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**Supply Chain Decoupling: Geopolitical Debates
and Economic Dynamism in East Asia**

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"Supply Chain Decoupling: Geopolitical Debates and Economic Dynamism in East Asia"

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Abstract

Supply chain decoupling in the context of the US-China confrontation has generated serious uncertainties for private businesses working on global value chains (GVCs). This paper focuses on machinery international production networks (IPNs) in East Asia and tries to find quantitative evidence on supply chain decoupling by employing international trade statistics, particularly from the viewpoint of middle powers standing between two superpowers such as Japan. While the sectoral level of trade figures does not show any clear evidence of supply chain decoupling in East Asian machinery IPNs, some specific US export controls indeed affect international transactions at the finely disaggregated level of international trade. We econometrically measure the effect of some of the US policies on Japanese exports to China. The recent strengthening of the US export control related to supercomputers and advanced integrated circuits is likely to generate much larger effects in the near future. Nevertheless, the supply chain decoupling seems to end up with a partial one, and the large portion of IPNs may remain active. In conclusion, the paper briefly discusses the policy implication.

Key Words

Global value chains, international production networks, geopolitical tension, export control, the US-China confrontation

JEL Classification

F13, F14, F51

1. Introduction

Enhancing geopolitical tensions have become a major concern particularly for middle powers standing between the US and China such as Japan. The logic of national security policy is strong, and policy debates tend to neglect its implication for business environment. Our private sector start facing various government controls and restrictions under the name of national security, and policy uncertainties become enormous. One of the frontline issues is supply chain decoupling.

In the past three decades, Japan and the rest of East Asia including both Northeast and Southeast Asia have led the world in developing the task-by-task international division of labor or international production networks (IPNs), particularly in machinery industries (Ando and Kimura 2005). In Baldwin's wording, it is called "second unbundling", which consists of the core of Factory Asia (Baldwin 2016). Although the frontier of the international division of labor has started shifting from manufactured goods to digitalized services, machinery IPNs are still very important for Japan and the rest of East Asia. Machinery IPNs is now under the explicit and implicit pressure of supply chain decoupling.

For middle powers such as Japan, issues are not just "defensive" decoupling that intends to prepare for possible disruption of important items but also "offensive" decoupling in the context of technological competition between the superpowers. The US is exercising the extraterritoriality on some parts of its export controls that hit non-US companies located outside the US. The US also calls for the participation in offensive decoupling, notably on items and technologies related to supercomputers and high-end semiconductors.

What sort of national security policy is desirable is an important question, but we put it out of the scope of this paper. What we would like to discuss here is to comprehend what has happened so far on the supply chain decoupling and how we should design our related economic policies to provide less stressful business environment for the private sector.

What is happening now? There are two contrasting views on the supply chain decoupling. One view comes from various daily news in mass media. The US-China confrontation has steadily escalated, and various trade controls have been introduced by the US. The US allies such as Japan are about to cooperate with offensive decoupling, and the whole world may eventually experience serious decoupling. The other view is from trade statistics for broadly classified machinery sectors. Global value chains (GVCs) and its sophisticated portion, IPNs, have so far been moving actively after overcoming COVID-19, particularly in East Asia. Even the US-China trade recorded the highest ever, for both total exports and imports, in 2022. Both views capture some part of the reality. We must rightly assess the current situation and construct a well-balanced policy framework for both national security and economic dynamism.

Readers of this paper should understand that empirical studies face enormous difficulties in quantifying the effect of trade controls. Although the scope of trade controls in terms of traded items, technologies, export destinations, targeted importing companies, and end-use is officially announced, it is set very widely and does not show the actual scope of strict trade restrictions or bans. Governments do not disclose the information on which transactions were finally restricted or stopped while issuing the large number of export permissions. The private sector may stop transactions based on precautionary moves rather than direct orders by the government. Trade statistics is not matched with exporting firms and importing firms without connecting with customs office data. The commodity classification of trade statistics does not specify high-tech products properly; for example, high-end semiconductors cannot be isolated in the commodity classification. Despite these difficulties, we try to provide some evidence of trade controls, even indirectly. Our tentative judgment at this moment is that trade controls are real and start showing significant negative effects on trade flows. However, the scope of supply chain decoupling will not cover the whole economy; it is likely to leave the "rest" of the economy out of strict trade controls. The situation is urgent. Even if hard evidence is not completed, we must make meaningful

policy discussion.

The paper plan is as follows: the next section briefly discusses defensive and offensive decoupling of supply chains in the context of middle powers such as Japan. Section 3 looks at the sectoral-level trade statistics and confirms the strong performance of East Asia's machinery IPNs. Some recent changes in China's machinery trade with major trading partners are highlighted. Section 4 digs into the finely classified trade statistics up to late 2022 to capture the effect of some of the US export controls on semiconductors and related products. Although we still cannot isolate high-end semiconductors in trade statistics, we try to detect the effect of the US export controls, particularly the entity list control for Huawei, on Japanese exports by a simple econometric exercise. The last section summarizes our major findings and discusses the policy implication particularly for middle powers such as Japan.

2. Defensive and offensive decoupling of supply chains

The debate on geopolitics and economic security is often confusing because policy purposes and policy measures are not clearly specified. To make the argument on supply chain decoupling, we would like to introduce the concept of "defensive" and "offensive" decoupling of supply chains. Defensive decoupling means policy measures to decouple supply chains to avoid sudden disruptions of the supply of some important items due to geopolitical turmoil. Offensive decoupling is policy measures to decouple supply chains to hit the opponent in the strategic competition. These two kinds of decoupling are partially overlapped but are useful to understand the nature and characteristics of decoupling policies, particularly in the context of middle powers.

In Japan, with enhancing geopolitical tensions, the Economic Security Law was enacted in May 2022, and along the line, a series of economic security-related policies started being implemented. It consists of four pillars: (i) securing stable supplies of important items, (ii) securing the stable provision of basic infrastructure services, (iii) supporting the development of cutting-edge important technologies, and (iv) allowing some patents not published. The first pillar is directly related to the supply chain decoupling, mostly defensive. Some measures would promote reshoring, i.e., pulling back production from abroad to Japan, and others would seek more diversification of production sites to secure the supply.

As for offensive decoupling, some politicians in Japan would like to promote the development of indispensable products or technologies that can potentially be utilized as economic statecraft. However, it is not easy to develop such a weapon. Japan's involvement in offensive decoupling has so far mainly come in the context of extraterritoriality of the US export controls. As far as keeping a close relationship with the US, firms located outside the US must obey them. In addition, some specific items such as high-end semiconductor producing machines were recently added in the list of Japan's export controls in collaboration with the US. This paper focuses on offensive decoupling of this kind, which is particularly important for East Asian machinery IPNs.

