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**The Impact of COVID-19 on Global Production:  
Evidence from Japanese Multinational Firms  
(Revised)**

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**The Impact of COVID-19 on Global Production:  
Evidence from Japanese Multinational Firms\***

**Hongyong ZHANG<sup>†</sup>**

**Abstract**

Using quarterly aggregate-level data on Japanese manufacturing affiliates in major host countries, this paper examines the impact of COVID-19 on global production by multinational corporations. Our findings can be summarized as follows: First, we found significantly negative impacts of COVID-19 on the performance of Japanese affiliates, especially sales in Q2 2020. Second, local sales, exports to Japan, and exports to third countries almost recovered in Q4 2020, implying the resilience of multinational production and global supply chains. Third, lockdown policies, in particular workplace closure orders for all-but-essential workplaces had significant negative effects on the sales and employment of Japanese affiliates.

**Keywords:** COVID-19; Global production; Lockdown; Multinational corporations; Foreign affiliates.

**JEL classification:** F14, F23

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## 1. Introduction

The COVID-19 pandemic has had substantial impacts on the world economy. In 2020, world real GDP fell by 3.6%, the volume of world merchandise trade declined by 5.3%, and foreign direct investment (FDI) flow dropped by 42% (Source: IMF, WTO, and UNCTAD). Supply chains have been disrupted and both supply and demand shocks have been transmitted through supply chains and propagated across borders. As Baldwin and Tomiura (2020) point out, COVID-19 is contagious economically as it is medically. To slow down the spread of the coronavirus, many countries imposed some form of restrictions on people and businesses. Since Japanese multinational corporations (MNCs) are important drivers and players in FDI and global value chains (GVCs), their overseas production and supply chains were hit hard by the COVID-19 pandemic.

**Figure 1** shows the year-on-year (y-o-y) changes in total sales (sum of local sales and exports) of Japanese manufacturing affiliates in major regions from Q1 2019 to Q4 2020.<sup>1</sup> Due to the outbreak of COVID-19 in Q1 2020, the total sales of Japanese affiliates in China declined substantially by 21.3% y-o-y. Japanese affiliates in non-China regions except newly industrialised economies (NIEs) also saw significant declines in total sales. In Q2 2020, China had a ‘V-shaped’ recovery from COVID-19. However, due to the fast spread of COVID-19 in non-China regions, on a y-o-y basis, total sales decreased sharply by 43.8% in the Association of Southeast Asian Nations (ASEAN), by 42.4% in North America, and by 48.2% in the rest of the world (ROW), respectively. In Q3 2020, sales in non-China partially recovered relative to Q2 but growth rates were still very low in Europe, North America, and especially in ASEAN (–22.2% y-o-y). In Q4 2020, most regions recovered to the pre-COVID-19 levels.

To understand the overseas business environment for Japanese affiliates, Figure 2 and Figure 3 provide an overview of COVID-19 and policy responses in the host countries and regions. **Figure**

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<sup>1</sup> Local sales, which account for about 70% of foreign affiliates’ total sales, also show a similar pattern.

2 depicts the monthly number of COVID-19 cases by region. China was at the height of the COVID-19 pandemic in February, with more than 60,000 cases in 1 month. Afterwards, owing to China's extremely restrictive measures, there was a significant decline in the number of new cases in March, and the spread of coronavirus was almost under control after Q1 2020. However, the virus spread fast around the world and COVID-19 cases increased exponentially in ASEAN, other Asian countries, Europe, North America, and the ROW in Q2-Q4 2020.

**Figure 3** shows the monthly stringency index in major regions in 2020. The stringency index measures the strictness of lockdown policies that primarily restrict people's behaviour, with larger numbers signifying stronger levels of containment. The index for China jumped from January to February and stayed at a very high level during the period. The index for ASEAN, other Asian countries, Europe, North America, and the ROW soared in February and March and remained at relatively high levels as well. The performance of Japanese foreign affiliates is likely to be heavily affected by the strong lockdown policies in the host countries.

The aim of this study is to examine the impacts of COVID-19 and lockdown policies on global production by MNCs. To that end, we use quarterly country-level data from Q1 2019 to Q4 2020. We use the numbers of COVID-19 cases and deaths as measures of the impact of COVID-19 but our results are robust to the use of the ratio of cases or deaths to total population. We find that COVID-19 had substantial negative impacts on the performance of Japanese foreign affiliates, especially sales in Q2 2020. However, local sales, exports to Japan, and exports to third countries almost recovered in Q4 2020, implying the resilience of multinational production and global supply chains. Importantly, the performance of Japanese foreign affiliates was also affected by the lockdown for COVID-19 in host countries. Workplace closure orders, which especially mandated the closure of all-but-essential workplaces (e.g., grocery stores, hospitals), had significant negative effects on sales and employment. This implies that the shutdown of factories significantly affects the supply side and global production. On the other hand, stay-at-home orders, which especially required not leaving home (with exceptions for daily exercise, grocery shopping,

and essential trips), had significant negative effects on firm investment. This suggests that declines in demand and consumption due to stay-at-home lead to a decrease in firm investment. Although there have been some simulation and empirical analyses examining the impacts of COVID-19 and lockdown on international trade and GVCs, this is the first paper to use observed data on foreign affiliates of MNCs to examine how COVID-19 and lockdown affected multinational production. As MNCs account for large shares of world output, exports, and employment (Antràs and Yeaple, 2014; UNCTAD, 2017), COVID-19 and lockdown can affect a substantial share of global economic activity.<sup>2</sup> However, the impacts of COVID-19 and lockdown policies on global production by MNCs is understudied. This study aims to fill this gap.

This study is closely related to recent studies on the impacts of COVID-19 on international trade and GVCs. Using monthly trade data, Hayakawa and Mukunoki (2021a) and Hayakawa and Mukunoki (2021b) find significantly negative effects of COVID-19 on international trade and GVCs, respectively.<sup>3</sup> Using a unique Japanese firm-level survey conducted in January 2020 that contains information on sales forecasts, Chen et al. (2021) find that the outbreak of COVID-19 in late January led to a substantial increase in firms' subjective uncertainty. This effect is especially large for Japanese firms that have direct exposure to China through supply chains and overseas production. Baldwin and Freeman (2020) argue the possibilities of manufacturing contagion and reinfection from the 'COVID concussion'. As manufacturers around the world rely on inputs from China, the industrial disruption in China hit the rest of the world via supply-chain contagion first. However, after that, the pandemic in other manufacturing giants, such as Germany and the United States (US), is likely to create a reverse effect, i.e. supply-chain reinfection.<sup>4</sup> Furthermore, based

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<sup>2</sup> Multinational affiliate sales as a share of world GDP was 50% in 2017, and MNCs employ 82 million people and account for most of the world R&D expenditure (UNCTAD, 2017).

<sup>3</sup> Hayakawa and Mukunoki (2021a) find that COVID-19 had negative effects on the trade of importing and exporting countries. With a focus on machinery products, Hayakawa and Mukunoki (2021b) find that exports of final goods decrease if an exporting country imports inputs from countries more seriously affected by COVID-19.

<sup>4</sup> As policy responses, Baldwin and Freeman (2020) argue that international coordination on containment exceptions for essential goods may reduce the chances that multiple waves of supply-chain contagion hobble global production. Furthermore, Kimura et al. (2020) argue that regional policy coordination is critical to mitigate and isolate COVID-19 shocks and note the importance

on quantitative estimations, Bonadio et al. (2020) show that the average real gross domestic product downturn due to the pandemic is expected to be  $-32.6\%$ , with one-fifth of the total due to transmission through global supply chains. However, no studies have studied the impacts of COVID-19 on global production by MNCs and the performance of their foreign affiliates.

This paper is also related to the literature on the effects of lockdown for COVID-19. Inoue and Todo (2020) simulate the propagation effects of a possible lockdown of Tokyo on the whole Japanese economy through domestic supply chains. Hayakawa and Mukunoki (2021c) find that workplace closures had significant negative effects on international trade, except for intra-Asian trade. However, stay-at-home orders did not have significant and robust effects on trade. Furthermore, Aum et al. (2020) examine the impacts of lockdown policies on employment. In contrast, this paper investigates the effects of lockdown policies on global production and the performance of foreign affiliates of MNCs.

The rest of the paper is organised as follows. Section 2 introduces the data and Section 3 presents the descriptive evidence. Section 4 presents the empirical results. Section 5 concludes.

## **2. Data and Variables**

### **2.1 Data on Japanese foreign affiliates**

To implement the analysis, we use the Quarterly Survey of Overseas Subsidiaries (QSOS) collected by the Ministry of Economy, Trade and Industry (METI), Japan. This survey covers Japanese foreign affiliates with 50 or more employees in manufacturing industries.<sup>5</sup> The QSOS data contain information on country and industry classifications, sales, acquisitions of tangible fixed assets (excluding land), and the number of employees. Importantly, a firm's total sales can

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of identifying pandemic events early to flatten the pandemic curve at the national and regional levels. They also emphasise that the stability of the GVC is critical during the pandemic.

