When Export Controls Backfire: Evidence from 2019 Korea-Japan Trade Dispute*

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Abstract

Can export controls backfire, leading to an increase in productivity and exports in the targeted country? I use Korea's response to the 2019 Korea-Japan trade dispute to answer this question. In 2019, Japan announced export controls on South Korea for national strategic items, leaving enforcement up to Japanese officials. Although no export restrictions were imposed in practice, the potential risk alone triggered substantial changes in Korea's imports and exports. Imports from Japan declined significantly, irrespective of whether items were subject to the announcement. However, imports from Japan decreased disproportionately in sectors where Japan had been the primary supplier, and Korean producers' revenue also increased in these sectors, suggesting import substitution. Notably, Korea's exports expanded more in these sectors while prices declined, suggesting increased productivity. Motivated by these empirical findings, I structurally estimate the strength of scale economies in Korea (and elsewhere) leveraging variation in exposure to Korea's substitution away from Japan across industries (and across countries). The results support the presence of large scale economies, suggesting that export-control-induced positive shocks to domestic demand increased productivity, which in turn boosted exports.

JEL Classification: F12, F13, F14, F51

Keywords: Trade Policy, Export Controls, Scale Economies.

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1 Introduction

Export controls have recently emerged as a pivotal tool in geopolitics. For instance, since October 2022, the US has required multinational firms to obtain prior authorization before exporting advanced semiconductors and related manufacturing equipment to China. Some argue that such measures could be detrimental to the targeted country due to restricted access to crucial intermediate goods. Others, however, view it as an opportunity for the targeted country to bolster domestic production. The feasibility of the latter depends on whether production exhibits increasing returns to scale, allowing the industry to become more productive as it scales up to meet increased domestic demand.

I examine this issue in the context of Korea's response to Japan's 2019 announcement of export controls. In this paper, I answer the following question: Can export controls backfire, leading to an increase in productivity and exports in the targeted country? Scale economies in production are key to the possibility that export controls backfire. Foreign export controls increase domestic demand, which enhances productivity in the presence of scale economies. This, in turn, drives down prices and boosts exports. My empirical findings provide strong support for this mechanism, showing that Korean producers' revenue and exports increased, accompanied by a decrease in prices, precisely in the goods in which Korea had depended most strongly on Japan. Motivated by these empirical findings, I structurally estimate the strength of scale economies, exploiting demand-side variation. I find strong scale economies, indicating that a 1% increase in total sales leads to a 0.9% increase in exports, driven by a 0.4% increase in productivity.

In late 2018, tensions between Korea and Japan emerged following a Korean Supreme Court ruling that ordered Japanese companies to compensate Korean victims forced into labor during World War II, a decision Japan strenuously contested. In July 2019, the Japanese government responded to this decision by announcing potential export controls on three items essential to Korea's semiconductor and display industries. In September 2019, Japan removed Korea from its list of preferential trade partners, resulting in all national strategic items exported to Korea to be subject to potential export controls. As a result of this removal, Japanese firms exporting these national strategic items to Korea were required to obtain government approval. The approval decision was uncertain, as the Japanese government was legally authorized to ban or restrict shipments to Korea. Despite this possibility, in practice the Japanese government did not enforced any export restrictions on these items following the announcement of export controls.

Although the controls were not enforced, I demonstrate that the announcement itself led to significant shifts in Korea's imports from Japan. First, Korea's overall imports from

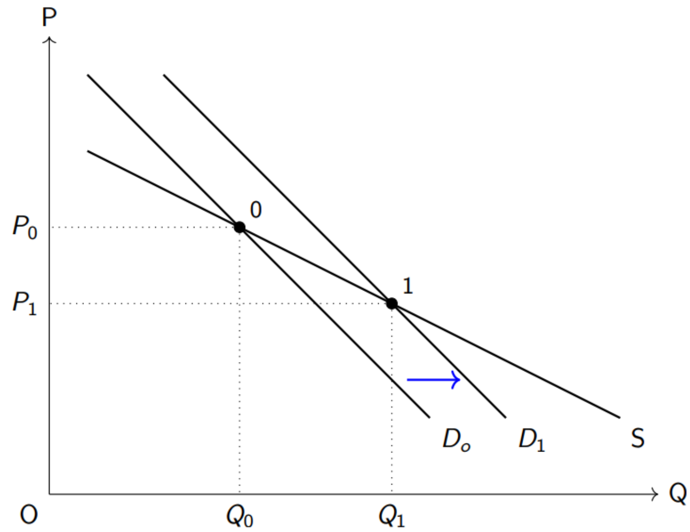


Figure 1: Downward Supply Curve

Notes: Supply curves in a partial equilibrium model can slope downward in the presence of scale economies. Applying this concept to foreign export controls, positive shocks to domestic demand shift the demand curve to the right from D_0 to D_1. In turn, this leads to an increase in quantity (from Q_0 to Q_1) and a decrease in price (from P_0 to P_1) along the downward-sloping supply curve. This framework is in line with my empirical findings in Section 3.

Japan substantially declined compared to the pre-event period and relative to imports from other countries during the post-event period. Second, non-exposed goods experienced a similarly significant decrease in imports from Japan as exposed goods following the announcement of export controls. This suggests that Korean firms perceived Japan as an unreliable source, not only for exposed goods but also for non-exposed goods.[1] Third, Korea's imports from Japan decreased disproportionately in goods where Japan had been the primary supplier to Korea. This indicates that the reduction in imports from Japan depended more on the degree of dependence on Japanese goods than on whether the goods were directly exposed. Fourth, despite the substantial decrease in imports from Japan, Korea's imports from the rest of the world in those sectors did not increase during the post-event period, compared to the pre-event period.

Instead, Korean producers' revenue rose rapidly, precisely in the sectors in which Korea had previously most depended on Japan, precisely in the quarters following the announcement of export controls. This finding implies that, in the Korean market, goods previously imported from Japan were replaced with domestically produced alternatives.

[1] Note that the Korean government did not impose any import restrictions on Japanese goods during the post-event period. Instead, it provided support to expedite imports from Japan before the export controls were actually implemented. This suggests that the decrease in imports from Japan was primarily due to Korean firms' response to the potential risk posed by Japan's announcement of export controls.

More interestingly, Korea's exports of these goods increased disproportionately compared to the pre-event period, while the prices of these exports fell.

To demonstrate how export controls can lead to an increase in exports with a price decline in the targeted country, I present an Armington trade model featuring external economies of scale, following Kucheryavyy et al. (2023) and Bartelme et al. (2019). As in a simple partial equilibrium model, supply curves can slope downward in the presence of scale economies, as shown in Figure 1. In my framework, an increase in domestic demand (caused by foreign export controls) increases domestic sales and reduces domestic prices, as also shown in Figure 1. Applying this model to Japan's export controls on Korea, the positive shocks to demand for domestic goods resulted in an increase in Korean producers' revenue, an increase in export quantities and a decrease in export prices, exactly as observed in my empirical analysis.

Based on this structural model, I estimate the strength of scale economies by projecting changes in origin-sector-destination exports on changes in origin-sector total sales. To address the endogeneity of total sales due to correlation with supply-side shocks, I instrument total sales using a demand-side variable. In the first part of the analysis, the estimation is restricted to Korea as the sole origin country. Japan's 2018 share in Korea's imports is used as a demand-side instrument for changes in Korea's total sales. This instrument captures sector-specific exposure to the event by reflecting both the perceived rise in import costs from Japan and the subsequent increase in demand for domestically produced goods. The results strongly support the presence of large scale economies in Korea. The estimate of scale economies, including additional price effects, is 0.9, indicating that a 1% increase in total sales leads to a 0.9% increase in exports across destinations. Note that this strength of scale economies is estimated by tracing the exogenous variation on the demand-side caused by Japan's announcement of export controls. Moreover, when excluding additional effects from price reductions, the estimate is 0.4, indicating that a 1% increase in total sales leads to a 0.4% increase in productivity or a 0.4% decrease in prices.

The analysis is then extended to all other countries, excluding Korea and Japan, to investigate the presence of scale economies in these countries. They may have expanded their sales to Korea to take over Japan's market share in Korea, which could have increased their productivity and overall exports. To address the endogeneity of origin-sector total sales using demand-side variation induced by the event, I construct an instrumental variable as the product of two components: first, the share of the Korean market in exports from origin-sector during the pre-event period, reflecting the importance of the Korean market to the origin's sector; second, Japan's share in the Korean market for that sector during the pre-event period, indicating the magnitude of positive shocks to Korea's sector-specific demand for other sources. The results provide strong evidence of scale economies across all other countries. The estimate of scale elasticity is also in line with that from the Korea-only analysis, though with a slightly smaller estimate. This suggests that when an origin country had previously exported more to Korea and Korea had been more reliant on goods from Japan, the origin's sector experienced a greater increase in sales in Korea, which led to a greater increase in productivity during the post-event period.

Related literature. This paper contributes to several strands of literature. First, it relates to a growing literature on contemporary trade policy, including trade wars and sanctions. Amiti et al. (2019), Fajgelbaum et al. (2020), and Waugh (2019) among others assess the economic effects of substantial tariff increases resulting from the US-China trade war.[2] Morgan et al. (2023) survey the related literature on economic sanctions, and Becko (2024) studies the optimal sanction design for imposing countries. Itskhoki and Mukhin (2023), and Lorenzoni and Werning (2023) examine the effects of the Russian invasion of Ukraine through the lens of exchange rates. I provide novel evidence documenting how export controls can benefit the targeted country by increasing its productivity and exports. To the best of my knowledge, this paper is the first to present evidence of the unintended consequences of current export controls, studying a trade dispute between two major players in advanced industries.

Second, this paper contributes to the extensive literature on economies of scale. (Antweiler and Trefler (2002), Bartelme et al. (2019), Kucheryavyy et al. (2023), and Lashkaripour and Lugovskyy (2023)). Kucheryavyy et al. (2023) develop the generalization of the Ricardian model with external economies of scale. Bartelme et al. (2019) propose an empirical strategy that estimates sector-level scale economies by exploiting changes in sector size driven by long-run variation in domestic demand. Building on these frameworks, I estimate the strength of scale economies using bilateral trade data at the 6-digit level of the Harmonized System (HS). This granular data enables a more detailed analysis at the product level. Moreover, I provide direct evidence on the impact of export controls on the targeted country through economies of scale.

Third, this paper also contributes to the literature on trade policy in the presence of scale economies. Breinlich et al. (2023) develop an empirical methodology that employs changes in trade policies to test for the presence of scale economies, showing that the

[2] Fajgelbaum and Khandelwal (2022) provide a comprehensive review of the economic consequences of the US-China trade war.

permanent normalization of US trade relations with China in 2001 reduced US export growth. Similarly, I demonstrate that Japan's 2019 announcement of export controls against Korea boosted Korea's exports, highlighting the importance of scale economies in production. These findings also align with those of Juhàsz (2018), which examines a historic event during the Napoleonic Wars to show that temporary trade protection increased production and exports of France's mechanized cotton spinning. Fajgelbaum et al. (2024) show that third countries increased their global exports in products subject to escalated tariffs by the US or China following the US-China trade war, which can be explained by downward-sloping supply curves. My findings further support the evidence of downward-sloping supply curves, demonstrating that Korea's exports increased in sectors where Japan had been the primary supplier to Korea, accompanied by a decline in prices.

Fourth, this paper is also closely connected to empirical tests of the home-market effect (Head and Ries (2001), Davis and Weinstein (2003), and Costinot et al. (2019)). The home-market effect, which posits a positive relationship between domestic demand and exports, inherently suggests the existence of economies of scale. In light of this, I provide evidence for the home-market effect, highlighting that an increase in domestic demand for domestically produced goods, induced by foreign export controls, can lead to a rise in domestic productivity, which in turn reduces prices and boosts exports.

Lastly, this paper also contributes to the extensive literature on trade policy uncertainty (Handley and Limão (2015), Pierce and Schott (2016), Handley and Limão (2017), Feng et al. (2017), Crowley et al. (2018), and Alessandria et al. (2019)). I show that, even though export controls were not actually enforced, uncertainty over imports from Japan significantly shifted Korea's sourcing away from Japan. Moreover, this paper illustrates the indirect effects of trade policy uncertainty by demonstrating that, due to this uncertainty, Korean firms increased their purchases of domestically produced goods, which in turn increased productivity and exports in Korea.

Outline. The remainder of the paper is structured as follows. Section 2 provides the background on Japan's 2019 announcement of export controls against Korea. Section 3 presents empirical findings regarding changes in Korea's imports and exports following the event. Section 4 outlines a model of trade that incorporates external economies of scale, and its application to the empirical findings. Section 5 estimates the strength of scale economies, first focusing on Korea exclusively and then extending the analysis to all other countries. Section 6 concludes.

2 Background

Decades-long disputes between South Korea and Japan stem from a historical issue of reparations for Korean forced laborers who served under Japanese colonial occupation during World War II. In late 2018, political tensions between Korea and Japan escalated once more, following a ruling by the Korean Supreme Court that mandated Japanese corporations to compensate Korean victims who had been coerced into labor for Japanese entities in the 1940s. Japan vehemently opposed the Korean court's decision, claiming that the 1965 Korea-Japan treaty had already resolved Korean claims for indemnification for forced labor.

In the midst of heightened tensions, the Japanese government announced abruptly in July 2019 that it would tighten export procedures for South Korea for the shipment of three chemicals—photoresist, fluorinated polyimide and hydrogen fluoride—, citing national security. The new measures required Japanese firms exporting these chemicals to Korea to obtain government authorization for each individual shipment. In response, the Korean government immediately expressed concerns regarding the announcement, as Korean companies importing these chemicals from Japan were confronted with uncertainty over being permitted to import from Japan. Moreover, these chemicals were essential inputs for manufacturing semiconductors and display panels, key industries in Korea, and Japan was the primary supplier of these chemicals to Korea.