One serious problem for the private sector is that the boundary of export controls and other security measures is not clearly publicized. The scope of controls is set very widely, and many trade permissions are also issued quickly. What items and technologies are under actual restrictions is not open information, either ex-ante or ex-post.¹ In addition, other measures such

¹ Some fragmented information is available. For example, according to the Country Analysis Report for U.S. Trade with China in 2021 by the U.S. Department of Commerce, even in U.S. exports to China, 98.5% of total exports are those under the No License Required. Out of the total license applications for China, 67.4% are approved, which is lower than the approval rate for the world (86.1%). Nevertheless, 73% of unapproved applications are classified as "Returned Without Act" (e.g., due to

as restrictions on mergers and acquisitions (M&A) are implemented though the borderline of such restrictions is not clear. In addition, even if private sector cooperates with the government's restrictions, no compensation scheme is prepared. Although the government seems to try communicating with the private sector well, a series of policies at the end generate a lot of uncertainties for the private sector.

3. The after-COVID performance of East Asian IPNs and China

Now let us look at the sectoral international trade data for machinery IPNs and see if some signs of supply decoupling are detected or not. Our conclusion is that international trade data aggregated up to the industry level do not provide any clear evidence of the reduction of trade due to supply chain decoupling.

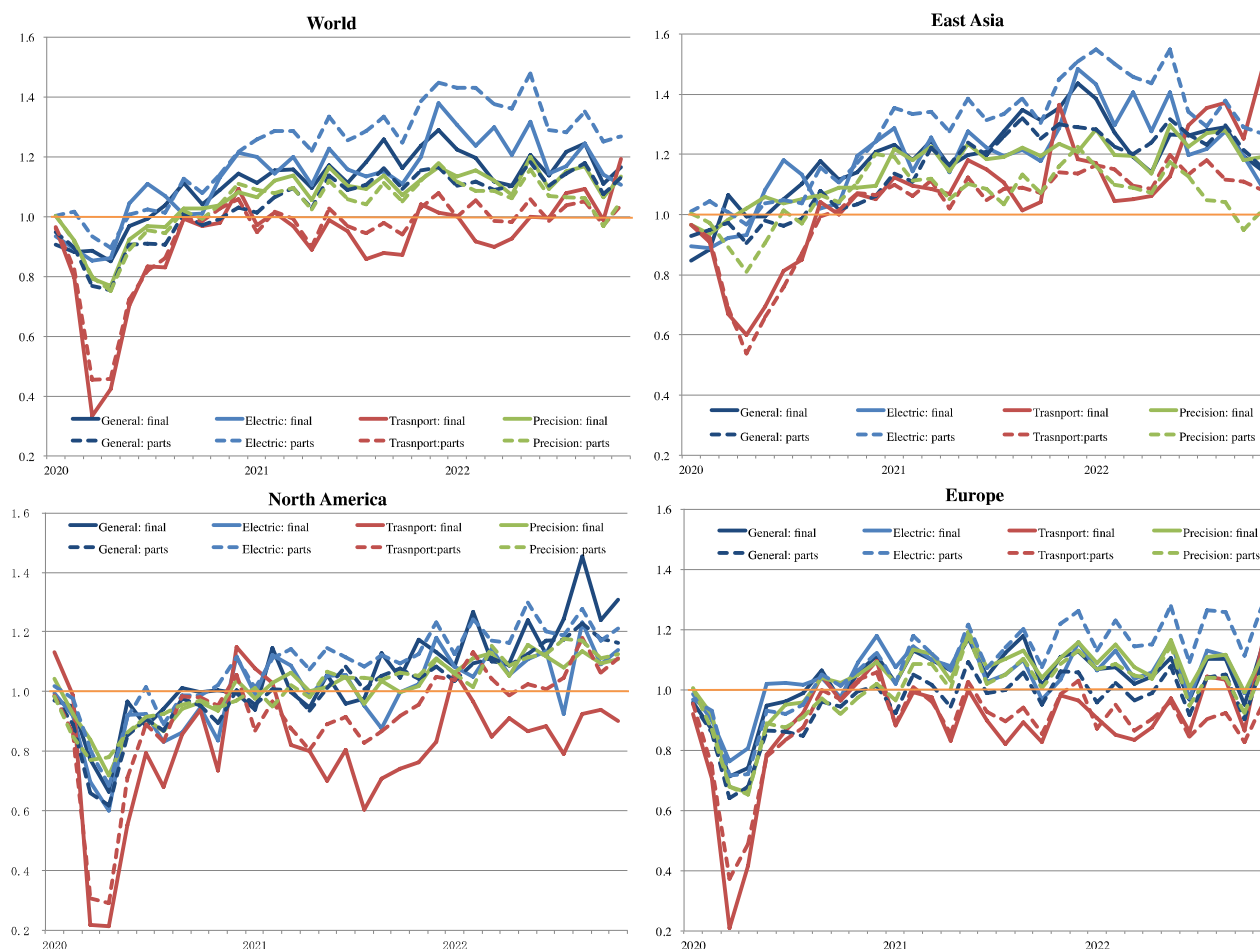
First, we check the overall performance of machinery IPNs during the COVID-19 period. Figure 1 shows machinery exports of three regions with dense machinery IPNs, namely, East Asia, North America, and Europe, in addition to worldwide machinery exports. It presents machinery final products and parts and components separately by four sectors; general machinery (harmonised system (HS) 84), electric machinery (HS85), transport equipment (HS86–89), and precision machinery (HS90–92)).² Although machinery exports of all three regions experienced a rapid V-shape recovery with a bottom in April to May 2020, machinery IPNs in East Asia had much smaller downturns than those in other regions. Moreover, East Asia's exports of general, electric and precision machinery goods, both final products and parts and components, returned to their pre-pandemic levels by July 2020.³ Even in the transport equipment sector with the largest negative impacts, the year-on-year decline at the bottom was at most 40 percent for East Asia, while that was as large as 80 percent for North America and Europe.

Figure 1 Major Machinery IPNs: Machinery Exports to the World (Each Month of 2019 = 1)

incomplete, inconsistent, or inaccurate application submission) rather than “Denied.” The top denied Export Control Classification Number for China was “Telecommunication equipment, not controlled by 5A001” (5A991). The average processing time of review for China is increasing from 37 calendar days in 2017 to 81 days in 2021.

² The definition of machinery parts and components is based on Kimura and Obashi (2010), and machinery goods other than parts and components are regarded as machinery final products.

³ East Asia's exports of general machinery final products exceeded the pre-pandemic level already in April 2020, partly due to the drastic expansion of demand for laptop computers etc.