<sup>5</sup> Specifically, this survey targets overseas affiliates of Japanese parent firms that meet all of the following criteria as of the end of the surveyed quarter: manufacturing affiliates; affiliates with 50 or more employees; and affiliates with 50% or more of their capital coming from parent firms, including both direct and indirect funds (such as funds provided via local affiliates).

be decomposed into local sales, sales (exports) to Japan, and sales (exports) to third countries (other than Japan). This allows us to investigate the impact of COVID-19 on the global production of Japanese MNCs as well as global supply chains. We use country-level and industry-level aggregate data based on the quarterly surveys in 2019–2020.<sup>6</sup> However, there are some limitations in the data. It only contains aggregated information by seven major regions and country-level information on sales, employment, and investment in 17 major countries. In the econometric analysis, we focus on 17 major countries. Appendix A reports the list of these regions and countries.

The QSOS data also has unique information on qualitative forecasts of sales, capital investment, and the number of employees. We use the Diffusion Index (DI), which captures the business confidence of Japanese foreign affiliates. In the survey, answers from the responding foreign affiliates (‘Increase, Unchanged, and Decrease’) are aggregated into the DI as follows: DI (percentage points) = percentage share of firms responding ‘Increase’ minus the percentage share of firms responding ‘Decrease’. For instance, ‘investment DI’ indicates a respondent’s judgement on the acquisition of tangible fixed assets. Foreign affiliates are asked to choose one out of the three judgments, ‘Increase’, ‘Unchanged’, and ‘Decrease’. The percentage share of the number of firms for each judgment is calculated, and the percentage share of those which replied ‘Decrease’ is subtracted from those that replied ‘Increase’.<sup>7</sup>

## 2.2 COVID-19 confirmed cases and deaths

The number of COVID-19 confirmed cases and the number of deaths are obtained from the Johns Hopkins Coronavirus Resource Center.<sup>8</sup> These data are recorded daily. We use the number of

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<sup>6</sup> The data is publicly available on the METI’s website.

<https://www.meti.go.jp/english/statistics/tyo/genntihou/index.html>

Firm-level data is not available for the time being, and we leave it as future work. In a previous study using the firm-level data of QSOS, Sun et al. (2019) find that relative to affiliates in other Asian countries, Chinese affiliates, especially those with high exposure to trade with North America, in general see a decline in sales since the US–China trade war began in March 2018.

<sup>7</sup> Unfortunately, questions on firm expectations are excluded from the survey since Q2 2020.

<sup>8</sup> <https://coronavirus.jhu.edu/map.html>

new cases and the number of new deaths in each country by the end of each quarter as measures of the impacts of the COVID-19 pandemic. As a robustness check, we also use the ratio of cases or deaths to total population, which is measured as the number of cases or deaths per 100,000 people. We obtain the data on population in 2019 from the World Development Indicators by the World Bank.<sup>9</sup> We use 2019 population figures for two reasons. First, we intend to avoid population variables from containing the impacts of COVID-19. Second, quarterly data on population is not available.<sup>10</sup>

### **2.3 Lockdown policies**

The measures of lockdown policies for COVID-19 are constructed by the Oxford Blavatnik School of Government Coronavirus Government Response Tracker (Hale et al. 2020). The Government Response Tracker (GRT) systematically records government responses to the coronavirus worldwide on 17 indicators such as workplace closures and stay-at-home.<sup>11</sup> Specifically, we use the stringency index, which records the strictness of ‘lockdown style’ policies that primarily restrict people’s behaviour. It is calculated using all ordinal containment and closure policy indicators, plus an indicator recording public information campaigns. The index ranges from 0 to 100, and a larger number reflects stronger levels of government action. These data are recorded daily. As our analysis is quarterly, we take the average value for the stringency index by country and quarter.

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<sup>9</sup> Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values are midyear estimates. Population data for Taiwan is obtained from the website of National Statistics, Republic of China (Taiwan).

<sup>10</sup> We also try 2020 population figures and the results are quantitatively similar.

<sup>11</sup> The GRT includes (1) an overall government response index, which measures how the response of governments has varied over all indicators in the database, becoming stronger or weaker over the course of the outbreak; (2) a stringency index, which measures the strictness of lockdown policies that primarily restrict people’s behaviour; (3) an economic support index, which records measures such as income support and debt relief; and (4) a containment and health index, which combines lockdown restrictions with measures such as testing policies and contact tracing, as well as investment in health care and vaccines.

<https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker>



In addition to the overall stringency index, we use two subcategory indicators, (i) workplace closing and (ii) stay-at-home requirements, to examine the possible heterogeneous effects of such policies. These indicators record daily ordinal scale of related orders and restrictions. More specifically, workplace closing includes “1 - recommend closing or recommend work from home,” “2 - require closing or work from home for some sectors or categories of workers,” and “3 - require closing or work from home for all-but-essential workplaces (e.g., grocery stores, doctors).” Similarly, stay-at-home requirements include “1 - recommend not leaving home,” “2 - require not leaving home, with exceptions for daily exercise, grocery shopping, and 'essential' trips,” and “3 - require not leaving home with minimal exceptions (e.g., allowed to leave once a week, only one person can leave at a time, etc.).” Following Hayakawa and Mukunoki (2021c), these indicators are measured as the shares of days when closings of workplaces and orders to shelter-in-place above strictness levels 1, 2, or 3 are in effect in each quarter, respectively.<sup>12</sup> For example, workplace closing above level 1 is defined as the share of days when a country orders workplace closures 1, 2, or 3. Workplace closing above level 2 is defined as the share of days when a country orders workplace closures 2 or 3, and workplace closing above level 3 is defined as the share of days when a country orders workplace closures 3. Thus, these variables range from 0 to 1. A higher level indicates a stricter workplace closure order. Similarly, we define stay-at-home requirements and orders by country and quarter.

### **3. Descriptive Evidence**

Based on the combined dataset on Japanese foreign affiliates, COVID-19 cases/deaths, and the stringency index, we document four sets of descriptive evidence: (1) supply chain disruption, (2) COVID-19 shocks and global production, (3) heterogeneous effects by industry, and (4) lockdown for COVID-19 and firm performance.

#### **3.1 Supply chain disruption**

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<sup>12</sup> Hayakawa and Mukunoki (2021c) define the degrees of workplace closure and stay-at-home at monthly level.

COVID-19 disrupted supply chains regionally and globally. **Figure 4A** shows the y-o-y changes of overseas affiliates' exports to Japan by region from Q1 2019 to Q4 2020. In Q1 2020, due to the rapid spread of COVID-19 in China, Japanese affiliates' exports from China to Japan had a substantial decrease by 17.8% y-o-y. COVID-19 shocks hit China–Japan trade hard as the supply chains of Japanese firms rely heavily on China.<sup>13</sup> On the contrary, in ASEAN, NIEs, North America, and Europe, exports to Japan increased by 0.7%, 44.5%, 7.4%, and 11.7% y-o-y, respectively. The sudden increase in NIEs, especially the Republic of Korea and Taiwan, may reflect the substitution effect as imports from China was disrupted in Q1. However, in Q2 2020, although Japanese affiliates' local sales in China recovered and increased by 6.7% y-o-y, their exports to Japan continued to see a y-o-y decrease of 12%. The situation in non-China regions such as ASEAN and Europe was even worse (about –20% y-o-y). ASEAN, which is expected to be an important alternative sourcing origin, also experienced significant decreases. The supply chains between ASEAN and Japan were in crisis as well. In Q4 2020, exports to Japan were recovering in all regions except the ROW.

Similarly, **Figure 4B** shows that Japanese manufacturing affiliates' exports to third countries fell sharply during Q1–Q2 2020. Importantly, the impact was much larger relative to exports to Japan. On average, the y-o-y changes of exports to third countries were –9.5% and –33.4% in Q1 and Q2, whilst the y-o-y changes of exports to Japan were –5.5% and –16.5% during the same period. Foreign affiliates' exports to third countries were recovering in Q3 2020 but did not return to pre-COVID-19 levels. It is also worth noting that ASEAN-based affiliates had the lowest recovery in Q3. Whilst their exports to Japan were –7.2% y-o-y in Q3, their exports to third countries were much lower, at –24.7% y-o-y. This suggests that the negative demand shock was much larger in the third countries, relative to Japan. In Q4 2020, exports to third countries almost recovered in all regions.

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<sup>13</sup> According to the QSOS data, the total sales of Japanese overseas affiliates was US\$1,129.6 billion in 2019, of which China accounted for 21%. Amongst total sales, sales (exports) to Japan were US\$100.5 billion, and China accounted for 37.5%.

### 3.2 COVID-19 shocks and global production

Next, we document the impact of COVID-19 on the performance of Japanese affiliates in major host countries. **Figure 5** shows the relationship between the number of COVID-19 cases (in logarithms) and the y-o-y changes of total sales. The plots of y-o-y changes in sales against COVID-19 cases across countries show that sales decline significantly with increases in COVID-19 cases in each quarter. In other words, COVID-19 cases are significantly negatively associated with sales of Japanese manufacturing affiliates in major countries, especially in Q2. In Q1 2020, affiliates' sales in China and Brazil sharply decreased by about 20% y-o-y, whilst sales in Taiwan and Singapore only increased. In Q2, whilst China had almost recovered from the COVID-19, the sales of Japanese affiliates dropped substantially in all other countries. India, Brazil, and Indonesia were the worst amongst them. Importantly, the fitted lines for Q1 and Q2 show that the negative correlations between COVID-19 cases and sales growth rates became significantly stronger from Q1 to Q2 2020. This suggests that the pandemic and the performance of Japanese foreign affiliates were getting worse in major countries, except China. In Q3, affiliates' sales in China continued to increase. The situation in other countries was getting better relative to Q2, but most of them still had large decreases in sales. In Q4, there are still large variations across countries, implying the differences in recovery from the pandemic.

