ERIA Discussion Paper Series

No. 405

Identifying the Impact of Supply Chain Disruption Caused by COVID-19 on Manufacturing Production in Japan

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September 2021

Abstract: *COVID-19 has disrupted all aspects of our lives, including international trade. This paper investigates the effect of supply chain disruption on production activities, in particular by exploiting the difference in the timing of the lockdowns in China and Japan. Using monthly production data, monthly export and import data, Japan's input–output tables, and international input–output tables, the analyses find evidence of a negative impact of supply chain disruption by COVID-19 on Japan's manufacturing production activities.*

Keywords: COVID-19, Supply chain disruption

JEL Classification: F10

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[♣] This research was conducted as a part of the project of Economic Research Institute for ASEAN and East Asia (ERIA) 'COVID-19 and Regional Economic Integration'. The opinions expressed in this paper are the sole responsibility of the authors and do not reflect the views of ERIA. A part of the works for this paper is financially supported by Japan Society for Promotion of Science KAKENHI grant number 20H01501.

1. Introduction

Coronavirus disease (COVID-19) has devastated all aspects of our lives. Besides rapidly increasing numbers of infections, steadily increasing death tolls, and overwhelmed medical systems in many countries, it also hit hard the globalised world where people and goods go back and forth, which is widely thought to have contributed to the prosperity of the post Second World War era. International supply chains that were constructed over the last 30–40 years face the most challenging threat from COVID-19, as the Economic Research Institute for ASEAN and East Asia (ERIA) (2020) and Kimura (2020) have pointed out.

Baldwin (2020), Baldwin and Freeman (2020), and Baldwin and Tomiura (2020) have argued that the world manufacturing sector is getting a triple hit.

- Direct supply disruptions are hindering production since the disease is focused on the world's manufacturing heartland (East Asia) and spreading fast in the other industrial giants – amongst which are the United States (US) and Germany.
- Supply chain contagion will amplify the direct supply shocks as manufacturing sectors in less-affected nations find it harder and/or more expensive to acquire the necessary imported industrial inputs from the hard-hit nations and, subsequently, from each other.
- There are also demand disruptions due to (i) macroeconomic drops in aggregate demand (i.e. recessions); (ii) wait-and-see purchase delays by consumers; and (iii) investment delays by firms.

There are many studies emerging about the impact of COVID-19 on the world economy. The effect on world trade has been examined, for example, by Hayakawa and Mukunoki (2020). Using worldwide trade data on 186 countries for the first quarter of 2020, they find that the COVID-19 infection in exporting countries had a negative impact on bilateral trade, but this was not the case for importing countries. The impact of the pandemic on production through supply chain disruption, argued as the second hit in Baldwin and Freeman (2020) and this paper's research question, is also being studied. Using a simulation model based on international input–output tables, Eppinger et al. (2020) quantified the welfare impact of a drastic lockdown of the Chinese economy in February and March on the world economy. Their simulation analyses showed that China experienced a welfare loss of roughly –30%, and this shock had spillover effects on all other countries through global value chains (GVCs). Sforza and Steininger (2020) incorporated the production barriers induced by the COVID-19 shock into a Ricardian model with sectoral linkages, trade in intermediate goods, and sectoral heterogeneity in production, and applied international input–output data into the model to simulate the welfare impact of the COVID-19 shock. They found that global production linkages have a clear role in magnifying the effect of the production shock. Using US data, Meier and Pinto (2020) showed that US sectors with a large exposure to intermediate goods imports from China contracted significantly and robustly more than other sectors and that the estimated effects were short-lived and dissipated by July. Using Chinese data, Friedt and Zhang (2020) showed that against a COVID-19-free counterfactual that the pandemic reduced Chinese exports by as much as 40%–45% during the first half of 2020, and that amongst the three shocks of (i) the domestic supply shock, (ii) the international demand shock, and (iii) the effects of GVCs, the impact of GVC contagion explains around 75% of the total reduction in Chinese exports.

Whereas the previous studies are either simulation studies on the welfare effect or the economic effects in the US or China, this paper aims to identify the impact of supply chain disruption caused by COVID-19 on production activities in Japan using Japanese monthly production and trade data and exploiting the differences in the timing of the lockdowns in China and Japan as described below in more detail. A study for the case of Japan is particularly important because the Japanese economy is closely interconnected with the Chinese economy due to the supply chains in the so-called 'Factory Asia'. The use of monthly production data is also a merit of this paper, compared with the other studies.

