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A Study on South Korea's "Decoupling from Japan" Response to Japan's Reinforcement of Export Regulations

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Abstract | The purpose of this research is to provide a preliminary methodology to predict the sustainability of South Korea's "decoupling from Japan" in response to Japan's strengthening of export regulations. To this end, the reinforcement of Japan's export regulations is here identified as "weaponized interdependence," and South Korea's response as "decoupling from Japan." Currently it is difficult to conclude that Japan has weaponized interdependence because the ruling of the Supreme Court of Korea has not yet been implemented. Even after the implementation of the Court's decision, it might be difficult for Japan to weaponize at least the three most important regulated items, Photoresist (PR), Hydrogen Fluoride (HF), and Fluorinated Polyimides (FP), because of the highly interdependent relation of the two countries on the global supply chain (GSC). Japan's hub position in the production of the semiconductor GSC does not seem predominant enough to achieve the "panopticon effect," or the "chokepoint effect." Regardless of the types of decoupling employed by South Korea, either "decoupling from Japan (DJ)" or "decoupling from Japanese firms (DJF)," the major production arena is still within South Korea due to the strong competitiveness and purchasing power of the South Korean semiconductor industry. The essence of South Korea's "decoupling from Japan" policy is to increase the robustness and resilience of the supply chain, including not only South Korea and third countries, but also Japan. On the other hand, it is noteworthy whether the DJF type will become a touchstone for South Korea, which faces Japan's "weaponized interdependence," to show its capability to escape from the Japanese-hub network or build its own. In this regard, the phenomenon of South Korea's decoupling from Japan spreading to other non-regulated items requires careful observation.

Keywords | South Korea-Japan relations, export regulations, weaponized interdependence, decoupling from Japan, decoupling from Japanese firms

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Introduction

The purpose of this study is to present a methodology to analyze the status and sustainability of Korea's "decoupling from Japan" phenomenon against Japan's strengthening export regulations to Korea.

On July 1, 2019, Japan announced an amendment to the Export Trade Control Order to strengthen export regulations to South Korea for core semiconductor materials. In response, the Korean government began to pursue a strategy of "decoupling from Japan" in relation to key components, materials, and equipment, with the aim being to reduce technological reliance on Japan. Since then, and against predictions, Korea has seen little damage from Japan's export regulations. If so, is the perception that the "decoupling from Japan" would show positive short-term results true? And what does this mean? Will it be sustainable in the long term? This paper asks the following specific questions to help us to answer these broad questions.

First, how can we understand the Japanese government's export regulations? Farrell and Newman (2019b) define the concept of "weaponized interdependence" as the reality in which a global economic network involving multiple countries has an asymmetric structure such as a hub-and-spoke network in which the former enforces its interests on the latter. Here, the hub country benefits from "panopticon effects," while the interests of the spoke country are blocked by "chokepoint effects" through by means of a "jurisdictional grasp" or institutions within the hub.

In their contributions to the *Washington Post*, Farrell and Newman (2019a) have regarded Japan's strengthening of export regulations as an economic retaliatory measure to prevent the implementation of the 2018 South Korean Supreme Court's ruling which ordered compensation from several Japanese firms who engaged in the forced mobilization of Korean labor during the colonial period. Therefore, for these arguments to be persuasive, Japan is supposed to be in a hub position in the global supply chain of semiconductors to the extent that Japan enjoys the "panopticon effects," and export regulations need to have institutional maturity enough to obtain the "chokepoint effects." Meanwhile, Farrell and Newman pointed out the limited application of the concept of "weaponized interdependence" (2019b, 76). This is because neither all sectors or nor countries are internationalized, nor do all markets have asymmetric structures even when internationalized.

Goodman pays attention to the semiconductor industry-specific characteristics.[1] The semiconductor industry is a typical imperfect competitive market

1. For detailed discussions, refer to Goodman et al. (2019).

with huge, fixed investment costs and a small number of advanced technology firms. Therefore, long-term transactions among a few companies that specialize in equipment, materials, design, and manufacturing processes respectively are common in this industry to minimize production costs. As a result, if a disruption occurs in the global supply chain (hereinafter GSC), a serious risk emerges to find an alternative company in a short period of time. In addition, since "dual use" cutting edge technologies that can be applicable for both civil and military use in industry have become predominant nowadays, geopolitical risks also tend to remain at the forefront of the competition for technological supremacy between the US and China. Therefore, there may be limitations in defining corporate relations in the semiconductor industry as asymmetric relations. This study aims to understand the characteristics of Japan's export regulations, considering whether the concept of "weaponized interdependence" can be applied to the GSC of semiconductors.

Second, will South Korea's "decoupling from Japan" be sustainable? Farrell and Newman (2019b, 76-77) have argued that countries subject to "weaponized interdependence" by the hub countries of the global economic network are either deviating from the network or rebuilding the network to minimize the resulting volatility. The most notable case is China's "decoupling from America" and the US sanctions against ZTE and Huawei. South Korea's "decoupling from Japan" in response to Japanese export regulations can also be seen in this regard.

The term "decoupling" is literally defined as "a situation in which two or more activities are separated, or do not develop in the same way" by the Cambridge Dictionary. In terms of economics, it refers to a phenomenon in which economic entities such as countries, sectors, and corporations, which have shown synchronized movements in close relationship with each other, begin moving in different directions or are artificially separated. Recently, it is often used as a term referring to the separation of the two countries that had a relationship of a division of labor in the GSC. The implicit premise is that decoupling between countries is synonymous with decoupling between companies. However, in the phenomenon of South Korea's "decoupling from Japan," decoupling between countries is separated from the decoupling between companies. In other words, "decoupling from Japan" does not necessarily mean "decoupling from Japanese firms." I consider that this perspective gives a useful clue to help understand the characteristics of South Korea's "decoupling from Japan." Kim Yang-Hee (2020) is one of the few previous researchers to attempt to provide an analytical approach rather than an enumeration of the "decoupling from Japan" phenomena. The current study is similarly different from previous literature in that while it inherits Kim Yang-Hee's methodology, it intends to further improve such and

predict the sustainability of "decoupling from Japan."

In the second section of this study, the characteristics of Japan's export regulations are identified based on the concept of "weaponized interdependence." The third section analyzes the status of South Korea's "decoupling from Japan" by category. The fourth section examines the interactions between the two governments over Japan's export regulations to South Korea and the effects of them on both countries, highlighting the interdependence of the two countries. In the final section, conclusions, prospects, and future research tasks are drawn based on the above discussion.