In September 2019, Japan removed South Korea, its third largest trading partner, from its "White List" of 27 countries, leading South Korea to lose its status as a preferential trade partner. The exclusion from the "White List" served as an extension of the export controls in essence, since Japanese firms were required to obtain approval when exporting national strategic goods to Korea. Approximately 17 percent of all goods exported from Japan to Korea were exposed to potential export controls due to this exclusion.[3] In retaliation, the Korean government took a similar action against Japan, and refused to renew the General Security of Military Information Agreement with Japan, a military agreement that was critically important to Japan and even to the United States in their efforts against North Korea. The Korean government also filed a complaint with the WTO regarding the Japan's announcement of export controls. The escalating measures on both sides intensified bilateral tensions, eventually leading to a trade dispute between the two countries.

Despite the tension, for nearly four years, the Japanese government did not imple-

[3]Korea imported a total of 5,734 items at the HS-6 level during the pre-event period (from January 2018 to June 2019), and of these, 989 were identified as Japanese national strategic items by the Korean Security Agency of Trade and Industry. See Appendix A for details.

ment any actual export restrictions, suggesting it was primarily a coercive tactic to influence the resolution of the historical dispute in Japan's favor. In March 2023, the leaders of South Korea and Japan held their first summit in four years, agreeing to normalize trade relations to their pre-dispute status. In June 2023, the Japanese government officially lifted the export controls and reinstated South Korea to its "White List", restoring its status as a preferential trade partner.

3 Empirical Facts

In this section, I report empirical facts regarding changes in Korea's imports, exports, and domestic producers' revenue following the announcement of Japan's 2019 export controls. The key finding is that Korean producers' revenue increased in sectors where Japan had been the leading supplier to Korea, referenced in Fact 5. Furthermore, Korea's exports in these sectors also increased, accompanied by a decrease in export prices, as described in Fact 6. These empirical facts lead to an exploration into economies of scale in Section 4 and Section 5.

Data. The empirical analysis uses two data sources. The first is Korea's trade data at the 6-digit level of the Harmonized System (HS) from the Korea Customs Service. The sample includes all goods imported and exported by Korea, covering 240 countries and 5,734 goods at the HS-6 level. The sample period spans seven years, from July 2016 to June 2023, with the monthly data aggregated into quarterly data for analysis. The second source is Korean producer data for all manufacturing sectors from Statistics Korea. The annual data include 433 sectors at the 5-digit level of the Korean Standard Industrial Classification (KSIC), a localized adaptation of the United Nations' International Standard Industrial Classification (ISIC). The sample period spans seven years, from 2016 to 2022. In this section, 'goods' refer to the HS-6 level, and 'sectors' refer to the KSIC-5 level.

Fact 1: Korea's imports from Japan significantly decreased relative to the pre-event period and relative to imports from other countries during the post-event period.

To investigate the effect of Japan's announcement of export controls on Korea's imports, I use a difference-in-differences specification:

$$\log m^{kor}_{c,g,t} = \alpha_{c,g} + \alpha_{g,t} + \beta\Big(Japan_c\Big) \times \Big(Post_t\Big) + \varepsilon_{c,g,t},$$

where $m^{kor}_{c,g,t}$ is Korea's imports of good g from country c at time t. $\alpha_{c,g}$ and $\alpha_{g,t}$ denote country-good and good-time fixed effects, respectively. $Japan_c$ is a country indicator variable for Japan and $Post_t$ is a time indicator for the post-event period, which spans from the third quarter of 2019 to the second quarter of 2023. Standard errors are clustered at country c and good g levels. The coefficient β is estimated to be -0.190, as shown in Column (1) of Table 1. This indicates that Korea's imports from Japan decreased by 17.3 percent relative to the pre-event period and relative to imports from other countries during the post-event period. Time-varying coefficients β_t, estimated using an event-study, are also illustrated in Panel (A) of Figure 2, along with 95 percentage intervals for the estimates. This event-study analysis confirms the absence of a pre-trend. In a similar pattern, Japan's exports to Korea also decreased relative to the pre-event period and relative to exports to other countries during the post-event period. See Appendix A for details.

Fact 2: The decrease in imports from Japan was not limited to goods exposed to the export controls but also occurred to a similar extent for goods that were not exposed.

To examine whether the substantial decrease in imports from Japan is limited to goods directly exposed to the announcement of Japan's export controls, I use a difference-in-differences specification:

$$\begin{aligned}\log m^{kor}_{c,g,t} = \alpha_{c,g} + \alpha_{g,t} &+ \beta_1 \Big(Japan_c\Big) \times \Big(Post_t\Big) \times \Big(Exposed_g\Big) \\ &+ \beta_2 \Big(Japan_c\Big) \times \Big(Post_t\Big) \times \Big(NonExposed_g\Big) + \varepsilon_{c,g,t},\end{aligned}$$

where $Exposed_g$ is an indicator variable for goods that were directly exposed to the announcement of export controls, and $NonExposed_g$ is an indicator variable for goods that were not exposed.[4] The remaining terms and clustering level are consistent with those previously described. The coefficients β_1 and β_2 are estimated to be -0.200 and -0.187, respectively, as shown in Column (2) of Table 1. This indicates that the extent of the decline in $NonExposed_g$ goods from Japan is not significantly different from that of $Exposed_g$ goods. Moreover, time-varying coefficients, $\beta_{1,t}$ and $\beta_{2,t}$, estimated from an event-study, further support the lack of difference in imports from Japan between

[4] *Exposed* goods are identified using a list provided by the Korean Security Agency of Trade and Industry (KOSTI). After Japan removed Korea from its "White List" countries, a substantial number of national strategic items intended for export to Korea became subject to individual approval by the Japanese government. The KOSTI compiled a list of Japan's national strategic items affected by the policy changes at the HS-10 level, and these items are identified as $Exposed_g$ goods. See Appendix A for details.

Exposed and *NonExposed* goods, as shown in Panel (B) of Figure 2. This indicates that Korean firms' concerns about potential restrictions on their imports from Japan extended to the items that were not directly affected by Japan's announcement. This reflects a widespread perception of Japan as an unreliable source across industries. Additionally, Japan's exports to Korea showed no significant difference between goods exposed to the announcement and those not exposed. This aligns with findings from Korea's imports from Japan, indicating a similar declined in both categories. See Appendix A for details.

Fact 3: Korea's imports from Japan decreased disproportionately in goods where Japan had been the leading supplier to Korea.

To explore whether the decrease was disproportionately larger in sectors where Korea had been most reliant on Japan, I use a difference-in-differences specification:

$$\begin{aligned}\log m^{kor}_{c,g,t} = \alpha_{c,g} + \alpha_{g,t} &+ \beta_1 \Big(Japan_c\Big) \times \Big(Post_t\Big) \times \Big(Dominant_g\Big) \\ &+ \beta_2 \Big(Japan_c\Big) \times \Big(Post_t\Big) \times \Big(NonDominant_g\Big) + \varepsilon_{c,g,t},\end{aligned}$$

where $Dominant_g$ is an indicator variable for goods where Japan was the leading supplier to Korea during the pre-event period (July 2018 to June 2019), and $NonDominant_g$ is an indicator variable for goods where Japan was not. The remaining terms and clustering level are the same as previously described. The coefficients β_1 and β_2 are estimated to be -0.340 and -0.162, respectively, as shown in Column (3) of Table 1. This suggests that Korea's imports from Japan decreased more in sectors where Japan had previously been dominant in the Korean market. This also implies that Korean firms previously more reliant on Japan reduced their imports from Japan to a greater extent, as higher dependence could have resulted in more severe impacts if export controls had been enforced. Panel (C) of Figure 2 demonstrates that time-varying coefficients, $\beta_{1,t}$ and $\beta_{2,t}$, consistently support a notable difference in imports from Japan between *Dominant* and *NonDominant* goods. In addition, Japan's exports to Korea decreased disproportionately in goods where Japan had been the leading supplier to Korea, in line with the trends observed in Korea's imports from Japan. See Appendix A for details.

Fact 4: Korea's imports from the rest of the world in goods where Japan had been the leading supplier to Korea did not increase relative to the pre-event period.

Motivated by Fact 3, where imports from Japan decreased disproportionately in *Dominant* goods, I use the following difference-in-differences specification to examine if Korea's imports from the rest of the world in these goods increased to replace those from Japan:

$$\log m^{kor}_{c,g,t} = \alpha_{c,g} + \alpha_{c,t} + \beta_1 \Big(Japan_c\Big) \times \Big(Post_t\Big) \times \Big(Dominant_g\Big) \\ + \beta_2 \Big(RoW_c\Big) \times \Big(Post_t\Big) \times \Big(Dominant_g\Big) + \varepsilon_{c,g,t},$$

where RoW_c is an indicator variable for the rest of the world, and $\alpha_{c,t}$ denotes country-time fixed effects. Good-time fixed effects, $\alpha_{g,t}$, are excluded to investigate whether there are differential effects between Japan and the rest of the world in *Dominant* goods during the *Post* period. The remaining specification details and clustering level are consistent with those previously described. Column (4) of Table 1 reports the estimated coefficients. The estimate of β_1 is -0.210 and is statistically significant at the 1% level, whereas that of β_2 is -0.032 and is not significant even at the 10% level. This indicates that Korea's imports from the rest of the world in *Dominant* goods did not significantly increase relative to the pre-event period, suggesting that imports from Japan were not substituted with those from the rest of the world. Time-varying coefficients, $\beta_{1,t}$ and $\beta_{2,t}$, also support the absence of a significant increase in imports from the rest of world in *Dominant* goods, as illustrated in Panel (D) of Figure 2.

Fact 5: Korean producers' revenue increased in sectors where Japan had been the leading supplier, relative to sectors where Japan had not and to the pre-event period.

Motivated by Fact 3 and Fact 4, the following difference-in-differences specification is employed to investigate whether Korean producers' revenue increased in sectors where Japan had previously been dominant in the Korean market after Japan's 2019 announcement of export controls:

$$\log R^{kor}_{s,t} = \alpha_s + \alpha_t + \beta \Big(Dominant_s\Big) \times \Big(Post_t\Big) + \varepsilon_{s,t},$$

where $R^{kor}_{s,t}$ is Korean producers' revenue in sector s at time t. α_s and α_t denote sector and time fixed effects, respectively.[5] The remaining terms are the same as previously described. The estimated coefficient β of 0.065, as shown in Column (5) of Table 1, suggests that Korean producers' revenue in *Dominant* sectors increased, both relative to that in

[5]Note that this analysis is based on more aggregated sector-level data compared to previous ones, as Korean producer data is categorized by KSIC-5 sector levels rather than HS-6 good levels. Sectors where Japan was the leading exporter are identified by aggregating HS-6 goods to KSIC-5 sector-level using a concordance provided by Statistics Korea. A single KSIC-5 sector typically corresponds to multiple HS-6 goods.

other sectors during the same period and relative to that in *Dominant* sectors during the pre-event period. Combined with Fact 3 and Fact 4, these results further imply that, in the Korean market, goods previously imported from Japan were replaced with domestically produced goods. Panel (E) of Figure 2 presents time-varying coefficients β_t, which also support the increase in the revenue in *Dominant* sectors following the event.

Fact 6: Korea's export quantities of goods where Japan had been the leading supplier to Korea increased relative to the pre-event period, while their prices decreased.

Given the previous empirical findings, we would anticipate a decline in Korea's exports of goods where Japan had previously been the dominant supplier, as these goods were expected to be consumed more domestically to meet the increased demand following Japan's export controls announcement. To test this hypothesis, I employ the following difference-in-differences specification:

$$\log x_{g,t}^{kor} = \alpha_g + \alpha_t + \beta\Big(Dominant_g\Big) \times \Big(Post_t\Big) + \varepsilon_{g,t},$$

where $x_{g,t}^{kor}$ is Korea's export quantity of good g at time t. α_g and α_t denote good and time fixed effects, respectively. Standard errors are clustered at good g levels. The remaining terms are consistent with those previously described. As documented in Column (6) of Table 1, the coefficient β is estimated to be 0.091. This indicates that Korea's export quantities of goods where Japan had been the primary supplier increased, both relative to those of goods where Japan had not and to the pre-event period, contrary to the hypothesis above.

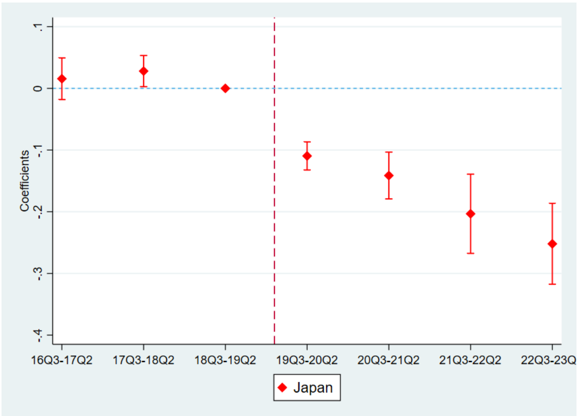
We would also expect Korea's export prices for *Dominant* goods to rise, driven by increased domestic demand and the anticipated upward slope of the supply curve. To test this hypothesis, the dependent variable $x_{g,t}^{kor}$ is redefined as the unit value of exports. All other terms of the specification remain the same. The new coefficient β is estimated to be -0.051, as shown in Column (7) of Table 1. This result indicates that, contrary to the hypothesis, Korea's export prices of *Dominant* goods declined. This suggests that Korea experienced a productivity increase in the production of *Dominant* goods after the event. Furthermore, this implies that the supply curve for these goods slopes downward rather than upward, aligning with the concept of scale economies, as illustrated in Figure 1. An event-study specification is used to examine the timing of these two contrasting changes. The time-varying coefficients β_t for export prices (red dots) and export quantities (blue dots) are presented in Panel (F) of Figure 2. The red dots show a significant drop, while the blue dots exhibit a noticeable rise, following the event.

