.0821]	[0.0580]	[0.111]	[0.0531]
LCOVID*Network Low	0.0281	0.00684	0.128**	0.0319	0.233**	0.0835**
	[0.0329]	[0.0120]	[0.0545]	[0.0217]	[0.103]	[0.0349]
N	55,580	55,501	18,429	18,403	9,002	8,990
Adj. R-squared	0.954	0.959	0.946	0.953	0.927	0.936
Affiliate FE	x	x	x	x	x	x
Year-quarter FE	x		x		x	
Country-year-quarter FE		x		x		x
Industry-year-quarter FE		x		x		x

Notes: Estimation results for the three periods were obtained using the OLS method. The dependent variable is the log of total sales. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered by affiliate.

Sources: OxCGRT and QSQS.

Table 3. Estimation Results of Equation (6) for Various Sales

	2020-2022		2020		2020Q1Q2	
	(I)	(II)	(III)	(IV)	(V)	(VI)
(i) Local sales						
LCOVID	-0.402***		-1.236***		-1.677***	
	[0.0914]		[0.277]		[0.184]	
Network	-0.0058	0.00409	0.0332	0.00747	-0.38	-0.305
	[0.0875]	[0.0750]	[0.133]	[0.145]	[0.250]	[0.226]
LCOVID*Network	-0.0271	0.0172	-0.201*	0.0163	-0.236	0.0321
	[0.0839]	[0.0509]	[0.101]	[0.0635]	[0.153]	[0.0813]
LCOVID*Network Low	0.0247	-0.0257	0.163***	0.0510**	0.260*	0.0942*
	[0.0427]	[0.0229]	[0.0592]	[0.0245]	[0.134]	[0.0468]
N	50,097	50,026	16,555	16,532	8,016	8,002
Adj. R-squared	0.947	0.951	0.943	0.949	0.929	0.935
(ii) Exports to Japan						
LCOVID	-0.238***		-0.515***		-0.815***	
	[0.0513]		[0.127]		[0.152]	
Network	-0.113	-0.152	-0.298	-0.346	-0.298	-0.351
	[0.143]	[0.132]	[0.236]	[0.244]	[0.271]	[0.262]
LCOVID*Network	0.0412	0.0242	-0.0818	-0.0746	-0.141	-0.0788
	[0.0478]	[0.0470]	[0.0874]	[0.122]	[0.0886]	[0.0930]
LCOVID*Network Low	0.0223	0.0338	0.0600*	0.0472	0.198***	0.148***
	[0.0237]	[0.0263]	[0.0328]	[0.0331]	[0.0344]	[0.0391]
N	32,130	32,044	10,398	10,371	4,924	4,906
Adj. R-squared	0.917	0.919	0.927	0.928	0.924	0.924
(iii) Exports to third countries						
LCOVID	-0.119*		-0.461***		-0.708***	
	[0.0656]		[0.106]		[0.106]	
Network	-0.0396	-0.067	-0.242*	-0.250*	-0.588**	-0.606***
	[0.0842]	[0.0629]	[0.131]	[0.132]	[0.227]	[0.217]
LCOVID*Network	-0.0241	-0.0329	-0.0184	0.0502	-0.14	-0.0512
	[0.0563]	[0.0534]	[0.103]	[0.0749]	[0.119]	[0.0978]
LCOVID*Network Low	-0.0341	-0.0297	-0.0165	-0.05	0.0595	0.00954
	[0.0213]	[0.0241]	[0.0683]	[0.0350]	[0.0874]	[0.0569]
N	33,632	33,538	10,928	10,898	5,196	5,182
Adj. R-squared	0.922	0.923	0.923	0.924	0.917	0.917
Affiliate FE	x	x	x	x	x	x
Year-quarter FE	x		x		x	
Country-year-quarter FE		x		x		x
Industry-year-quarter FE		x		x		x

Notes: Estimation results for the three periods were obtained using the OLS method. The dependent variable is the log of local sales, exports to Japan, or exports to third countries. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered by affiliate.

Sources: OxCGRT and QSQS.

Table 4. Estimation Results of Equations (5) and (6) for Total Sales by Affiliates in East Asia