2. Methodology and Data

2.1. Methodology

The biggest obstacle in the identification of the effect of supply chain disruption due to COVID-19 on production activities is that supply chain disruption and the decline in production because of a lockdown generally occur simultaneously.

However, in the case of Japan, there was a difference in the timing of the supply chain disruption arising from China in February and March and Japan's national lockdown starting in April. Starting with the lockdown of Wuhan from 23 January 2020, the Chinese government strictly limited the movement of people in major cities in China. In China, the number of infected persons reached close to 5,000 at the beginning of February, whereas the number in Japan was only small. The number in China rose to more than 15,000 on 13 February, whilst the number in Japan was a mere 17 on 21 February. The number in Japan increased from around 50 to 254 in the last week of March, which led to the Japanese government's announcement of a state of emergency from 7 April. Namely, in February and March, whereas the supply from China was disrupted abruptly (import values from China decreased by about 50% in February compared with the same month of the previous year), firms and workers in Japan remained unscathed from COVID-19 and kept working almost as usual. This paper exploits this difference in timing to identify the effect of supply chain disruption on production activities.

2.2. Data

Four datasets are used for the purpose of this paper: Japan's monthly trade data, Japan's monthly production data, Japan's input–output data, and world input–output data.

Monthly trade data are drawn from the Customs Office of the Ministry of Finance, Government of Japan. The Customs Office of Japan publishes monthly trade data at the Harmonized System (HS) 9-digit code for every partner country. There are about 8,000 product codes at the 9-digit level, although the number of actually traded products is approximately 6,000.

Production data are drawn from the Monthly Report of Current Production Statistics (hereinafter, MRCPS), collected by the Ministry of Economy, Trade and Industry of the Government of Japan. The information in this dataset is collected monthly for industries that are considered to represent Japan's manufacturing industries. This survey aims to report the current production quickly and, thus, it does not cover all products.

Japan's input–output data are drawn from the Ministry of Internal Affairs and Communications of the Government of Japan. They are constructed every 5 years. This paper uses the enlarged input–output table for the year 2015, which is the most recent version.

The 2016 release of the world input–output data is from the European Commission. We use the data for 2014, the most recently available year.

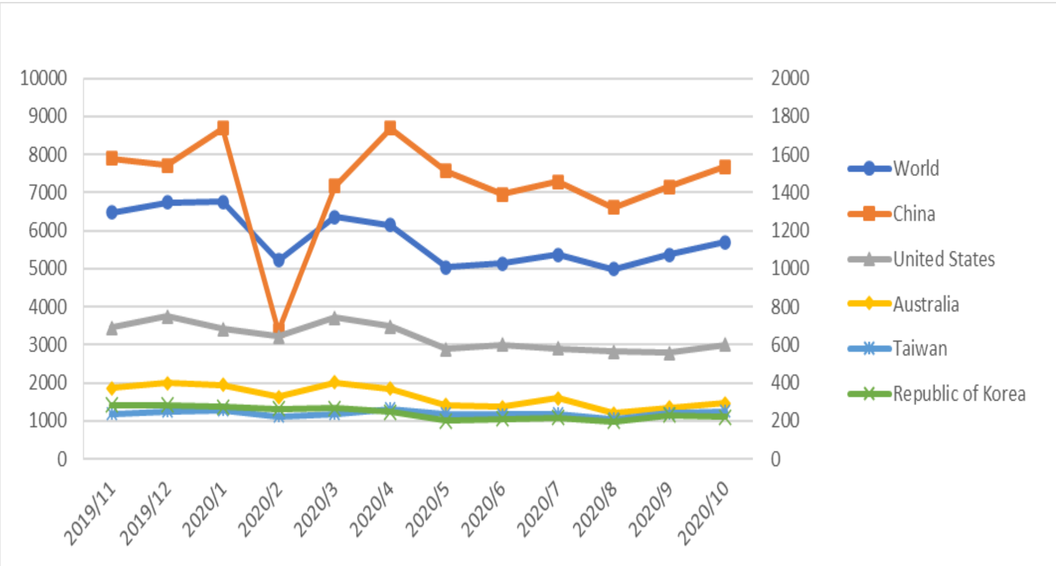
3. Analyses

3.1. Descriptive analyses

This section shows the descriptive analyses of the impact of COVID-19 on trade and production. Figure 1 shows the monthly import value for Japan from November 2019 to October 2020. Imports from the world dropped in February 2020, but, most notably, imports from China dramatically decreased in that month. Imports from other countries decreased but not so drastically as they did from China. This clearly shows a sudden and sharp decrease in imports from China.