Data: Authors' calculation, using Global Trade Atlas

Notes: Data for January and February are aggregated to consider the effects of Lunar (Chinese) New Year. 36 export countries are included for (a) World; six ASEAN countries, China, Hong Kong, Taiwan, South Korea (hereinafter referred to Korea), and Japan for (b) East Asia; U.S., Mexico, and Canada for (c) North America; and 14 EU countries, U.K., and Switzerland for (d) Europe. 'Final' and 'Parts' indicate final products and parts and components, respectively.

These findings confirm the robust and resilient nature of IPNs in East Asia amid the COVID-19 pandemic, as is the case of past shocks.⁴ What is distinctive for the COVID-19 pandemic is that it caused three major shocks, i.e., negative supply shocks, negative demand shocks, and positive demand shocks. Positive demand shocks are due to COVID-19-specific demand for certain products related to teleworking, stay-at-home activities, and preventing infection, which are often available through e-commerce (Ando, Kimura, and Obashi, 2021).⁵ In the case of East Asia, negative supply and demand shocks were relatively small partly because the COVID-19 spread *per se* was less serious, compared with other regions, and also governments took policy responses to the pandemic with an emphasis on IPNs. In addition, the benefit from positive demand shock products was large because East Asian countries have international

⁴ Miroudot (2020) explains the terms of “robustness (less likely to be interrupted)” and “resiliency (more likely to be resumed even if being interrupted)”.

⁵ See Hayakawa, Mukunoki, and Urata (2021) for the mitigating effects of e-commerce on the import decline due to the COVID-19.

competitiveness effectively utilizing IPNs for many of these products.⁶ These positive demand shocks, together with activated e-commerce for their purchases amid COVID-19, have contributed to such a rapid recovery by partially compensating for the effects of negative supply and demand shocks.

In 2021, IPNs in East Asia faced several challenges, including a shortage of containers (and high transport costs), a shortage of semiconductors, and the emergence of the delta variant of COVID-19. Furthermore, additional direct and indirect causes of concern emerged in 2022, such as aggravated U.S-China frictions with intensified export controls by the U.S., “zero-COVID policy” implemented by China, and the unjustifiable Russian invasion of Ukraine. At least at the regional level, however, machinery parts and components as well as machinery final products in all machinery sectors maintain exports beyond the pre-pandemic levels in 2021. Moreover, they still retained exports in 2022 within a similar range of growth rates in 2021 as a whole region, except a notably high growth rates (relative to 2019) for electric machinery parts and components during the first half of 2022 that partly reflects the expanding demand for semiconductors as well as a drastic increase for final products of transport equipment during the second half of 2022. With considering the facts that exports of transport equipment are sometimes below the pre-pandemic levels and exports of other machinery goods remain to be fluctuating around the pre-pandemic levels in North America and Europe, the export pattern of East Asia indicates how machinery IPNs in East Asia are still doing well at least as a whole region.

Note that general and electric machinery sectors show a slightly declining trend during the second half of 2022, partly due to a slack of two markets for computers and smartphones. The major products that reduced substantially in these sectors during this period include laptop computers (HS841730) for HS84 final products, DRAM module for computers (HS847330) for HS84 parts and components, smartphones (HS851712) for HS85 final products, and memory integrated circuit (IC) (HS854232) and parts of smartphones (HS851770) for HS85 parts and components. Exports of computers started to drop, reflecting the shrinkage of their demand because their users have already relatively new ones that were bought as COVID-19-specific demand.⁷ Export values of memory ICs dropped, largely due to a drastic decline of their unit price.⁸ Exports of smartphones also dropped, partly reflecting the insufficient supply due to unexpected lockdown in major factories in China as well as significant decline in demand.⁹

Figure 2 looks at overtime changes in values of China's machinery exports and imports (HS 84-92) by trading partners in which HS 84-85 occupies 90 percent of machinery exports and 80 percent of machinery imports. Our finding is threefold. First, at least up to 2022, no clear evidence of supply chain decoupling can be detected at the aggregated level of machinery sectors. Overall, machinery trade did not slow down though imports seem to slow down perhaps due to lock-down in Shanghai in April-May and expansion of infection after October. Second, machinery exports enjoyed the upward trend, particularly with ASEAN, Taiwan, South Korea (hereinafter referred to Korea), Europe, and Mexico. A possibility is that some part of supply chains has been reorganized through moving production sites from China to other countries, a part of which is

⁶ Among the top 20 countries of machinery exports in the world in 2019, East Asian countries occupies the half for general and electric machinery and precision machinery parts and components, and 30 to 40 percent even for their final products (Ando, Kimura, and Yamanouchi, 2022).

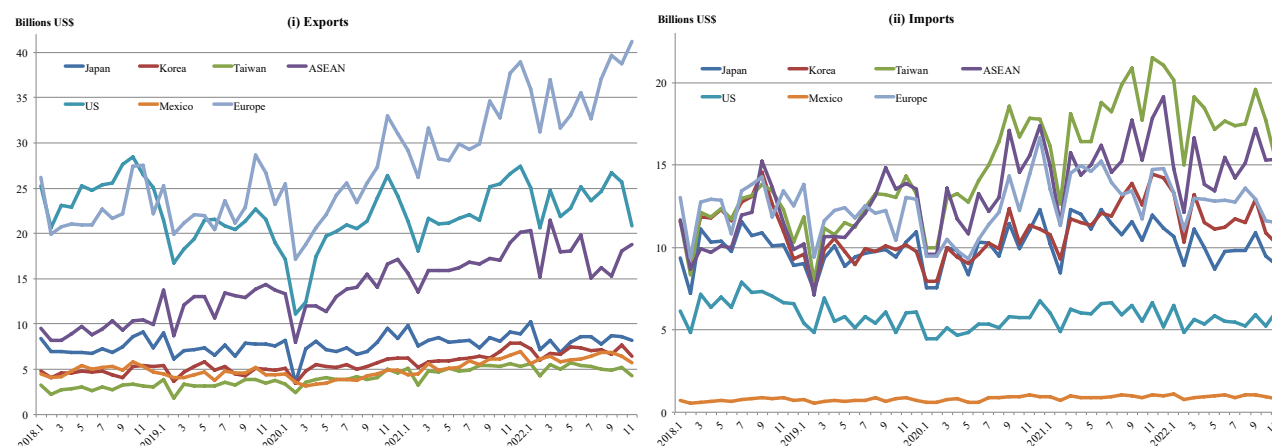
⁷ <https://jbpres.ismedia.jp/articles/-/73544> (in Japanese)

⁸ The unit price of exports for memory ICs was the highest in May and lowered to be less than half in December in 2022. (<https://www.jetro.go.jp/biz/areareports/2023/c21124a5dbd3db79.html> in Japanese).

⁹ <https://www.itmedia.co.jp/mobile/articles/2301/27/news093.html> (in Japanese)

through foreign direct investment by multinationals including Chinese.¹⁰ Third, machinery exports and imports with the US also stay strong at least up to 2022 compared with 2019.

