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

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Abstract

I show that export controls can "backfire," increasing productivity and exports in the target country. This productivity response mitigates the negative welfare effect in the target country and exacerbates it in the imposing country. I leverage Korea's response to the 2019 Korea-Japan Trade Dispute. 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), finding their significant magnitude. Quantitatively, I show that the presence of scale economies mitigates the negative welfare effect of the export controls in Korea and exacerbates it in Japan.

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 target country due to restricted access to crucial intermediate goods. Others, however, view it as an opportunity for the target 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. This paper shows that Japan's export controls backfire by increasing Korea's productivity and exports, thereby mitigating the welfare loss in Korea while exacerbating it in Japan. The key mechanism driving this effect is scale economies in production. By shifting demand toward domestic goods, foreign export controls lead to an increase in domestic production. In the presence of scale economies, this increased output enhances productivity, which in turn drives down prices and boosts exports. My empirical findings provide strong support for this mechanism. Korean producers' revenue and exports increased, accompanied by a decrease in prices, precisely in sectors where Korea had been most reliant on Japan. Motivated by these empirical findings, I structurally estimate the strength of scale economies, leveraging demand-side variation in exposure to Korea's substitution away from Japan across industries. The results indicate that they are substantial: a 1% increase in total sales leads to a 0.18% increase in productivity. The welfare implications of scale economies are quantitatively significant. Compared to a scenario without them, their presence offsets 15% of the welfare loss in Korea while amplifying the welfare loss in Japan by 17%.

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, which means that all national strategic items exported to Korea were now subject to potential export controls. Therefore, 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 enforce 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 a significant decline in Korea's imports from Japan. First, Korea's overall imports from Japan declined substantially, both relative to the pre-event period and to imports from other countries. Second, non-exposed goods experienced a similarly significant decrease in imports from Japan as did exposed goods. 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 sectors where Japan had been the primary supplier. This indicates that Korea's prior dependence on Japan was a more significant factor in the import decline than an item's direct exposure to the controls. Fourth, despite the substantial decrease in imports from Japan, Korea's imports from the rest of the world in those sectors did not increase, both compared to the pre-event period and to less-dependent sectors.

Instead, Korean producers' revenue rose rapidly, precisely in Korea's most Japan-dominant sectors, 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. More interestingly, Korea's exports of these goods increased disproportionately, while the prices of these exports fell—both relative to the pre-event period and to other goods. This indicates that Korea experienced a productivity increase in sectors where Japan had been dominant.

To demonstrate how foreign export controls can lead to an increase in exports with a price decline in the target country, I present an Armington trade model featuring external economies of scale, following Kucheryavyy et al. (2023) and Bartelme et al. (2025). The key mechanism of the model is that an increase in size enhances productivity, which in turn lowers prices and boosts sales. To provide intuition for this, supply curves in a partial equilibrium model can slope downward in the presence of scale economies, as shown in Figure 1. Along this downward-sloping supply curve, an increase in demand leads to a decrease in price and an increase in quantity. Applying this framework to Japan's export controls on Korea, the positive shocks to demand for domestically produced goods (caused by foreign export controls) resulted in an increase in Korean producers' revenue, an increase in export quantities and a decrease in export prices—exactly as observed in

[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 accelerate imports from Japan before the export controls were actually implemented by the Japanese government. This suggests that the decrease in Korea's imports from Japan was primarily due to Korean firms' response to the potential risk posed by Japan's announcement of export controls.