Japan's Export Regulations

1. Japan's Export Regulations against South Korea

Japan announced the revision of the Export Trade Control Order on July 1, 2019, and it took effect on August 28 of the same year.[2] The core of the amendment is to change the category of export regions from "White/Non-White Countries," to "Group A (Existing White Countries)," "Group B (New)," "Group C (Existing Non-White Countries)," "Group D (Existing Non-White Country)," and South Korea was moved from the existing white country to "Group B." Here, a "White Country" is a member of the four major international export control regimes[3] and does not require catch-all regulations because the operation of the export control system is reliable, and South Korea was included within this group in 2004.

There are two main types of export regulations on goods that are important to Japan's security. The first category is a "list control" for "strategic items," which have a high possibility of military use, which is further divided into sensitive and non-sensitive items. The second category is for non-strategic items which are regulated according to the situation, also known as the "catch-all control."

If South Korea is assigned to "Group B," first, the method of permitting non-sensitive items among strategic supplies is changed to "Individual Export License" from the "General Bulk Export License" that applied to the existing white countries. This increases uncertainty in exports because the Japanese

2. For detailed discussions, refer to Kim Yang-Hee (2019).

3. The Wassenaar Arrangement (WA); the Missile Technology Control Regime (MTCR); the Nuclear Suppliers Group (NSG); the Australia Group (AG)

Table 1. Changes due to the amendment of Japan's Export Trade Control Order

Type	Category (number of items)			Group A (white country)	Group B (South Korea)
List control	Strategic items (1,120)	Sensitive items (263)	Permission types	Individual export license	
		Non-sensitive items (857)		- General bulk export license - Special general bulk export license - Individual export license	- Special general bulk export license (excluding three items) - Individual export license
			Validity period	3 years	6 months
			License review period	Less than 1 week	Around 90 days
			Number of submission documents	2-3 documents	7-9 documents
Catch-all control	Non-strategic items			Non-applicable	Applicable (if necessary)

Source: Based on the websites of the Japan Center for Information on Security Trade Control (CISTEC) and Korean Security Agency of Trade and Industry (KOSTI).

government can arbitrarily shorten the valid period of a one-time permit, increase the number of documents to be submitted, and prolong the processing period. However, in the case of Japanese companies that have acquired the "ICP" (Internal Compliance Program), a kind of export certification system, the "Special General Bulk Export License," which is almost identical to the General Bulk Export License can be applied. However, when exporting products or technologies with some specifications for the three core materials for semiconductors and displays, Photoresist (PR), Hydrogen Fluoride (HF), and Fluorinated Polyimide (FP), the amendment to allow only "Individual Export License" went into effect from July 4 in advance.

Japan cited inappropriate export control operations on the Korean side as the background to its move to strengthen export regulations, but it has been confirmed through several channels that this was in fact a retaliatory measure

related to the forced labor issue.[4] For example, at an internal meeting of the Liberal Democratic Party held on January 11, 2019, after the ruling of the Supreme Court of South Korea, Councilor Akaike Masaaki insisted on a ban on the export of hydrogen fluoride (Akaike 2019), and Deputy Prime Minister Asō Tarō also said in March of the same year in the Diet that several retaliatory measures were possible ("Kankoku no handōtai seizō" 2019).

South Korea showed strong opposition immediately. The Center for Information on Security Trade Control (CISTEC), the agency in charge of Japan's export control system, repeatedly emphasized that South Korea had misunderstood the situation, and that there would be little impact on export regulations for the following reasons.[5] First, the "Special General Bulk Export License" is applied when about 1,300 companies that have acquired "ICP" are used for exporting other items except the three items to South Korea. Second, out of 857 non-sensitive items, only 18.6 percent (159 items) were those that South Korea had a high reliance on Japan for. Third, among the non-strategic items subject to catch-all regulation, there were only seventy-four major export items to South Korea.

2. Characteristics of the Three Items Subject to Export Regulations

Understanding the characteristics of the three regulated items offers a useful clue to grasp the reality of South Korea's decoupling from Japan. Among PR, only PR for EUV (extra ultraviolet) is subject to export regulations and is a high-tech material that is essential for the lithography process of EUV to produce DRAMs below 7nm or next-generation system semiconductors. PR's major suppliers JSR, Shin-Etsu Chemical, Tokyo Ohka Industries (TOK), Sumitomo Chemical, and Fujifilm are all Japanese companies, and account for about ninety percent of the world market but monopolize PR-EUV production. Shin-Etsu, TOK, and Sumitomo Chemical each have production subsidiaries in South Korea.

HF is a product that is frequently used in large quantities in the etching and cleaning processes of semiconductors and displays, and it accounts for the largest importing quantity among the three items. Liquids requiring high purity are mainly used in semiconductors and gases in display manufacturing. Japan's Stella Chemifa, Morita, and Showa Denko account for about eighty percent of the world market share. These companies are currently operating joint ventures

4. For detailed discussions, refer to Kim Yang-Hee (2019, 2020).

5. For detailed discussions, refer to journal published by CISTEC.

with Korean companies such as Fect Co., Pam Technology Co., and Hankook Showa Chemicals Co. respectively to supply products just-in-time and facilitate technical cooperation with Korean buyers. For example, Soulbrain Co., which developed high-purity HF for the first time after Japan's exports ban, has procured HF undiluted materials from Fect Co., a joint venture between Soulbrain and Stella Chemifa, and then refined these to supply them to Samsung Electronics and SK Hynix. South Korea's dependence on imports from Japan for HF was 41.9 percent, the lowest among the three. On the other hand, the share of Japan's hydrogen fluoride exports to South Korea accounted for 85.9 percent in the first half of 2019, which is overwhelmingly higher than South Korea's dependence on Japan. This is because South Korea used to produce HF until 2012, which was later converted to imports from Japan and China after environmental regulations were strengthened owing to an accident of HF leakage that year (Hattori 2019).

The exports curb for FP is only applicable to the specification that it is used as a film material with a "bound fluorine content of ten percent or more." However, among them, the display material for foldable phones had already been replaced by Ultra-Thin Glass. Japanese companies such as Daikin and Kaneka account for ninety percent of the world market, including Sumitomo Chemical, which has the largest market share. Of them, Sumitomo's wholly owned subsidiary Dongwoo Fine-Chem is a manufacturing company, whereas the other two subsidiaries perform market research and sales functions only in Korea.