Table 1: Empirical Facts (Difference-in-Differences)

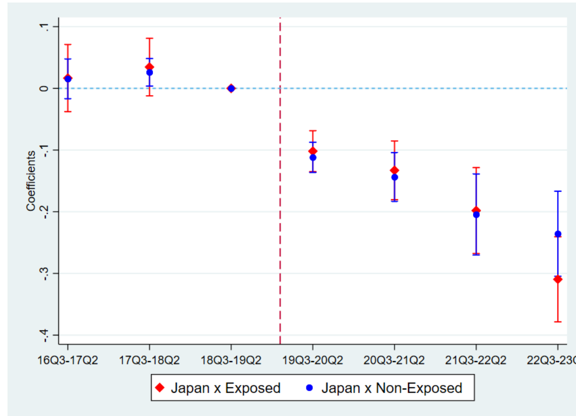
	Fact 1 (1) $\ln m$	Fact 2 (2) $\ln m$	Fact 3 (3) $\ln m$	Fact 4 (4) $\ln m$	Fact 5 (5) $\ln R$	Fact 6 (6) $\ln x^q$	Fact 6 (7) $\ln x^p$
JP x Post	-0.190***						
	(0.025)						
JP x Post x Exposed		-0.200***					
		(0.031)					
JP x Post x NonExposed		-0.187***					
		(0.025)					
JP x Post x Dominant			-0.340***	-0.210***			
			(0.033)	(0.002)			
JP x Post x NonDominant			-0.162***				
			(0.026)				
RoW x Post x Dominant				-0.032			
				(0.022)			
Dominant x Post					0.065**	0.091**	-0.051**
					(0.027)	(0.042)	(0.020)
Origin x Good Fixed Effects	Yes	Yes	Yes	Yes			
Good x Time Fixed Effects	Yes	Yes	Yes				
Origin x Time Fixed Effects				Yes			
Sector Fixed Effects					Yes		
Year Fixed Effects					Yes		
Good Fixed Effects						Yes	Yes
Time Fixed Effects						Yes	Yes
Num. of Goods	5,734	5,734	5,734	5,734		5,488	5,488
Num. of Exposed Goods		989					
Num. of Dominant Goods			669	669		657	657
Num. of Sectors					433		
Num. of Dominant Sectors					61		
Observations	2,018,536	2,018,536	2,018,536	2,026,511	2,977	125,442	125,442
R-squared	0.84	0.84	0.84	0.82	0.98	0.90	0.86

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

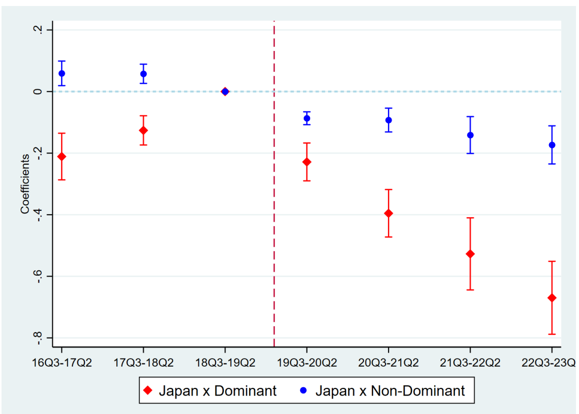
Notes: Table 1 presents the estimation results for the difference-in-differences specifications discussed in Section 3. Columns (1) to (5) correspond to Facts 1 to 5, respectively. Both Columns (6) and (7) correspond to Fact 6, with Column (6) representing the export quantity, and Column (7) the export price. The dependent variable in Columns (1) to (4) is the log of Korea's import value of good g from country c at time t. In Column (5), it is the log of Korean producers' revenue in sector s at time t. In Columns (6) and (7), it is the log of Korea's export quantity or price of good g at time t. The estimation results in all columns are based on HS-6 good levels except for Column (5). Column (5) is derived from more aggregated sector-level data because Korean producer data is categorized by KSIC-5 sector levels, rather than HS-6 good levels.
Source: Korea Customs Service (2016-2023) and Statistics Korea (2016-2022).



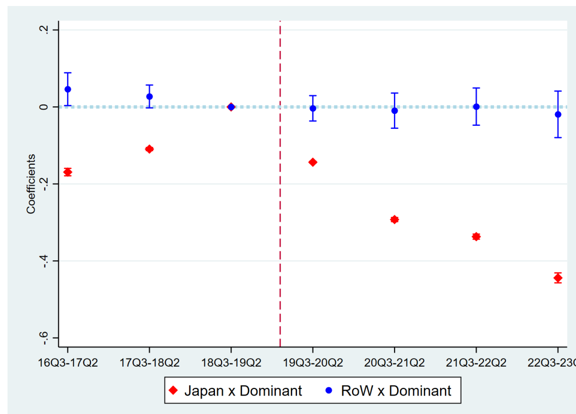
(A) Fact 1: Imports from Japan



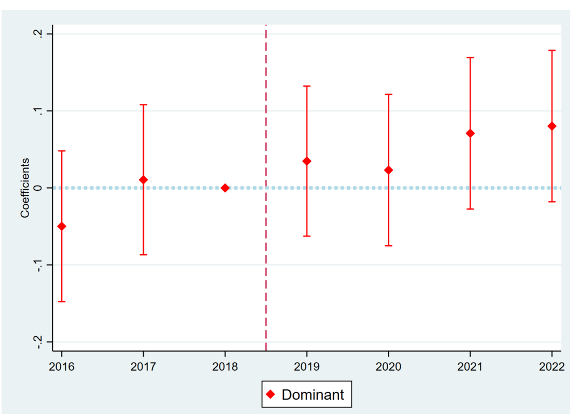
(B) Fact 2: Exposed vs. Non-Exposed



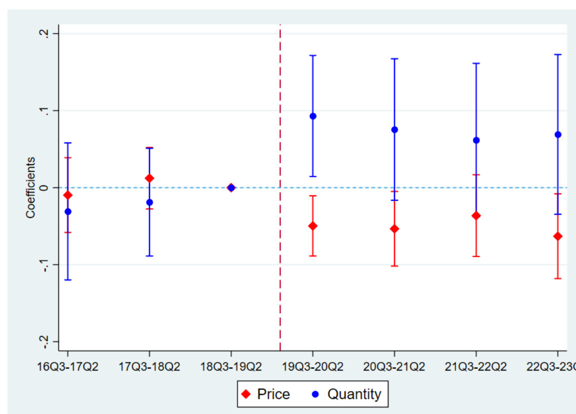
(C) Fact 3: Dominant vs. Non-Dominant



(D) Fact 4: Japan vs. RoW



(E) Fact 5: Korean Producers' Revenue



(F) Fact 6: Korea's Exports

Figure 2: Empirical Facts (Event Study)

Notes: Figure 2 illustrates the estimation results for the event-study specifications discussed in Section 3. Panels (A) to (F) correspond to Facts 1 to 6, respectively. The estimation results in all panels are based on HS-6 good levels except for Panel (E), which is derived from more aggregated sector-level data. In all panels except for Panel (E), the period covers seven years, from Q3 2016 to Q2 2023, with quarterly data. Panel (E) spans the same seven years from 2016 to 2022, with annual data.
Source: Korea Customs Service (2016-2023) and Statistics Korea (2016-2022).

What then explains the observed increase in Korea's export quantities and the decrease in their prices, beyond the simple substitution of goods previously imported from Japan? The answer lies in increasing returns to scale in production, characterized by a downward sloping supply curve. If scale economies exist, an increase in production can enhance productivity, which in turn lower prices and boosts exports.

4 Model

This section presents an Armington model of trade featuring external economies of scale to demonstrate how foreign export controls can lead to an increase in productivity and exports in the targeted country. The model follows Kucheryavyy et al. (2023) and Bartelme et al. (2019).

4.1 Environment

Consider a general equilibrium trade model with multiple countries, indexed by i (origin) or j (destination), and multiple sectors, indexed by k. Each country produces a differentiated good in each sector. Labor is the only factor of production and is immobile across countries but perfectly mobile across sectors within a country. L_j and w_j denote the inelastic labor supply and wage level in country j, respectively.

Each country has a representative consumer with two-tier preferences across sectors and goods. The upper-tier preferences are represented by a Cobb-Douglas utility function:

$$U_j = \prod_{k=1}^{K} q_{j,k}^{\beta_{j,k}},$$

where $q_{j,k}$ is the consumption index for sector k in country j, and $\beta_{j,k}$ is the sector-level expenditure shares such that $\sum_k \beta_{j,k} = 1$. The lower-tier preferences take the form of CES, with the elasticity of substitution $(1+\theta_k)$ between goods from different origins within sector k:

$$q_{j,k} = \Big(\sum_i q_{ij,k}^{\frac{\theta_k}{1+\theta_k}} \Big)^{\frac{1+\theta_k}{\theta_k}},$$

where $q_{ij,k}$ is the quantity of good k produced in origin i and consumed in destination j. Then, the demand in destination j for good k produced in origin i is:

$$q_{ij,k} = p_{ij,k}^{-1-\theta_k} P_{j,k}^{\theta_k} \beta_{j,k} w_j L_j, \tag{1}$$

where $p_{ij,k}$ is the price of good k produced in origin i and sold in destination j, and $P_{j,k}$ is the price index for sector k in destination j given by $P_{j,k} = \left(\sum_i p_{ij,k}^{-\theta_k}\right)^{-\frac{1}{\theta_k}}$.

The production technology features increasing returns to scale through external economies of scale. Specifically, the labor productivity of sector k in country i is given by $\tilde{A}_{i,k} = A_{i,k}L_{i,k}^{\gamma}$, where $A_{i,k}$ is an exogenous productivity parameter and $L_{i,k}$ is the total employment in sector k in country i. The parameter γ governs the strength of scale economies across sectors, referred to as the *scale elasticity* (Kucheryavyy et al. (2023)). Note that if $\gamma = 0$, the production exhibits constant returns to scale as in the standard Armington model. This production technology, together with the iceberg costs incurred in bilateral trade, $\tau_{ij,k} \geq 1$, yields the unit cost of good k produced in origin i for sale in destination j as follows:

$$c_{ij,k} = \frac{\tau_{ij,k} w_i}{A_{i,k} L_{i,k}^{\gamma}}. \tag{2}$$

The unit cost decreases at the rate of the scale elasticity γ as the sector size $L_{i,k}$ increases.

Assuming that all markets are perfectly competitive ($p_{ij,k} = c_{ij,k}$) and using the labor market clearing condition ($w_i L_{i,k} = Y_{i,k}$) to substitute for $L_{i,k}$ in equation (2), we obtain

$$p_{ij,k} = \frac{\tau_{ij,k} w_i^{1+\gamma}}{A_{i,k} Y_{i,k}^{\gamma}}, \tag{3}$$

where $Y_{i,k}$ is the total sales of good k across destinations by origin i such that $Y_{i,k} = \sum_j X_{ij,k}$. This equation highlights how scale economies impact the relationship between the total sales $Y_{i,k}$ and the price $p_{ij,k}$. Specifically, when scale economies exist (i.e., $\gamma > 0$), an increase in $Y_{i,k}$ enhances productivity, leading to a reduction in $p_{ij,k}$.

4.2 Bilateral Trade

To derive the bilateral trade equation, equation (3) is first substituted into the demand function (1). The good market clearing condition, $\beta_{j,k} w_j L_j = X_{j,k}$, is then applied, where $X_{j,k}$ denotes the total expenditure on good k by destination j such that $X_{j,k} = \sum_i X_{ij,k}$. This yields the expenditure by destination j on good k produced in origin i as follows:

$$X_{ij,k} = \left(\frac{\tau_{ij,k} w_i^{1+\gamma}}{A_{i,k}}\right)^{-\theta_k} Y_{i,k}^{\gamma\theta_k} X_{j,k} P_{j,k}^{\theta_k}, \tag{4}$$

where $X_{ij,k} = p_{ij,k} q_{ij,k}$.

The elasticity of bilateral trade to the total sales $Y_{i,k}$, referred to as the *output elasticity*, is the product of the trade elasticity (θ_k) and the scale elasticity (γ). The scale elasticity governs the rate at which the price $p_{ij,k}$ declines as $Y_{i,k}$ rises, as shown in equation (3). The trade elasticity governs the rate at which the demand $q_{ij,k}$ increases as $p_{ij,k}$ declines, as shown in equation (1). If $\gamma = 0$, as in the standard Armington model, the output elasticity is zero, indicating that origin i's total sales ($Y_{i,k}$) do not affect its exports to destination j ($X_{ij,k}$). In contrast, if $\gamma > 0$, indicating the presence of scale economies, the output elasticity is positive. This means that an increase in $Y_{i,k}$ leads to an increase in $X_{ij,k}$.

4.3 Application: Japan's 2019 Export Controls on Korea

Japan's announcement of export controls on Korea led to a perceived increase in trade costs from Japan to Korea, $\tau_{JP\,KR,k}$, where JP denotes Japan and KR denotes Korea. The bilateral trade equation (4) shows that an increase in $\tau_{JP\,KR,k}$ directly reduces Korea's imports from Japan, $X_{JP\,KR,k}$, aligning with Fact 1 in Section 3.

Then, how do the announcement of export controls affect Korea's exports? The model suggests that the potential export controls could increase Korea's exports across destinations, $X_{KR\,j,k}$. The mechanism behind this is as follows: First, the increase in $\tau_{JP\,KR,k}$ leads to an increase in Korea's domestic sales, $X_{KR\,KR,k}$, which in turn raises Korea's total sales, $Y_{KR,k}$. This is consistent with Fact 5 in Section 3. This occurs through an increase in the price in Korea for good k produced in Japan, $p_{JP\,KR,k}$, which subsequently raises the sectoral price index in Korea, $P_{KR,k}$. Second, the bilateral trade equation (4) demonstrates that the increase in $Y_{KR,k}$ leads to an increase in Korea's exports to other country j, $X_{KR\,j,k}$. This effect is facilitated by a reduction in destination j's price for goods produced in Korea, $p_{KR\,j,k}$, as shown in equation (3). The increase in $Y_{KR,k}$, the increase in $X_{KR\,j,k}$, and the reduction in $p_{KR\,j,k}$ align with Fact 5 and Fact 6 discussed in Section 3.

The key assumption in this mechanism is the presence of scale economies, indicated by $\gamma > 0$. In contrast, suppose there are constant returns to scale: $\gamma = 0$. As a result, the bilateral trade equation (4) suggests that Korea's exports to other countries, $X_{KR\,j,k}$, are independent of Korea's total sales, $Y_{KR,k}$, which invalidates the second part of the proposed mechanism above. Thus, this fails to explain Fact 6 in Section 3, which refers to both the increase in Korea's export quantities and the decrease in export prices in sectors where Japan was previously the primary supplier.