Figure 1: Import Values for Japan, November 2019–October 2020

(¥ billion)



Note: World (left-hand axis); countries (right-hand axis).

Source: Author's computation from Customs Data, Ministry of Finance, Japan.

As explained above, to exploit the gap in the timing of the lockdowns between China and Japan, Table 1 focuses on the year-on-year change in imports in February. Imports from China, which is by far the largest importer for Japan, decreased by half.

Table 1: Year-on-Year Change in Imports by Partner Country, February 2019–February 2020

(¥ thousand)

Partner country	Month	Import value 2019	Import value 2020	Growth
HKG	February	11,412,102	6,035,036	-0.47117
CHN	February	**1,272,570,788**	673,733,732	**-0.47057**
NOR	February	15,905,967	9,985,797	-0.3722
BEL	February	29,675,557	21,362,150	-0.28014
DNK	February	22,663,137	16,977,419	-0.25088
PRT	February	3,875,918	3,125,364	-0.19365
AUS	February	392,897,886	324,557,092	-0.17394
FRA	February	89,114,365	73,680,250	-0.17319
POL	February	8,932,153	7,469,026	-0.1638
IDN	February	182,314,877	157,204,479	-0.13773
FIN	February	18,383,331	15,948,253	-0.13246
CAN	February	97,748,876	84,981,121	-0.13062
NLD	February	26,087,939	22,723,869	-0.12895
DEU	February	221,661,494	195,323,607	-0.11882
THA	February	244,377,525	216,410,295	-0.11444
SGP	February	77,608,729	70,699,252	-0.08903
VNM	February	167,510,706	157,305,240	-0.06092
ITA	February	94,519,831	88,865,389	-0.05982
USA	February	683,581,976	643,113,622	-0.0592
NZL	February	18,821,018	17,729,204	-0.05801

Source: Author’s computation from Customs Data, Ministry of Finance, Japan.

Whereas Table 1 shows the import value changes by country, Table 2 shows the year-on-year change in imports for February 2019–February 2020 by industry. The manufacture of wearing apparels decreased the most, by 38%. In terms of the levels of the import values, the decrease in the manufacture of computer, electronic, and optical products; the manufacture of motor vehicles, trailers and semi-trailers; and the manufacture of machinery and equipment, are notable and decreased by approximately 25%. These industries have been typically thought to be characterised by international supply chains.

Table 2: Year-on-Year Change in Imports by Industry, February 2019–February 2020

(¥ thousand)

ISICrev4_description	Month	Import value 2019	Import value 2020	Growth
Manufacture of wearing apparel	February	231,785,648	145,127,968	-0.3739
Manufacture of textiles	February	70,131,950	45,920,370	-0.3452
Manufacture of furniture	February	51,684,108	35,945,039	-0.3045
Manufacture of fabricated metal products, except machinery and equipment	February	102,367,451	74,839,830	-0.2689
Manufacture of leather and related products	February	101,838,548	74,873,266	-0.2648
Fishing and aquaculture	February	15,214,756	11,278,817	-0.2587
Manufacture of motor vehicles, trailers and semi-trailers	February	**247,672,946**	184,774,521	-0.2540
Manufacture of machinery and equipment n.e.c.	February	**312,499,676**	237,913,400	-0.2387
Mining of coal and lignite	February	209,363,274	159,457,262	-0.2384
Manufacture of other non-metallic mineral products	February	40,444,837	30,908,710	-0.2358
Manufacture of rubber and plastics products	February	100,405,473	78,817,423	-0.2150
Manufacture of wood and of products of wood and cork, except furniture;…	February	89,496,573	70,750,208	-0.2095
Manufacture of electrical equipment	February	241,521,691	191,327,944	-0.2078
Waste collection, treatment and disposal activities; materials recovery	February	297,101	238,353	-0.1977
Manufacture of computer, electronic and optical products	February	**898,642,651**	726,481,500	-0.1916
Manufacture of chemicals and chemical products	February	402,091,539	331,999,339	-0.1743
Manufacture of paper and paper products	February	36,174,999	29,934,551	-0.1725
Other manufacturing	February	152,548,375	132,231,814	-0.1332
Crop and animal production, hunting and related service activities	February	155,083,905	135,881,293	-0.1238
Other mining and quarrying	February	13,494,888	12,020,520	-0.1093

Source: Author's computation from Customs Data, Ministry of Finance, Japan.