Figure 2: Machinery Trade of China by Major Countries/Regions



Source: Global Trade Atlas.

Notes: Chinese exports are based on data for the corresponding imports of trading partners. Monthly data for January and February of 2020, which are reported by China and available from Global Trade Atlas, are equal because they are a half of the aggregated value for two months.

4. Effects of the US export controls on high-tech products

4.1. Background

To detect the sign of supply chain decoupling, we must go into more disaggregated trade data. This section digs into the US export controls on high-tech products and tries to quantify the extent of decoupling, at least partially.

Let's start from a brief review of the US trade controls. The U.S. government first introduced policy measures to reduce not only imports from China but also exports to China. In the initial phase of this war, i.e., 2018 and 2019, the main measure was the imposition of additional bilateral import tariffs between the U.S. and China. In the next stage of the war, the main measure shifted from tariffs to export control regulations. In August 2018, the U.S. strengthened export controls from the perspective of national security and regulated exports of key technologies and components to China. In May 2019, the U.S. added Huawei Technologies Co., Ltd. (hereafter, Huawei) and 68 affiliates to the Entity List (EL), which is a list of parties of concern. Huawei is a Chinese company that designs, develops, manufactures, and sells telecommunications equipment, consumer electronics, and smart devices. When a firm exports, reexports, or transfers any items subject to the U.S. Export Administration Regulations (EAR) to them, its applications are reviewed with a presumption of denial by the U.S. government.

Since 2020, furthermore, the U.S. government has asked even firms outside of the U.S. to obtain permission if products using U.S.-origin technology or software (called "direct products") are exported directly or even indirectly to Huawei and related affiliates. In May 2020, the Foreign

¹⁰ <https://www.nikkei.com/article/DGXZQOGN020PJ0S2A800C2000000/> (in Japanese), <https://www.jetro.go.jp/biznews/2023/01/ea3a3affc5253510.html> (in Japanese)

Direct Product Rule (FDPR) of the EAR was strengthened to require prior authorization if “direct products” are used in the production or development of chipsets and other products designed by Huawei and its affiliates. In August 2020, the regulations were further tightened to require prior authorization to the production or development of chipsets purchased or ordered by Huawei or its affiliates. For example, universal chips designed by Taiwan Semiconductor Manufacturing Company Ltd. (hereafter, TSMC) can be supplied to Huawei under the regulation in May but cannot be after August. In particular, license applications are denied for foreign-produced items that are capable of supporting the development or production of telecom systems, equipment, and devices of the 5G level. In December 2020, the U.S. also added Semiconductor Manufacturing International Corporation (hereafter SMIC) to the EL. It is a semiconductor (SC) foundry company and the largest chip maker in China. Presumption of denial is applied for items uniquely required for production of SCs at advanced technology nodes. Since then, some more Chinese companies have been added to the EL.

4.2. Overview of Trade Statistics

This subsection takes an overview of exports of SC-related products, especially integrated circuits (ICs), to China. The top exporter of ICs to China in 2019 was Taiwan, followed by Korea, Malaysia, Japan, Vietnam, and the U.S. As the main exporters of advanced products, we here focus on exports by Japan, Korea, Taiwan, and the U.S. The data are obtained from the import side, i.e., China’s imports of HS8542 at an HS eight-digit level. Table 1 reports the share of exports of each IC product out of total IC exports by exporters in 2019. The main export products are memory ICs (HS85423290) from Korea and logic ICs (HS85423190) from the U.S., which account for 69% and 84% of total IC exports of each country, respectively. Samsung Electronics Co., Ltd. and SK Hynix Inc. are large manufacturers of memory ICs in Korea, while GlobalFoundries is a U.S. manufacturer of logic ICs. On the other hand, IC products exported from Japan and Taiwan are diversified over memory ICs (HS85423290), logic ICs (HS85423190), and other ICs (HS85423390). Although this table reports the statistics of China’s imports only, this trend does not change even if we examine the sum of imports by China and Hong Kong. Also, the statistics for China’s imports in 2022 show a similar structure.

Table 1. Shares of Exports of Various IC Products (HS8542) to China in 2019 (%)

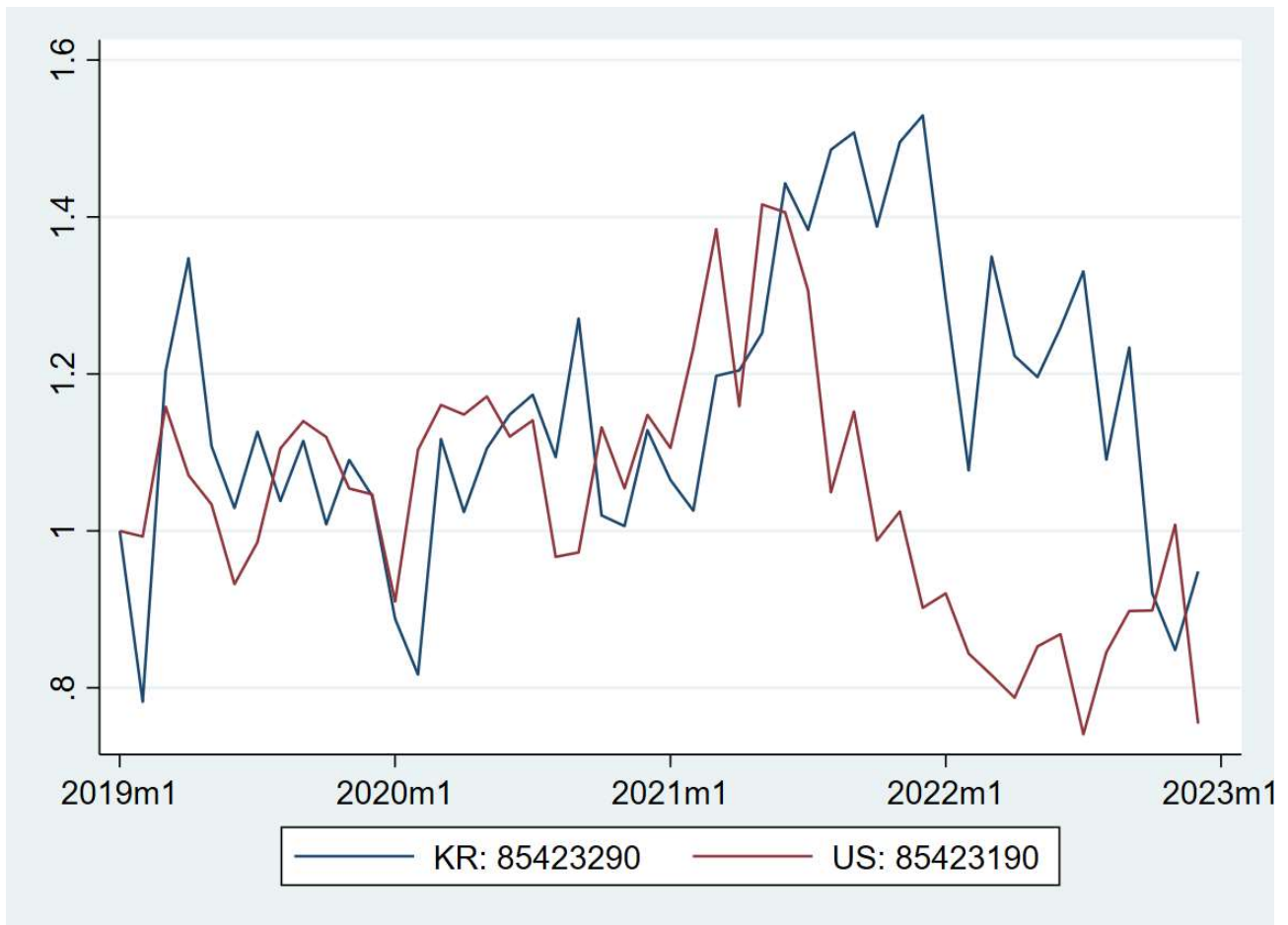
HS	Description	Japan	Korea	Taiwan	USA
85423111	Semiconductor Modules with Converting Function	0.3	0.1	0.2	0.0
85423119	Other Multi-Component Integrated Circuits, As Processors and Controllers	2	3	9	0.1
85423190	Other Integrated Circuits, As Processors and Controllers	28	14	42	84
85423210	Multi-Component Integrated Circuits, As Memories	0.0	1	0.1	0.0
85423290	Other Integrated Circuits, As Memories	37	69	25	2
85423310	Multi-Component Integrated Circuits, As Amplifiers	1	2	0.0	0.1