	2020-2022		2020		2020Q1Q2	
	(I)	(II)	(III)	(IV)	(V)	(VI)
Equation (5)						
LCOVID	-0.440***		-1.220***		-1.353***	
	[0.0665]		[0.281]		[0.245]	
Network	0.062	0.053	-0.046	-0.064	-0.271	-0.250*
	[0.0626]	[0.0594]	[0.0848]	[0.0795]	[0.193]	[0.131]
LCOVID*Network	-0.0244	-0.0134	0.016	0.110	-0.0141	0.098
	[0.0303]	[0.0269]	[0.0532]	[0.0649]	[0.0429]	[0.0711]
N	41,805	41,805	13,865	13,865	6,784	6,784
Adj. R-squared	0.951	0.956	0.943	0.949	0.920	0.928
Equation (6)						
LCOVID	-0.445***		-1.274***		-1.450***	
	[0.0658]		[0.277]		[0.250]	
Network	0.0634	0.053	-0.0311	-0.0615	-0.23	-0.243
	[0.0650]	[0.0595]	[0.0877]	[0.0798]	[0.211]	[0.138]
LCOVID*Network	-0.0502	-0.0156	-0.11	0.088	-0.227	0.0209
	[0.0557]	[0.0303]	[0.0740]	[0.0535]	[0.153]	[0.0637]
LCOVID*Network Low	0.030	0.003	0.140**	0.0242	0.243	0.0853*
	[0.0457]	[0.0134]	[0.0553]	[0.0172]	[0.145]	[0.0411]
N	41,805	41,805	13,865	13,865	6,784	6,784
Adj. R-squared	0.951	0.956	0.943	0.949	0.921	0.928
Affiliate FE	x	x	x	x	x	x
Year-quarter FE	x		x		x	
Country-year-quarter FE		x		x		x
Industry-year-quarter FE		x		x		x

Notes: Estimation results for the three periods were obtained using the OLS method. The dependent variable is the log of total sales. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered by affiliate.

Sources: OxCGRT and QSQS.

Table 5. Estimation Results of Equation (6) for Various Sales by Affiliates in East Asia

	2020-2022		2020		2020Q1Q2	
	(I)	(II)	(III)	(IV)	(V)	(VI)
(i) Local sales						
LCOVID	-0.423***		-1.490***		-1.797***	
	[0.106]		[0.330]		[0.306]	
Network	0.0639	0.0555	0.149	0.15	-0.349	-0.237
	[0.131]	[0.119]	[0.221]	[0.226]	[0.497]	[0.395]
LCOVID*Network	-0.107	-0.0256	-0.187*	0.0721	-0.187	0.122
	[0.120]	[0.0784]	[0.0994]	[0.0619]	[0.190]	[0.0731]
LCOVID*Network Low	0.0214	-0.0368	0.187***	0.0313**	0.288	0.0829
	[0.0589]	[0.0262]	[0.0596]	[0.0112]	[0.196]	[0.0469]
N	37,177	37,172	12,274	12,272	5,952	5,952
Adj. R-squared	0.942	0.946	0.938	0.943	0.923	0.928
(ii) Exports to Japan						
LCOVID	-0.231***		-0.593***		-0.760***	
	[0.0489]		[0.168]		[0.213]	
Network	-0.0481	-0.0926	-0.406	-0.492*	-0.253	-0.356
	[0.184]	[0.166]	[0.278]	[0.272]	[0.303]	[0.290]
LCOVID*Network	-0.0166	0.015	0.029	0.132	-0.146	-0.0115
	[0.0431]	[0.0461]	[0.0961]	[0.0770]	[0.138]	[0.122]
LCOVID*Network Low	0.022	0.0334	0.0496*	0.024	0.179***	0.125**
	[0.0266]	[0.0283]	[0.0263]	[0.0320]	[0.0333]	[0.0514]
N	26,252	26,212	8,534	8,518	4,076	4,068
Adj. R-squared	0.921	0.922	0.931	0.932	0.930	0.930
(iii) Exports to third countries						
LCOVID	-0.276***		-0.543***		-0.766***	
	[0.0392]		[0.0963]		[0.0806]	
Network	-0.122	-0.154**	-0.273	-0.309	-0.785*	-0.841**
	[0.0907]	[0.0635]	[0.200]	[0.183]	[0.367]	[0.343]
LCOVID*Network	0.0507	0.0645	-0.0884	0.0221	0.0355	0.124
	[0.0571]	[0.0541]	[0.0943]	[0.0706]	[0.135]	[0.0698]
LCOVID*Network Low	-0.0208	-0.0223	-0.00514	-0.0549	-0.000653	-0.0304
	[0.0185]	[0.0290]	[0.0628]	[0.0349]	[0.0934]	[0.0473]
N	24,483	24,463	7,919	7,911	3,774	3,770
Adj. R-squared	0.915	0.916	0.917	0.919	0.914	0.914
Affiliate FE	x	x	x	x	x	x
Year-quarter FE	x		x		x	
Country-year-quarter FE		x		x		x
Industry-year-quarter FE		x		x		x

Notes: Estimation results for the three periods were obtained using the OLS method. The dependent variable is the log of local sales, exports to Japan, or exports to third countries. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered by affiliate.

Sources: OxCGRT and QSQS.