The three export-regulated items are materials for cutting-edge information and communication technology's products such as semiconductors, displays, and foldable smartphones. PR-EUV and high-purity hydrofluoric acid, which are highly dependent on Japan, are essential materials for the semiconductor industry. Therefore, the key question is whether Japan will be able to "weaponize interdependence" based on its asymmetrical advantage as a hub in semiconductor GSC.

The South Korean semiconductor industry has developed as a growth engine for the economy, in part, thanks to technology transfer from Japan and the reflective benefits of the US-Japan semiconductor disputes during the 1980s (Okuyama 2014a, 2014b). However, in today's semiconductor GSC, South Korea (memory) and Japan (materials and equipment) engage in an efficient division of labor by specializing in their respective fields based on competitive advantage. South Korea occupying seventy-five percent of the world's memory semiconductor (DRAM, NAND) production is a crucial supplier to its downstream industries such as ICT, electronics, and automobiles. South Korea became the world's largest semiconductor equipment market in 2017 and accounted for 16.8

Table 2. Overview of Japan's trade and investment in three export-regulated items

	Japan's global market share / major suppliers		Korea-Japan trade and investment status	
	Market share (%)	Firms (year of establishment)	Imports from Japan (%)	Production subsidiary in Korea (year of establishment)
Photoresist (PR)	About 90% (EUV 100%)	JSR (1957)*	93.2% (EUV 100%)	JSR Micro Korea (2004)
		Shin-Etsu Chemical (1926)*		Shin-Etsu Silicone Korea (1986)
		Tokyo Ohka Kogyo Co., Ltd. (1940)		TOK Advanced Materials (2012)
		Sumitomo Chemical (1913)*		Dongwoo Fine-Chem Co., Ltd. (1991)
		Fujifilm (1934)*		
Hydrogen fluoride (HF)	About 80%	Stella Chemifa (1916)	41.9%	FECT (1994)
		Morita Chemical (1917)		FEM Technology (2010)
		Showa Denko (1939)*		Korea Showa Chemicals Co. (2006) SK Showa Denko (2017)
Fluorinated polyimide (FP)	About 90%	Sumitomo Chemical (1913)*	85%	Dongwoo Fine-Chem Co., Ltd. (1991)
		Daikin (1933)*		
		Kaneka (1949)		

Note: The * mark on the right of the year of establishment refers to ICP company. However, in the case of Shin-Etsu Chemical, its subsidiaries Shin-Etsu Quartz and Shin-Etsu Polymer are included, and some ICP companies are not on the public list of ICP Japanese companies.

Source: Based on each company's website.

percent of the global semiconductor material market in 2018. About forty percent of Japan's total semiconductor equipment exports are bound for South Korea. That is why it is difficult for not only Japanese but also global material companies to ignore the presence of South Korean memory semiconductor companies, which constitute a de facto monopsony.

Hence, once a GSC-related problem occurs in the long-term trading relationship between them in the industry, it is difficult to find an alternative in a short period of time. As such, not only is Korea's dependence on Japan an

unavoidable factor, but the reverse is also true. This is reflected in the fact that major Japanese materials companies run subsidiaries in Korea for R&D cooperation with and just-in-time procurements to Korean semiconductor companies.

South Korea's "Decoupling from Japan"

1. Government Response

The Ministry of Trade, Industry and Energy of South Korea issued the "Measures to Strengthen Competitiveness of Materials, Parts, and Equipment" (hereinafter MPE) on August 5, just one month after Japan began restricting exports of the three items on July 4. The main contents of this were first the early stabilization of the 100 key items. The government's goal here was to quickly secure alternative importing countries for the three items, achieve supply stabilization of top twenty items within a year, and support R&D investment on the core items for five years, and then seek to replace imports with domestic products, and expand inventory for the rest.

The second is to strengthen national competitiveness in the MPE industries. Over the two decades, the South Korean MPE industry has grown threefold in production and fivefold in exports. However, in consequence of the catch-up strategy focusing on limited general-purpose items, the chronic external dependence of key strategic items continued, and as the concerns of futility over the strategy spread, the supporting law was going to end by 2021. However, the inception of export regulation was a decisive moment in which the law was revived to become a regular law, and rather, a reversal of the total mobilization of the national policy capabilities occurred. The scope of this support includes R&D, fostering clusters, establishing a reciprocal relationship between supply and demand companies, and supporting overseas sales channels. In this regard, Japan's export regulations could be termed as form of "disguised blessing" for Korean small-and medium-sized businesses that compete with Japanese products. The export regulations no doubt accelerated decoupling from Japan, yet the tendency started even before the export regulations came into being. For instance, Samsung Electronics' proactive decoupling from Japan, such as investing about 187.4 billion won through a capital increase to support the decoupling from Japan of six domestic MPE companies, became an important driver of decoupling from Japan (Pak Ho-Hyŏn 2020).

It is worth noting that the MPE policy is evolving. With the outbreak of the coronavirus intensifying strategic competition between the US and China, GSC

is being reshaped in the direction of localization and regionalization (Kwan'gye buch'ŏ haptong 2020). Under these circumstances, the Korean government, fortunately, has obtained an advantageous step forward in responding to the climate changes in the wake of Japan's export regulations in advance. Accordingly, the MPE policy has been transmitted to a GSC risk management policy that goes beyond decoupling from Japan and suggests the following goals. First, in terms of GSC risk management, the 100 core items should be expanded to 338 items to strengthen the resilience of supply chains. Moreover, based on the importance of industrial security and its effects on other industries, the government should select 100 technologies to internally foster. Second, establish a strong supply and demand system through international cooperation and support for diversification of supply and demand by companies. Third, transform South Korea into "Safe Korea," a transparent and safe high-tech industry.

2. Analysis on Korean Companies' "Decoupling from Japan" by Type

As shown in table 3, "decoupling from Japan" is first divided into two types in terms of whether the producers are Japanese or not and further six types in terms of production areas in theory. The first is the "DJ" (decoupling from Japan) type, where "decoupling from Japan ≠decoupling from Japanese firms," when the production site is out of Japan, but the producers are Japanese companies. "DJ" is further divided into two types: "DJ-JK," where the production area is in South Korea, and "DJ-JT" where the production area is in a third country. The second type is the "DJF" (decoupling from Japanese firms), which decouples not only from Japan but also from Japanese companies, so "decoupling from Japan = decoupling from Japanese firms." This further divides into four types: "DJF-KK," Korean company producers in South Korea, "DJF-TK," the third countries' producers in South Korea, "DJF-KT," Korean producers in the third countries, and "DJF-TT," the third countries' companies in the third countries.