Related to this, Figures B1-B2 in the Appendix show that the employment and investment of Japanese affiliates also had large declines in most of host countries regardless of the number of COVID-19 new cases. The correlations between the number of COVID-19 cases and employment/investment are weak, suggesting the heterogeneous effects of COVID-19 on firms' hiring and investment decisions. Regardless of the number of COVID-19 cases, lockdown policies, COVID-19-induced uncertainties, and the changes in firm expectations among others may explain such heterogeneities.

To better understand the impact of COVID-19 on Japanese affiliates, we consider firms'

judgement on business conditions. **Figure 6** shows that relative to Q1 2020, the current (Q2) DI of total sales, employment, and investment is significantly negatively correlated with the number of COVID-19 cases, respectively. Specifically, compared with Q1 (previous quarter), the business confidence of Japanese foreign affiliates in Q2 (current quarter) was getting worse very quickly in countries such as Indonesia, India, Brazil, the US, and the United Kingdom, which were hit hard by COVID-19. This is especially true in terms of investment, which is costly and irreversible relative to employment. Interestingly, since the COVID-19 pandemic was almost under control in China in April, the DI of sales and investment in China improved by approximately 10 percentage points. The investment DI in Taiwan was even higher as Taiwan has been one of the most successful regions in fighting against COVID-19.<sup>14</sup> In sum, COVID-19 had substantial impacts not only on firm performance but also on firm expectations and business plans.

### 3.3 Heterogeneous effects by industry

COVID-19 has had heterogeneous effects on production and trade by industry. **Table 1** presents the heterogeneous effects by decomposition of total sales and by industry in Q1–Q4 2020. Panels A-C present the y-o-y changes of Japanese manufacturing affiliates' local sales, exports to Japan, and exports to third countries, respectively. First, in panel A, local sales in most industries had sharp declines in Q1-Q2. Especially, compared with the manufacturing industry in total (–33.9%) in Q2, transportation equipment dropped by –40.8% y-o-y, which was the largest decline. Miscellaneous manufacturing, iron and steel, and textiles also saw significant declines.<sup>15</sup> Local sales partly recovered in Q3 and manufacturing industry in total increased by 5.7% y-o-y in Q4. Second, panel B shows that foreign affiliates' exports to Japan had a large decrease by 16.6% y-o-y in Q2. Among manufacturing industries, transportation equipment and miscellaneous manufacturing experienced the largest declines in Q2. However, electrical machinery is an exception. The relatively small negative impact of COVID-19 on electronic machinery may

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<sup>14</sup> Moreover, the next DI, i.e. business outlook on Q3 relative to Q2, shows that more Japanese foreign affiliates answered that they will not increase their investment and hiring in Q3 relative to Q2.

<sup>15</sup> Hayakawa and Mukunoki (2021a) find that the COVID-19 has negative effects on trade particularly in the textile, footwear, and plastic industries.

reflect the increasing work-from-home demand in Japan for computers and other related electronic products. Third, panel C shows that Japanese affiliates' exports to third countries fell sharply during Q1–Q3 2020 and the negative impact was much larger relative to exports to Japan. In addition to transportation equipment and miscellaneous manufacturing, the exports to third countries in textiles, ceramic, iron and steel also declined substantially in Q2–Q3.

Importantly, there are large variations across industries. Compared with nondurable consumption goods such as foods, durable goods such as cars and other transportation equipment, are more likely to be hit hard by the pandemic. This is similar to the great trade collapse during the global financial crisis (GFC) in 2008–2009. The disruption of supply chains also led to significant declines in trade in capital goods such as general machinery, which rely heavily on international production, and intermediate inputs for production such as iron and steel.

### **3.4 Lockdown for COVID-19 and firm performance**

To prevent the spread of COVID-19, many countries imposed citywide or nationwide lockdowns. These policies are expected to affect the activities of both domestic firms and foreign firms. **Figure 7** shows the correlations between the stringency index and the y-o-y changes of Japanese foreign affiliates' total sales in major countries. It is obvious that the index shifts significantly to the right in Q2–Q4, suggesting that lockdown policies became very strong in all countries in Q2–Q4 relative to Q1 2020. The stronger lockdown policies are significantly negatively associated with declines in total sales, especially in Q2. This is quite similar to the effects of COVID-19 on firm performance shown in Figures 5.

## **4. Empirical Analysis**

### **4.1 Specifications**

Our empirical specifications explore the across-country variations in COVID-19 cases and deaths and lockdown policies. The number of countries is 17 and the sample period is Q1 2019–Q4 2020. First, we estimate the impact of the COVID-19 on firm performance as follows:

$$Y_{ct} = \alpha_0 + \alpha_1 COVID_{ct} + FE_c + FE_q + FE_t + \varepsilon_{ct} \quad (1)$$

where  $Y_{ct}$  is the logarithm of total sales, number of employees, and capital investment of Japanese foreign affiliates in country  $c$  and time  $t$ .<sup>16</sup>  $COVID_{ct}$  is the logarithm of the number of COVID-19 cases or the number of deaths, which measures the impacts of COVID-19 pandemic in country  $c$  and time  $t$ . The numbers of cases and deaths are set to zero for Q1–Q4 2019. We control for country fixed effects  $FE_c$  to eliminate the time-invariant differences across countries. We also include quarter fixed effects  $FE_q$  and time (i.e., year-quarter) fixed effects  $FE_t$  to control for seasonality and various macroeconomic shocks. Note that  $FE_q$  and  $FE_t$  are separately included into the estimations as quarter fixed effects will be dropped automatically (due to short sample period) if we further control for time fixed effects.

Second, to estimate the effects of lockdown policies on the firm performance of Japanese affiliates, we run the regressions as follows:

$$Y_{ct} = \beta_0 + \beta_1 Lockdown_{ct} + FE_c + FE_q + FE_t + \varepsilon_{ct} \quad (2)$$

where  $Lockdown_{ct}$  measures the country-specific lockdown policies for the COVID-19 pandemic, including the overall stringency index and two subcategory indicators, i.e., workplace closing and stay-at-home requirements.<sup>17</sup> As defined previously, these two indicators are measured as the shares of days in each quarter when workplace closure orders and shelter-in-place orders above strictness levels 1, 2, or 3 are in effect, respectively. The stringency index and two subcategory indicators are set to zero for Q1–Q4 2019.

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<sup>16</sup> The aggregate-level data of QSOS publicly available at the METI's website contains country-level information on total sales, number of employees, and capital investment in 17 countries only. In addition, the information on exports to Japan and exports to third countries is available by major region (China, ASEAN, NIEs, North America, etc.), not by country, so it is not possible to estimate the impacts of the demand shock in destination countries.

<sup>17</sup> Note that the Oxford COVID-19 GRT points out that 'government responses vary significantly from one country to another, and like any policy interventions, their effect is highly contingent on the local political and social context. COVID-19 government response indices, like all aggregate indices which combine different indicators into a general index, should not be interpreted as measuring the appropriateness or effectiveness of a country's response.' Thus, it is not easy to estimate the impact of such policies and evaluate which COVID-19 policy is effective or not.

The coefficients of interest are  $\alpha_1$  and  $\beta_1$ . We expect  $\alpha_1$  and  $\beta_1$  are negative. Using the combined datasets, we estimate  $\alpha_1$  and  $\beta_1$  in equations (1) and (2). The summary statistics of the variables used in the estimation are reported in Tables B1 in the Appendix.

## 4.2 Empirical results

### 4.2.1 Impact of COVID-19 on Firm Performance

**Table 2** reports the estimation results of equation (1). Panel A presents the results using the number of COVID-19 cases and panel B presents the results using the number of deaths. We control for quarter fixed effects in columns (1)–(3) and year-quarter (time) fixed effects in columns (4)–(6), respectively.

Columns (1)–(3) of panel A show that COVID-19 has statistically significant negative impacts on the sales, employment, and investment of Japanese manufacturing affiliates in host countries. Specifically, a 100% increase in the number of COVID-19 cases decreases sales by 1.7%, employment by 0.3%, and investment by 2.2%, respectively. The magnitude of the negative impact is not small because the number of new confirmed COVID-19 cases in these 17 host countries increased from 0.46 million in Q1 2020 to 27.41 million in Q4 2020, which is approximately 5852%. These are our main results.

In columns (4)–(6) of panel A, controlling for time fixed effects, the coefficient remains significantly negative for sales but the coefficients for employment and investment are not significant. Note that it does not mean that COVID-19 had no negative impacts on employment and investment. As shown in Figures B1-B2 in the Appendix, both employment and investment of Japanese affiliates did have large declines in most of host counties due to the pandemic but it is regardless of the number of COVID-19 cases. For example, although the sales in China have recovered from Q2, the employment in China are always around  $-5\%$  y-o-y during Q1-Q4 2020. Another possible explanation is that as our estimations rely on aggregated data on 17 countries with non-zero COVID-19 in 4 quarters only, the effects of COVID-19 variables are partly

absorbed by time fixed effects.<sup>18</sup> In panel B of Table 2, we use the number of deaths and the results are qualitatively similar to those in panel A.