85423390	Other Integrated Circuits, As Amplifiers	2	1	2	3
85423910	Other Multi-Component Integrated Circuits	2	0.3	1	0.2
85423990	Other Integrated Circuits	27	10	21	10
85429000	Parts For Electronic Integrated Circuits	1	0.2	0.3	0.1
8542		100	100	100	100

Source: Authors' compilation using the Global Trade Atlas.

Next, we examine the time-series changes in exports of the main products. Figure 3 depicts the monthly changes in exports of memory ICs (HS85423290) from Korea and logic ICs (HS85423190) from the U.S. to China during 2019-2022. The export values are indexed so that those in January 2019 are set at a value of 1. The exports to China seem to decline from the U.S. from mid-2021 and in Korea from 2022. Figure 4 shows the changes in exports from Japan and Taiwan to China. Japan seems to increase the exports of logic ICs but decrease those of memory ICs in 2022. The exports of other ICs remain at a higher level compared with those in 2019. As for Taiwan, exports of memory ICs do not change much, while those of logic and other ICs have experienced a remarkable rise. In summary, the U.S. has experienced a decrease in the exports of the main IC product to China since the earlier period, compared with the other countries. This decrease may indicate that the U.S. export controls were effective in advancing supply chain decoupling in high-tech industries between the U.S. and China. In the other countries, exports of memory ICs start to decline in 2022, but those of logic and other ICs increase or do not change much. As mentioned in Section 3, the former decline may be due largely to the price drop in memory ICs in 2022 rather than the response to the U.S. export controls.

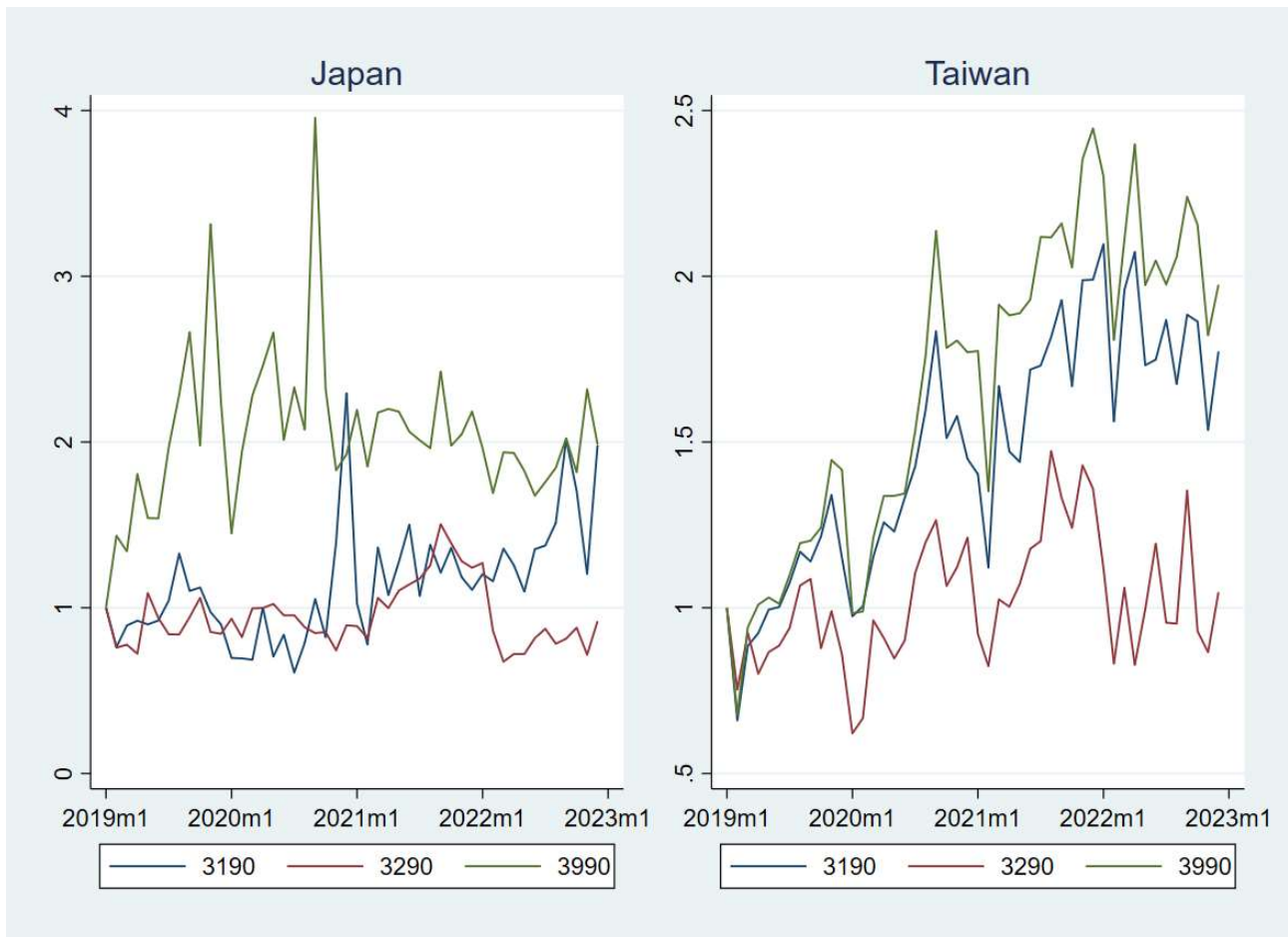
Figure 3. Monthly Changes of Exports of Major IC Products from Korea and the U.S. to China (1 for January 2019)



Source: Authors' compilation using the Global Trade Atlas.