Table 6. Estimation Results of Equation (7) for Total Sales

	2020-2022		2020		2020Q1Q2	
	(I)	(II)	(III)	(IV)	(V)	(VI)
LCOVID	-0.397***		-1.111***		-1.421***	
	[0.108]		[0.271]		[0.210]	
LCOVID*LInput	-0.022	-0.039	-0.0564	-0.084	-0.208*	-0.254**
	[0.0854]	[0.0598]	[0.0838]	[0.0517]	[0.122]	[0.0921]
FInpCOVID	0.030	0.008	-0.143	-0.091	-0.310	-0.096
	[0.0563]	[0.0491]	[0.118]	[0.0643]	[0.184]	[0.128]
Network	0.222**	0.183**	-0.168	-0.200**	-0.616**	-0.475***
	[0.0841]	[0.0697]	[0.1000]	[0.0926]	[0.242]	[0.0963]
LCOVID*Network	-0.0644	-0.0262	-0.215**	-0.00816	-0.333**	-0.0512
	[0.0541]	[0.0538]	[0.0897]	[0.0937]	[0.150]	[0.0893]
LCOVID*Network Low	0.024	0.014	0.150**	0.0244	0.276**	0.067
	[0.0433]	[0.0171]	[0.0610]	[0.0313]	[0.124]	[0.0442]
N	17,260	17,154	5,791	5,752	2,844	2,822
Adj. R-squared	0.955	0.963	0.944	0.952	0.919	0.926
Affiliate FE	x	x	x	x	x	x
Year-quarter FE	x		x		x	
Country-year-quarter FE		x		x		x
Industry-year-quarter FE		x		x		x

Notes: Estimation results for the three periods were obtained using the OLS method. The dependent variable is the log of total sales. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered by affiliates.

Sources: BSOBA, GTA, OxCGRT, and QSQS.

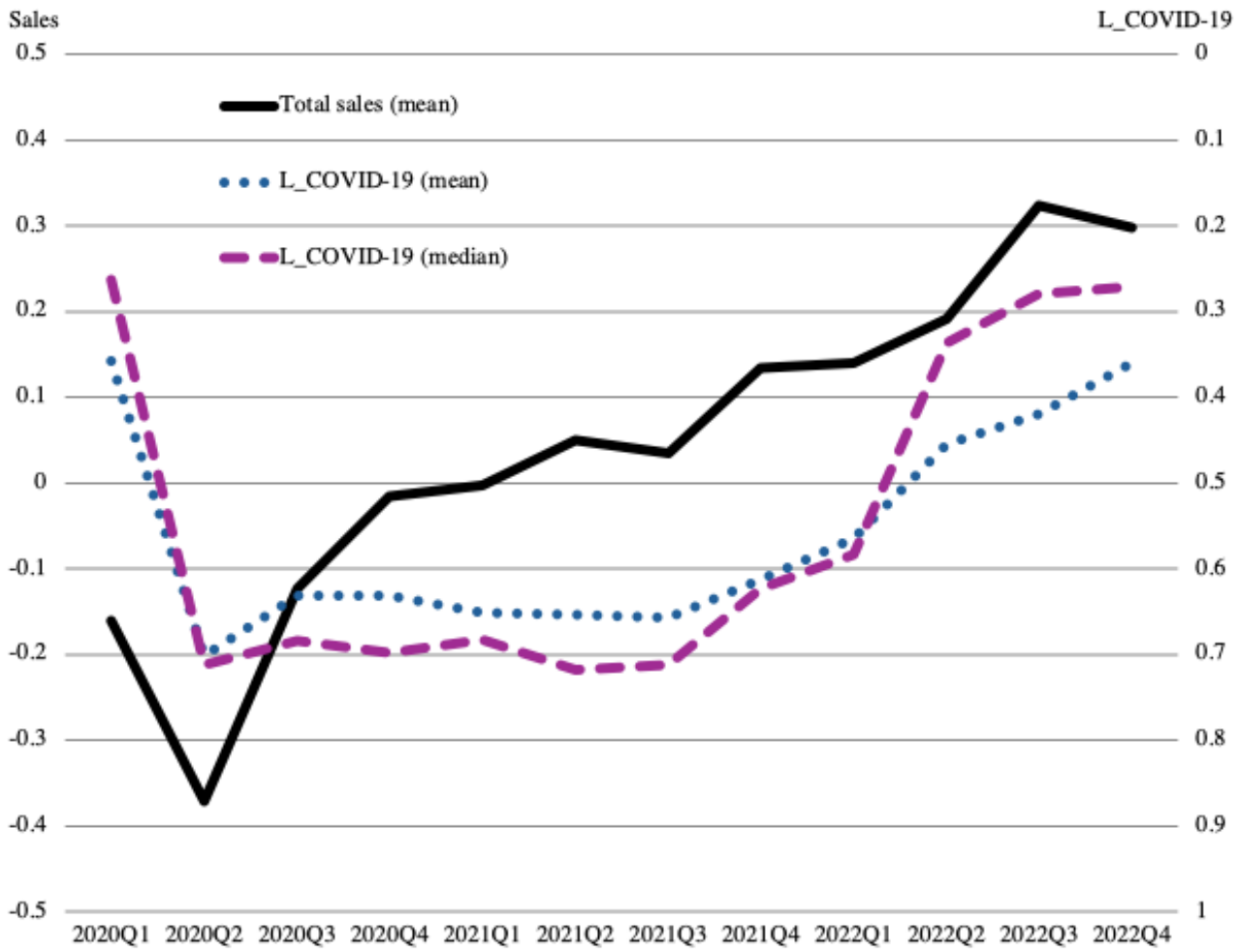
Table 7. Estimation Results of Equation (7) for Total Sales by Affiliates in East Asia