There are potential concerns that countries with larger population tend to have larger numbers of COVID-19 cases and deaths, which may affect our estimation results. To address these potential concerns, we conduct a robustness check using the ratio of cases or deaths to total population. As shown in **Table B2** in the Appendix, the results are similar to our main results.

Given that the pandemic is spreading around the world over time, the effects of COVID-19 on firm performance may differ by quarter. To examine this difference, we interact the number of cases (deaths) with quarter dummy variables and set Q1 2020 as the base quarter. The results are presented in **Table 3**. First, in column (1) in panel A, the coefficients of COVID-19 cases and its interaction terms with Q2 dummy are significantly negative for sales, implying a significant increase in the negative effects on Japanese foreign affiliates in Q2 2020. However, the interaction terms with dummy variables on Q3 is not significant and on Q4 has significantly positive coefficient, indicating a decline in the negative effects on sales after Q2.<sup>19</sup> Second, in the case of employment, the interaction terms with dummy variables on Q2 and Q3 in column (2) in panel A have significantly negative coefficients, indicating the rise in the number of COVID-19 cases led to declines in employment in Q2–Q3. However, the negative effect is not significant in Q4. Third, in the case of investment, in column (3) in panel A, the coefficient for non-interacted cases is estimated to be significantly negative but all interaction terms are not statistically significant. We take these results as our main results of this table.

In columns (4)–(6) in panel A, controlling for time fixed effects, the coefficients remain similar

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<sup>18</sup> Using monthly country-product level trade data, previous studies such as Hayakawa and Mukunoki (2021a,b,c) have more variations across countries, products, and times.

<sup>19</sup> This result is consistent with Hayakawa and Mukunoki (2021a), who found the negative effects of COVID-19 on the international trade tended to become insignificant since July 2020. The harmful impacts of COVID-19 on trade were accommodated after the first wave of the pandemic to some extent.



for sales but the coefficients for employment and investment become insignificant. Again, this does not mean that firm employment and investment were not affected by the pandemic. As shown in Figures B1-B2 in the Appendix, both employment and investment of Japanese affiliates did have large declines in 2020 and it seems that Japanese manufacturing affiliates reduced their local employment and investment even in counties with fewer COVID-19 cases. In addition, repeatedly, as our estimations rely on highly aggregated data, the significance of estimated coefficients are partly absorbed by time fixed effects. Therefore, we prefer the results in columns (1)-(3) in panel A. In panel B, we further use the number of deaths and the results are quantitatively similar to those in panel A.

In summary, we find that the COVID-19 has significantly negative impacts on the performance of Japanese foreign affiliates, especially for sales in Q2 2020. However, the negative effects on sales have been insignificant since Q3 2020. This implies the the resilience of multinational production by foreign affiliates of MNCs.

#### **4.2.2 Impact of Lockdown on Firm Performance**

**Table 4** presents the estimation results for equation (2), using the stringency index. In columns (1)-(3), the coefficients of the stringency index are significantly negative, indicating that the strict lockdown policies primarily restrict people's movement decrease the sales, employment, and investment of Japanese foreign affiliates. Note that the dependent variables are in logarithm while the stringency indices are in levels in equation (2). Therefore, all the estimated coefficients are multiplied by 100 in order to better interpret the results. Based on the estimates in columns (1)-(3), one unit increase in stringency index decreases sales by 0.35%, employment by 0.05%, and investment by 0.41%, respectively. Therefore, a complete lockdown (i.e., the stringency index equals 100) approximately decreases sales by 35%, employment by 5%, and investment by 41%, respectively. In columns (4)-(6), controlling for time fixed effects, the coefficients remain significantly negative for sales and employment but the coefficient for investment is not significant.

In **Table 5**, we use workplace closing and stay-at-home orders to examine the heterogeneous effects by different lockdown policies. Panel A, panel B, and panel C report the results based on lockdown policies above level 3, level 2, and level 1, respectively. Level indicates the strictness of the indicator variables. In panel A, the results show that the coefficients of workplace closing are significantly negative in columns (1)-(2) and (4)-(5). Thus, the workplace closing orders above level 3, i.e., “3 - require closing or work from home for all-but-essential workplaces”, resulted in significant decreases in sales and employment. This implies that workplace closure orders lead to a stop of production activities and decreases in sales and employment. As for investment, the coefficient of workplace closing is not significant in column (3) but it is positive and statistically significant in column (6). One possible explanation is that under level 3 of workplace closure order, Japanese affiliates attempted to sustain economic activity by introducing telecommuting equipment and systems, although it is very hard for manufacturing activities.<sup>20</sup> On the other hand, the coefficients of stay-at-home are significantly negative in columns (3) and (6). The stay-at-home orders above level 3, i.e., “3 - require not leaving home with minimal exceptions”, resulted in significant decrease in firm investment. This implies that decreases in consumption due to stay-at-home orders lead to downward shifts in demand, which further decrease firm investment. Furthermore, compared with stay-at-home orders, the negative effects of workplace closing orders on sales and employment were larger and statistically significant.<sup>21</sup> Above are our main results of this table.

In panel B and panel C, we use workplace closing and stay-at-home orders above level 2 and level 1, respectively. In columns (1)-(3) of panels B-C, the coefficients of workplace closing are significantly negative while the coefficients of stay-at-home are not robust. It is worth noting that stay-at-home orders above levels 1 and 2 had some negative effects on sales and employment,

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<sup>20</sup> Dingel and Neiman (2020) estimate that about 22 percent of jobs in manufacturing sectors can be done at home in the United States.

<sup>21</sup> This result is consistent with Hayakawa and Mukunoki (2021c), who found that workplace closures, rather than stay-at-home, had significant negative effects on international trade.

respectively. However, compared with workplace closing orders above level 3, stay-at-home orders at lower levels had smaller negative effects. In columns (4)-(6) of panels B-C, controlling for time fixed effects, the effects of workplace closing and stay-at-home orders at lower levels are insignificant in many columns. One possible explanation is that once the lockdown policies at lower levels were introduced, they tended to be maintained in many countries regardless the number of COVID-19 new cases. Therefore, time fixed effects may capture the effects of such time-invariant policies.

## **5. Concluding Remarks**

Using aggregate-level data on Japanese manufacturing affiliates in major countries and regions, we examine the impact of COVID-19 on global production by MNCs. Not surprisingly, COVID-19 had large negative impacts on the global production and performance of Japanese foreign affiliates, especially in Q2 2020. However, local sales, exports to Japan, and exports to third countries almost recovered in Q4 2020, implying the resilience of multinational production and global supply chains. Furthermore, we find that lockdown policies are negatively associated with firm performance, especially for sales and employment.

The ongoing COVID-19 pandemic will likely transform global production. UNCTAD (2020) argues that reshoring, diversification, and regionalisation will drive the restructuring of GVCs in the coming years. Our findings provide some evidence-based policy implications for global production and the re-evaluation of supply chain strategy in the post-COVID era. To reduce the reliance on supply chains in China, in April 2020, the Japanese government approved a fiscal stimulus package including ¥220 billion (US\$2 billion) for manufacturing firms to move production home and ¥23.5 billion (\$0.2 billion) to move it to ASEAN countries. However, China has brought the spread of COVID-19 under control, and the supply chains and economic activities have recovered since Q2 2020. On the other hand, Japan, ASEAN, and the ROW were hit hard by the pandemic at the same time. As shown in Bonadio et al. (2020), the renationalisation of global supply chains does not make countries more resilient to pandemic-induced contractions in

the labor supply. Therefore, it is geographical diversification in sourcing and sales, not the reallocation of production and supply chains, that makes firms and the economy more resilient to supply chain disruptions and disasters. For example, it is estimated that the 2003 SARS epidemic reduced Chinese firm imports by 8% on average, but it was as much as 56% for firms without any diversification (Huang, 2019). Resilience in global supply chains can be increased through building buffer stocks and making standardised inputs easier to be replaced, identifying places and suppliers less subjective to risk, and assessing the time to recover for each type of supplier (Miroudot, 2020). Policies in the future should support business efforts to build more robust and resilient supply chains.

Finally, as this study uses aggregate-level data, there are many limitations to the analysis. When micro-level data is available, it will be interesting to investigate how did Japanese MNCs adjust their global production and whether they reorganise their global supply chains. To separate and estimate the supply shock and demand shock on global production is also challenging. We leave these research questions as future work.