Alternatively, suppose there are increasing returns to scale: $\gamma > 0$. This assumption connects the first and second parts of the mechanism discussed above. Specifically, the event-induced increase in trade costs from Japan to Korea, $\tau_{JP\,KR,k}$, triggers a rise in Korea's exports to other destinations, $X_{KR\,j,k}$. As the total sales expand, sector-level productivity also increases due to economies of scale, which in turn boost exports. This presence of scale economies can explain all the reduced-form empirical findings presented in Section 3.

5 Estimation of Scale Elasticity

Motivated by the empirical findings from Section 3, this section estimates the strength of scale economies by leveraging a specification derived from the model presented in Section 4. First, I focus on estimating the strength of scale economies in Korea. Second, using the same specification, I estimate the strength of scale economies in all other countries, excluding Korea and Japan. These countries may have increased their sales to Korea, which seeks to replace Japanese goods with alternatives. This leads to a rise in their total sales, which enhances their productivity driven by scale economies. This increase in productivity, in turn, facilitates an increase in their exports across other destinations. The estimation results strongly support the presence of scale economies in Korea and in all other countries.

Data. The empirical analysis uses three data sources. The first is bilateral trade data for all countries from the CEPII BACI database (Gaulier and Zignago (2010)). The data include 5,199 goods at the 6-digit level of the Harmonized System (HS) under the 2012 classification, covering 227 countries. The sample period spans seven years, from 2016 to 2022, on an annual basis. All small countries with a population below one million in 2018 are excluded for analytical purposes. The second source is Korean producer data for all mining and manufacturing sectors from Statistics Korea. The annual data include 478 sectors at the 5-digit level of the Korean Standard Industrial Classification (KSIC), a localized adaptation of the United Nations' International Standard Industrial Classification (ISIC). The sample period spans seven years, from 2016 to 2022. The third source is a concordance between HS-6 goods and KSIC-5 sectors provided by Statistics Korea. This concordance is used to match HS-6 goods with KSIC-5 sectors. Since KSIC-5 sectors are more aggregated than HS-6 goods, a single KSIC-5 sector typically corresponds to multiple HS-6 goods.

Baseline Specification. The estimation specification is derived from the bilateral trade equation (4). Taking the logarithmic differences of equation (4) yields:

$$\Delta \ln X_{ij,k} = \gamma\theta_k \Delta \ln Y_{i,k} - \theta_k(1+\gamma)\Delta \ln w_i + \Delta \ln \left(X_{j,k} P_{j,k}^{\theta_k} \right) + \theta_k \Delta \ln A_{i,k} - \theta_k \Delta \ln \tau_{ij,k}. \tag{5}$$

Changes in origin i's exports to destination j, $\Delta \ln X_{ij,k}$, depend on changes in origin i's supply-side factors, which comprise the total sales, $Y_{i,k}$, the wage, w_i, and the primitive productivity, $A_{i,k}$. $\Delta \ln X_{ij,k}$ also depends on changes in destination j's demand, $X_{j,k} P_{j,k}^{\theta_k}$, and trade costs from origin i to destination j, $\tau_{ij,k}$. From equation (5), the baseline specification can be derived as follows:

$$\Delta \ln X_{ij,k} = \gamma\theta_k \Delta \ln Y_{i,k} + \alpha_i + \alpha_{j,k} + \alpha_{i,k} + \varepsilon_{ij,k}. \tag{6}$$

α_i is origin i fixed effects, which capture changes in origin i that do not vary by j or k, such as the wage w_i in equation (5). $\alpha_{j,k}$ denotes destination-sector fixed effects, which capture changes in demand for good k in destination j, such as $X_{j,k} P_{j,k}^{\theta_k}$ in equation (5). $\alpha_{i,k}$ is origin-sector fixed effects, which capture changes in the supply-side characteristics in origin i-sector k , such as $A_{i,k}$ in equation (5). The error term $\varepsilon_{ij,k}$ represents supply-side shocks that are not controlled by fixed effects mentioned above.

5.1 Analysis 1: Korea Only

In the first analysis, the estimation focuses solely on Korea as the origin country, excluding all other countries. This approach is taken because Korea was directly targeted by the Japanese announcement of export controls, and in response Korean producers' revenue increased following the announcement, as shown in Fact 5 in Section 3.

Specification. The estimation specification for Korea is derived from the baseline equation (6), substituting KR for i.

$$\Delta \ln X_{KR\,j,k} = \beta \Delta \ln Y_{KR,k} + \alpha_{KR} + \alpha_{KR\,j} + \delta \Delta \ln Z_{KR,k} + \varepsilon_{KR\,j,k}. \tag{7}$$

The estimation is performed in differences between two periods: a pre-event period from 2016 to 2018 and a post-event period from 2020 to 2022. The year 2019 is excluded because the shock occurred in July of that year. The dependent variable $\Delta \ln X_{KR\,j,k}$, defined as $\Delta \ln X_{KR\,j,k} = \ln X_{KR\,j,k}^{Post} - \ln X_{KR\,j,k}^{Pre}$, is the change in Korea's exports of good k

to destination j between the post (2020-2022) and pre-period (2016-2018). Similarly, the independent variable $\Delta \ln Y_{KR,k}$ is the change in Korea's total sales in good k between the same periods.

β is the coefficient of interest, which represents the effect of the change in Korea's total sales, $\Delta \ln Y_{KR,k}$, on the change in Korea's exports across destinations, $\Delta \ln X_{KR\,j,k}$, conditional on the fixed effects and sector-specific controls. β corresponds to the output elasticity $\gamma\theta_k$, as specified in the baseline equation (6).[6] The remaining terms in the specification (7) are included to control for other variations that affect the change in Korea's exports, aligning with each variable in equation (5). The constant term α_{KR} captures changes in Korea that do not vary by j or k, such as the wage w_{KR} in equation (5). The Korea-destination fixed effects $\alpha_{KR,j}$ absorb changes in destination j's overall demand for Korean goods that do not vary by k. The destination-sector fixed effects $\alpha_{j,k}$ are not included, as they would absorb all the variation in the dependent variable $\Delta \ln X_{KR\,j,k}$.[7] The Korea-sector fixed effects $\alpha_{KR,k}$ are also not included, as they would absorb all the variation in the independent variable $\Delta \ln Y_{KR,k}$. Instead, I include $\Delta \ln Z_{KR,k}$, the changes in total payments to workers in each k as sector-specific characteristics to control for variations within Korea-sector.

The error term $\varepsilon_{KR\,j,k}$ in the specification (7) includes, as such, the following components of equation (5). First, it contains variations in the primitive productivity, $A_{KR,k}$. Second, it entails variations in destination j' demand that vary by sector k, $X_{j,k}P_{j,k}^{\theta_k}$, which are not captured by $\alpha_{KR\,j}$. Third, the error term $\varepsilon_{KR\,j,k}$ includes variations in Korea-destination-sector level, such as $\tau_{KR\,j,k}$, which are not controlled by $\alpha_{KR\,j}$ and $\Delta \ln Z_{KR,k}$. As a result, Korea's exports to destination j, $X_{KR\,j,k}$, depend on productivity shocks to $A_{KR,k}$, foreign demand shocks to $X_{j,k}P_{j,k}^{\theta_k}$, and bilateral trade cost shocks to $\tau_{KR\,j,k}$. This leads to $\varepsilon_{KR\,j,k} \neq 0$. Additionally, the total sales, $Y_{KR,k}$, may respond endogenously to these shocks, implying $E[\Delta \ln Y_{KR,k} \times \varepsilon_{KR\,j,k}] \neq 0$. Therefore, the estimation of the supply-side parameter β necessitates the use of a demand-side instrumental variable.

Instrumental Variable. Due to the potential endogeneity of $\Delta \ln Y_{KR,k}$, identification of β requires an instrument variable that is correlated with $\Delta \ln Y_{KR,k}$, but uncorrelated with supply-side shocks in Korea. To address this endogeneity issue, $\Delta \ln Y_{KR,k}$ is instru-

[6] Aside from the output elasticity, β can also be interpreted as the scale elasticity γ, if the dependent variable $X_{KR\,j,k}$ is adjusted by the sector-specific trade elasticity θ_k. An examination of this interpretation will be provided in the product-level analysis at the end of Section 5.1.

[7] These arise from the practical limitation of having only a single observation per $(KR\,j,k)$ in the sample, which is exclusively restricted to Korea as the sole origin country. The limitation will be addressed in Section 5.2 by incorporating destination-good fixed effects, $\alpha_{j,k}$, when all other countries are included in the sample.

mented by a demand-side variable: Japan's 2018 share in Korea's total imports of good k, denoted as follows:

$$Share^{2018}_{JP\,KR,k} = \frac{X_{JP\,KR,k}}{\sum_{i \neq KR} X_{i\,KR,k}}.$$

This instrumental variable captures Korea's demand for Japanese goods prior to the event, thereby measuring sector k exposure to Japan's 2019 export controls on Korea: A higher $Share^{2018}_{JP\,KR,k}$ indicates greater exposure to the event. Specifically, it implies that the higher the Japanese share during the pre-event period, the greater the residual demand for domestic sources to substitute goods from Japan. This increase in demand results in higher sales growth for Korean producers. This implication aligns with Fact 3 and Fact 5 in Section 3, demonstrating that sectors with a higher share from Japan during the pre-event period experienced greater decreases in imports from Japan and greater increases in Korean producers' revenue.

The model in Section 4, which serves as the basis of this structural estimation of scale economies, ensures that the instrumental variable satisfies the relevance condition. $Share^{2018}_{JP\,KR,k}$ is positively correlated with $Y_{KR,k}$ through the following mechanism in the model: $Share^{2018}_{JP\,KR,k}$ reflects the perceived increase in importing costs from Japan, $\tau_{JP\,KR,k}$, due to the Japanese announcement of export controls on Korea.[8] This rise in $\tau_{JP\,KR,k}$ increases the price in Korea for good k produced in Japan, $p_{JP\,KR,k}$, as shown in equation (3). This increase in $p_{JP\,KR,k}$, in turn, raises the sectoral price index in Korea, $P_{KR,k}$, through the nested CES aggregation. This increase in $P_{KR,k}$ leads to a rise in Korea's domestic sales, $X_{KR\,KR,k}$, as indicated in equation (4). Finally, the increase in $X_{KR\,KR,k}$ contributes to an increase in Korea's total sales $Y_{KR,k}$, since $Y_{KR,k}$ is the sum of $X_{KR\,j,k}$ across all destinations: $Y_{KR,k} = \sum_j X_{KR\,j,k}$. Thus, since the relevance condition is satisfied, the instrumental variable provide a consistent estimate of the parameter β under the exclusion restriction, $E[Share^{2018}_{JP\,KR,k} \times \varepsilon_{KR\,j,k}] = 0$. This requires that there be no systematic relationship between $Share^{2018}_{JP\,KR,k}$ and the supply-side shocks $\varepsilon_{KR\,j,k}$.

Threats to the Exclusion Restriction. The violation of the exclusion restriction could occur if there are productivity shocks during the post-period that are correlated with $Share^{2018}_{JP\,KR,k}$. For instance, in response to Japan's 2019 announcement of export controls,

[8] Japan's 2018 share in Korea's total imports, $Share^{2018}_{JP\,KR,k} = \frac{X_{JP\,KR,k}}{\sum_{i \neq KR} X_{i\,KR,k}}$ is modeled as a perceived increase in Korea's importing costs from Japan. This is reasonable because, as discussed in Fact 2 and Fact 3 in Section 3, the extent of the reduction in the imports from Japan depended on the degree of reliance on Japanese goods, rather than on whether the goods were directly exposed to the Japanese announcement of export controls. In other words, the share was perceived as a potential threat point by Korean firms, as the Japanese government could use it as a point of leverage.

the Korean government may have subsidized sectors according to Japan's market share in these sectors to boost domestic production. This leads to an overestimate of the strength of scale economies.

To address this issue, I examine how the Korean government actually responded to Japan's 2019 export controls. Immediately following Japan's announcement, the Korean government provided support-packages to domestic firms that were importing goods from Japan. These packages consisted of two main strategies: First, they were designed to expedite imports from Japan before the export controls would be fully enforced. Second, the measures aimed to help Korean firms shift their sources from Japan to foreign countries. Thus, these immediate 2019 measures did not constitute supply-side shocks, as they primarily targeted import-side challenges for Korean firms. Following the 2019 policies, the Korean government also introduced measures to address supply chain disruptions caused by the COVID-19 pandemic, such as subsidizing sourcing and production. However, these 2020 measures are not systematically correlated with the instrumental variable $Share^{2018}_{JP\,KR,k}$, as they were not devised based on Japan's 2018 share in the Korean market. Given these policy implementations in response to the Japanese export controls and the pandemic, the instrumental variable satisfies the exclusion restriction.

Additionally, to control for supply-side shocks at sector k-level, the sector control variable $\Delta \ln Z_{KR,k}$ is included in the main specification (7). In robustness exercises at the disaggregated product-level, the Korea-sector fixed effects $\alpha_{KR,k(g)}$ are incorporated into equations (8) and (9), as discussed at the end of Section 5.1.[9] These inclusions also address threats to the exclusion restriction, as $\Delta \ln Z_{KR,k}$ and $\alpha_{KR,k(g)}$ control for changes in sector-specific characteristics, such as production subsidies, which may be systematically correlated with the instrumental variable. The robustness results are consistent with the main results, reaffirming that the instrumental variable $Share^{2018}_{JP\,KR,k}$ is not correlated with the supply-side shocks $\varepsilon_{KR\,j,k}$.

Results. Table 2 reports the estimate of output elasticity, defined as the product of the trade elasticity (θ_k) and the scale elasticity (γ).[10] This estimate captures the effect of changes in total sales on exports across destinations by accounting for both the impact

[9] Note that the robustness exercises are performed at the more disaggregated good g-level rather than the k-level. The k-level refers to the KSIC-5 level, which is a higher classification level than g, corresponding to the HS-6 level. Specifically, a single KSIC-5 sector corresponds to multiple HS-6 goods.