	2020-2022		2020		2020Q1Q2	
	(I)	(II)	(III)	(IV)	(V)	(VI)
LCOVID	-0.528***		-1.320***		-1.493***	
	[0.119]		[0.333]		[0.302]	
LCOVID*LInput	-0.047	-0.076	-0.094	-0.098	-0.098	-0.145
	[0.119]	[0.0790]	[0.123]	[0.0855]	[0.160]	[0.115]
FInpCOVID	-0.090	0.056	-0.391*	-0.153*	-0.537*	-0.217
	[0.0959]	[0.0418]	[0.216]	[0.0729]	[0.248]	[0.171]
Network	0.222**	0.194**	-0.25	-0.274*	-0.655**	-0.560***
	[0.0790]	[0.0768]	[0.154]	[0.128]	[0.254]	[0.133]
LCOVID*Network	0.00835	0.0283	-0.0768	0.157*	-0.263	0.0775
	[0.0422]	[0.0519]	[0.0617]	[0.0857]	[0.186]	[0.119]
LCOVID*Network Low	0.015	0.002	0.134**	0.004	0.266	0.0602
	[0.0546]	[0.0200]	[0.0593]	[0.0381]	[0.159]	[0.0705]
N	13,831	13,795	4,649	4,637	2,282	2,276
Adj. R-squared	0.954	0.961	0.942	0.948	0.913	0.919
Affiliate FE	x	x	x	x	x	x
Year-quarter FE	x		x		x	
Country-year-quarter FE		x		x		x
Industry-year-quarter FE		x		x		x

Notes: Estimation results for the three periods were obtained using the OLS method. The dependent variable is the log of total sales. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered by affiliates.

Sources: BSOBA, GTA, OxCGRT, and QSQS.

Figure 1 Local Mobility Restriction Measures and Total Sales by Japanese Overseas Manufacturing Affiliates (indexed to the same quarter of 2019)

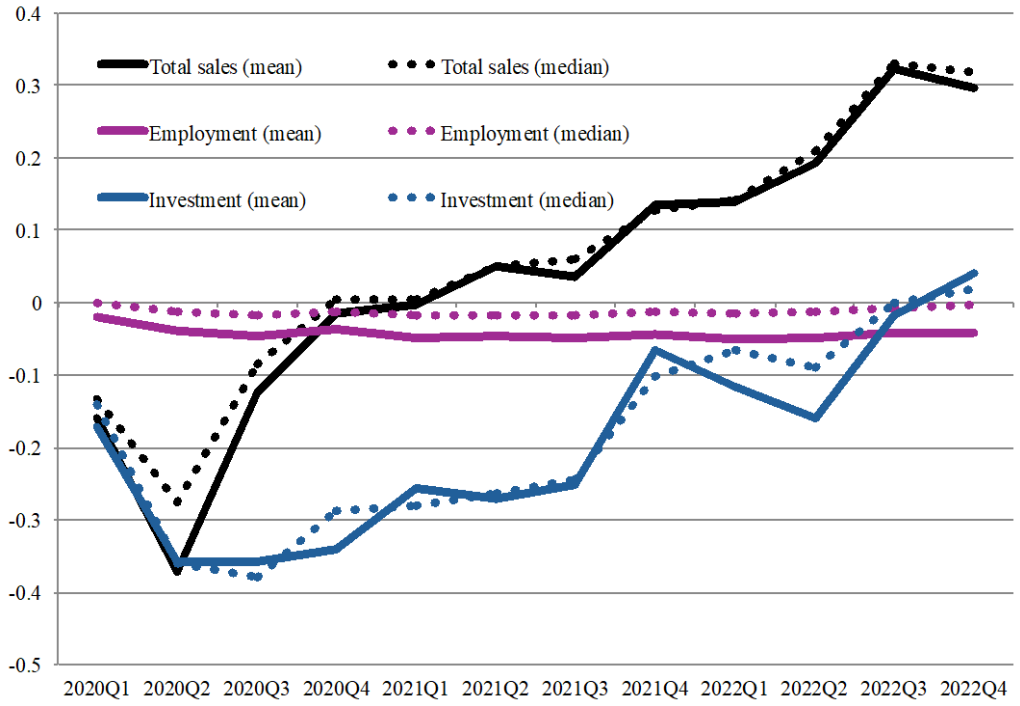


Source: OxCGRT and QSQS.