Taking a look at the production side, Table 3 shows the growth in production quantity by industry. The survey on production has 1,589 products. Although the information on production quantity is available for almost all these products, the information on production values is largely missing (available only for 806 products). Thus, the growth in Table 4 is computed as the simple average of production quantity growth for these 1,589 products by industry. Although it only partially represents the production activities as it does not take into account the importance of the value for each product, we can take a broad view of the production change. Transport equipment, whose trade activity was disrupted as documented above, decreased in production, too.

Table 3: Year-on-Year Production Quantity Growth for February, 2019–2020

Industry Name	Growth
Other products	-8.21%
Iron and steel	-7.28%
Transport equipment	**-5.69%**
Plastic products	-4.81%
Ceramics and building materials	-3.83%
Rubber products	-3.46%
Textiles	-3.42%
Fabricated metals	-3.38%
Chemical industry	-3.35%
Non-ferrous metals	-3.22%
Mining, petroleum and coal products	-3.19%
Electrical machineries, electronic devices, information and communication equipment	-2.62%
Pulp, paper and paper products	-0.65%
General-purpose, production and business oriented machinery	13.40%

Source: Author’s computation from the Current Survey of Production, Ministry of Economy, Trade and Industry, Government of Japan.

Although the information on values is largely missing as mentioned above, Table 4 shows the growth in values. Because of the missing information on values, the number of industries is smaller than for the quantity case. However, we can see that the transport equipment industry and machinery industry showed substantial decreases in their production values.

Table 4: Year-on-Year Value Growth for February, 2019–2020

Industry Name	Value2019	Value 2020	Growth
Transport equipment	**9700017**	**8210124**	**-15.36%**
General-purpose, production and business oriented machinery	**245040656**	**221715726**	**-9.52%**
Electrical machineries, electronic devices, information and communication equipment	**1244744**	**1176942**	**-5.45%**
Other products	61674	58980	-4.37%
Fabricated metals	248382349	237826559	-4.25%
Pulp, paper and paper products	51384040	52137391	1.47%
Ceramics and building materials	2174744	2277812	4.74%

Source: Author's computation from the Current Survey of Production, Ministry of Economy, Trade and Industry, Government of Japan.

3.2. Estimation analyses

This subsection carries out econometric estimation analyses to see if the disruption in supply chains negatively affected production activities in Japan.

3.2.1. Monthly production data (MRCPS)

The benchmark estimation investigates the impact of COVID-19's supply chain disruption on production activities using the monthly production data (MRCPS). The data used in the analyses have a panel structure of industry, year, and month. The data spans from January 2015 to October 2020. Production quantity data from the MRCPS are available for approximately 1,500 products. I construct several indices that represent the importance of intermediate inputs coming from China based on Japan's input–output tables and trade data. To see the relation between production change and the importance of China as a supplier, both the production data and the import data are concorded with Japan's input–output industry codes, which include approximately 390 industries. As the production information is available not for all industries, but only for some industries, the number of concorded industries decreases to 156.

To see whether industries that rely on Chinese supply are more likely to have been negatively affected by COVID-19-induced supply chain disruption, a simple cross-sectional analysis is done, followed by panel data analyses. We first estimate the following equation by ordinary least squares.

$$Production\_change_i = EffectiveChinaShare_i + \varepsilon_i, \qquad (1)$$

where $Production\_change_i$ is the year-on-year production change in February or March, i.e. Production_change$_i$ = (Production quantity of industry *i* in 2020 – Mean of production quantity of industry *i* in 2018 and 2019)/Mean production quantity of industry i in 2018 and 2019[1], and $EffectiveChinaShare_i$, is a variable that represents the importance of China as an intermediate inputs supplier, which is

[1] For the base production, i.e. the denominator, the mean of 2018 and 2019 are taken to better represent the average production level in February. We also estimated the same equation using the 2019 production as the denominator, which yields estimation results close to the 10% significance level.

defined as the sum of the product of the input coefficient times the import penetration of input industry times China's import share in the year 2019, the most recent year unaffected by the COVID-19 shock. In symbols, $EffectiveChinaShare_i = \sum_j a_j * importpenet_j * ChinaShare_j$, where j is the input industry of industry i. The illustration in the Appendix describes the construction of this variable. To carry out this analysis, we need to concord the product codes of the monthly production data, which are recorded with the original code numbers made by the Ministry of Economy, Trade and Industry (METI), to Japan's input–output industry codes. I first concorded the monthly production data to the product codes of the Census of Manufactures using the concordance table that I constructed. Then, I concorded the product code of the Census of Manufactures to Japan's input–output industry code using the concordance table I made. The concordance procedures are described in the Appendix.