Note: HS85423290 refers to memory ICs, while HS85423190 includes logic ICs.

Figure 4. Monthly Changes of Exports of Major IC Products from Japan and Taiwan to China (1 for January 2019)



Source: Authors' compilation using the Global Trade Atlas.

Note: "3190," "3290," and "3990" refer to logic ICs (HS85423190), memory ICs (HS85423290), and other ICs (HS85423390), respectively.

4.3. Empirical Framework

We now systematically investigate the effect of U.S. export controls on exports to China. The recent export controls by the U.S. government intends to restrict exports from third countries to China by strengthening the FDP. Therefore, it is important to examine quantitatively how these new measures work in the third economy. We try to quantify the effects of the measures on Huawei and its affiliates on Japan's exports to China. As discussed in Section 4.1, the U.S. has introduced and strengthened export control measures against them, which would have direct and indirect effects on the third countries' exports to China. The direct one is based on the EAR and to decrease the exports of "direct products" to produce telecom systems, equipment, and devices of the 5G level. The indirect one is based on the decrease of sales in Huawei and its affiliates, which would push down the demand for inputs regardless of the technology level. Indeed, Huawei announced that sales in consumer business (e.g., smartphones or personal computers) decreased by 50% in 2021.¹¹

For Japan, we focus on the indirect effect. Since TSMC is the main supplier of 5G chips to Huawei, the direct effect must appear in Taiwan's exports to China. However, as found in Figure

¹¹ <https://www.huawei.com/en/annual-report>

4, Taiwan has increased the exports of logic ICs to China, indicating that it is technically not easy to detect this direct effect without more detailed trade data (e.g., trade data by product technology or by importing firms). On the other hand, Nikkei Inc. identified parts and components inputted in the Huawei P30 Pro smartphone (released in 2019) and found that the largest number of inputs was sourced from suppliers in Japan. Out of 1,631 parts, 869 parts were from Japan, accounting for 53%. The number of parts from China was 80. Thus, Japan's exports are expected to receive a large indirect effect from the U.S. sanction against Huawei.

Specifically, we estimate the following equation on Japan's exports of HS six-digit product p to country c in year-month t (*Export*). Our study period includes January 2019 to October 2022. The export data for all commodities are obtained from the Customs in Japan.

$$\ln \text{Export}_{cpt} = \beta_1 \cdot \text{SCIC}_p \cdot \text{CHN}_c \cdot \text{Aug2020}_t + \beta_2 \cdot \text{Phone}_p \cdot \text{CHN}_c \cdot \text{Aug2020}_t + \beta_3 \cdot \text{SCIC}_p \cdot \text{Phone}_p \cdot \text{CHN}_c \cdot \text{Aug2020}_t + \delta_{cp} + \delta_{pt} + \delta_{ct} + \epsilon_{cpt} \quad (1)$$

We examine the interaction terms among some variables. *SCIC* is an intensity of SC or IC inputs. It is computed as a value of those inputs to produce product p of one Japanese yen (JPY). *Phone* is an input intensity of product p in wireless communications equipment (WCE), including smartphones and is computed as a value of product p to produce the WCE of one JPY. These two variables are computed by using the Input-Output Table in Japan for 2015. *CHN* is a dummy variable taking a value of one if export destination c is China. *Aug2020* takes a value of one after August 2020, which is when the FDPR was strengthened.

The three interaction terms are as follows.¹² The coefficient for $\text{SCIC}_p \cdot \text{CHN}_c \cdot \text{Aug2020}_t$ intends to capture how exports of products using SCs or ICs as inputs change after August 2020. This variable may take care of the advanced technology level in exported products. The coefficient for $\text{Phone}_p \cdot \text{CHN}_c \cdot \text{Aug2020}_t$ indicates how exports of products inputted in the WCE change after August 2020. Since Huawei is a manufacturer of the WCE, the coefficient for this variable will show the indirect effect (and the direct effect if available) mentioned above. The coefficient for $\text{SCIC}_p \cdot \text{Phone}_p \cdot \text{CHN}_c \cdot \text{Aug2020}_t$ represents how this indirect effect is stronger in high-tech products, i.e., products that use SCs or ICs as inputs. We expect this variable to have a significantly negative coefficient. Nevertheless, notice that there are some other manufacturers of the WCE in China, who are not listed in the EL and may increase their imports from Japan. Thus, our estimate indicates the net effect in total inputs for the WCE.

Other variables are as follows. We control for three kinds of fixed effects. The first is country-product fixed effects, which control for (time-invariant) preferences for Japanese products in each country. In addition, since our study period is short, i.e., four years, the potential size of product-level demand in export destination countries may be controlled for by this type of fixed effect. The second is product-time (year-month) fixed effects, which will control for technology changes and factor prices at a product level in Japan. The last is country-time fixed effects and controls for the time-variant total demand size in export destination countries. ϵ_{cpt} is an error term. Importing countries include all countries in the world. Also, our study products cover all products. As a result, the size of study observations defined at a country-product-time level could be huge. Therefore, we estimate this equation by the ordinary least square (OLS) method by dropping observations with zero-valued exports.

4.4. Empirical Results

We report our estimation results of equation (1) by the OLS method. The standard errors

¹² In contrast, Hayakawa et al. (2023) simply investigated how exports of HS8517 products (e.g., smartphones) to China changed after April 2020.

are clustered at a country-product level. We begin with the specification that includes only $SCIC_p \cdot CHN_c \cdot Aug2020_t$ and $Phone_p \cdot CHN_c \cdot Aug2020_t$ (in addition to fixed effects). The result is shown in column (I) in Table 2. The coefficients for both interaction terms are negative but insignificant. In column (II), we add the interaction term among $SCIC$, $Phone$, CHN , and $Aug2020$ and found a significantly negative coefficient for this term, as is consistent with our expectation. Namely, the effect of strengthening the FDPR significantly decreased Japan's exports of advanced technology products used in the production of WCE to China. The interaction term among $SCIC$, CHN , and $Aug2020$ has an insignificant coefficient, while the coefficient for the interaction term among $Phone$, CHN , and $Aug2020$ is estimated to be significantly positive. The latter result implies that exports of less advanced technology products inputted in the WCE production may increase slightly after strengthening the FDPR.