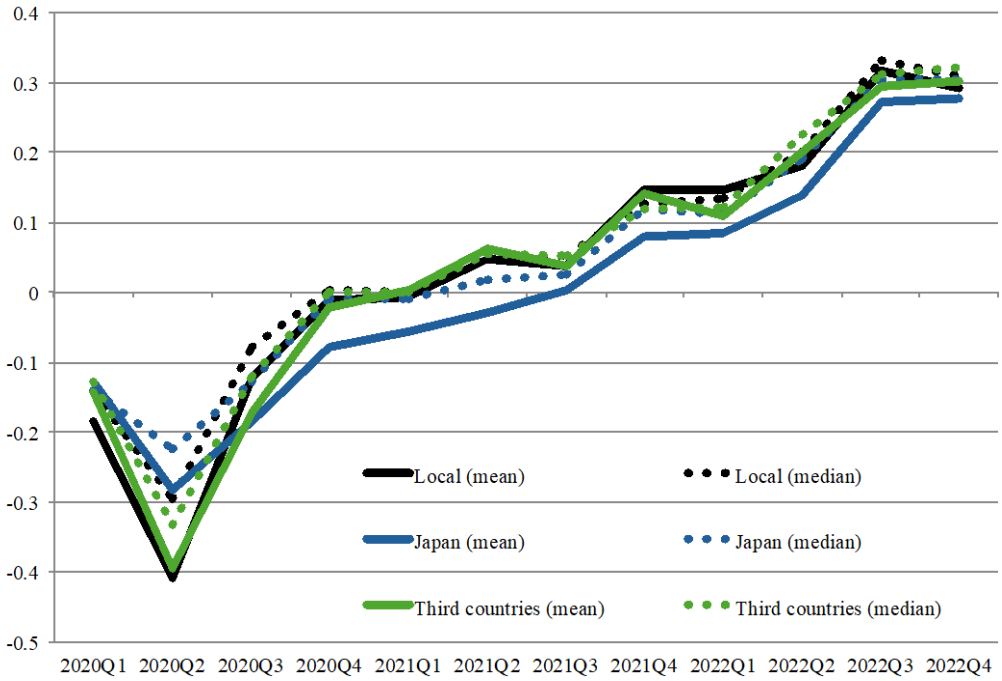
Note: Larger LCOVID indicates more restrictive local mobility restrictions.

Figure 2 Economic Activities of Japanese Overseas Manufacturing Affiliates (indexed to the same quarter of 2019)

(i) Total Sales, Employment, and Investment



(ii) Sales by Destinations: Local Sales, Exports to Japan, and Exports to Third Countries



Source: QSQS.

Appendix. Other Tables and Figures

Table A1. Shares of Country/Region for Sales/Purchases by Location of Affiliates in 2019

(i) Sales

	Country/region for sales				
Location	Local	Japan	Asia	N. America	Europe
East Asia	61.8	22.0	10.8	2.5	2.9
N. America	85.2	3.8	1.6	7.7	1.7
Europe	35.5	5.2	6.1	2.3	50.9

(ii) Purchases

	Country/region for purchases				
Location	Local	Japan	Asia	N. America	Europe
East Asia	62.9	26.2	8.9	1.2	0.7
N. America	54.3	37.8	3.1	3.5	1.3
Europe	43.1	36.1	2.4	1.2	17.2

Sources: BSOBA and QSQS.

Note: This table covers only the subset of our sample used for the analysis because figures in this table are calculated based on the data available in both databases.

Table A2. Basic Statistics

Variables	Obs	Mean	Std. dev.	Min	Max
Total sales	55,673	7.42	1.50	0.00	13.86
Local sales	50,209	6.74	1.93	0.00	13.86
Sales to Japan	32,288	5.01	2.22	0.00	11.43
Sales to third countries	33,799	5.56	2.19	0.00	12.12
Employment	56,454	5.82	1.15	0.69	10.90
Investment	31,933	3.78	1.92	0.00	11.62
LCOVID	55,673	0.56	0.21	0.06	0.91
FInpCOVID	17,814	0.52	0.16	0.06	0.91
Network	55,673	0.80	0.40	0	1
Network Low	55,673	0.61	0.49	0	1
LInput	20,952	0.65	0.32	0.00	1.00

Sources: BSOBA, GTA, OxCGRT, and QSQS.