First, the types of decoupling from Japan are as follows.[6] As for the PR-EUV, both DJ and DJF appeal to dynamic interactions. Regarding DJ-JT (in other words, import diversification) type, prior to export regulations, JSR, Shin-Etsu, and TOK's Korean subsidiaries only produced Argon Fluoride (ArF) and Krypton Fluoride (KrF) resists, while PR-EUV, a high-tech material, imported from Japan for the fear of technology leakage to Korean companies. Accordingly,

6. This is based on the announcements of the relevant governments and companies, and there is a limit that it is difficult to confirm the facts beyond that.

Table 3. Types of South Korea's "decoupling from Japan"

Type	Type	Producer	Production area
DJ	DJ-JK	Japanese firm (J)	South Korea (K)
	DJ-JT	Japanese firm (J)	Third country (T)
DJF	DJF-KK	Korean firm (K)	South Korea (K)
	DJF-TK	Third country firm (T)	South Korea (K)
	DJF-KT	Korean firm (K)	Third country (T)
	DJF-TT	Third country firm (T)	Third country (T)

Korean semiconductor companies, which became urgent after export regulations, responded with DJ-JT, which was an easier way to procure the necessary volume of PR-EUV. In other words, Korean companies detoured imports from Japan to RMQC in Belgium, a joint venture between JSR and Belgian company IMEC.

The first DJF type is DJF-TT. DuPont, an American company that once attempted to develop PR-EUV decided to establish a factory in Korea to retry to develop PR-EUV. Since DuPont previously supplied PR to Samsung Electronics through its subsidiary Dow DuPont in South Korea, it expects rapid commercialization utilizing two plants and an R&D center in South Korea. In doing so, DuPont intends to access semiconductor clusters in South Korea with Samsung as a hub, which is consistent with the South Korean government's interest in fostering semiconductor clusters.

Meanwhile, Samsung Electronics and SK Hynix jointly participated in the US start-up Inpria in cooperation with Japan's leading PR-EUV manufacturer JSR, and Taiwan's world's number one foundry company TSMC to develop next-generation PR-EUV. This is a unique mix of the three types, DJF-KT (Samsung, SK Hynix) and DJF-TT (Inpria, TSMC) and DJ-JT (JSR).

DuPont's swift actions sparked DJ-JK. TOK also decided to produce PR-EUV in Korea to maintain its position vis-à-vis competitors. As such, the five different types appearing in PR-EUV imply the strong purchasing power of the domestic semiconductor industry. Although the DJF-KK type has yet to be seen, this type will likely be to emerge with the help of other types in the long term.

DJF-KK is the most common type found regarding HF. This is because of Korean companies' experience in production, which had a hiatus in production due to reinforcement of environmental regulations that later eased in the wake of export regulations. A good example is Foosung Co., Ltd., and other firms like

Ram Technology and ENF Technology have also begun production. However, Japanese companies are directly or indirectly related to this type. Soulbrain reached the stage of mass production of high-purity hydrofluoric acid liquid for semiconductors (Kwan'gye buch'ŏ haptong 2020). However, it was supplying HF to Samsung after processing hydrofluoric acid undiluted made by Fect Co., Ltd., a joint venture with Stellar (Sakabe 2019). Samsung also invested in this company to help develop relevant technology. SK Showa Denko, a joint venture between SK materials of Korea and Showa Denko of Japan succeeded in producing hydrogen fluoride prototypes at the end of 2019 and began mass production in June 2020. The DJ-JT type can also be found because as South Korea switches its imports from Stellar and Morita in Japan to their Chinese and Taiwanese subsidiaries, respectively.

For FP, Sumitomo's wholly owned company Dongwoo Fine-Chem started domestic production, which is classified as DJ-JK type in DJ. Among the DJF types, Kolon, SKC, and SK Innovation that began production are classified as DJF-KK. Meanwhile, Dowoo Insys, a subsidiary of Samsung Display, replaced FP materials imported from Sumitomo, greatly reducing FP's dependence on imports from Japan. The company imported Ultrathin Glasses from Germany's Schott, then processed, and delivered them for Samsung Display's foldable phone display. However, there are still a few companies that import FP from Sumitomo (Company interview by the author, October 13, 2019).

Decoupling from Japan is also spreading to other trade arenas, mainly in the semiconductor industry.[7] Among the DJ types, DJ-JK is as follows. Tosoh Quartz, which occupies twenty to thirty percent of the world market share of quartz glass, an optical fiber material, established a new factory with the aim of mass production by the end of 2021. Nikka Chemical also plans to produce fluorine chemicals used for screen processing of precision equipment. Kanto Denka Industries, which exported all the carbonyl sulfide imported into Korea, a special gas used in the pre-processing of semiconductors, will begin production in South Korea utilizing an established subsidiary, and a technical support center will also be opened in the Ch'ŏnan plant. Daiyo, a conglomerate that accounts for eighty to ninety percent of the global dry film solder resist market, announced the launch of local production of it for semiconductor package substrates. Previously manufactured and exported from the factory in Kyushu, the solder resist will be procured by establishing a new subsidiary in South Korea to supply the item not only for electronics companies, but also for auto-

7. As the following contents may overlap with those described by the Ministry of Trade, Industry and Energy by anonymizing the company name, all those announced by the Ministry of Industry are excluded.

Table 4. Overview of South Korean firms' "Decoupling from Japan" by type: three items under export regulations

Type		Company name		
		PR-EUV	HF	FP
DJ	DJ-JK	Tokyo Ohka Kogyo Co., Ltd.		Sumitomo
	DJ-JT	JSR (Inpria)	Stella, Morita	
DJF	DJF-KK		Soulbrain, SK Materials Foosung Co. Ltd., Ram Technology, ENF Technology, Dongjin Semichem, SKC Solmics	Kolon, SKC SK Innovation
	DJF-TK	Dupont		
	DJF-KT	Samsung, SK (Inpria)		
	DJF-TT	Inpria		

nomous vehicles made by the Hyundai Motor Company. ADEKA, a chemical company, also converted exporting semiconductor materials to local production and now supplies them to DRAM manufacturing. Tokyo Electron, the fourth biggest semiconductor equipment maker in the world, will establish a new technology center in P'yŏngt'aek, where Samsung Electronics' cutting-edge memory factory is located, and will be potentially producing parts in the future. In addition, there are also Fujikin (manufacturing gas units for semiconductor manufacturing equipment), Roche (automatic wafer transfer equipment), and Toray Advanced Materials (manufacturing advanced nonwoven fabrics for masks) (Hattori 2020a).