Table 2. Baseline Results by the OLS

	(I)	(II)	(III)	(IV)
SCIC * CHN * Aug2020	-0.045 [0.297]	0.168 [0.283]	0.124 [0.281]	0.219 [0.281]
Phone * CHN * Aug2020	-0.203 [0.981]	2.240** [0.981]	2.003** [1.003]	2.227** [0.985]
SCIC * Phone * CHN * Aug2020		-44.428*** [8.278]	-42.146*** [8.361]	-44.271*** [8.466]
In World			0.019*** [0.001]	
COVID controls	NO	NO	NO	YES
Number of observations	2,497,240	2,497,240	1,801,057	2,459,192
Adjusted R-squared	0.844	0.844	0.856	0.844

Notes: This table reports the estimation results obtained using the OLS method. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively. Standard errors reported in parentheses are clustered at a country-product level. In all specifications, we control for country-product fixed effects, product-time (year-month) fixed effects, and country-time fixed effects. "COVID controls" indicates whether or not we introduce the interaction term of the degree of lockdown orders' strictness with industry dummy variables.

To see quantitatively how much this US export control decreased exports from Japan to China, we compute the following:

$$(\hat{\beta}_2 \cdot Phone_p + \hat{\beta}_3 \cdot SCIC_p \cdot Phone_p) \times \sum_{t=January2019}^{December2019} Export_{China,pt}$$

We use the estimates in column (II) in this computation. In total, it decreased exports by 453 billion JPY (approximately 4 million USD), which accounted for 3.3% of total exports to China in 2019. In the general and electronic machinery industries (HS Section 16, i.e., HS 84 and 85), exports decreased by 181 billion JPY (3.0% of total exports in these industries to China in 2019).

We conduct two kinds of robustness checks. One is to control for time-variant product-

level import demand in export destination countries. To this end, we introduce a log of product-level imports from the world (*World*). To avoid the simultaneity issue, this variable does not include imports from Japan. Since the data are obtained from the import side in each country, the availability of this measure depends on the availability of monthly import data. As a result, we can compute this measure for 40 countries¹³. The estimation results are shown in column (III). The results in the three interaction terms are quantitatively unchanged. The coefficient for imports from the world is significantly positive, indicating that Japan exports products to countries with greater import demand.

The other is to control for the effect of the coronavirus (COVID-19) pandemic since 2020. To prevent the spread of the COVID-19 virus, most countries implemented various kinds of nonpharmaceutical interventions. Many studies have shown that those interventions have significant effects on trade. For example, work-from-home impositions decreased production in factories that reduced the export of goods. The common effects of this pandemic across industries are already controlled for by country-time fixed effects. However, prior studies have revealed the heterogeneous effects across industries (e.g., Hayakawa and Mukunoki, 2021). To control for them, we introduce the interaction term of the degree of lockdown orders' strictness with industry dummy variables. The data on its degree are obtained from the COVID-19 Data Repository maintained by the Center for Systems Science and Engineering at Johns Hopkins University.¹⁴ This variable is defined at a country-time level. The industry dummy variables are defined based on the HS Section classification. The results are shown in column (IV). To save space, we do not report the results on COVID-19 variables. The results in the three interaction terms are quantitatively unchanged.

Last, we estimate an extended version of equation (1). As mentioned in Section 5.1, SMIC was added to the EL in December 2020. Presumption of denial is applied when exporting machines or materials to produce advanced SCs to this largest chip maker in China. To investigate this effect on Japan's exports, we add $Material_p \cdot CHN_c \cdot 2021_t$ to equation (1). *Material* is a share of the input value of product p out of total inputs in SCs and ICs, which is computed using the Input-Output Table in Japan for 2015. "2021" takes a value of one for observations after 2020. The coefficient for this new interaction term is expected to indicate how exports of inputs for SCs and ICs change after the addition of SMIC to the EL. The results are reported in Table 3. The interaction term among *SCIC*, *Phone*, *CHN*, and *Aug2020* again has significantly negative coefficients. On the other hand, the coefficient for the new interaction term is significantly positive, which is opposite to our expectation. This result suggests that exports of inputs for SCs and ICs from Japan to China significantly increased after the addition of SMIC to the EL.

Table 3. The OLS Results: Materials of SCs and ICs

	(I)	(II)	(III)
SCIC * CHN * Aug2020	0.092	0.043	0.143
	[0.286]	[0.284]	[0.285]
Phone * CHN * Aug2020	0.563	0.248	0.562
	[1.005]	[1.036]	[1.007]

¹³ Those countries are as follows: ARG, AUS, AUT, BEL, BRA, CAN, CHE, CHN, CIV, DEU, DNK, ESP, FIN, FRA, GBR, GRC, HKG, IDN, IND, IRL, IRN, ISR, ITA, KEN, KOR, LUX, MEX, MYS, NLD, NZL, PHL, PRT, RUS, SGP, SWE, THA, TWN, USA, VNM, and ZAF.

¹⁴ <https://github.com/CSSEGISandData/COVID-19>. Also see Dong, Hongru, and Lauren (2020).

SCIC * Phone * CHN * Aug2020	-45.320***	-43.063***	-45.158***
	[6.711]	[7.387]	[6.656]
Material * CHN * 2021	2.169**	2.270**	2.153**
	[0.881]	[0.892]	[0.878]
In World		0.019***	
		[0.001]	
COVID controls	NO	NO	YES
Number of observations	2,497,240	1,801,057	2,459,192
Adjusted R-squared	0.844	0.856	0.844

Notes: This table reports the estimation results obtained using the OLS method. ***, **, and * indicate the 1%, 5%, and 10% levels of statistical significance, respectively. Standard errors reported in parentheses are clustered at a country-product level. In all specifications, we control for country-product fixed effects, product-time (year-month) fixed effects, and country-time fixed effects. “COVID controls” indicates whether or not we introduce the interaction term of the degree of lockdown orders’ strictness with industry dummy variables.

There would be some possible reasons for obtaining the positive coefficient for the new interaction term. First, other SC manufacturers in China may increase their imports of necessary materials from Japan to prepare for possible future sanctions by the U.S. government. Second, Japan may enjoy the trade diversion effect. In place of the U.S., Japan may increase exports of sanctioned products to China because those products made in Japan are not necessarily direct products of U.S.-origin technology or software. Third, the indirect effect of listing SMIC may be small. Indeed, according to the SMIC Environmental, Social, and Governance Report, the total revenue increased by 39.3% in 2021. While 5G chips are indispensable for Huawei’s smartphone business, restricted products for the SMIC, i.e., items required for production of SCs at advanced technology nodes (10 nanometers and below), may not yet occupy a major share of its total business.