Table A3. Basic Results by Two Groups Based on the Employment Size of Affiliates

	Dep. var.	Level	Change	Level	Change
	Indep. var.	Level	Level	Change	Change
Size		(I)	(II)	(III)	(IV)
Total sales					
	2020-2022	-0.381***	-0.385***	-0.501***	-0.450***
Large	2020	-1.125***	-0.931***	-0.678***	-0.601***
	2020Q1Q2	-1.542***	-1.378***	-0.830***	-0.744***
	2020-2022	-0.340***	-0.350***	-0.436***	-0.390***
Small	2020	-0.941***	-0.783***	-0.581***	-0.503***
	2020Q1Q2	-1.213***	-1.068***	-0.699***	-0.620***
Local sales					
	2020-2022	-0.470***	-0.495***	-0.616***	-0.550***
Large	2020	-1.440***	-1.187***	-0.836***	-0.744***
	2020Q1Q2	-1.884***	-1.707***	-1.001***	-0.913***
	2020-2022	-0.353***	-0.376***	-0.487***	-0.475***
Small	2020	-1.040***	-0.934***	-0.643***	-0.617***
	2020Q1Q2	-1.346***	-1.280***	-0.771***	-0.737***
Sales to Japan					
	2020-2022	-0.248***	-0.218***	-0.296***	-0.279***
Large	2020	-0.485***	-0.488***	-0.327***	-0.336***
	2020Q1Q2	-0.717***	-0.697***	-0.391***	-0.380***
	2020-2022	-0.144***	-0.229***	-0.209***	-0.235***
Small	2020	-0.559***	-0.575***	-0.328***	-0.276***
	2020Q1Q2	-0.713***	-0.678***	-0.420***	-0.384***
Sales to third countries					
	2020-2022	-0.208***	-0.229***	-0.296***	-0.332***
Large	2020	-0.609***	-0.663***	-0.394***	-0.463***
	2020Q1Q2	-0.872***	-1.000***	-0.474***	-0.542***
	2020-2022	-0.174**	-0.217***	-0.193***	-0.172***
Small	2020	-0.373***	-0.217***	-0.242***	-0.176***
	2020Q1Q2	-0.615***	-0.403***	-0.346***	-0.234***

Sources: OxCGRT and QSQS.

Notes: "Large" and "Small" refer to the larger half of the sample based on the number of employment and the smaller half, respectively. In all specifications, we control for affiliate fixed effects and year-quarter fixed effects. Standard errors are clustered at the affiliate level.

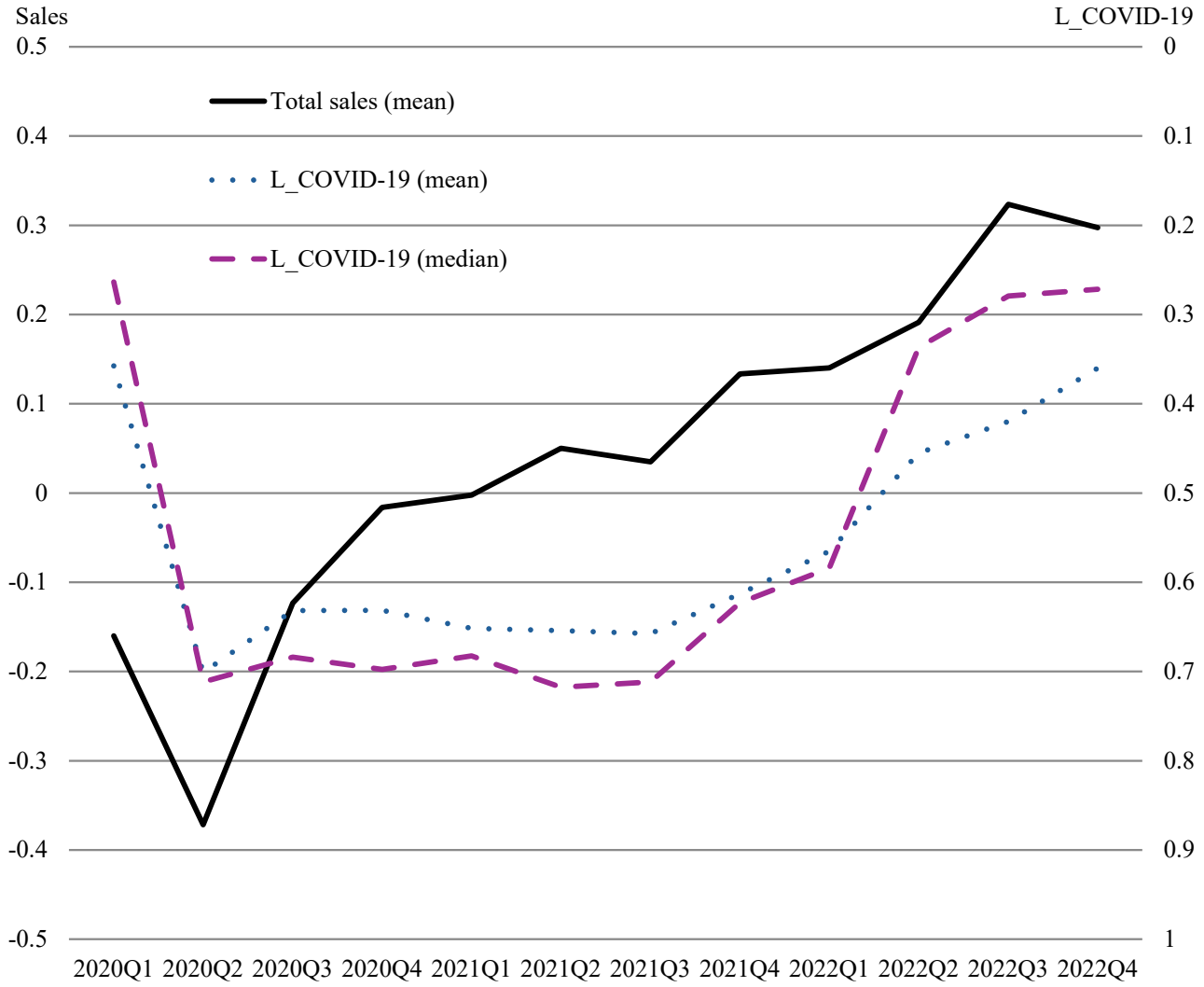
Table A4. Estimation Results of the Sales-side Version of Equation (7) for Total Sales