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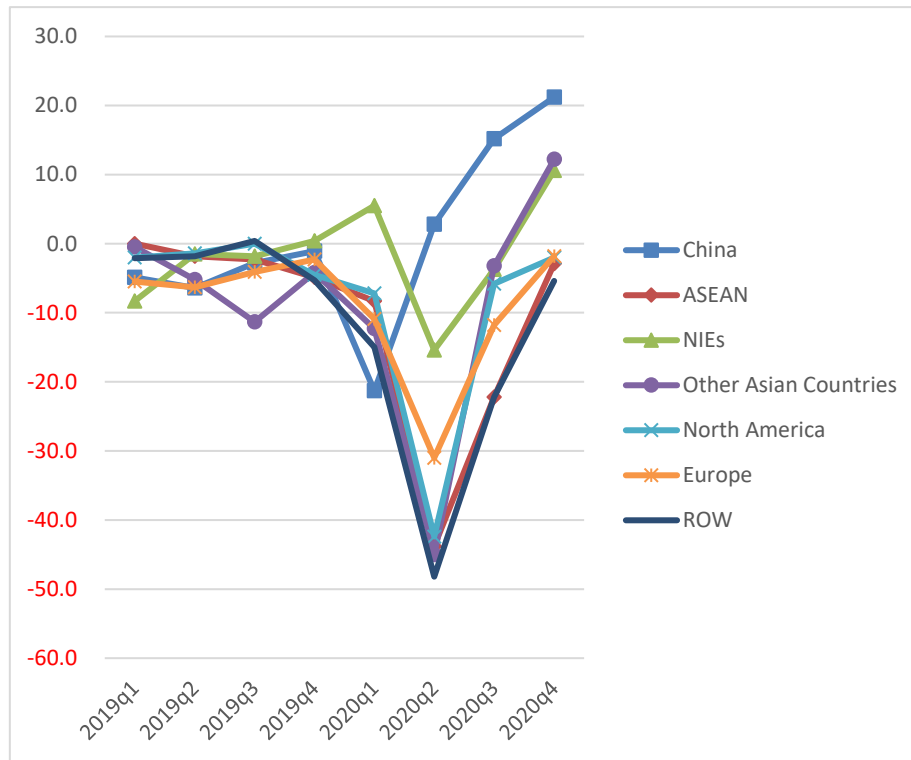
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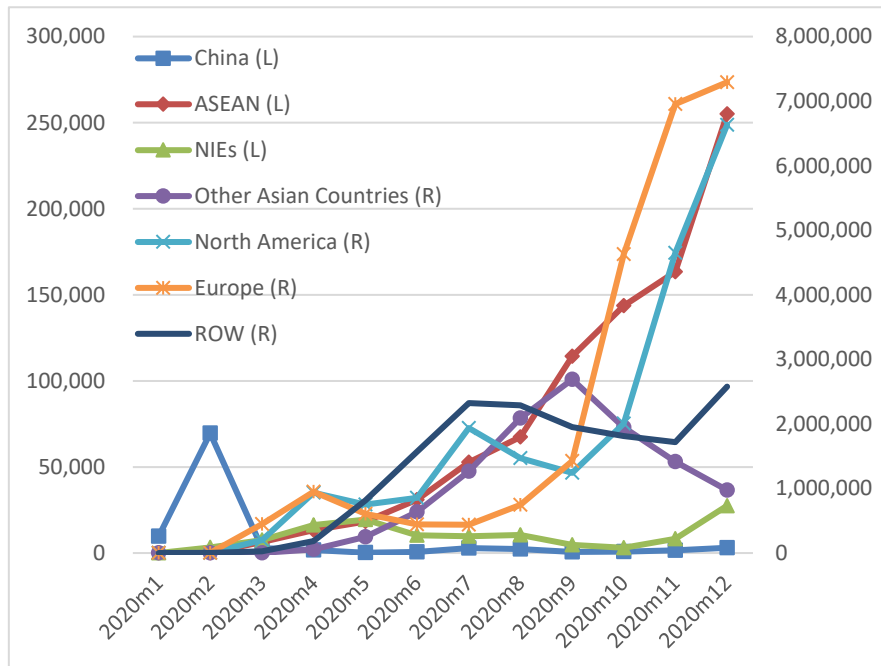
## Figures and Tables

**Figure 1. Industrial Disruption and Recovery: Total Sales by Region (% , y-o-y)**



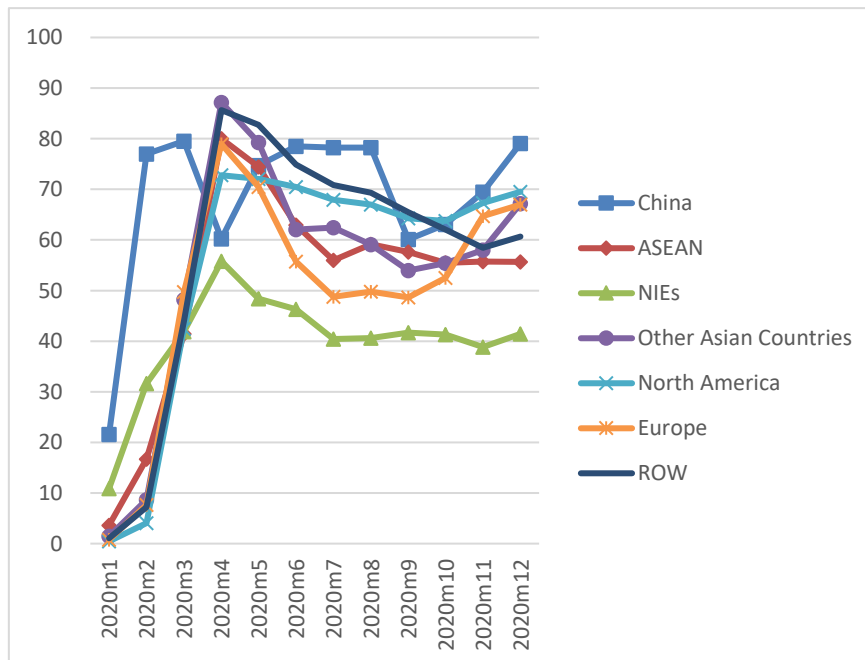
Source: Author's own compilation based on the Quarterly Survey of Overseas Subsidiaries (QSOS), Ministry of Economy, Trade and Industry (METI).

**Figure 2. Number of COVID-19 Cases by Region**



Source: Author's own compilation based on data from the Johns Hopkins Coronavirus Resource Center.

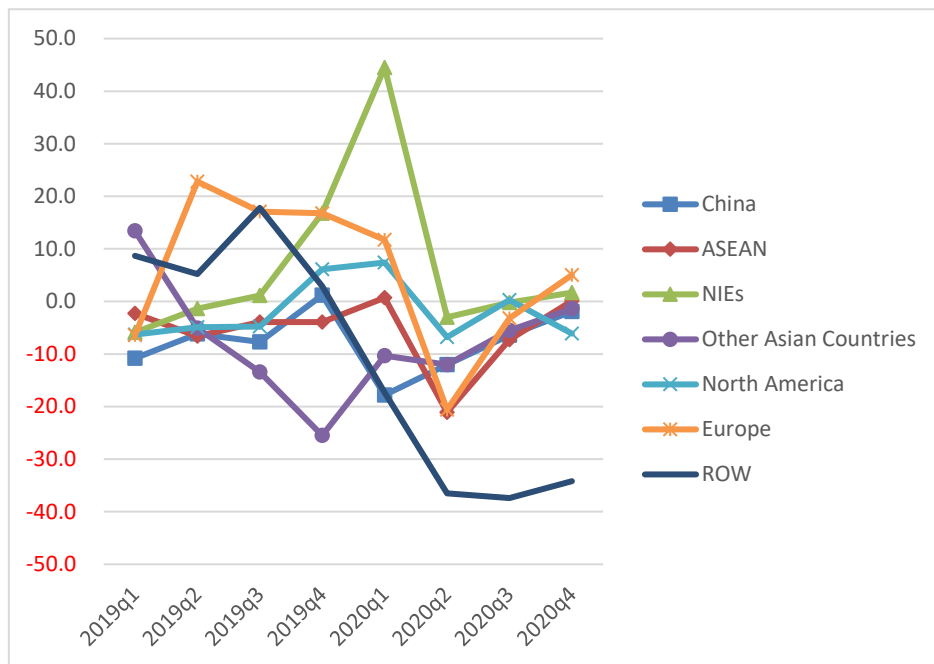
**Figure 3. Stringency Index by Region**



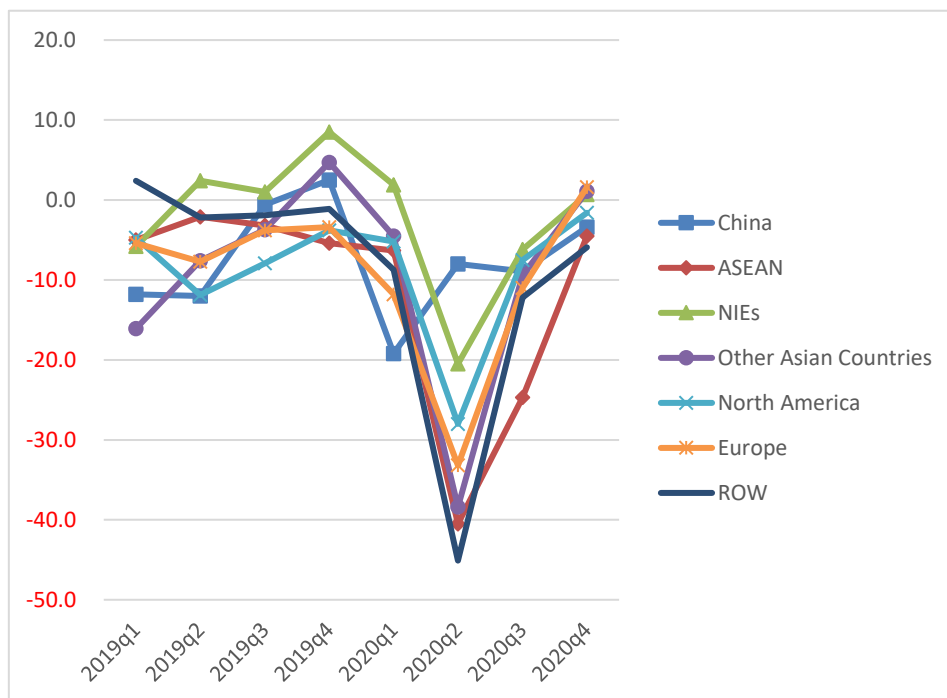
Source: Author's own compilation based on data from the Oxford COVID-19 Government Response Tracker.