[10] The coefficient β can also be interpreted as the scale elasticity γ if the dependent variable $X_{KR\,j,k}$ is adjusted by the trade elasticity (θ_k). However, due to the lack of estimates for θ_k at the k-level, the interpretation of the main results is restricted to output elasticity. The interpretation as scale elasticity is applied in the HS-6 good level analysis at the end of Section 5.1 as a robustness check. In this analysis, the dependent variable is adjusted using the existing estimates for θ_g from the CEPII (Fontagné et al. (2020)).

Table 2: Estimates of Output Elasticity (KSIC-5)

	$\Delta \ln X_{KR\,j,k}$		
	2SLS	OLS	Reduced-form
	(1)	(2)	(3)
$\Delta \ln Y_{KR,k}$	0.893***	1.244***	
	(0.254)	(0.020)	
$Share^{2018}_{JP\,KR,k}$			0.221***
			(0.069)
$\Delta \ln Z_{KR,k}$	-1.039***	-1.475***	
	(0.331)	(0.100)	
First-stage Coefficient	0.264		
First-stage F-statistic	259.66		
Destination Fixed Effects	Yes	Yes	Yes
Number of Sectors	407	407	407
Observations	40,367	40,367	40,367

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Table 2 presents the estimate of output elasticity derived from the KSIC-5 sector-level analysis, based on specification (7). Columns (1) and (2) display the 2SLS and OLS estimates, respectively. The first-stage coefficient and F-statistic are reported below the main estimate in Column (1). Column (3) shows the reduced-form coefficient. The instrument for $\Delta \ln Y_{KR,k}$ used is Japan's 2018 share in Korea's total imports at the KSIC-5 level, $Share^{2018}_{JP\,KR,k}$. The data used in this analysis are as follows: The total sales for Korean producers, $Y_{KR,k}$, are sourced from the KSIC-5 data provided by Statistics Korea. The export data, $X_{KR\,j,k}$, are aggregated from the HS-6 level to the KSIC-5 level using a concordance table from Statistics Korea. Korea's domestic sales, $X_{KR\,KR,k}$, and exports to Japan, $X_{KR\,JP,k}$, are excluded from the analysis, as they are directly affected by the trade-dispute event. Additionally, all countries with a population below one million in 2018 are omitted from the dataset.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2016-2022)

of increased sales on prices (scale elasticity) and the subsequent effect of reduced prices on exports (trade elasticity). Column (1) of Table 2 documents the results of the Two-Stage Least Squares (2SLS) estimation, using Japan's 2018 share in Korea's total imports, $Share^{2018}_{JP\,KR,k}$, as a demand-side instrument for Korea's total sales, $Y_{KR,k}$. The 2SLS results provide strong evidence of the presence of large scale economies in Korea, specifically showing that a 1% increase in total sales results in a 0.9% increase in exports across destinations. The results also support the mechanism in the model that an increase in $Y_{KR,k}$ leads to a decrease in $p_{KR\,j,k}$ by enhancing productivity, thereby resulting in an increase in Korea's exports, $X_{KR\,j,k}$. In addition, the first-stage results confirm that the instrumental variable, $Share^{2018}_{JP\,KR,k}$, is positively correlated with the endogenous variable, $Y_{KR,k}$, as shown below the 2SLS estimate in Column (1) of Table 2. This means that a sector in Korea with a higher Japanese share during the pre-event period experienced greater sales growth during the post-event period.

The OLS estimate in Column (2) of Table 2 is greater than its corresponding 2SLS estimate in Column (1). This implies that $Y_{KR,k}$ is positively correlated with supply-side shocks. Specifically, this upward OLS bias is to be expected in cases where sectors experiencing an increase in total sales also face positive supply-side shocks, such as a decrease in production costs (w_i or $\tau_{ij,k}$) or an increase in exogenous productivity ($A_{i,k}$), as specified in equation (5). This upward OLS bias highlights the need for employing a demand-side instrumental variable that is correlated with $\Delta \ln Y_{KR,k}$ but uncorrelated with supply-side shocks. The results in Column (1) of Table 2 demonstrate that the instrument $Share^{2018}_{JP\,KR,k}$ effectively addresses the endogeneity of $\Delta \ln Y_{KR,k}$.

Additionally, the reduced-form parameter estimate is presented in Column (3) of Table 2, capturing the direct impact of the instrumental variable $Share^{2018}_{JP\,KR,k}$ on the dependent variable $X_{KR\,j,k}$. This estimate suggests that Korean sectors that had a higher share of imports from Japan during the pre-event period exhibit a greater increase in exports during the post-event period. This aligns with Fact 6 in Section 4 and further confirms the presence of scale economies. Specifically, export-control-induced positive shocks to domestic demand lead to an increase in domestic sales, which subsequently lower prices through scale economies, thus resulting in expanded exports. This exemplifies the home-market effect.

Robustness. To check the robustness of the output elasticity estimate reported in Table 2, the baseline specification (6) is re-estimated at a more disaggregated HS-6 good level,

Table 3: Estimates of Output and Scale Elasticities (HS-6)

	$\Delta \ln X_{KR\,j,g}$		
	2SLS (1)	OLS (2)	Reduced-form (3)
A. Output Elasticity			
$\Delta \ln Y_{KR,g}$	0.809***	0.403***	
	(0.180)	(0.009)	
$Share^{2018}_{JP\,KR,g}$			0.155***
			(0.034)
First-stage Coefficient	0.191		
First-stage F-statistic	471.23		
Destination Fixed Effects	Yes	Yes	Yes
Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,123	5,123	5,123
Observations	198,632	198,632	198,632
	$\frac{1}{\theta_g}\Delta \ln X_{KR\,j,g}$		
	2SLS (1)	OLS (2)	Reduced-form (3)
B. Scale Elasticity			
$\Delta \ln Y_{KR,g}$	0.410**	0.080***	
	(0.168)	(0.009)	
$Share^{2018}_{JP\,KR,g}$			0.082**
			(0.034)
First-stage Coefficient	0.201		
First-stage F-statistic	523.67		
Destination Fixed Effects	Yes	Yes	Yes
Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,123	5,123	5,123
Observations	195,069	195,069	195,069

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Panels A and B present the estimates of output and scale elasticity, respectively, derived from the HS-6 good-level analysis, based on equations (8) and (9). The only distinction between these two is the dependent variable: $\Delta \ln X_{KR\,j,g}$ for Panel A and $\frac{1}{\theta_g}\Delta \ln X_{KR\,j,g}$ for Panel B. Columns (1) and (2) report the 2SLS and OLS estimates, respectively. Column (3) reports the reduced-form coefficient. The instrumental variable for changes in total sales, $\Delta \ln Y_{KR,g}$, is Japan's 2018 share in Korea's total imports, $Share^{2018}_{JP\,KR,g}$. The first-stage coefficient and F-statistic are reported below the main estimates in Column (1). A concordance table from Statistics Korea is used to assign an HS-6 good (g) to a KSIC-5 sector (k), in order to identify the Korea-sector fixed effects, $\alpha_{KR,k(g)}$, at the g-level.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

as shown below:

$$\Delta \ln X_{KR\,j,g} = \beta \Delta \ln Y_{KR,g} + \alpha_{KR} + \alpha_{KR\,j} + \alpha_{KR,k(g)} + \varepsilon_{KR\,j,g}. \tag{8}$$

The key difference between this analysis and the previous one based on equation (7) lies in the level of aggregation. Whereas the main analysis includes 407 sectors at the KSIC-5 level, this more disaggregated analysis covers 5,123 goods at the HS-6 level, allowing for a more detailed analysis at the product level. Moreover, in this HS-6 analysis, the total sales in Korea, $Y_{KR,g}$, do not include Korea's domestic sales, $X_{KR\,KR,g}$, due to the unavailability of this data at the g level. $Y_{KR,g}$ is thus defined as $Y_{KR,g} = \sum_{j \neq KR} X_{KR\,j,g}$ in equation (8). The Korea-sector fixed effects $\alpha_{KR,k(g)}$ are also included in the specification (8), instead of the sector-specific characteristics, $\Delta \ln Z_{KR,k}$, used in equation (7). Due to the lack of detailed good-level characteristics, such as total payments to workers, which are available at the KSIC-5 level, $\alpha_{KR,k(g)}$ is included in the specification to control for sector-specific factors at the k level. The remaining terms are consistent with those previously defined in the main analysis, except that they are specified at the g-level rather than the k-level.

The results, displayed in Panel A of Table 3, provide strong evidence supporting the presence of large scale economies, consistent with the baseline findings in Table 2. Specifically, the 2SLS estimate in Column (1) of Panel A of Table 3 is similar to the baseline estimate in Column (1) of Table 2, highlighting that the baseline estimation results are robust to the more disaggregated good-level analysis.[11] In addition, the OLS estimate in Column (2) is smaller than the corresponding 2SLS estimate in Column (1) of Panel A of Table 3, suggesting that $Y_{KR,g}$ is negatively correlated with supply-side shocks. This downward OLS bias is expected when good-level sector g, which experiences a sales increase, also encounters rising production costs. This downward bias alleviates threats to the exclusion restriction of the instrumental variable, as it indicates that the these sectors did not benefit from reduced costs, such as government subsidies.

The second robustness exercise estimates the scale elasticity using existing estimates of the trade elasticity (θ_g) from the CEPII (Fontagné et al. (2020)).[12] Specifically, the

[11]The results are also in line with the theoretical and empirical findings from Bartelme et al. (2019), which suggests that excluding domestic sales from the total sales yields estimates of scale economies similar to those obtained when they are included. Likewise, my robustness check at the HS-6 level, which omits Korea's domestic sales due to data limitations, produces results that closely match the baseline estimates where Korea's domestic sales are included.

[12]Refer Kucheryavyy et al. (2023).

baseline specification (6) is re-estimated at the HS-6 good level as follows:

$$\frac{1}{\theta_g}\Delta \ln X_{KR\,j,g} = \gamma \Delta \ln Y_{KR,g} + \alpha_{KR} + \alpha_{KR\,j} + \alpha_{KR,k(g)} + \varepsilon_{KR\,j,g}. \tag{9}$$

The primary and only distinction from the previous robustness check based on equation (8) is that the dependent variable is adjusted by the trade elasticity (θ_g), $\frac{1}{\theta_g}\Delta \ln X_{KR\,j,g}$. This adjustment allows for estimating the scale elasticity (γ). The estimate of γ can be interpreted in three different ways: (i) the sole effect of an increase in total sales on exports across destinations, excluding additional effects from price reductions, as shown in the bilateral trade equation (4); (ii) the effect of an increase in total sales on productivity, as described by the production technology $\tilde{A}_{i,g} = A_{i,g}(\frac{Y_{i,g}}{w_i})^{\gamma}$; and (iii) the effect of an increase in total sales on price, as shown in equation (3).

Panel B of Table 3 presents the estimate of scale elasticity. The results in Column (1) of Panel B are consistent with the baseline results in Table 2 and the first robustness results in Panel A of Table 3, providing strong evidence of large scale economies in Korea. More importantly, the 2SLS estimate in Column (1) of Panel B suggests that a 1% increase in total sales leads to a 0.4% increase in productivity or a 0.4% decrease in price. All the estimates—2SLS, OLS, and reduced-form—are smaller compared to those of output elasticity (Panel A of Table 3), because trade elasticity typically exceeds 1. In other words, when trade elasticity is considered alongside scale elasticity, the impact of increased sales on exports is amplified, enhancing the overall effect of the shock.

I also test the robustness of the results in Table 3 by varying the level of aggregation for k in the Korea-sector fixed effects, $\alpha_{KR,k(g)}$. The estimates for $\alpha_{KR,k(g)}$ at the 2-digit level (Table A2) and the 3-digit level (Table A3) are consistent with the main results at the 5-digit level (Table 3), further supporting the robustness of the findings. The estimates tend to be slightly lower as the sector k-level becomes more disaggregated, aligning with the expectation that the Korea-sector fixed effects, $\alpha_{KR,k(g)}$ capture more detailed sector-level variation as k becomes more granular.

5.2 Analysis 2: All Other Countries

In the second approach, the empirical analysis is extended to all other countries except Korea and Japan. This approach examines whether scale economies exist beyond Korea. Other countries might have expanded their production to take over the market share previously held by Japan, leading to an increase in their exports through scale economies.

Specification. The estimation specification for all other countries builds upon the baseline equation (6).

$$\Delta \ln X_{ij,g} = \beta \Delta \ln Y_{i,g} + \alpha_i + \alpha_{ij} + \alpha_{j,g} + \alpha_{i,k(g)} + \varepsilon_{ij,g}. \tag{10}$$

The specification closely follows equation (8) used for the HS-6 good-level analysis for Korea in Section 5.1, with two key differences: First, KR is replaced by i to extend the analysis to all other countries. Second, the inclusion of destination-sector fixed effects, $\alpha_{j,k}$, is now possible because the analysis includes all other countries as origins.

The dependent variable $\Delta \ln X_{ij,g}$ is the change in origin i's exports of good g to destination j between the post-event period (2020-2022) and the pre-event period (2016-2018). The independent variable $\Delta \ln Y_{i,g}$ is the change in origin i's total sales in good g over the same periods.[13] β is the coefficient of interest, corresponding to the output elasticity, $\gamma\theta_g$, as specified in the baseline equation (6). β can also be interpreted as the scale elasticity γ, if the dependent variable $X_{ij,g}$ is adjusted by the good-specific trade elasticity θ_g as follows:[14]

$$\frac{1}{\theta_g} \Delta \ln X_{ij,g} = \gamma \Delta \ln Y_{i,g} + \alpha_i + \alpha_{ij} + \alpha_{j,g} + \alpha_{i,k(g)} + \varepsilon_{ij,g}. \tag{11}$$

The only difference between equations (10) and (11) is whether the dependent variable is adjusted by the trade elasticity θ_g.[15] Aside from this, all other components and definitions are identical across both equations.

The remaining terms in the specifications (10) and (11) are included to control for other variations that affect origin i's exports, based on the components in the bilateral equation (5). The origin fixed effects α_i capture changes in the wage w_i in equation (5). The origin-destination fixed effects α_{ij} capture changes in the bilateral relationship between origin i and destination j. The destination-good fixed effects $\alpha_{j,g}$ absorb changes in destination j's overall demand for good g, such as $X_{j,g} P_{j,g}^{\theta_g}$ in equation (5). The origin-good fixed effects $\alpha_{i,g}$ are not included because they would absorb all the variation in the

[13] Origin i's domestic sales, $X_{ii,g}$, are excluded due to the lack of available data at the HS-6 level. Thus, $Y_{i,g}$ is defined as $Y_{i,g} = \sum_{j \neq i} X_{ij,g}$, instead of $Y_{i,g} = \sum_j X_{ij,g}$.