	2020-2022		2020		2020Q1Q2	
	(I)	(II)	(III)	(IV)	(V)	(VI)
(i) All						
LCOVID	-0.257***		-0.802***		-1.002***	
	[0.0848]		[0.294]		[0.214]	
LCOVID*LOutput	-0.131**	-0.071	-0.224	-0.190*	-0.394***	-0.336***
	[0.0631]	[0.0589]	[0.148]	[0.101]	[0.123]	[0.0856]
FOutCOVID	-0.085	-0.056	-0.202	-0.219**	-0.378**	-0.294**
	[0.0515]	[0.0486]	[0.126]	[0.100]	[0.175]	[0.117]
Network	0.169**	0.141*	-0.121	-0.152*	-0.449**	-0.434***
	[0.0749]	[0.0738]	[0.0860]	[0.0802]	[0.188]	[0.106]
LCOVID*Network	-0.0447	-0.0104	-0.197*	0.0209	-0.266*	0.0171
	[0.0536]	[0.0384]	[0.102]	[0.0638]	[0.148]	[0.0632]
LCOVID*Network Low	0.017	0.00802	0.110*	0.0136	0.168	0.0201
	[0.0406]	[0.0234]	[0.0597]	[0.0354]	[0.120]	[0.0475]
N	20,172	20,060	6,755	6,717	3,326	3,306
Adj. R-squared	0.962	0.968	0.956	0.963	0.944	0.952
(ii) East Asia						
LCOVID	-0.421***		-1.038***		-1.166***	
	[0.0722]		[0.318]		[0.271]	
LCOVID*LOutput	-0.109	-0.109	-0.348	-0.252	-0.464**	-0.398**
	[0.106]	[0.0824]	[0.207]	[0.156]	[0.177]	[0.126]
FOutCOVID	-0.276**	-0.149**	-0.506**	-0.360***	-0.691***	-0.481***
	[0.0953]	[0.0642]	[0.204]	[0.109]	[0.211]	[0.130]
Network	0.143	0.126	-0.19	-0.167	-0.509*	-0.418**
	[0.0912]	[0.0899]	[0.122]	[0.115]	[0.251]	[0.136]
LCOVID*Network	0.0163	0.0472	-0.0581	0.132***	-0.132	0.117
	[0.0576]	[0.0507]	[0.0638]	[0.0384]	[0.169]	[0.0650]
LCOVID*Network Low	0.009	-0.015	0.105	-0.016	0.186	-0.000596
	[0.0545]	[0.0231]	[0.0630]	[0.0366]	[0.156]	[0.0574]
N	15,506	15,449	5,208	5,188	2,564	2,554
Adj. R-squared	0.961	0.966	0.956	0.963	0.944	0.950
Affiliate FE	x	x	x	x	x	x
Year-quarter FE	x		x		x	
Country-year-quarter FE		x		x		x
Industry-year-quarter FE		x		x		x

Notes: Estimation results for the three periods were obtained using the OLS method. The dependent variable is the log of total sales. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered by affiliates. The upper panel (i) shows the results for all affiliates and the lower panel (ii) shows the results for affiliates in East Asia.