Table shows the summary statistics. The mean of production growth is approximately –7.7%, whilst the mean of $EffectiveChinaShare_i$ i.e. China's share as an input supplier is approximately 4.5%. Table shows the list of industries with a high effective China share. Electronic machinery comes first at 23.30%, followed by bicycles, light bulbs, leather footwear, and electronic computers (excluding personal computers). The estimation results are shown in Table . The first column shows the impact of the effective Chinese share as an input supplier on the year-on-year production change in February, whereas the second column shows the estimation result for the year-on-year production change in March. Both estimation results show statistically significant negative coefficients. In the case of February, i.e. the first column, the coefficient estimate of –1.380 indicates that an increase of 0.1 in the effective Chinese share as an input supplier is associated with a 13% decrease in production.

Table 5: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Growth of production quantity	157	-.076739	.238191	-1	1.6208
Effective Chinese share as input supplier	161	.045268	.034815	.001243	.233048

Source: Author’s calculations.

Table 6: Effective China Share, Top 30 Industries

IO_code	Description	Effective China share
339909	Electronic machinery	23.30%
359901	Bicycles	22.79%
339901	Light bulbs	16.99%
231101	Leather footwear	13.65%
342102	Electronic computers (excluding personal computers)	12.17%
152901	Bedding	11.19%
321103	Liquid crystal panels	10.68%
391101	Toys	10.57%
231201	Tanned leather, leather products, fur (excluding leather footwear)	9.80%
321101	Semiconductor element	9.08%
311501	Optical machines/lenses	8.97%
391902	Clocks	8.35%
205101	Thermosetting resin	8.33%
205103	High-function resin	8.18%
152209	Other apparel and accessories	8.15%
341201	Video and digital cameras	8.12%
331104	Wiring devices	8.10%
332102	Consumer electrical equipment (excluding air conditioners)	7.77%
342103	Computer accessories	7.69%
342101	Personal computers	7.67%
204902	Plasticiser	7.63%
341202	Electro-audio equipment	7.56%
341104	Radio, television receivers	7.15%

311201	Devices for amusement and services	6.95%
152102	Knitted garments	6.94%
152909	Other ready-made textiles	6.89%
341103	Wireless telecommunications equipment (excluding mobile phones)	6.87%
151301	Knit fabric	6.86%
331103	Open/close control devices/switchboards	6.85%
311109	Other office machinery	6.84%

Source: Author's calculations.

Table 7: Estimation Results – Impact of COVID-19 on Monthly Production, Cross-section Analysis

VARIABLES	(1) COVID-19 shock February Growth of production quantity	(2) COVID-19 shock March Growth of production quantity
Effective Chinese share as input supplier	-1.380*	-0.862*
	(0.533)	(0.428)
Observations	157	156
R-squared	0.041	0.026

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Source: Author's calculations.

As cross-sectional analyses are known to be susceptible to problems leading to biased estimators, we investigate the issue using panel data, applying difference-in-difference estimation. The estimation equation is:

$$Production_{iym} = \beta_0 + \beta_1 Covid19Shock_{iym} + \tilde{\beta} + \varepsilon_{iym} \quad (2)$$

where subscript i, y, m represents the industry, year, and month, respectively. $Production_{iym}$ is the production quantity of industry i at year y and month m.[2]

[2] Production quantity is used instead of production values, mainly because production values are missing for two-thirds of the approximately 1,500 product codes, whereas information for production quantity is available for almost all the product codes, and partially because quantity can capture the disruption in production more precisely than values, especially under sudden and large shocks, such as in the current case of COVID-19.

$Covid19Shock_{iym}$ is an indicator variable which takes 1 if China's share as an input supplier for production in industry i exceeds certain levels, of which details are described below. $\tilde{\beta}$ is a vector of industry, year, month fixed effects. ε_{iym} is the independent and identically distributed error term. $Covid19Shock_{iym}$, an indicator variable, takes the value 1 when $EffectiveChinaShare_i$ is more than or equal to certain percentages and the year-month corresponds to the period of the COVID-19 shock, namely February 2020 or March 2020. Estimations are done for the cases of $EffectiveChinaImpact_i$ being more than or equal to 5% or 10%. The effective China share is more than or equal to 5% in 53 out of around 157 input–output industries left after matching concordances. For 10%, it is 8 out of 157 industries. The estimation results are shown in Table . Column (1) is the case in which $Covid19Shock_{iym}$ is defined with $EffectiveChinaShare_i$ being more than or equal to 5% and February 2020. Column (2) is the case with the same 5% but with March 2020. Both cases show statistically insignificant coefficient estimates. Columns (3) and (4) show the cases of $EffectiveChinaShare_i$ being more than or equal to 10% for February and March, respectively. The coefficient estimates are statistically significant with negative signs. These results indicate, although not very strongly, that the supply chain disruption by COVID-19 affected the production activities in Japan for the industries relying on input supply from China.