[14] The estimate of γ can be interpreted in three different ways: (i) the sole effect of an increase in total sales on exports across destinations, excluding additional effects from price reductions, as shown in the bilateral trade equation (4); (ii) the effect of an increase in total sales on productivity, as described by the production technology $\tilde{A}_{i,g} = A_{i,g}(\frac{Y_{i,g}}{w_i})^{\gamma}$; and (iii) the effect of an increase in total sales on price, as shown in equation (3).

[15] The estimates for θ_g are borrowed from the CEPII (Fontagné et al. (2020)). They estimated the elasticity for more than 5,000 goods at the 6-digit level of the Harmonized System (HS), using bilateral trade data from 2001 to 2016.

independent variable $\Delta \ln Y_{i,g}$. Instead, the origin-sector fixed effects $\alpha_{i,k(g)}$ are included in the specifications (10) and (11) to control sector-specific characteristics at the k level.[16]

The error term $\varepsilon_{ij,g}$ includes the following components from the baseline equation (5): First, it contains variations in the primitive productivity, $A_{i,g}$. Second, $\varepsilon_{ij,g}$ entails variations at the origin-destination-good level, such as bilateral trade costs, $\tau_{ij,g}$, which are not controlled by α_{ij} and $\alpha_{j,g}$. This is due to practical limitations of having only one observation per (ij,g) in the sample. Consequently, origin i's exports of good g to destination j, $X_{ij,g}$, depend on supply-side shocks that affect $A_{i,g}$ and $\tau_{ij,g}$, which are not controlled by the fixed effects in the specifications (10) and (11). This leads to $\varepsilon_{ij,g} \neq 0$. Furthermore, origin i's total sales, $Y_{i,g}$, may respond endogenously to these shocks, indicating $E[\Delta \ln Y_{i,g} \times \varepsilon_{ij,g}] \neq 0$. In hence, estimating the supply-side parameters, β and γ, require a demand-side instrumental variable.

Instrumental Variable. Due to the possible endogeneity of $\Delta \ln Y_{i,g}$, identifying β and γ necessitates an instrumental variable that is correlated with $\Delta \ln Y_{i,g}$ but not correlated with supply-side shocks in origin i that impact the primitive productivity $A_{i,g}$ or bilateral trade costs $\tau_{ij,g}$. To address this endogeneity concern, $\Delta \ln Y_{i,g}$ is instrumented by the product of the share of the Korean market in origin i's total exports of good g and the share of Japanese good g in the Korean market, expressed as follows:

$$EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g},$$

where $EXShare^{2018}_{i\,KR,g} = \frac{X_{i\,KR,g}}{\sum_{j \neq i} X_{ij,g}}$ and $IMShare^{2018}_{JP\,KR,g} = \frac{X_{JP\,KR,g}}{\sum_{i \neq KR} X_{i\,KR,g}}$. This instrumental variable captures the exposure of country i's sector g to Japan's 2019 export controls on Korea. The first term, $EXShare^{2018}_{i\,KR,g}$, indicates the importance of the Korean market to origin i. The second term, $IMShare^{2018}_{JP\,KR,g}$, reflects the magnitude of the shock experienced by the Korean market.[17] Thus, the product of these two terms, which reflects the contributions of both origin i and destination KR, quantifies the sector-specific exposure of country i to the event in Korea. Specifically, as origin i had exported more of good g to Korea in 2018 (higher $EXShare^{2018}_{i\,KR,g}$), and as the 2019 shock to the Korean market

[16]Note that the k-level refers to the KSIC-5 level, which is a higher classification level than g, corresponding to the HS-6 level. Specifically, a single KSIC-5 sector corresponds to multiple HS-6 goods, as KSIC-5 sectors are more aggregated than HS-6 goods. The origin-sector fixed effects $\alpha_{i,k(g)}$ effectively account for origin-sector-specific characteristics, since manufacturing data for each country, including production, investments, and employment, are typically reported at the k level to international organizations, such as the UN, OECD, and World Bank.

[17]$IMShare^{2018}_{JP\,KR,g}$ is employed as an instrument for Korea's total sales, $Y_{KR,g}$ in Section 5.1, which focuses on the estimation restricted to Korea.

for g was more severe (higher $IMShare^{2018}_{JP\,KR,g}$), origin i's sector g has experienced a more positive impact on its sales.

The model in Section 4, which is the basis of this empirical analysis, ensures that the instrumental variable satisfies the relevance condition through the following mechanism: $IMShare^{2018}_{JP\,KR,g}$ mirrors the perceived increase in trade costs from Japan to Korea, $\tau_{JP\,KR,g}$, due to the event. This increase in $\tau_{JP\,KR,g}$ raises the price in Korea for good g produced in Japan, $p_{JP\,KR,g}$. The rise in $p_{JP\,KR,g}$, in turn, increases the sectoral price index in Korea, $P_{KR,g}$. This increase in $P_{KR,g}$ leads to an increase in origin i's exports to Korea, $X_{i\,KR,g}$, as indicated in equation (4), which results in a rise in $Y_{i,g}$. To reflect the importance of the Korean market to origin i, $IMShare^{2018}_{JP\,KR,g}$ is multiplied by Korea's share in origin i's exports, $EXShare^{2018}_{i\,KR,g}$. This allows us to construct the origin-sector-specific instrumental variable, $(EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$, which is positively correlated with $Y_{i,g}$.

Threats to the Exclusion Restriction. To satisfy the exclusion restriction, there should be no systematic relationship between $(EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$ and the supply-side shocks $\varepsilon_{i\,j,g}$. The violation of the exclusion restriction could occur if foreign firms received subsidies from their governments in response to Japan's 2019 announcement of export controls on Korea. In particular, such subsides would be more likely given to sectors that had exported more to Korea and to those where the shock to Korea was more substantial. However, the likelihood of this scenario occurring is highly improbable. The Korean market is not as dominant in the global economy as those of the United States or China. Furthermore, the announcement of export controls impacted over 5,000 goods at the HS-6 level in Korea. It is not plausible that foreign governments would tailor subsidies to their industries based on the Korean market's importance to them and the extent of the shock to the Korean market. Additionally, the origin-sector fixed effects $\alpha_{i,k(g)}$ are incorporated into the specifications (10) and (11) to control for supply-side shocks at the k level.[18] This inclusion also addresses threats to the exclusion restriction, as $\alpha_{i,k(g)}$ captures variations in origin-sector-specific characteristics, such as production subsidies, that may be systematically correlated with the instrumental variable. Therefore, the improbability of such subsidies, combined with the inclusion of the origin-sector fixed effects $\alpha_{i,k(g)}$, ensures that the instrumental variable, $(EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$, is plausibly exogenous to supply-side shocks to the origin-sector following the event.

Results. Panel A of Table 4 presents the estimate of output elasticity across all countries other than Korea and Japan. This estimate captures the effect of changes in total sales on

[18] k refers to a KSIC sector, a broader classification than g, which denotes an HS-6 good.

Table 4: Estimates of Output and Scale Elasticities (HS-6)

	$\Delta \ln X_{ij,g}$		
	2SLS (1)	OLS (2)	Reduced-form (3)
A. Output Elasticity			
$\Delta \ln Y_{i,g}$	0.991***	0.429***	
	(0.217)	(0.002)	
$EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g}$			0.789***
			(0.142)
First-stage Coefficient	0.795		
First-stage F-statistic	17.89		
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,693,927	9,693,927	9,693,927
	$\frac{1}{\theta_g}\Delta \ln X_{ij,g}$		
	2SLS (1)	OLS (2)	Reduced-form (3)
B. Scale Elasticity			
$\Delta \ln Y_{i,g}$	0.194***	0.090***	
	(0.064)	(0.002)	
$EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g}$			0.159***
			(0.045)
First-stage Coefficient	0.822		
First-stage F-statistic	19.28		
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,455,460	9,455,460	9,455,460

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Panels A and B present the HS-6 good-level estimates of output and scale elasticity for other countries, derived from equations (10) and (11), respectively. The only distinction between these two is the dependent variable: $\Delta \ln X_{ij,g}$ for Panel A and $\frac{1}{\theta_g}\Delta \ln X_{ij,g}$ for Panel B. Columns (1) and (2) report the 2SLS and OLS estimates, respectively. Column (3) reports the reduced-form coefficient. The instrumental variable for changes in total sales, $\Delta \ln Y_{i,g}$, is $EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g}$. The first-stage coefficient and F-statistic are reported below the main estimates in Column (1). A concordance table from Statistics Korea is used to assign an HS-6 good (g) to a KSIC-5 sector (k), in order to identify the origin-sector fixed effects, $\alpha_{i,k(g)}$, at the g-level. Standard errors in parentheses are clustered at the origin-good level.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

exports across destinations, incorporating both the impact of increased sales on prices (scale elasticity) and the subsequent effect of reduced prices on exports (trade elasticity). Column (1) of Panel A documents the results of the Two-Stage Least Squares (2SLS) estimation, using $(EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$ as an instrument for origin i's total sales in good g, $Y_{i,g}$. The 2SLS results are consistent with those in Table 2 and Panel A of Table 3, where the origin is restricted to Korea. This demonstrates that scale economies exist not only in Korea but also in all other countries, showing that a 1% increase in total sales leads to a 1% increase in exports across destinations. Specifically, an increase in $Y_{i,g}$ due to the event in Korea leads to a decrease in $p_{ij,g}$ by enhancing productivity, thereby resulting in a rise in origin i's exports, $X_{ij,g}$. Additionally, the first-stage results, located below the 2SLS estimate in Column (1) of Panel A, confirm that the instrumental variable, $(EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$, is positively correlated with the endogenous variable, $Y_{i,g}$.

Panel B of Table 4 presents the estimate of scale elasticity, capturing the sole effect of an increase in total sales on exports across destinations, excluding additional effects from price reductions.[19] The primary distinction between Panels B and A of Table 4 lies in the specification used: Panel B is based on equation (11), where the dependent variable is adjusted by the trade elasticity θ_g. The 2SLS results in Column (1) of Panel B are consistent with those from the Korea-only analysis in Table 3, with a smaller estimate. This provides strong evidence of scale economies across other countries, specifically showing that a 1% increase in total sales leads to a 0.2% increase in productivity or an equivalent 0.2% decrease in price. The 2SLS estimate of scale elasticity (Column (1) of Panel B) is smaller than that of output elasticity (Column (1) of Panel A), because trade elasticity normally greater than 1.

The OLS estimates in Column (2) of Panels A and B are lower than the corresponding 2SLS estimates in Column (1) of Panels A and B. This suggests that $Y_{i,g}$ is negatively correlated with supply-side shocks, leading to an underestimation of scale economies. This occurs in cases where sectors with increased sales also experience rising production costs. This OLS bias further supports the exclusion restriction of the instrumental variable, indicating that these sectors did not benefit from reduced production costs through government subsidies. Column (3) of both Panels A and B reports the reduced-form parameter estimates of the impact of the instrument, $(EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$, on the dependent variable. These estimates imply that when origin i's sector had previously

[19] Note that this estimate can be interpreted both as the effect of an increase in total sales on productivity and as the effect of an increase in total sales on price, based on the structural model presented in Section 4.

exported more to Korea in 2018 and the Korean market for this sector was more significantly affected by Japan's export controls in 2019, this origin-sector had experienced a greater increase in exports during the post-period. This finding supports the presence of increasing returns to scale.

Robustness. To test the robustness of the estimates of output and scale elasticities in Table 4, I conduct two key exercises. First, I vary the level of aggregation for k in the origin-sector fixed effects, $\alpha_{i,k(g)}$, within specifications (10) and (11). Second, I re-estimate these two specifications using alternative instrumental variables for the endogenous variable $Y_{i,g}$.

The first robustness exercise explores the sensitivity of the estimates of β and γ to the different levels of aggregations for sector k in the origin-sector fixed effects, $\alpha_{i,k(g)}$, within the specifications (10) and (11).[20] The estimation results are presented in Table A4 for the 2-digit k and Table A5 for the 3-digit k, which are consistent with the baseline results in Table 4, regardless of the level of aggregations for k. All the estimates—2SLS, OLS and reduced-form—are closely similar in magnitude to the baseline results, for both scale and output elasticities. This confirms the robustness of the main findings, which apply a more disaggregated 5-digit level for sector k is applied to the origin-sector fixed effects, $\alpha_{i,k(g)}$. These results also address potential threats to the exclusion restriction of the instrumental variable $(EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$. Specifically, the robustness exercises indicate that origin-good-specific supply-side shocks, reflected in the error term of specifications (10) and (11), do not exhibit systematic correlation with the instrumental variable, thereby strengthening the validity of the identification strategy.

The second robustness exercise examines the sensitivity of the estimates of β and γ to using alternative instrumental variables. In the baseline analysis, the endogenous variable $\Delta \ln Y_{i,g}$ is instrumented by the product of Korea's share in origin i's total exports of good g and Japan's share of good g in the Korean market, $(EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$.[21] As an alternative measure to capture the importance of the Korean market to origin i, an indicator variable for whether Korea is ranked among the top two importers of origin i's exports of good g, $Top^{2018}_{i\,KR,g}$, is used in place of the first term of the baseline instrumental variable. Specifically, the alternative instrumental variable is rep-

[20] k refers to sectors categorized under the Korean Standard Industrial Classification (KSIC), which is based on the United Nations' International Standard Industrial Classification (ISIC). The KSIC, as a localized adaptation of the ISIC, classifies industries across 2-digit, 3-digit and 5-digit levels. I use the Korean classification to ensure consistency with the prior analysis focused on Korea in Section 5.1 and to leverage an official correspondence table between KSIC and HS-6 provided by the Korean government.