DJF-KK is as follows. Among the twenty items with high dependence on Japan, SKC has newly established a high-tech facility for blank masks, a core material for the semiconductor exposure process. SK Siltron, the only wafer manufacturer in Korea that supplies silicon wafers to Samsung Electronics, SK Hynix, TSMC, Micron, and Toshiba Memory, has acquired DuPont's SiC wafer division. The acquisition is regarded as a move to lower the high dependence of non-silicon substrates from Japan by means of export regulations. Dongjin Semichem is working on the internalization of ArF and KrF resist. SK Materials also has a localized hard mask ArF resist. Iljin Materials Co., Ltd. succeeded in developing 1.5 μm ultra-thin copper foil for semiconductors. Paik Kwang Industrial Co., Ltd. is developing high-purity hydrogen chloride (HCI) with Samsung Electronics and is conducting quality evaluation for application to

Table 5. Overview of South Korea's "decoupling from Japan" by type: other items

Type		Company name (item name)	
DJ	DJ-JK	Tosoh Quartz (optical fiber material) Nikka Chemical (fluorine chemical product) Kanto Denka (carbonyl sulfide) Daiyo (semiconductor solder resist) Tokyo Electron (semiconductor equipment R&D)	ADEKA (DRAM material) Fujikin (gas unit for semiconductor equipment) Roche (wafer automatic transfer machine) Toray Advanced Materials (nonwoven fabric for mask)
	DJ-JT		
DJF	DJF-KK	SKC (blank mask facility) SK Siltron (acquisition of DuPont wafers) SK Materials (hard mask, ArF) Hanwha Solutions (xylylene XDI) LG Innotek (ferrite)	S&S Tech (EUV photo mask) SEMES (track equipment) Dongjin Semichem (ArF, KrF) Solus Advanced Materials (ultrathin) Iljin Materials (ultrathin copper foil for semiconductor) Paik Kwang Industrial Co., Ltd. (HCI)
	DJF-TK	DuPont (USA, pad for CMP) Lam Research (USA, semiconductor equipment)	AMAT (USA, EUV photo mask) MEMC (Taiwan, silicon wafer)
	DJF-KT	Circuit Foil Luxembourg (Luxembourg, high-end ultrathin copper foil)	

mass production. This product is used as an etchant in the cleaning and etching process of semiconductor wafers, which had been supplied by oligopoly of Toagosei of Japan and Linde of Germany. Hanwha Solutions announced in May 2020 that it has succeeded in developing xylylene diisocyanate (XDI), a high value-added optical lens material monopolized by Japan.

There is also a DJF-TK type. Lam Research, an American company with the fourth largest share of the global semiconductor equipment market, announced in November 2019 that it would establish an R&D center in Kyŏnggi-do by relocating its base from Silicon Valley. As MEMC Korea, a subsidiary of Taiwanese company Global Wafers, also revealed the completion of a new silicon wafer plant in November 2019, potentially diversifying the supply of silicon wafer, an area that had a large dependence on Japan.

There is also a DJF-KT type. Circuit Foil Luxembourg, a Luxembourg subsidiary of Solus Advanced Materials, succeeded in developing an ultrathin

copper foil for system semiconductors with a thickness of 2 μm. Circuit Foil Luxembourg received an order in the domestic market that was monopolized by Japanese materials companies (Solus Advanced Materials 2020). High-end ultrathin copper is a core material of the microcircuit manufacturing method (MSAP: Modified Semi-Additive Process) and is widely used in PCBs (printed circuit boards) for system semiconductors such as mobile and wearable devices.

Interdependence between South Korea and Japan

1. Policy Interactions between the Two Governments

While the conflict between the two governments over export regulations superficially seems like an obvious example of tit-for-tat reprisals and brinkmanship, it looks as if they have also set a Maginot line and made a promise to avoid extreme confrontation. Summarizing the interactions between the two governments over time will provide useful information for assessing whether Japan is able to utilize its "weaponized interdependence" and South Korea's possibility of "decoupling from Japan."

(1) Japanese Government[8]

After South Korea showed strong opposition to the reinforcement of export regulations, Japan repeatedly emphasized through the agency in charge that South Korea misunderstood this new imperative. First, Japan asserted that it had strengthened its export regulations as there were inappropriate export cases found in South Korea. Japan further urged that they were not retaliatory measures in response to South Korea's Supreme Court ruling, but rather caused by the shortcomings in the operation of export regulations in South Korea. Second, the reason for targeting the three items was that there were many "inappropriate (not illegal)" export cases. Japan insisted that it was responsible for addressing these cases because the major suppliers were all Japanese firms. Third, while South Korea argued that the rise of uncertainty deriving from the export regulations will bring about a negative impact on the Korean economy and the GSC, Japan allegedly emphasized that this was not an embargo, rather reinforcement without critical changes to full compliance. Fourth, according to

8. This part is based on the data published after the export regulation by CISTEC, an agency in charge of strategic materials, established jointly between Japan's Ministry of Economy, Trade, and Industry and strategic materials exporting companies.

Japan, of the three items under export regulations, only PR for EUV use and less than one percent of polyimide fluoride for new use are subject to regulation. In the case of Individual Export License, Japan argued that it such are usually approved within thirty to forty days, ninety days at the most, and the submission of increased documents will become easier overtime. South Korea also admitted that there was little damage after these export regulations, contrary to the concerns voiced in the national private and public spheres. Fifth, Japan justified that its export management is in accordance with the WTO's GATT Article 21 (security exception), and therefore, Korea should withdraw and find a solution through dialogue.

Despite the assertions made by Japan, there remain some questions. For example, it was only hydrogen fluoride that Japan cited as an inappropriate export case found in South Korea, whereas the other two items were not mentioned at all. On the other hand, it is true that South Korea had some misunderstanding and showed an oversensitive reaction in the beginning.

However, the fact that Japan gradually eased rather than tightened the export regulations is also in effect. The Japanese government allowed exports of the three items intermittently starting on August 8, the day after the amendment to the export order was announced. For Japan to strictly enforce the issue of "inappropriate" exports to South Korea, it should have restricted supply to circumvent exports from third-country subsidiaries of Japan or their production of such items in South Korea. Japan, however, did not take such action. On December 20, among the three items, the PR-EUV was changed from "Individual Export License" to "Special Bulk Export License." Japan explained the reason as being that there was stable accumulation of six export licenses to South Korea. Until the end of 2019, Japan permitted such exports at least seven times. In the final analysis, it is hard to recognize the presence of export restrictions as if they no longer apply.