Table 8: Estimation Results – Impact of COVID-19 on Monthly Production, Difference-in-Difference Estimation

VARIABLES	(1) China share>=5% COVID-19 shock February Log of production quantity	(2) China share>=5% COVID-19 shock March Log of production quantity	(3) China share>=10% COVID-19 shock February Log of production quantity	(4) China share>=10% COVID-19 shock March Log of production quantity
COVID-19 shock	0.0334	0.00199	-0.144*	-0.157*
	(0.0235)	(0.0235)	(0.0626)	(0.0626)
Year fixed effects	✓	✓	✓	✓
Month fixed effects	✓	✓	✓	✓
Industry fixed effects	✓	✓	✓	✓
Observations	9,516	9,516	9,516	9,516
R-squared	0.997	0.997	0.997	0.997

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Source: Author’s calculations.

3.2.2. Impacts on exports

As an alternative way to study the issue of this paper, analyses using export data are shown below. When imports from China were disrupted by the COVID-19 in February or March, exports should have been affected because of disrupted production. Although this effect is indirect as it goes through production, whereas the previous analysis is more direct, i.e. supply chain disruption to production, a merit of using export data instead of production data is the greater data availability. Whereas, as mentioned above, the information in the monthly production data (MRCPS) of METI is limited to the industries that METI regards as representative of manufacturing production in Japan, export data cover all industries, including those not covered by the MRCPS. Difference-in-difference estimation is applied to the following equation:

$$Exports_{iym} = \beta_0 + \beta_1 Covid19Shock_{iym} + \tilde{\beta} + \varepsilon_{iym}, \qquad (3)$$

where the definition of $Covid19Shock_{iym}$ and the subscripts are the same as the above benchmark estimation. $Exports_{iym}$ is export values to the world excluding China for industry i, year y, and month m. Export values to China are excluded because of an obvious reason: the export values to China dropped not because of production disruption in Japan but because of a sharp decrease in Chinese import demand due to the COVID-19 lockdown in China. Export and import data at Japan's 9-digit codes are concorded to Japan's Input–Output Data industry codes using a publicly available concordance table provided by the Ministry of Internal Affairs and Communications of the Government of Japan.

Table shows the estimation results. The COVID-19 shock shows statistically significant negative coefficients, indicating a negative effect of COVID-19.

Table 9: Estimation Results – Impact of COVID-19 on Exports, Difference-in-Difference Estimation

VARIABLES	(1) China share>=5% COVID-19 shock February Log of export values	(2) China share>=5% COVID-19 shock March Log of export values
COVID-19 shock	-0.699*	-0.810**
	(0.294)	(0.294)
Year fixed effects	✓	✓
Month fixed effects	✓	✓
Industry fixed effect:	✓	✓
Observations	15,696	15,696
R-squared	0.682	0.682

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Source: Author's calculations.

3.2.3. Analyses using international input–output tables

As another way to analyse the issue, this sub-section uses international input–output tables. In the previous analyses, China's impact on industry i was computed as the product of the input coefficients of industry i from industry j times import penetration of industry j multiplied by China's share in imports in industry j. This is most probably the best way to measure China's impact on the production of industry i. Namely,

$$EffectiveChinaImpact_i = \sum_j a_j * importpenet_j * ChinaShare_j \quad ,$$

where j is the input industry of industry i, as described above. However, it has the drawback of the inevitable assumption of the same input coefficients for both domestic and imported inputs. Instead, the international input–output tables are not subject to this constraint. As a measure of China's importance as an input supplier, China's backward participation in Japan's exports is used in this sub-section. The backward participation is a measure of international supply chains widely accepted in the literature. Economies can participate in GVCs in two ways. One is through receiving foreign value added via imports of intermediate goods for their own production. This is called backward participation as it comes from backward linkages (procuring inputs) in input–output relations. The other is through putting their own (domestic) value added into the production of foreign countries. This is called forward linkage as it refers to forward linkages (selling inputs) in input–output relations. Backward participation is relevant in the context of the issue studied in this paper because Japanese domestic production in February–March was affected by disrupted intermediate imports from China battered by COVID-19. I compute the backward participation using the World Input–Output Database (WIOD) following the methodology proposed by Koopman, Wang, and Wei (2014) and Wang, Wei, and Zhu (2018). The estimation equation is the same as above, namely:

$$Exports_{iym} = \beta_0 + \beta_1 Covid19Shock_{iym} + \tilde{\beta} + \varepsilon_{iym}$$

However, $Covid19Shock_{iym}$ now takes the value 1 if China has the highest backward participation amongst all partner countries for industry i and the year-month corresponds to the period of the COVID-19 shock, namely February 2020 or March 2020.