**Figure 4A. Exports to Japan (% , y-o-y)**

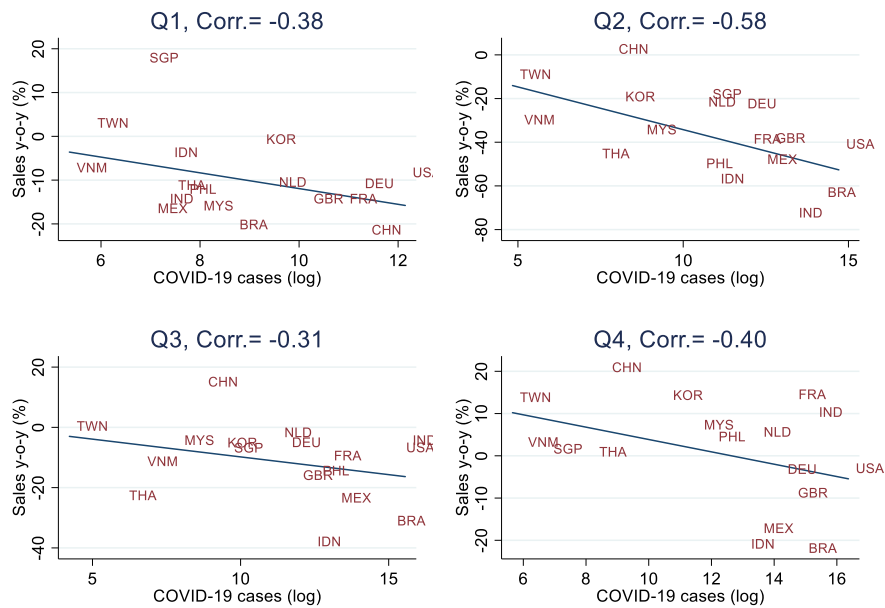


**Figure 4B. Exports to Third Countries (% , y-o-y)**



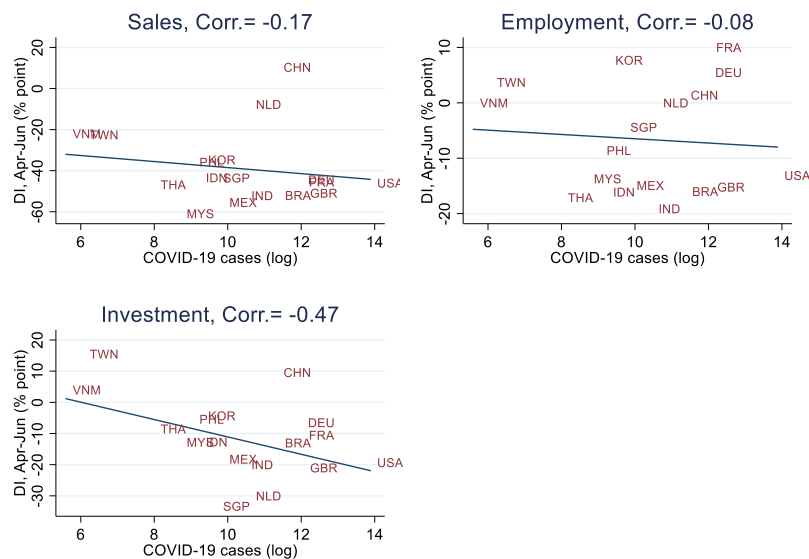
Source: Author's own compilation based on the QSOS, METI.

**Figure 5. COVID-19 and Global Production: Sales**



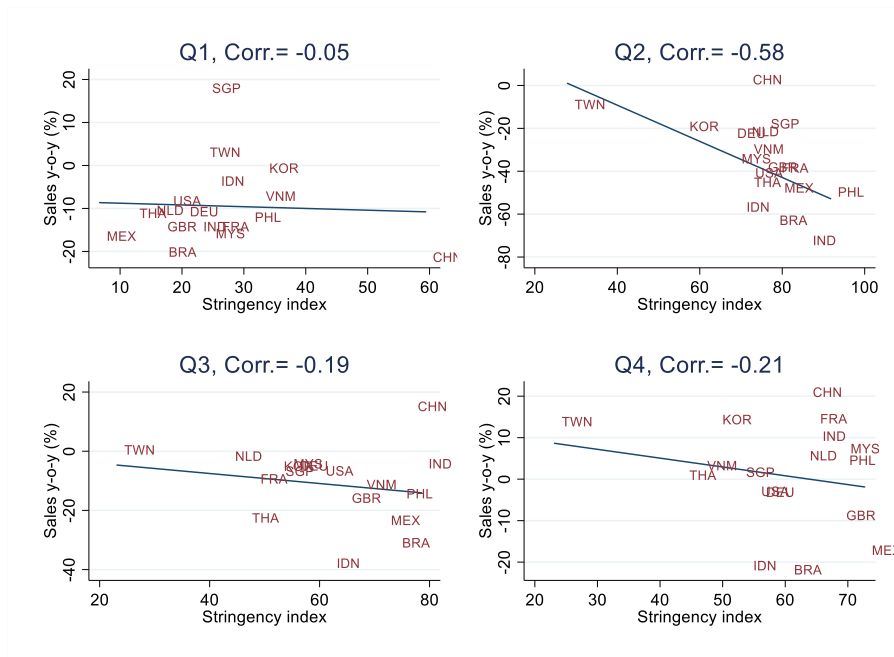
Source: Author's own compilation based on data from the QSOS, METI, and Johns Hopkins Coronavirus Resource Center.

**Figure 6. COVID-19 and Firm Expectations**



Source: Author's own compilation based on data from the QSOS, METI, and Johns Hopkins Coronavirus Resource Center.

**Figure 7. Lockdown Policies and Firm Performance**



Source: Author's own compilation based on data from the QSOS, METI, and Oxford COVID-19 Government Response Tracker.

**Table 1. Heterogeneous Effects by Industry (% , y-o-y)**

| <b>Panel A. Local Sales</b>                                 | Q1           | Q2           | Q3           | Q4          |
|---|--------------|--------------|--------------|-------------|
| <u>Manufacturing industry in total</u>                      | <u>-12.6</u> | <u>-33.9</u> | <u>-4.8</u>  | <u>5.7</u>  |
| Food and tobacco  | 1.7          | -9.3         | -1.3         | -0.6        |
| Textiles  | -14.8        | -28.9        | -12.8        | 0.8         |
| Lumber, pulp, paper and paper products                      | -3.3         | -0.1         | 9.5          | 12.8        |
| Chemicals   | -3.2         | -17.5        | -7.3         | 6.9         |
| Ceramic, stone and clay products                            | -20.0        | -26.9        | -3.5         | 3.9         |
| Iron and steel  | -14.1        | -30.2        | -11.3        | 6.1         |
| Non-ferrous metals  | -0.3         | -25.7        | -12.6        | 20.3        |
| Fabricated metal products                                   | -9.7         | -26.9        | -33.9        | 8.2         |
| General-purpose, production and business oriented machinery | -8.8         | -13.7        | -2.9         | 4.0         |
| Electrical machinery  | -12.8        | -23.9        | -5.1         | 6.4         |
| Transportation equipment                                    | -14.6        | -40.8        | -4.1         | 6.3         |
| Miscellaneous manufacturing                                 | -12.4        | -32.5        | -6.5         | -2.7        |
| <b>Panel B. Exports to Japan</b>                            | Q1           | Q2           | Q3           | Q4          |
| <u>Manufacturing industry in total</u>                      | <u>-5.5</u>  | <u>-16.6</u> | <u>-6.8</u>  | <u>-1.4</u> |
| Food and tobacco  | 2.9          | -8.4         | -2.3         | -0.8        |
| Textiles  | -15.7        | -20.6        | -20.8        | -12.3       |
| Lumber, pulp, paper and paper products                      | -4.0         | -10.5        | -20.8        | -10.4       |
| Chemicals   | 3.5          | -11.0        | -9.4         | 3.0         |
| Ceramic, stone and clay products                            | -19.8        | -24.1        | -16.1        | 12.3        |
| Iron and steel  | -23.6        | -27.4        | -21.8        | -5.1        |
| Non-ferrous metals  | -1.0         | -0.3         | 0.0          | -2.6        |
| Fabricated metal products                                   | -15.3        | -20.6        | -21.3        | -7.7        |
| General-purpose, production and business oriented machinery | -17.5        | -23.0        | -12.4        | -5.0        |
| Electrical machinery  | 5.4          | -7.5         | 3.0          | 1.6         |
| Transportation equipment                                    | -18.1        | -34.2        | -24.4        | -2.2        |
| Miscellaneous manufacturing                                 | -16.3        | -37.0        | -15.7        | -12.6       |
| <b>Panel C. Exports to Third Countries</b>                  | Q1           | Q2           | Q3           | Q4          |
| <u>Manufacturing industry in total</u>                      | <u>-9.4</u>  | <u>-34.4</u> | <u>-15.1</u> | <u>-1.5</u> |
| Food and tobacco  | -8.5         | -8.9         | 0.9          | 4.7         |
| Textiles  | -19.9        | -39.3        | -28.2        | -16.1       |
| Lumber, pulp, paper and paper products                      | -16.6        | 0.7          | -10.4        | 4.0         |
| Chemicals   | -12.4        | -18.2        | -6.6         | 7.9         |
| Ceramic, stone and clay products                            | -4.9         | -33.5        | -1.0         | 15.8        |
| Iron and steel  | -6.9         | -39.5        | -31.0        | -11.1       |
| Non-ferrous metals  | -20.6        | -16.8        | 10.8         | 6.4         |
| Fabricated metal products                                   | -10.7        | -26.8        | 65.4         | -32.9       |
| General-purpose, production and business oriented machinery | -1.8         | -17.6        | -11.8        | -6.3        |
| Electrical machinery  | -12.7        | -26.9        | -14.6        | -2.4        |
| Transportation equipment                                    | -9.2         | -49.0        | -22.3        | -2.2        |
| Miscellaneous manufacturing                                 | -9.4         | -34.2        | -14.1        | -2.3        |