4.5. Possible Effects of Further Measures

In the previous analyses, we showed that listing Huawei in the EL significantly decreased Japan’s exports to China through the supply chain formed by Huawei. Such an adverse effect was realized because Huawei was a large and global company and had a large number of suppliers in the world, especially Japan. It was significant but would be limited to suppliers within one company’s supply chain. In contrast, the effect of the measure introduced in October 2022 by the U.S. may be spread to much more companies potentially. According to Part 744.23 in the EAR, firms are prohibited from exporting the items destined for the development or production of a “supercomputer” located in or destined to China or Macau or for the development or production of ICs at an SC fabrication facility located in China or Macau that fabricates “advanced ICs¹⁵.” This measure is not the one that targets specific firms (e.g., Huawei or SMIC) but restricts firms’ exports based on the end-use of exported products.

In short, firms in Japan may not be allowed to export “direct products” to all firms,

¹⁵ These ICs include (A) logic ICs using a nonplanar transistor architecture or with a production technology node of 16/14 nanometers or less; (B) NOT AND (NAND) memory ICs with 128 layers or more; and (C) Dynamic random-access memory (DRAM) ICs using a production technology node of 18 nanometer half-pitch or less.

including Japanese affiliates,¹⁶ in China if the items are destined for the above end-use. Furthermore, the Japanese government will join forces with the U.S. and introduce similar export restrictions as above in 2023. In this case, exports of the products subject to the above end-use from Japan to China will be prohibited by the Japanese government even if they are not “direct products” of U.S.-origin technology or software. In Japan, SC manufacturing equipment (HS 8486) is the four-digit code with the fourth largest exports to the world in 2021.¹⁷ Therefore, the export restriction above will have great impacts on Japan’s exports quantitatively. Indeed, Japan is the largest exporter of “machines and apparatus for the manufacture of boules or wafers (HS848610, accounting for 54% of world exports in 2021)” and “machines and apparatus for the manufacture of SC devices or of electronic integrated circuits (HS848620, 26%)” in the world.

As of 21 February 2023, it remains unknown what export control measures the Japanese government is supposed to introduce.¹⁸ Although exporting concerned products to Chinese firms is prohibited, firms in Japan may be allowed to export to Japanese affiliates in China based on the compliance plans. This will reduce the adverse effects on Japan’s exports to some extent. Nevertheless, the decrease in exports to Chinese firms will be a huge loss of business. It will be crucial for Japanese exporters to make a strategy to overcome this restriction. One of the solutions may be to develop and export technologically-downgraded products that do not conflict with the export control measures. For example, Nvidia Corporation, which is an American fabless company, developed downgraded graphics processing units, which are called “A800” and meet the U.S. export control rules. Namely, foreign firms may need to differentiate technology levels according to customers (i.e., Chinese or not).

5. Conclusion and policy implication

It is not easy to quantitatively capture the supply chain decoupling, but this study tries to comprehend it with a focus on machinery IPNs in East Asia based on international trade data. The major findings are as follows: a large portion of machinery IPNs in East Asia are still moving actively. Sectoral-level trade statistics does not show a clear sign of massive supply chain decoupling. However, going down to the disaggregated level of international trade data, we can find some adjustments obviously due to offensive decoupling, particularly based on the US entity-list controls. Japan's exports to China experienced a statistically significant decrease, mainly through indirect channels. The recent strengthening of the US export control on high-end semiconductors will likely augment the effect on some part of machinery IPNs. Firms in middle powers including Japan will bear a part of its costs.

How far the offensive decoupling led by the US would expand its scope is unknown yet. The middle-power governments must make a proper judgment on how closely they would work along the US move. Policymakers must consider possible economic burden accompanied with offensive decoupling in the national security discussion. In addition, more information disclosure on export controls is essential to meaningful economic assessment of policies.

¹⁶ According to Part 742.6(b)(10) in the EAR, license applications for SC manufacturing items destined to end users in China that are headquartered in the U.S. or some developed countries (countries in Country Group A:5 or A:6 in Supplement No. 1 to Part 740 in the EAR) will be considered on a case-by-case basis, taking into account factors including technology level, customers, and compliance plans.

¹⁷ Passenger cars (HS 8703) occupy the largest exports, followed by ICs (HS 8542) and automobile parts (HS 8708).

¹⁸ On March 2023 (after this version of the draft is completed), the Japanese Government announced to add 23 items (including machines and apparatus for the manufacture of SC related products) to the list of export controls.

At the same time, we should realize that a large part of the economy, not under the strict trade controls, is still moving. Even the US firms find a lot of business opportunities in Chinese-related businesses. Unless the US-China confrontation would be escalated up to a real hot war, the political economy in the US would eventually set a border line between the economy under strict trade controls and the "rest" of the economy somewhere. The supply chain decoupling is likely to be partial.

Then the issue for middle powers such as Japan is how to cooperate with the US for offensive decoupling while keeping economic dynamism in the "rest" of the economy. The following three points are listed as policy implication of our study, particularly for middle powers and the US allies such as Japan. First, we must set a border line between the economy placed under strict trade controls and the "rest" of the economy as clearly as possible, and the compliance cost to obey trade controls should be minimal. From the viewpoint of government officials, a blur border line may be easier to work with. In the current world, it becomes increasingly difficult to distinguish potentially military-use technologies from purely private-use technologies. Thus, trade controls tend to cover a very wide range of items and technologies while strict export restriction or ban is applied only a small part of it. Such a regulatory environment generates a lot of uncertainties for private sector to make trade and investment decisions, which may end up with the precautionary shrinkage of cross-border corporate activities. Also, large compliance cost for trade controls would kill vigorous economic activities. These costs are hit particularly on small and medium enterprises. Issues are not just trade controls by middle power governments but also on the US export controls. Middle power governments need to communicate with the US government and help private sector avoid the huge compliance cost, too.

Second, it is important to keep a good economic relationship with countries in neutral stance. In the context of machinery IPNs, ASEAN and other Asian countries are particularly important. As far as the supply chain decoupling will be partial, the large portion of Asian economies will stay in the "rest" of the economy. Their economies will certainly be connected to both superpowers at the same time. We must accept this situation and should not force them to choose a side. The backlash from offensive decoupling must be minimized for them.

Third, the rules-based trading regime must be kept for the "rest" of the economy. Policy tools for supply chain decoupling are often inconsistent with the WTO rule or conventional trade norms, which obviously weakens the rules-based trading regime. However, such policies, particularly by superpowers, cannot be stopped unfortunately. Nevertheless, we must keep the rules-based trading regime for the "rest" of the economy as extensively as possible. To do so, it is crucial to work closely with ASEAN and other Asian countries.

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