(2) South Korean Government

South Korea began implementing strong retaliatory measures such as excluding Japan from South Korea's list of white countries in their own export regulations, and not extending GSOMIA (General Security of Military Information Agreement), an agreement to share military information between the two governments. Furthermore, South Korea took the step of introducing a lawsuit at the WTO against Japan on export restrictions for the three items. South Korean consumers started boycotting Japanese consumer goods such as beer, clothing, cars, and travel to Japan. This was mainly attributable to the perception by most Koreans that Japan's export regulations were a targeted response to the Korean

Supreme Court ruling, one aimed at disrupting South Korea's semiconductor industry, which is widely considered as a symbolic driving force reflecting the growth of the South Korean economy.

Nonetheless, like Japan, the South Korean government was not consistent with its hardline position. After twists and turns, GSOMIA was eventually extended, and the WTO complaint was also suspended. And primarily, South Korea finally admitted its fault and improved the three issues Japan raised in the operation of the Korean export control system (interruption of Korea-Japan policy dialogue, lack of legitimate catch-all control over conventional weapons, insufficient export management organization and manpower) even though the South Korean government did not initially admit and strongly opposed the existence of these issues. When South Korea requested Japan to withdraw its tightened export restrictions after showing such measures of improvement, Japan's Ministry of Economy, Trade, and Industry did not engage in dialogue, and then the South Korean government initiated a complaint at WTO on June 29. Since then, the Japanese government has maintained its position that South Korea should withdraw the complaint and find a resolution through dialogue.

Why did South Korea demand the withdrawal of Japanese export regulations and then take the issue to the WTO despite the fact that these export regulations offered an opportunity to strengthen the competitiveness of MPE in Korea? Reinforcing the competitiveness of MPE has been a twenty-year-long task for South Korea. The reasons why the South Korean government elected to take this approach are as follows: Firstly, even if South Korea resolved the three causes for Japan's introduction of export regulations, if Japan does not withdraw them, then the legitimacy of Japan's export regulations will be weakened. In fact, it is a well-known secret that the goal of Japan's export regulations was to provoke a reassessment of the validity and utility of South Korea's Supreme Court ruling on forced labor, and slow if not derail its legal implementation. And, in this respect, both South Korea and Japan hold the dominant view that Japan's withdrawal of regulations will be unlikely unless this issue is resolved first.[9] Secondly, South Korea's WTO complaint was inevitable in practice, showing the realistic limits of decoupling from Japan. Moreover, South Korea had no choice but to decrease the uncertainty in imports of key items from Japan against the background of the Covid-19 pandemic, a circumstance that raised uncertainty about the entire South Korean economy overall. South Korea's Ministry of Trade, Industry, and Energy press briefing regarding the

9. For detailed discussions, refer to Kim Yang-Hee (2019, 2020).

WTO complaint also revealed this reality as well.[10] Additionally, while the governments of South Korea and Japan seemed to show consistent hardline responses, they were aware of the need for moderating brinkmanship in their joint approach, and the two governments have refrained from extreme confrontation for the sake of the close interdependence of two economies.

2. Economic Impact of Japan's Export Regulations

How did Japan's export regulations affect both countries? First, when analyzing the trend of imports of the three items before and after Japan's export regulations, it is important to note that Japan's export control system is different from that of South Korea. In both countries, the statistical standards for export control are different from the Harmonized System (HS) code, an international standard for statistics on trade in goods. Moreover, the HS code is internationally accepted only up to six digits, and the unit below it is different from country to country, with a minimum of ten digits in South Korea and nine digits in Japan. Therefore, as shown in table 6, the Korean Security Agency of Trade and Industry (KOSTI), the main export control agency in Korea, presented the three items in a ten-digit Korean standard aligned with the export control number of Korea for mere convenience in matching.[11] Therefore, the three export-regulated items do not correspond to a single item based on ten digits of HSK but are scattered in seven items.

However, most, if not all, research institutes in South Korea misunderstood PR to account for only 3707.90.1010 out of seven ten-digit HSK items. Moreover, for FP, they recognized not only the completely irrelevant "aromatic polyimide product" as a regulated item, but also misunderstood that it was only 3920.99.9010 out of seven items matched with ten digits of HSK. As a result, inaccurate information that HSK 3707.90.1010 and 3920.99.9010's imports from Japan had no significant impact or increased even after export restrictions has been circulated for over two years.

As chance would have it, the HF control number and HSK code are almost identical, making it easy to analyze the impact by means of trade statistics. This is mostly for semiconductor manufacturing (HSK 2811.11.1000) and other

10. "By objectively demonstrating the illegality and unfairness of Japan's export restrictions through the WTO dispute resolution procedure, we will do our best to respond to protect the legitimate interests of our company and to promptly resolve the uncertainty posed by companies in both countries and the global supply chain" (Sanŏp T'ongsang Chawŏnbu 2020).

11. Accordingly, KOSTI states that the item name/HSK matches does not correspond to a controlled item.

Table 6. Linkage of HSK with Korean control numbers of the three export-regulated items

Export control product name	Photoresist (PR)	Hydrogen fluoride (HF)	Fluorinated polyimide (FP)
Korean control number	3C002	1C350.24	1C009.b
HSK code	2931.90-9099 3707.10-0000 3707.90-1010 3707.90-1020 3707.90-1090 3905.99-0000 3911.90-9000	2811.11-1000 2811.11-9000 2826.19-9000 2902.90-9000 3808.91-1000 3822.00-2020 3824.99-3990	2930.90-9099 3902.90-0000 3904.69-0000 3905.91-0000 3905.99-0000 3906.90-9000 3911.90-9000

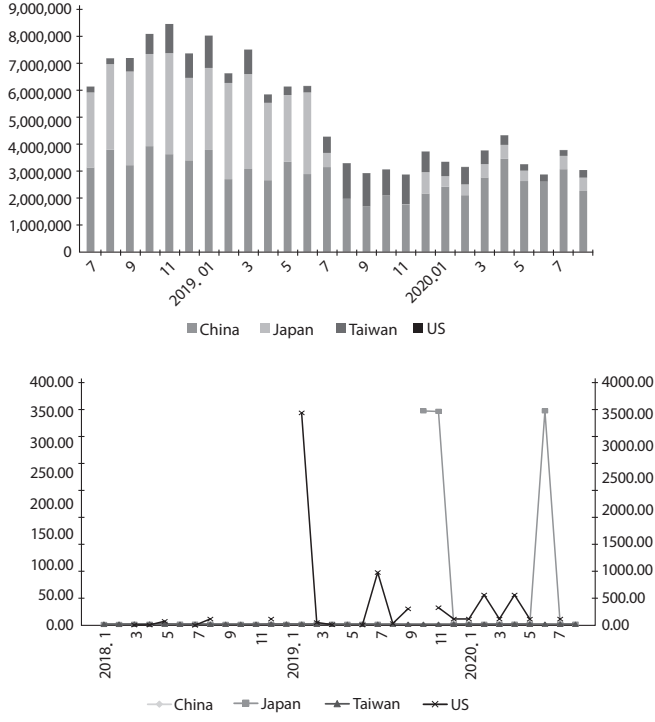
Source: Based on Chŏllyak Mulcha Kwalliwŏn (n.d.).