Sources: BSOBA, GTA, OxCGRT, and QSQS.

Figure A1 Local Mobility Restriction Measures and Total Sales by Japanese Manufacturing Affiliates in East Asia (indexed to the same quarter of 2019)

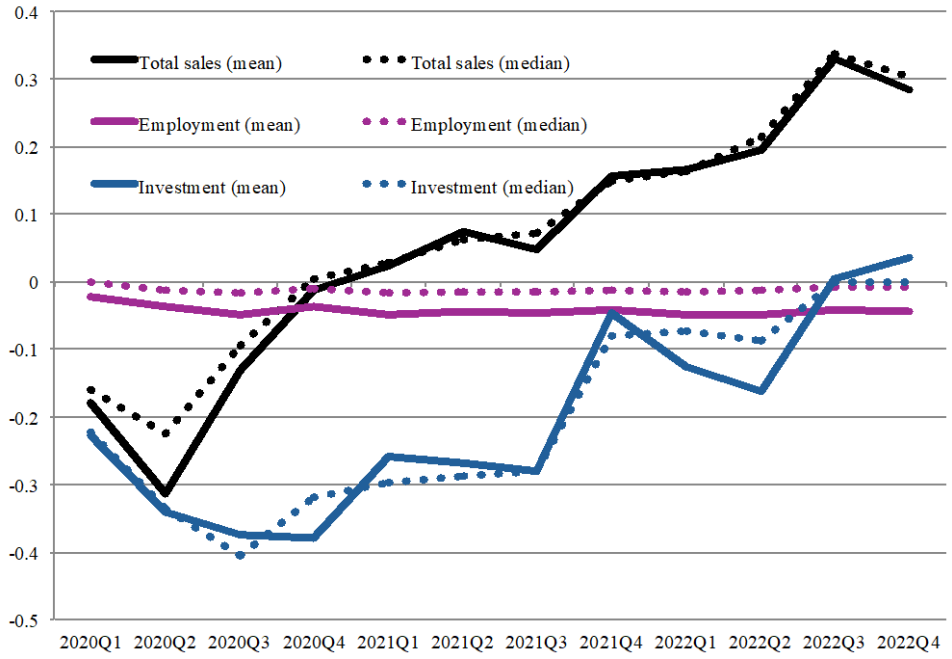


Source: OxCGRT and QSQS.

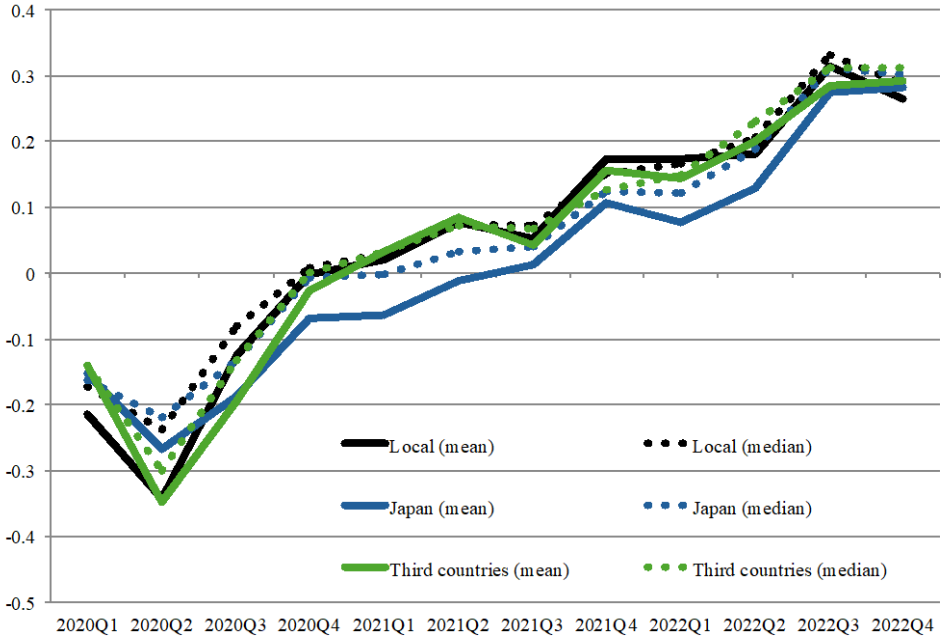
Note: Larger LCOVID indicates more restrictive local mobility restrictions.

Figure A2. Economic Activities by Japanese Manufacturing Affiliates in East Asia (indexed to the same quarter of 2019)

(i) Total Sales, Employment, and Investment



(ii) Sales by Destinations: Local Sales, Exports to Japan, and Exports to Third Countries



Source: QSQS.