Table shows the estimation results. Column (1), which is the case for the COVID-19 shock in February, shows a statistically significant negative coefficient. Column (2) is the case for March and shows a statistically insignificant coefficient estimate but with a rather high t-statistic, which corresponds to 0.11 for the p-value. These results indicate some evidence, although not strong evidence, of the negative effect of the COVID-19 shock.

Table 10: Estimation Results – Impact of COVID-19 on Exports, Backward Participation, Difference-in-Difference Estimation

VARIABLES	(1) Backward participation - China ranking 1 COVID-19 shock February Log of export values	(2) Backward participation - China ranking 1 COVID-19 shock March Log of export values
COVID-19 shock	-0.374*	-0.266
	(-1.968)	(-1.401)
Year fixed effects	✓	✓
Month fixed effects	✓	✓
Industry fixed effects	✓	✓
Observations	236,324	236,324
R-squared	0.643	0.643

t-statistics in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Source: Author's calculations.

4. Concluding Remarks and Discussion

COVID-19 has disrupted all aspects of our lives, including international trade. This paper attempts to investigate the effect of supply chain disruption on production activities. As COVID-19 shock affected imports, exports, and production almost simultaneously, the effect of the COVID-19-induced supply chain disruption on production activities is hard to identify. However, this paper exploits the difference in the timing of the lockdowns in China and Japan as an identification strategy. Whereas China suddenly stopped its production activities in February and March due to the rapid spread of the COVID-19 infection and its near collapsing medical system, Japan was not suffering from the COVID-19 problem in February or most of March. Using monthly production data, monthly export and import data, Japan's input–output tables, and international input–output tables, our analyses indicate a negative impact of the supply chain disruption by COVID-19 on Japan's manufacturing activities. The finding suggests the policy implication of the importance of supply-chain management, which has been already discussed in policy circles for the last few years, especially after United States President Donald Trump launched a series of unpredictable trade policies, most notably the trade war with China, and has now come to the forefront of policy debates due to the COVID-

19 pandemic. Although this paper studies the case of Japan because of the availability of monthly production data and the author's expertise on Japanese data and concordance tables, this paper's finding is significant for other Asian countries, too, because many Asian countries have become rapidly and heavily dependent on trade with China. Computations using monthly trade data at the HS 2-digit code level for January–March 2019 for 11 Asian countries (Republic of Korea, Japan, Indonesia, Malaysia, Thailand, Singapore, the Philippines, Viet Nam, Cambodia, Myanmar, and the Lao PDR) show that out of 1,100 country-HS-2-digit pairs, China's share exceeds 75% for 89 pairs, 50% for 262 pairs, and 25% for 526 pairs. The dependence ratio on China is very high for many HS 2-digit categories for Myanmar, Viet Nam, and the Philippines, as is shown in the table in the Appendix.

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Appendix

Figure A1: Concordance for the Regression of the Effective Chinese Shares as an Input Supplier on the Monthly Production Data (MRCPS)

Production data	MRCPS product code (Year 2018 (the most recent code))
	↓ *
	The Census of Manufacture product code (Year 2014 (the most recent code))
	↓ *
	Japan's Input-Ouput table industry codes (Year 2015 (the most recent code))
Import data	↑ **
	Japan's import product codes at 9 digit (Year 2019)
Note: * Contruction by the author, ** From the Ministry of Economy, Trade and Investment	

Source: Author’s elaboration.