manufacturing (HSK 2811.11.9000), and the proportion of imports from Japan accounted for about sixty-seven percent before export restrictions. Therefore, in the following, the impact of export regulations on Korea will be reviewed regarding only HF.[12]

The share of HF for semiconductor manufacturing (HSK 2811.11.1000) imported from Japan was 49.2 percent in June 2019 but dropped sharply to 12.4 percent in July, none in August and September, and only 300 kilograms and 400 kilograms were imported in October and November, no imports. After recovering to 21.4 percent in December, it continued to reach the ten percent level again, and then fell to virtually zero in June 2020, and again reached 16.2 percent in August. Due to the sharp decline in imports from Japan, total HF imports in August 2020 reached half the level of 2018, and profits were mainly taken from Taiwan. Consequently, in October and November, the unit price of the very small number of imports from Japan surged from two dollars to 353 dollars per kilogram. A similar surge occurred in June 2020. For the same reason, the unit price of imports from the US also surged to 870 dollars in July 2019 and 500 dollars in February and April 2020.

For HF for other manufacturing use (HSK 2811.11.9000), the share of imports from Japan was insignificant even before export restrictions, but the volume of imports increased until September immediately after export restrictions and then decreased until December, reaching zero in January 2020. Afterwards, imports from Japan declined close to zero, and only imports from

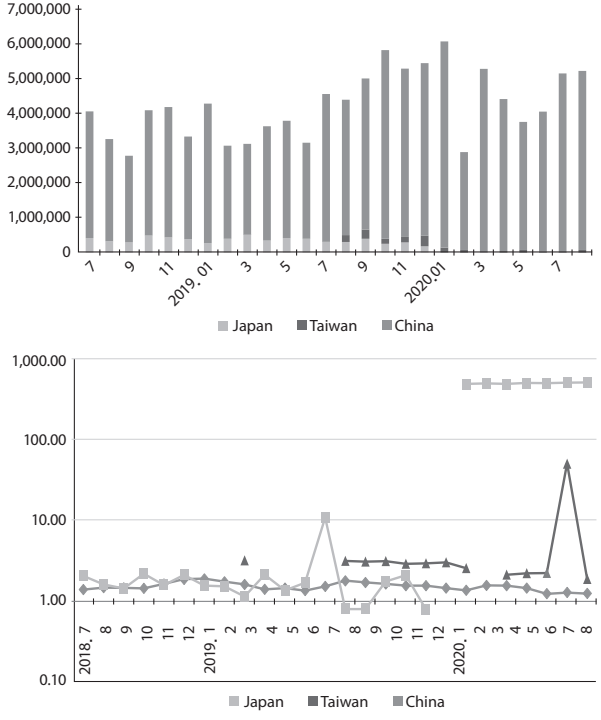
12. Among the hydrogen fluoride imported by South Korea, Japanese products are mainly used for semiconductors and Chinese products are for other manufacturing uses. Taiwanese products are mainly used for semiconductors, but the proportion of imports is small.



Source: K-stat (https://stat.kita.net/).

Figure 1. Hydrogen fluoride (for semiconductor manufacturing) imports and unit import price by country (Unit: kg, US dollar)

China continued. After a sharp increase in March 2020, there were ups and downs but an overall increase compared to the average year. Total imports in August 2020 increased by eighteen percent compared to the same month the previous year, owing to a surge in semiconductor demand following Covid-19, but this was only due to an increase in imports from China. However, in July 2019, the unit price of the product imported from Japan was around 500 dollars for the very small number of imports throughout 2020. In July 2020, the Taiwanese unit import price also reached fifty dollars, indicating the difficulty of securing supply. As such, in the early days of export restrictions, Korean companies paid very high import prices, but these gradually fell back to a normal level. Therefore, while there was some damage, no serious supply shortage occurred thanks to gradual import substitution. In other words, while the Korean buyers initially suffered from Japan's export regulations, Korean suppliers competing with Japanese suppliers eventually benefited at the expense



Source: K-stat (https://stat.kita.net/).

Figure 2. Hydrogen fluoride (for other manufacturing purposes) imports and unit import price (Unit: kg, US dollar)

of the Korean buyers and Japanese suppliers.

Decoupling from Japan was a great opportunity for Korean companies in competition with Japanese producers. In a survey conducted by the Korean Chamber of Commerce and Industry (Taehan Sanggong Hoeŭiso 2020) of 302 domestic companies, eighty-four percent of respondents answered that there was "no damage" by virtue of export regulations, while only sixteen percent said the opposite answer. Regarding the negative impact of export regulations on corporate competitiveness, ninety-one percent of respondents said that there was no significant impact, while only nine percent said that there was an impact. The evaluation of the Korean government's response to Japan's export restrictions was highly positive (seventy-eight percent). Helpful policies include "R&D support" (forty-two percent), "supply chain stabilization" (twenty-three percent), "regulation improvement" (eighteen percent), "win-win cooperation with large and small companies" (thirteen percent), and "overseas mergers and acquisitions

& technology incorporation support" (three percent).

What about the Japanese side? In the case of HF (HS 2811.11), Japan seemingly suffered more damage than South Korea. According to trade statistics from the Ministry of Finance of Japan, exports to Korea, which accounted for 85.3 percent of total exports in the first half of 2019, plunged to 14.2 percent in the second half. Hence, exports to South Korea from 7.5 billion yen in 2018 decreased to 4.5 billion yen in 2019, and total exports from Japan decreased by seventy percent. In 2020, exports to South Korea for one to five months have also decreased significantly compared to the same period in 2019, and the total export performance is only about a quarter of that of the first half of 2019.