[21] $EXShare^{2018}_{i\,KR,g} = \frac{X_{i\,KR,g}}{\sum_{j \neq i} X_{ij,g}}$ and $IMShare^{2018}_{JP\,KR,g} = \frac{X_{JP\,KR,g}}{\sum_{i \neq KR} X_{i\,KR,g}}$.

Table 5: Estimates of Output and Scale Elasticities (Alternative Instruments)

	2SLS		
	IV (Rank 1 to 2)	IV (Rank 3 to 5)	IV (Baseline)
	(1)	(2)	(3)
A. Output Elasticity			
$\Delta \ln Y_{i,g}$	0.826^{***}	4.568	0.991^{***}
	(0.272)	(7.608)	(0.217)
First-stage Coefficient	0.154	0.017	0.795
First-stage F-statistic	10.15	0.31	17.89
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,693,927	9,693,927	9,693,927
B. Scale Elasticity			
$\Delta \ln Y_{i,g}$	0.158^{*}	0.818	0.194^{***}
	(0.087)	(2.000)	(0.064)
First-stage Coefficient	0.155	0.014	0.822
First-stage F-statistic	10.26	0.21	19.28
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,455,460	9,455,460	9,455,460

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Panels A and B present the HS-6 good-level estimates of output and scale elasticity for other countries, derived from equations (10) and (11), respectively. The distinction between these two is the dependent variable: $\Delta \ln X_{ij,g}$ for Panel A and $\frac{1}{\theta_g}\Delta \ln X_{ij,g}$ for Panel B. Column (1) reports the 2SLS estimates using an alternative instrument, $(Top^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$, where $Top^{2018}_{i\,KR,g}$ is an indicator for whether Korea is ranked among the top two importers of origin i's exports of good g. Column (2) presents the 2SLS estimates using the same instrument, but $Top^{2018}_{i\,KR,g}$ is redefined to indicate whether Korea ranked as the third, fourth, or fifth largest importer. The first-stage coefficient and F-statistic are reported below the 2SLS estimates in both Columns (1) and (2). For comparison, the baseline results using $(EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$ as the instrumental variable are shown in Column (3). Standard errors in parentheses are clustered at the origin-good level.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

resented as $(Top^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$. The 2SLS results, shown in Column (1) of Table 5, are in line with the baseline results in Table 4 for both output and scale elasticities, reaffirming the robustness of the baseline results to the use of the alternative instrumental variable. As an additional robustness test, the first term of the instrumental variable $Top^{2018}_{i\,KR,g}$, which was initially defined to indicate whether Korea was one of the top two importers of origin i's good g, is redefined to indicate whether Korea ranks as the third, fourth, or fifth largest importer. As anticipated, the estimates for output and scale elsticities are statistically insignificant, presented in Column (2) of Table 5. This indicates that if an origin country had not considered Korea a main market, the origin would not have increased its exports to Korea following the Japan's announcement of export controls on Korea. As a result, increasing returns to scale would not be identifies in these countries, as they do not scale up production to meet the increased residual demand in the Korean market following the announcement. The detailed results for this robustness exercise are presented in Table A6, where $Top^{2018}_{i\,KR,g}$ indicates whether Korea is the first or second largest importer, and in Table A7, where $Top^{2018}_{i\,KR,g}$ indicates whether Korea is the third, fourth or fifth largest importer for origin i's good g.

6 Concluding Remarks

This paper examines how export controls can backfire, leading to an increase in productivity and exports in the targeted country. Through a case study of a recent well-documented event, I empirically show that the targeted country could enhance its production, productivity and exports, precisely in sectors where the targeted country depended most strongly on the imposing country. I also structurally estimate the strength of scale economies based on these findings. This paper is both timely and impactful, given that export controls have become a main measure in modern trade policies to address geopolitical issues.

The response of Korean producers to Japan's 2019 announcement of export controls exemplifies this unintended consequence of export controls. Specifically, Korean producers' revenue has grown in sectors where Japan was previously the leading supplier, suggesting that Korean firms have substituted imports from Japan with domestically produced goods. More notably, Korea's exports in these sectors have risen, while their prices have fallen. This indicates that an increase in residual domestic demand due to foreign export controls has boosted productivity, which in turn has lowered prices and expanded exports of the targeted country.

Building on these empirical findings, I estimate the strength of scale economies using an Armington model of trade that incorporates external economies of scale. Korean producers' total revenue is instrumented by Japan's market share in Korea during the pre-event period, which captures the rise in residual demand for domestically produced goods. The estimation results provide clear evidence of large economies of scale in Korea. Specifically, a 1% increase in total revenue results in a 0.9% increase in exports across destinations, driven by a 0.4% increase in productivity. I also find scale economies are present beyond Korea in the analysis that incorporates all other countries. This suggests that other countries for which the Korean market holds importance also increased their production to capture Japan's market share in Korea, thereby expanding their exports through economies of scale. Specifically, when Korea had previously imported more from Japan, and a third country had exported more to Korea in a given sector during the pre-event period, this sector in the third country experienced a greater increase in exports during the post-event period.

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A Appendix to Section 3

A.1 Empirical Facts regarding Japan's Exports

Data. This empirical analysis uses Japan's export data at the 6-digit level of the Harmonized System (HS) from the CEPII BACI database (Gaulier and Zignago (2010)). The sample includes all products exported by Japan, covering 215 countries and 5,165 goods at the HS-6 level. The sample period spans eight years on an annual basis, from 2015 to 2022.

Fact 1-2: Japan's exports to Korea significantly decreased relative to the pre-event period and relative to exports to other countries during the post-event period.

To investigate the change of Japan's exports to Korea following Japan's 2019 announcement of export controls against Korea, I use a difference-in-differences specification:

$$\log x^{jp}_{c,g,t} = \alpha_{c,g} + \alpha_{g,t} + \beta\Big(Korea_c\Big) \times \Big(Post_t\Big) + \varepsilon_{c,g,t},$$

where $x^{jp}_{c,g,t}$ is Japan's exports of good g to country c at time t. $\alpha_{c,g}$ and $\alpha_{g,t}$ denote country-good and good-time fixed effects, respectively. $Korea_c$ is a country indicator variable for Korea and $Post_t$ is a time indicator for the post-event period, which spans from 2019 to 2022. Standard errors are clustered at country c and good g levels. The coefficient β is estimated to be -0.118, as shown in Column (1) of Table A1. This indicates that Japan's exports to Korea decreased by 11.1 percent relative to the pre-event period and relative to exports to other countries during the post-event period. Time-varying coefficients β_t, estimated using an event-study, are also illustrated in Panel (A) of Figure A1, along with 95 percentage intervals for the estimates. This event-study analysis confirms the persistent decline in Japan's exports to Korea following the event. These results align well with Korea's imports from Japan, as described in Fact 1 in Section 3.

Fact 2-2: The decrease in exports to Korea was not limited to goods exposed to the export controls but also occurred to a similar extent for goods that were not exposed.

To examine whether the substantial decrease in exports to Korea is limited to goods directly exposed to the announcement of export controls, I use a difference-in-differences specification:

$$\log x^{jp}_{c,g,t} = \alpha_{c,g} + \alpha_{g,t} + \beta_1 \Big(Korea_c\Big) \times \Big(Post_t\Big) \times \Big(Exposed_g\Big) + \beta_2 \Big(Korea_c\Big) \times \Big(Post_t\Big) \times \Big(NonExposed_g\Big) + \varepsilon_{c,g,t},$$

where $Exposed_g$ is an indicator variable for goods that were directly exposed to the announcement of export controls against Korea, and $NonExposed_g$ is an indicator for goods that were not exposed. The remaining terms and clustering level are consistent with those previously described. The coefficients β_1 and β_2 are estimated to be -0.10 and -0.12, respectively, as shown in Column (2) of Table A1. This indicates that the extent of the decline in $NonExposed_g$ goods exported to Korea is not significantly different from that of $Exposed_g$ goods. Moreover, time-varying coefficients, $\beta_{1,t}$ and $\beta_{2,t}$, estimated from an event-study, further support the lack of difference in exports to Korea between *Exposed* and *NonExposed* goods, as shown in Panel (B) of Figure A1. These results align well with Korea's imports from Japan, as described in Fact 2 in Section 3. They also reconfirms that Korean firms' concerns about potential restrictions on their imports from Japan extended to *NonExposed* goods.

Fact 3-2: Japan's exports to Korea decreased disproportionately in goods where Japan had been the leading supplier to Korea.

To explore whether the decrease was disproportionately larger in sectors where Korea had been most reliant on Japan, I use a difference-in-differences specification:

$$\log x^{jp}_{c,g,t} = \alpha_{c,g} + \alpha_{g,t} + \beta_1 \Big(Korea_c\Big) \times \Big(Post_t\Big) \times \Big(Dominant_g\Big) + \beta_2 \Big(Korea_c\Big) \times \Big(Post_t\Big) \times \Big(NonDominant_g\Big) + \varepsilon_{c,g,t},$$

where $Dominant_g$ is an indicator variable for goods where Japan was the leading supplier to Korea in 2018, and $NonDominant_g$ is an indicator variable for goods where Japan was not. The remaining terms and clustering level are the same as previously described. The coefficients β_1 and β_2 are estimated to be -0.215 and -0.100, respectively, as shown in Column (3) of Table A1. This suggests that Japan's exports to Korea decreased more in sectors where Japan had previously been dominant in the Korean market. Panel (C) of Figure A1 demonstrates that time-varying coefficients, $\beta_{1,t}$ and $\beta_{2,t}$, consistently support a significant difference in exports to Korea between *Dominant* and *NonDominant* goods. These results align well with Korea's imports from Japan, as in Fact 3 in Section 3.

Fact 4-2: Japan's exports to the rest of the world in goods where Japan had been the leading supplier to Korea did not increase relative to the pre-event period.

Motivated by Fact 3-2, where exports to Korea decreased disproportionately in *Dominant* goods, I use the following difference-in-differences specification to examine if Japan's exports to the rest of the world in these goods increased during the post-event period:

$$\log x^{jp}_{c,g,t} = \alpha_{c,g} + \alpha_{c,t} + \beta\Big(Dominant_g\Big) \times \Big(Post_t\Big) + \varepsilon_{c,g,t},$$

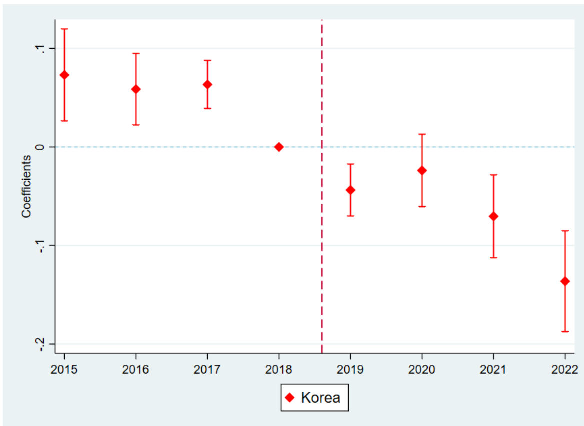
where $\alpha_{c,t}$ denotes country-time fixed effects. Note that Korea is excluded as a destination to isolate the effect of the event on Japan's exports to other countries in *Dominant* goods. The remaining specification details and clustering level are consistent with those previously described. Column (4) of Table A1 reports the estimated coefficients. The estimate of β is 0.000 and is not statistically significant even at the 10% level. This indicates that Japan's exports to the rest of the world in *Dominant* goods did not significantly increase relative to the pre-event period and relative to *Non-Dominant* goods, suggesting that the decrease in exports to Korea did not lead to an increase in exports to the rest of the world. Time-varying coefficients, β_t, also support the absence of a significant increase in exports to the rest of world in *Dominant* goods, as illustrated in Panel (D) of Figure A1.

Table A1: Empirical Facts (Difference-in-Differences)

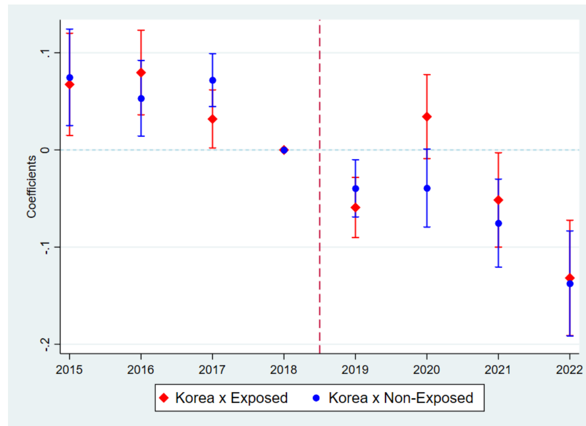
	Fact 1-2 (1) $\ln x$	Fact 2-2 (2) $\ln x$	Fact 3-2 (3) $\ln x$	Fact 4-2 (4) $\ln x$
KOR x Post	-0.117***			
	(0.019)			
KOR x Post x Exposed		-0.097***		
		(0.019)		
KOR x Post x Non-Exposed		-0.123***		
		(0.021)		
KOR x Post x Dominant			-0.215***	
			(0.022)	
KOR x Post x Non-Dominant			-0.100***	
			(0.020)	
Dominant x Post				0.000
				(0.017)
Destination x Good Fixed Effects	Yes	Yes	Yes	Yes
Good x Time Fixed Effects	Yes	Yes	Yes	
Destination x Time Fixed Effects				Yes
Num. of Goods	5,165	5,165	5,165	5,165
Num. of Exposed Goods		955		
Num. of Dominant Goods			636	636
Observations	1,652,228	1,652,228	1,652,228	1,619,908
R-squared	0.87	0.87	0.87	0.87