Source: Author's own compilation based on the QSOS, METI.

**Table 2. Impact of COVID-19 on Firm Performance**

|                       | (1)                  | (2)                  | (3)                  | (4)                      | (5)               | (6)              |
|-----------------------|----------------------|----------------------|----------------------|--------------------------|-------------------|------------------|
|                       | logsales             | logemp               | loginv               | logsales                 | logemp            | loginv           |
| <b>Panel A:</b>       |                      |                      |                      |                          |                   |                  |
| COVID-19 cases (log)  | -0.017***<br>[0.003] | -0.003***<br>[0.000] | -0.022***<br>[0.004] | -0.028***<br>[0.007]     | -0.002<br>[0.001] | 0.002<br>[0.015] |
| Fixed effects         | Country and Quarter  |                      |                      | Country and Year-Quarter |                   |                  |
| R-sq                  | 0.979                | 1.000                | 0.936                | 0.988                    | 1.000             | 0.940            |
| <b>Panel B:</b>       |                      |                      |                      |                          |                   |                  |
| COVID-19 deaths (log) | -0.026***<br>[0.004] | -0.004***<br>[0.001] | -0.028***<br>[0.006] | -0.021***<br>[0.005]     | -0.001<br>[0.001] | 0.010<br>[0.015] |
| Fixed effects         | Country and Quarter  |                      |                      | Country and Year-Quarter |                   |                  |
| R-sq                  | 0.980                | 0.999                | 0.932                | 0.988                    | 1.000             | 0.941            |

Note: The number of countries is 17 and the number of observations is 136. The sample period is Q1 2019–Q4 2020. Robust standard errors are in brackets. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 3. Impact of COVID-19 by Quarter**

|                       | (1)                  | (2)                 | (3)                | (4)                      | (5)               | (6)               |
|-----------------------|----------------------|---------------------|--------------------|--------------------------|-------------------|-------------------|
|                       | logsales             | logemp              | loginv             | logsales                 | logemp            | loginv            |
| <b>Panel A:</b>       |                      |                     |                    |                          |                   |                   |
| COVID-19 cases (log)  | -0.012***<br>[0.004] | -0.001<br>[0.001]   | -0.019*<br>[0.010] | -0.025*<br>[0.013]       | -0.002<br>[0.002] | 0.006<br>[0.033]  |
| *Dummy (2020Q2=1)     | -0.034***<br>[0.007] | -0.003**<br>[0.001] | -0.017<br>[0.013]  | -0.035*<br>[0.021]       | -0.003<br>[0.003] | 0.012<br>[0.043]  |
| *Dummy (2020Q3=1)     | 0.001<br>[0.005]     | -0.003**<br>[0.001] | 0.000<br>[0.013]   | 0.010<br>[0.014]         | 0.001<br>[0.002]  | -0.001<br>[0.040] |
| *Dummy (2020Q4=1)     | 0.011**<br>[0.005]   | -0.001<br>[0.001]   | 0.002<br>[0.012]   | 0.005<br>[0.013]         | 0.003<br>[0.002]  | -0.018<br>[0.042] |
| Fixed effects         | Country and Quarter  |                     |                    | Country and Year-Quarter |                   |                   |
| R-sq                  | 0.989                | 1.000               | 0.938              | 0.989                    | 1.000             | 0.941             |
| <b>Panel B:</b>       |                      |                     |                    |                          |                   |                   |
| COVID-19 deaths (log) | -0.024***<br>[0.006] | -0.001<br>[0.001]   | -0.028*<br>[0.017] | -0.020*<br>[0.011]       | -0.001<br>[0.002] | -0.004<br>[0.035] |
| *Dummy (2020Q2=1)     | -0.034***<br>[0.010] | -0.004**<br>[0.002] | -0.013<br>[0.019]  | -0.021<br>[0.016]        | -0.002<br>[0.002] | 0.023<br>[0.040]  |
| *Dummy (2020Q3=1)     | 0.006<br>[0.007]     | -0.004**<br>[0.002] | 0.014<br>[0.022]   | 0.007<br>[0.012]         | 0.000<br>[0.002]  | 0.033<br>[0.043]  |
| *Dummy (2020Q4=1)     | 0.014***<br>[0.004]  | -0.002<br>[0.001]   | 0.002<br>[0.013]   | 0.005<br>[0.014]         | 0.002<br>[0.002]  | -0.004<br>[0.049] |
| Fixed effects         | Country and Quarter  |                     |                    | Country and Year-Quarter |                   |                   |
| R-sq                  | 0.988                | 1.000               | 0.933              | 0.988                    | 1.000             | 0.942             |

Note: The number of countries is 17 and the number of observations is 136. The sample period is Q1 2019–Q4 2020. Robust standard errors are in brackets. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 4. Impact of Lockdown on Firm Performance**

|                  | (1)                 | (2)       | (3)       | (4)                      | (5)      | (6)     |
|------------------|---------------------|-----------|-----------|--------------------------|----------|---------|
|                  | logsales            | logemp    | loginv    | logsales                 | logemp   | loginv  |
| Stringency index | -0.339***           | -0.051*** | -0.405*** | -0.566***                | -0.056** | 0.399   |
|                  | [0.055]             | [0.008]   | [0.075]   | [0.166]                  | [0.026]  | [0.401] |
| Fixed effects    | Country and Quarter |           |           | Country and Year-Quarter |          |         |
| R-sq             | 0.981               | 1.000     | 0.936     | 0.988                    | 1.000    | 0.941   |

Note: The number of countries is 17 and the number of observations is 136. The sample period is Q1 2019–Q4 2020. Robust standard errors are in brackets. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% levels, respectively.

**Table 5. Impact of Lockdown on Firm Performance by Policy Category**

|  | (1)                  | (2)                  | (3)                  | (4)                      | (5)                  | (6)                |
|--|----------------------|----------------------|----------------------|--------------------------|----------------------|--------------------|
|  | logsales             | logemp               | loginv               | logsales                 | logemp               | loginv             |
| <b>Panel A: Level<math>\geq 3</math></b> |                      |                      |                      |                          |                      |                    |
| Workplace closing                        | -0.431***<br>[0.102] | -0.062***<br>[0.012] | -0.177<br>[0.116]    | -0.217**<br>[0.084]      | -0.039***<br>[0.015] | 0.263*<br>[0.149]  |
| Stay-at-home                             | -0.008<br>[0.266]    | -0.013<br>[0.030]    | -0.476***<br>[0.179] | 0.100<br>[0.220]         | -0.006<br>[0.029]    | -0.296*<br>[0.154] |
| Fixed effects                            | Country and Quarter  |                      |                      | Country and Year-Quarter |                      |                    |
| R-sq                                     | 0.980                | 1.000                | 0.927                | 0.987                    | 1.000                | 0.942              |
| <b>Panel B: Level<math>\geq 2</math></b> |                      |                      |                      |                          |                      |                    |
| Workplace closing                        | -0.157***<br>[0.039] | -0.020**<br>[0.008]  | -0.314***<br>[0.088] | -0.088<br>[0.074]        | 0.008<br>[0.012]     | 0.007<br>[0.189]   |
| Stay-at-home                             | -0.107<br>[0.079]    | -0.024*<br>[0.013]   | 0.064<br>[0.133]     | -0.093<br>[0.065]        | -0.026*<br>[0.013]   | 0.077<br>[0.138]   |
| Fixed effects                            | Country and Quarter  |                      |                      | Country and Year-Quarter |                      |                    |
| R-sq                                     | 0.979                | 1.000                | 0.934                | 0.987                    | 1.000                | 0.941              |
| <b>Panel C: Level<math>\geq 1</math></b> |                      |                      |                      |                          |                      |                    |
| Workplace closing                        | -0.115**<br>[0.052]  | -0.031***<br>[0.011] | -0.218**<br>[0.093]  | -0.150<br>[0.109]        | -0.013<br>[0.013]    | 0.056<br>[0.304]   |
| Stay-at-home                             | -0.110*<br>[0.059]   | -0.003<br>[0.012]    | -0.076<br>[0.108]    | -0.143*<br>[0.074]       | -0.006<br>[0.012]    | -0.074<br>[0.137]  |
| Fixed effects                            | Country and Quarter  |                      |                      | Country and Year-Quarter |                      |                    |
| R-sq                                     | 0.979                | 1.000                | 0.936                | 0.987                    | 1.000                | 0.940              |

Note: The number of countries is 17 and the number of observations is 136. The sample period is Q1 2019–Q4 2020. Robust standard errors are in brackets. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% levels, respectively.