Table A1: Construction of the Effective China Share

Production industry	Input industry	(1) Input coeffient	(2) Import penetration	(3) China's share in imports	Product of (1)*(2)*(3)	Effective China Share
Industry 1	Industry 1	a_{11}	r_1	s_1	$a_{11}r_1s_1$	
	Industry 2	a_{12}	r_2	s_2	$a_{12}r_2s_2$	
	Industry 3	a_{13}	r_3	s_3	$a_{13}r_3s_3$	$a_{11}r_1s_1+a_{12}r_2s_{2+}a_{13}r_3s_{3+}$
	Industry 4	a_{14}	r_4	s_4	$a_{14}r_4s_4$	$a_{14}r_4s_{4+}$…
	.	.	.	.	.	
	.	.	.	.	.	
Industry 2	Industry 1	a_{21}	r_1	s_1		
	Industry 2	a_{22}	r_2	s_2		
	Industry 3	a_{23}	r_3	s_3		$a_{21}r_1s_1+a_{22}r_2s_{2+}a_{23}r_3s_{3+}$
	Industry 4	a_{24}	r_4	s_4		$a2_4r_4s_{4+}$…
	.	.	.	.		
	.	.	.	.		
Industry 3	Industry 1	a_{31}	r_1	s_1		
	Industry 2	a_{32}	r_2	s_2		
	Industry 3	a_{33}	r_3	s_3		
	Industry 4	a_{34}	r_4	s_4		
	.	.	.	.		
	.	.	.	.		
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Source: Author’s elaboration.

Table A2: Dependence Ratio for Imports from China

Country	Number of HS 2 code: China share exceeding 75%	HS 2-digit code	China share Jan-Mar 2019
Myammar	21	50	99.73%
Myammar	21	53	98.54%
Myammar	21	43	96.59%
Myammar	21	66	96.33%
Myammar	21	98	95.95%
Myammar	21	51	94.86%
Myammar	21	78	93.63%
Myammar	21	57	91.98%
Myammar	21	72	87.29%
Myammar	21	61	86.61%
Myammar	21	36	84.23%
Myammar	21	55	83.58%
Myammar	21	6	82.11%
Myammar	21	76	80.51%
Myammar	21	60	80.22%
Myammar	21	54	79.38%
Myammar	21	5	79.38%
Myammar	21	44	79.38%
Myammar	21	85	77.19%
Myammar	21	42	76.27%
Myammar	21	59	75.46%
Viet Nam	15	46	99.64%
Viet Nam	15	66	97.14%
Viet Nam	15	7	94.69%
Viet Nam	15	69	93.73%
Viet Nam	15	67	90.22%
Viet Nam	15	53	88.06%
Viet Nam	15	95	87.56%
Viet Nam	15	94	84.64%
Viet Nam	15	86	83.96%
Viet Nam	15	42	83.64%
Viet Nam	15	57	82.64%
Viet Nam	15	61	80.00%
Viet Nam	15	62	79.98%
Viet Nam	15	43	78.38%
Viet Nam	15	63	78.02%
Philippines	14	66	99.54%
Philippines	14	43	99.21%
Philippines	14	61	92.59%
Philippines	14	58	92.27%
Philippines	14	67	90.80%
Philippines	14	64	87.91%
Philippines	14	52	87.82%
Philippines	14	69	84.48%
Philippines	14	62	83.81%
Philippines	14	46	83.17%
Philippines	14	3	82.71%
Philippines	14	94	80.87%
Philippines	14	63	76.08%
Philippines	14	42	75.27%

Continued

Cambodia	12	66	99.61%
Cambodia	12	53	99.13%
Cambodia	12	67	97.69%
Cambodia	12	14	93.91%
Cambodia	12	51	93.78%
Cambodia	12	37	88.39%
Cambodia	12	55	86.80%
Cambodia	12	52	84.06%
Cambodia	12	69	83.33%
Cambodia	12	44	82.24%
Cambodia	12	86	80.34%
Cambodia	12	94	76.67%
Malaysia	10	50	96.28%
Malaysia	10	66	91.30%
Malaysia	10	7	89.78%
Malaysia	10	69	88.71%
Malaysia	10	94	88.12%
Malaysia	10	46	85.31%
Malaysia	10	57	81.42%
Malaysia	10	95	79.10%
Malaysia	10	64	78.55%
Malaysia	10	5	77.76%
Lao PDR	8	51	100.00%
Lao PDR	8	93	99.65%
Lao PDR	8	36	96.67%
Lao PDR	8	98	96.44%
Lao PDR	8	53	95.45%
Lao PDR	8	57	95.39%
Lao PDR	8	76	79.55%
Lao PDR	8	5	76.71%
Indonesia	2	66	97.32%
Indonesia	2	50	91.46%
Japan	2	66	85.84%
Japan	2	46	78.14%
Republic of Korea	2	50	86.33%
Republic of Korea	2	53	83.26%
Thailand	2	66	93.77%
Thailand	2	67	82.49%
Singapore	1	66	75.47%

Source: Author’s computation from monthly trade data at the HS 2-digit level.

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