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

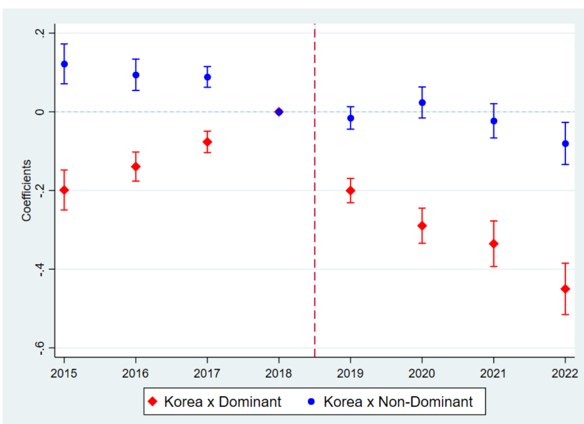
Notes: Table A1 presents the estimation results for the difference-in-differences specifications discussed in Section A.1. Columns (1), (2), (3) and (4) correspond to Facts 1-2, 2-2, 3-2 and 4-2, respectively. The dependent variable in all three columns is the log of Japan's export value of good g to country c at time t. The data used in Columns (1), (2), and (3) is Japan's export data at the HS-6 level, covering all goods and destination countries. For Column (4), the same data is used, but Korea is excluded as a destination to focus on Japan's exports to other countries. The sample period spans eight years on an annual basis, from 2015 to 2022. Standard errors in parentheses are clustered at country c and good g levels.
Source: CEPII BACI (Gaulier and Zignago (2010))



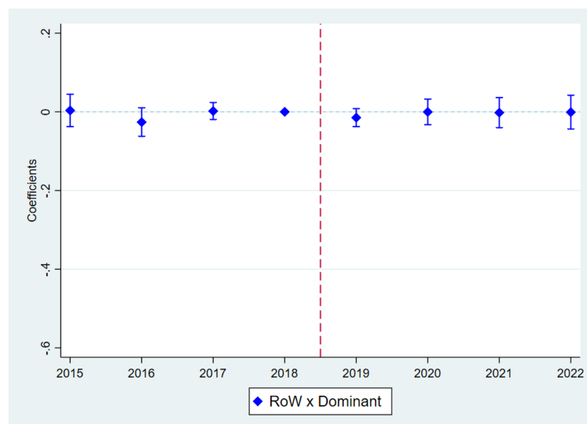
(A) Fact 1-2: Exports to Korea



(B) Fact 2-2: Exposed vs. Non-Exposed



(c) Fact 3-2: Dominant vs. Non-Dominant



(d) Fact 4-2: Exports to RoW

Figure A1: Empirical Facts (Event Study)

Notes: Figure A1 illustrates the estimation results for the event-study specifications discussed in Section A.1. Panels (A), (B), and (C) correspond to Facts 1-2, 2-2, and 3-2, respectively. The dependent variable in all three panels is the log of Japan's log export values of good g to country c at time t. The data used in this analysis is Japan's export data at the HS-6 level, covering all goods and destination countries. The sample period spans eight years on an annual basis, from 2015 to 2022. Standard errors in parentheses are clustered at country c and good g levels.
Source: CEPII BACI (Gaulier and Zignago (2010))

A.2 Descriptive Statistics on Korea-Japan Bilateral Trade

This section is currently being updated.

A.3 Identification of Goods Exposed to Japan's 2019 Announcement of Export Controls

This section is currently being updated.

B Appendix to Section 5.1

Table A2: Estimates of Output and Scale Elasticities (KSIC-2 Fixed Effects)

	2SLS (1)	OLS (2)	Reduced-form (3)
A. Output Elasticity			
$\Delta \ln Y_{KR,s}$	0.904***	0.439***	
	(0.200)	(0.008)	
$Share^{2018}_{JP\,KR,s}$			0.137***
			(0.030)
First-stage Coefficient	0.152		
First-stage F-statistic	321.30		
Destination Fixed Effects	Yes	Yes	Yes
Sector (KSIC-2) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,123	5,123	5,123
Observations	198,643	198,643	198,643
B. Scale Elasticity			
$\Delta \ln Y_{KR,s}$	0.543***	0.090***	
	(0.184)	(0.008)	
$Share^{2018}_{JP\,KR,s}$			0.088***
			(0.029)
First-stage Coefficient	0.162		
First-stage F-statistic	369.19		
Destination Fixed Effects	Yes	Yes	Yes
Sector (KSIC-2) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,123	5,123	5,123
Observations	195,073	195,073	195,073

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Panels A and B present the estimates of output and scale elasticity, respectively, derived from the HS-6 good-level analysis, based on equations (8) and (9). The only distinction between these two is the dependent variable: $\Delta \ln X_{KR\,j,g}$ for Panel A and $\frac{1}{\theta_g}\Delta \ln X_{KR\,j,g}$ for Panel B. Unlike the main robustness exercise in Table 3, the sector k is defined at the 2-digit level instead of the 5-digit level. As a result, the Korea-sector fixed effects $\alpha_{KR,k(g)}$ are applied at the KSIC 2-digit level. Columns (1) and (2) report the 2SLS and OLS estimates, respectively. Column (3) reports the reduced-form coefficient. The instrumental variable for changes in total sales, $\Delta \ln Y_{KR,g}$, is Japan's 2018 share in Korea's total imports, $Share^{2018}_{JP\,KR,g}$. The first-stage coefficient and F-statistic are reported below the main estimates in Column (1). A concordance table from Statistics Korea is used to assign an HS-6 good (g) to a KSIC-2 sector (k).
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

Table A3: Estimates of Output and Scale Elasticities (KSIC-3 Fixed Effects)

	2SLS (1)	OLS (2)	Reduced-form (3)
A. Output Elasticity			
$\Delta \ln Y_{KR,s}$	0.786***	0.423***	
	(0.211)	(0.008)	
$Share^{2018}_{JP\,KR,s}$			0.115***
			(0.031)
First-stage Coefficient	0.146		
First-stage F-statistic	297.69		
Destination Fixed Effects	Yes	Yes	Yes
Sector (KSIC-3) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,123	5,123	5,123
Observations	198,634	198,634	198,634
B. Scale Elasticity			
$\Delta \ln Y_{KR,s}$	0.529***	0.088***	
	(0.194)	(0.008)	
$Share^{2018}_{JP\,KR,s}$			0.083***
			(0.030)
First-stage Coefficient	0.156		
First-stage F-statistic	344.70		
Destination Fixed Effects	Yes	Yes	Yes
Sector (KSIC-3) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,123	5,123	5,123
Observations	195,072	195,072	195,072

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Panels A and B present the estimates of output and scale elasticity, respectively, derived from the HS-6 good-level analysis, based on equations (8) and (9). The only distinction between these two is the dependent variable: $\Delta \ln X_{KR\,j,g}$ for Panel A and $\frac{1}{\theta_g}\Delta \ln X_{KR\,j,g}$ for Panel B. Unlike the main robustness exercise in Table 3, the sector k is defined at the 3-digit level instead of the 5-digit level. As a result, the Korea-sector fixed effects $\alpha_{KR,k(g)}$ are applied at the KSIC 3-digit level. Columns (1) and (2) report the 2SLS and OLS estimates, respectively. Column (3) reports the reduced-form coefficient. The instrumental variable for changes in total sales, $\Delta \ln Y_{KR,g}$, is Japan's 2018 share in Korea's total imports, $Share^{2018}_{JP\,KR,g}$. The first-stage coefficient and F-statistic are reported below the main estimates in Column (1). A concordance table from Statistics Korea is used to assign an HS-6 good (g) to a KSIC-3 sector (k).
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

C Appendix to Section 5.2

Table A4: Estimates of Output and Scale Elasticities (KSIC-2 Fixed Effects)

	2SLS (1)	OLS (2)	Reduced-form (3)
A. Output Elasticity			
$\Delta \ln Y_{i,g}$	0.980^{***}	0.436^{***}	
	(0.228)	(0.002)	
$EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g}$			0.753^{***}
			(0.140)
First-stage Coefficient	0.768		
First-stage F-statistic	15.88		
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-2) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,698,880	9,698,880	9,698,880
B. Scale Elasticity			
$\Delta \ln Y_{i,g}$	0.173^{***}	0.096^{***}	
	(0.068)	(0.002)	
$EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g}$			0.134^{***}
			(0.047)
First-stage Coefficient	0.775		
First-stage F-statistic	16.11		
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-2) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,460,362	9,460,362	9,460,362

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Panels A and B present the HS-6 good-level estimates of output and scale elasticity for other countries, derived from equations (10) and (11), respectively. The only distinction between these two is the dependent variable: $\Delta \ln X_{ij,g}$ for Panel A and $\frac{1}{\theta_g}\Delta \ln X_{ij,g}$ for Panel B. Columns (1) and (2) report the 2SLS and OLS estimates, respectively. Column (3) reports the reduced-form coefficient. The instrumental variable for changes in total sales, $\Delta \ln Y_{i,g}$, is $EXShare^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g}$. The first-stage coefficient and F-statistic are reported below the main estimates in Column (1). A concordance table from Statistics Korea is used to assign an HS-6 good (g) to a KSIC-2 sector (k), in order to identify the origin-sector fixed effects, $\alpha_{i,k(g)}$, at the g-level. Standard errors in parentheses are clustered at the origin-good level.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

Table A5: Estimates of Output and Scale Elasticities (KSIC-3 Fixed Effects)

	2SLS (1)	OLS (2)	Reduced-form (3)
A. Output Elasticity			
$\Delta \ln Y_{i,g}$	1.002***	0.434***	
	(0.230)	(0.002)	
$EXShare^{2018}_{iKR,g} \times IMShare^{2018}_{JPKR,g}$			0.772***
			(0.140)
First-stage Coefficient	0.771		
First-stage F-statistic	15.75		
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-3) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,698,242	9,698,242	9,698,242
B. Scale Elasticity			
$\Delta \ln Y_{i,g}$	0.211***	0.094***	
	(0.071)	(0.002)	
$EXShare^{2018}_{iKR,g} \times IMShare^{2018}_{JPKR,g}$			0.165***
			(0.046)
First-stage Coefficient	0.783		
First-stage F-statistic	16.18		
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-3) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,459,728	9,459,728	9,459,728

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Panels A and B present the HS-6 good-level estimates of output and scale elasticity for other countries, derived from equations (10) and (11), respectively. The only distinction between these two is the dependent variable: $\Delta \ln X_{ij,g}$ for Panel A and $\frac{1}{\theta_g}\Delta \ln X_{ij,g}$ for Panel B. Columns (1) and (2) report the 2SLS and OLS estimates, respectively. Column (3) reports the reduced-form coefficient. The instrumental variable for changes in total sales, $\Delta \ln Y_{i,g}$, is $EXShare^{2018}_{iKR,g} \times IMShare^{2018}_{JPKR,g}$. The first-stage coefficient and F-statistic are reported below the main estimates in Column (1). A concordance table from Statistics Korea is used to assign an HS-6 good (g) to a KSIC-3 sector (k), in order to identify the origin-sector fixed effects, $\alpha_{i,k(g)}$, at the g-level. Standard errors in parentheses are clustered at the origin-good level.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

Table A6: Estimates of Output and Scale Elasticities (Rank 1 or 2)

	2SLS (1)	OLS (2)	Reduced-form (3)
A. Output Elasticity			
$\Delta \ln Y_{i,g}$	0.826^{***}	0.429^{***}	
	(0.272)	(0.002)	
$Top^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g}$			0.127^{***}
			(0.041)
First-stage Coefficient	0.154		
First-stage F-statistic	10.15		
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,693,927	9,693,927	9,693,927
B. Scale Elasticity			
$\Delta \ln Y_{i,g}$	0.158^{*}	0.090^{***}	
	(0.087)	(0.002)	
$Top^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g}$			0.024^{*}
			(0.013)
First-stage Coefficient	0.155		
First-stage F-statistic	10.26		
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,455,460	9,455,460	9,455,460

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Panels A and B present the HS-6 good-level estimates of output and scale elasticity for other countries, derived from equations (10) and (11), respectively. The distinction between these two is the dependent variable: $\Delta \ln X_{ij,g}$ for Panel A and $\frac{1}{\theta_g}\Delta \ln X_{ij,g}$ for Panel B. Column (1) reports the 2SLS estimates using an alternative instrument, $(Top^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$, where $Top^{2018}_{i\,KR,g}$ is an indicator for whether Korea is ranked among the top two importers of origin i's exports of good g. The first-stage coefficient and F-statistic are reported below the main estimates in Column (1). Columns (2) and (3) report the OLS estimates and the reduced-form coefficient. A concordance table from Statistics Korea is used to assign an HS-6 good (g) to a KSIC-5 sector (k), in order to identify the origin-sector fixed effects, $\alpha_{i,k(g)}$, at the g-level. Standard errors in parentheses are clustered at the origin-good level.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

Table A7: Estimates of Output and Scale Elasticities (Rank 3, 4 or 5)

	2SLS (1)	OLS (2)	Reduced-form (3)
A. Output Elasticity			
$\Delta \ln Y_{i,g}$	4.568	0.429***	
	(7.608)	(0.002)	
$Top^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g}$			0.078***
			(0.026)
First-stage Coefficient	0.017		
First-stage F-statistic	0.31		
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,693,927	9,693,927	9,693,927
B. Scale Elasticity			
$\Delta \ln Y_{i,g}$	0.818	0.090***	
	(2.000)	(0.002)	
$Top^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g}$			0.011
			(0.015)
First-stage Coefficient	0.014		
First-stage F-statistic	0.21		
Origin Fixed Effects	Yes	Yes	Yes
Origin-Destination Fixed Effects	Yes	Yes	Yes
Destination-Good Fixed Effects	Yes	Yes	Yes
Origin-Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Goods	5,199	5,199	5,199
Observations	9,455,460	9,455,460	9,455,460

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Panels A and B present the HS-6 good-level estimates of output and scale elasticity for other countries, derived from equations (10) and (11), respectively. The distinction between these two is the dependent variable: $\Delta \ln X_{ij,g}$ for Panel A and $\frac{1}{\theta_g}\Delta \ln X_{ij,g}$ for Panel B. Column (1) reports the 2SLS estimates using an alternative instrument, $(Top^{2018}_{i\,KR,g} \times IMShare^{2018}_{JP\,KR,g})$, where $Top^{2018}_{i\,KR,g}$ is an indicator for whether Korea ranked as the third, fourth or fifth largest importer of origin i's exports of good g. The first-stage coefficient and F-statistic are reported below the main estimates in Column (1). Columns (2) and (3) report the OLS estimates and the reduced-form coefficient. A concordance table from Statistics Korea is used to assign an HS-6 good (g) to a KSIC-5 sector (k), in order to identify the origin-sector fixed effects, $\alpha_{i,k(g)}$, at the g-level. Standard errors in parentheses are clustered at the origin-good level.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)