The performance of the three items of Japanese manufacturers in 2019 however, deteriorated significantly on the grounds of the impact of export regulations. JSR's 2019 operating profit fell 27.4 percent from the previous year to 32,884 billion yen, and Stella Chemifa, the number one hydrogen fluoride company, declined 31.7 percent to only 2.47 billion yen, the largest decline. Sumitomo, the number one FP company from which Samsung imported all for its foldable phone displays, also fell 10.5 percent from the previous year to 127.7 billion yen (Yun Sang-ho 2020).

Conclusion

The findings on the two research topics mentioned in the introduction are as follows.

First, the Japanese government's export regulations can be considered as a form of weaponized interdependence to prevent the implementation of the Korean Supreme Court's judgment on the issue of forced labor. Rather than wielding such a weapon to the full possible extent, Japan has used it to the degree that the Korean Supreme Court has not yet been able to monetize the assets of Japanese companies.

The semiconductor GSC hub was not dominant enough for Japan to create a "panopticon effect" in the case of all three regulated items. Here, rather than a hub-spoke system, the relationship between companies in South Korea and Japan comes close to symmetrical interdependence, with each one specialized relative to other's competitive edge. In the case of HF, as shown by the fact that the Japanese companies suffered more than Korean companies due to Japan's export regulations, Japan's dependence on South Korea was something that could not be ignored. Moreover, as the trend of decoupling from Japan spread, so did negative public opinion about this in Japan.

Under this circumstance, if Japan would fully weaponize interdependence, it would likely become a double-edged sword that hurt not only Korean but also Japanese companies and would disturb the GSC in a significant manner. In fact, immediately after the introduction of Japan's export regulations, six international organizations related to the two countries sent a joint letter urging the two governments to refrain from such dispute, indirectly confirming the status of the Korean semiconductor industry (Semiconductor Industry Association 2019). This is also the reason that South Korea has not suffered much damage from export regulations. Therefore, even if the Supreme Court ruling is carried out, it is highly likely that Japan will not weaponize the three items, but something else that Japan has a stronger hub position in relation to.

Another reason Japan had difficulty in strengthening export restrictions is presumed to be South Korea's decision not to file a complaint with the WTO. The lawsuit may unveil the implicit tension between export control and WTO rules which have existed in a totally different world, respectively. This also implies that Japan has not achieved "chokepoint effect" revealing the inconsistency with international law or legitimacy in their domestic export regulations.

Second, will South Korea's "decoupling from Japan" last for a long time? Such decoupling can be divided into two types, "DJ" and "DJF," in terms of Japanese firms' presence and the core criterion that separates the two stems from the extent of the Japanese company's competitive advantage. While the DJ is a type of decoupling which is difficult for Korea to accomplish in the short-term owing to the competitiveness of Japan's companies, the DJF is a type whose negative impacts on South Korea can be negated through internal development or cooperation with third countries.

Regarding the future prospects for decoupling from Japan, the important point, whoever the producer might be attempting to decouple from Japan, is that the core production area still lies in South Korea. That is, DJ-JK is the key among DJs, and DJF-KK and DJF-TK are the central axes among four DJFs. As of January 2021, twenty-three companies had built production facilities in South Korea among 100 items subject to decoupling from Japan (Sanŏp T'ongsang Chawŏnbu 2021). This is possible only with the strong purchasing power of the Korean semiconductor industry. The long-term trading relationship established between the best high-tech companies based in Korea means efficiency. The decoupling of South Korean companies from Japan requires expensive options to replace these efficient transactions with fewer efficient ones. Accordingly, as the GSC risk incited by Japan's export regulations and the outbreak of Covid-19 spreads, the interdependence between the two countries rather seemingly weaponized not Korea but Japan, yet paradoxically, it led to decoupling from

Japan in the South Korean base.

The discovery of the DJF type is also an interesting point that deserves attention. As Farrell and Newman (2019b, 76-77) point out, this becomes a touchstone for South Korea to demonstrate its ability to deviate from the Japanese-led network or attempt to rebuild its own network while facing Japan's "weaponized interdependence." Clark Tseng of the International Semiconductor Manufacturing Equipment and Materials Association (SEMI) said during SEMICON Japan 2019 held in Tokyo in December 2019, "Due to export regulations by the US and Japan, Asia, especially China and Korea, are rapidly heading to local sourcing as they establish new supply chains" (Hattori 2020b). As such, by creating a fissure in the GSC, Japan provided a motive for the formation of a new network that excluded not only new competitors but also Japan's domestic companies. And what would be more painful for Japan than DJ is DJF. Is South Korea's decoupling from Japan strong enough to neutralize Japan's "weaponized interdependence" in the long term? In this regard, the phenomenon of decoupling from Japan spreading from these three major trading items to other non-regulated items needs to be closely monitored.

The degree of South Korean dependence on Japanese technology is evident when looking at each phase of manufacturing. Intermediate goods, which accounted for sixty-eight percent of South Korea's total imports from Japan in 2019, accounted for the largest share of the trade deficit with Japan. However, this plunged from 26.2 billion dollars in 2010 to eleven billion dollars in 2019, the lowest level since 1996. In contrast, the deficit level of capital goods, which accounted for twenty-one percent of total imports from Japan in 2019, showed ups and downs but rarely decreases, suggesting the difficulty of reducing dependence on Japan. However, the deficit level sharply decreased to seven billion dollars in 2019 after rebounding from the level of 11.6 billion dollars in 2017. As such, South Korea's decoupling from Japan will be more challenging in capital goods.

Since focusing wholly on internalization is also dangerous, the supply chain must be diversified to disperse the risks. Securing the stability of imports from Japan is still important regardless of decoupling from Japan, which explains why the South Korean government resumed the WTO complaint. The damage to Japanese companies is still considered negligible in the Japanese economy. However, the wider decoupling from Japan spreads, the greater the loss on the Japanese side would be. On the Korean side, while decoupling from Japan can be considered positive for improving the innovation capacity of the Korean economy in the long term, the possibility of deteriorating economic efficiency if it becomes too excessive also cannot be ruled out. Furthermore, the boomerang

effect of causing Japan's decoupling from South Korea is also becoming a reality. Rather than prematurely assessing the impact on both countries, it is necessary to observe the outcomes of these processes from multiple perspectives over a long period of time. Therefore, in the current context, Korea's decoupling from Japan should be discrete in order to balance and harmonize technological feasibility with economic rationality. This is because the essence of any successful "decoupling from Japan" should not be framed in terms of localization but strengthening the robustness and resilience of the supply chain.

• *Translated by LEE Jeung Seung*

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