## **Appendix A. Regions and Countries**

The classification of countries and regions is based on the QSOS, METI.

### (a) Classification of countries and regions in Figures 1-4 and Table 1

China: CHN (including HKG);

ASEAN: BRN, IDN, KHM, LAO, MMR, MYS, PHL, SGP, THA, VNM;

NIEs: KOR, SGP, TWN;

Other Asian Countries: BGD, IND, LKA, PAK;

North America: CAN, USA;

Europe: AUT, BEL, BGR, CHE, CZE, DEU, DNK, ESP, FIN, FRA, GBR, GRC, HUN, IRL, ITA,

LUX, MNE, ROM, NLD, POL, PRT, RUS, SVK, SWE, TUR, UKR;

ROW: ARG, AUS, BRA, CHL, COL, CRI, EGY, GTM, ISR, KEN, MAR, MEX, NGA, NZL,

PER, SAU, SLV, SWZ, TUN, URY, VEN, ZAF

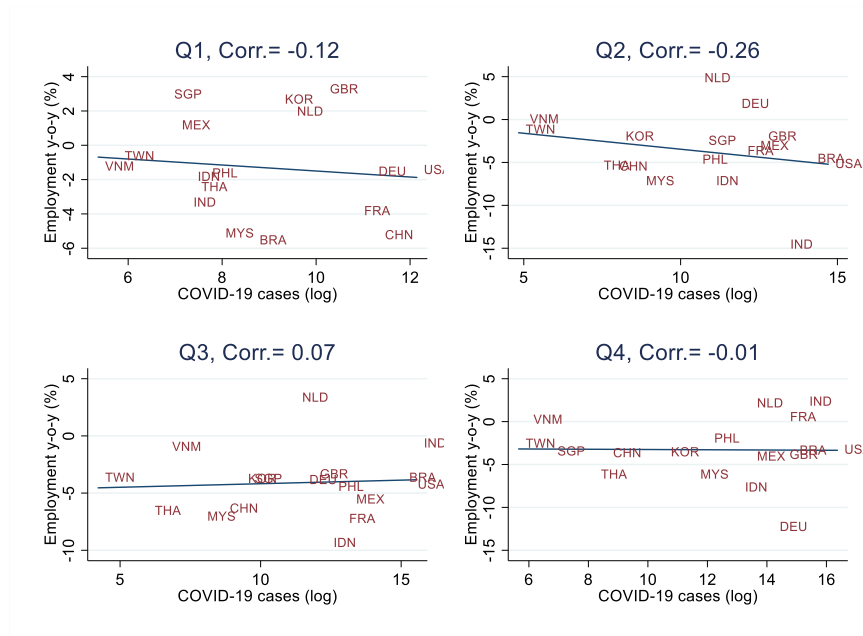
### (b) Countries and regions included in Figures 5-7, Tables 2-4, Tables B1-B2

CHN (including HKG), IDN, MYS, PHL, THA, VNM, KOR, SGP, TWN, IND, USA, DEU, FRA,

GBR, NLD, BRA, MEX

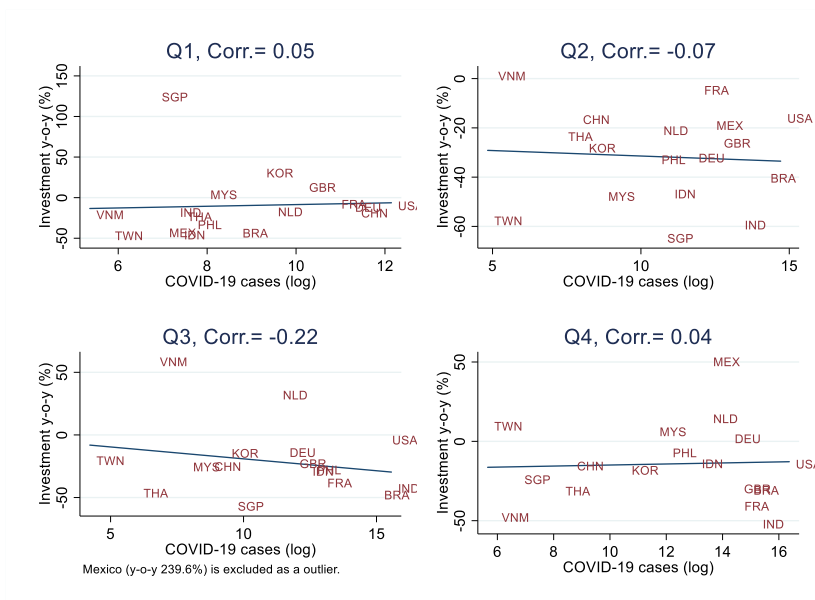
## Appendix B. Figures and Tables

**Figure B1. COVID-19 and Global Production: Employment**



Source: Author's own compilation based on data from the QSOS, METI, and Johns Hopkins Coronavirus Resource Center.

**Figure B2. COVID-19 and Global Production: Investment**



Source: Author's own compilation based on data from the QSOS, METI, and Johns Hopkins Coronavirus Resource Center.

**Table B1. Summary Statistics**

| Variables                         | Mean | Std. Dev. | Min  | Max  |
|-----------------------------------|------|-----------|------|------|
| COVID-19 cases (log)              | 5.2  | 5.6       | 0    | 16.4 |
| COVID-19 deaths (log)             | 3.2  | 4.1       | 0    | 11.9 |
| COVID-19 cases ratio (log)        | 1.9  | 2.6       | 0    | 8.3  |
| COVID-19 deaths ratio (log)       | 0.6  | 1.2       | 0    | 4.1  |
| Sales (log)                       | 22.7 | 1.0       | 21.3 | 25.1 |
| Employment (log)                  | 11.8 | 1.1       | 10.1 | 13.9 |
| Investment (log)                  | 19.3 | 1.0       | 17.3 | 21.7 |
| Stringency index                  | 27.0 | 31.3      | 0    | 91.8 |
| Workplace closure, level $\geq$ 1 | 0.38 | 0.47      | 0    | 1    |
| Workplace closure, level $\geq$ 2 | 0.34 | 0.45      | 0    | 1    |
| Workplace closure, level $\geq$ 3 | 0.12 | 0.24      | 0    | 1    |
| Stay-at-home, level $\geq$ 1      | 0.33 | 0.44      | 0    | 1    |
| Stay-at-home, level $\geq$ 2      | 0.19 | 0.34      | 0    | 1    |
| Stay-at-home, level $\geq$ 3      | 0.03 | 0.13      | 0    | 0.80 |

Note: The number of observations is 136. Sales and investment are in US dollars. Employment is the number of employees in persons.

Source: Author's own compilation based on the data from the QSOS, METI, Johns Hopkins Coronavirus Resource Center, and Oxford COVID-19 Government Response Tracker.

**Table B2. COVID-19 Ratio**

|                       | (1)                  | (2)                  | (3)                  | (4)                      | (5)               | (6)              |
|-----------------------|----------------------|----------------------|----------------------|--------------------------|-------------------|------------------|
|                       | logsales             | logemp               | loginv               | logsales                 | logemp            | loginv           |
| <b>Panel A:</b>       |                      |                      |                      |                          |                   |                  |
| COVID-19 cases ratio  | -0.034***<br>[0.006] | -0.005***<br>[0.001] | -0.043***<br>[0.010] | -0.024***<br>[0.008]     | 0.000<br>[0.001]  | 0.005<br>[0.018] |
| Fixed effects         | Country and Quarter  |                      |                      | Country and Year-Quarter |                   |                  |
| R-sq                  | 0.978                | 0.999                | 0.931                | 0.987                    | 1.000             | 0.940            |
| <b>Panel B:</b>       |                      |                      |                      |                          |                   |                  |
| COVID-19 deaths ratio | -0.074***<br>[0.013] | -0.010***<br>[0.002] | -0.064**<br>[0.025]  | -0.035**<br>[0.015]      | -0.001<br>[0.003] | 0.038<br>[0.037] |
| Fixed effects         | Country and Quarter  |                      |                      | Country and Year-Quarter |                   |                  |
| R-sq                  | 0.977                | 0.999                | 0.926                | 0.987                    | 1.000             | 0.941            |

Note: The number of countries is 17 and the number of observations is 136. The sample period is Q1 2019–Q4 2020. Robust standard errors are in brackets. \*\*\*, \*\*, and \* denote significance at the 1%, 5%, and 10% levels, respectively.