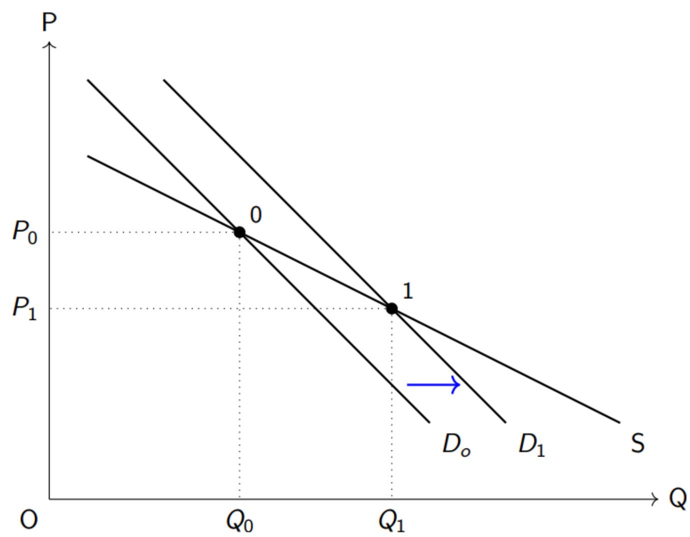


Figure 1: Downward Supply Curve

Notes: Supply curves in a partial equilibrium model can slope downward in the presence of scale economies. Within this framework, foreign export controls directly shift the demand curve for domestic goods to the right (from D_0 to D_1), as they act as a positive shock. This, in turn, 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 rationalizes my empirical findings in Section 3.

my empirical analysis.

Based on this structural model, I estimate the strength of scale economies by projecting changes in origin-destination-sector exports on changes in origin-sector total sales. A challenge is the potential endogeneity of total sales, which could be driven by unobserved supply-side shocks. To address this, I employ an instrumental variable strategy that uses purely demand-side variation. For the analysis of Korea, the instrument is the interaction between Japan's pre-event market share and the trade elasticity. This instrument, based on the structural model, is designed to capture the exogenous demand shocks from the 2019 Trade Dispute by leveraging the increase in demand for domestically produced goods that arose from Korea's substitution away from Japan. The results strongly support the presence of substantial scale economies in Korea. The estimate of scale economies is 0.18, indicating that a 1% increase in total sales leads to a 0.18% increase in productivity or a 0.18% decrease in price.

The analysis is then extended to all other countries, excluding Korea and Japan, to investigate the presence of scale economies. These countries could have expanded their sales to Korea to take over Japan's market share, which would have in turn increased their productivity. To address the endogeneity of changes in total sales, I construct an instrumental variable, based on the structural model, that exploits demand-side variation induced by the event. The instrument captures an origin's sector exposure to an increase in demand by interacting three components: first, the pre-event share of sales to Korea in an origin sector's exports; second, Japan's pre-event share in Korea for that sector; and third, the trade elasticity. The results provide strong evidence of scale economies across all other countries. The estimated scale elasticity is 0.22, indicating that a 1% increase in sales leads to a 0.22% increase in productivity. This estimate is consistent with that from the Korea-only analysis, though slightly large in magnitude.

The final part of the paper quantifies the welfare effects of the 2019 Korea-Japan Trade Dispute by integrating the scale elasticity estimates into the structural model. The core exercise is to compare the welfare outcomes for Korea and Japan across two scenarios: one without scale economies and one with scale economies. The analysis shows that the presence of scale economies substantially alters the welfare outcomes: it mitigates the negative welfare impact of the export controls in the target country (Korea) while exacerbating it in the imposing country (Japan). Quantitatively, compared to a scenario without scale economies, their presence offsets 15% of the welfare decline in Korea and amplifies the decline in Japan by 17%. This central finding proves to be robust across a range of alternative calibrations. These findings demonstrate how export controls can "backfire": by increasing productivity in the target country through scale economies, such policies can lead to unintended and self-harming consequences for the imposing country.

Related Literature. This paper contributes to several strands of literature. First, it relates to a growing literature on contemporary trade policy. A number of studies assess the economic effects of substantial tariff increases resulting from the US-China Trade War (e.g., Amiti et al. (2019); Fajgelbaum et al. (2020); Waugh (2019)).[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. This paper's primary contribution is to provide novel evidence that export controls backfire by increasing productivity in the target country, which in turn mitigates the welfare loss for the target country and exacerbates the loss for the imposing country. To the best of my knowledge, this is the first study to document such unintended, self-harming outcomes in the context of a modern trade dispute between two major, technologically advanced economies.

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

Second, this paper builds on the literature on economies of scale. (Antweiler and Trefler (2002); Kucheryavyy et al. (2023); Lashkaripour and Lugovskyy (2023); Bartelme et al. (2025)). Kucheryavyy et al. (2023) develop the generalization of the Ricardian model with external economies of scale. Bartelme et al. (2025) 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, this paper estimates the strength of scale economies using bilateral trade data at the 6-digit level of the Harmonized System (HS). This granular approach allows for the direct documentation of the presence of scale economies. The concurrent rise in export quantities and fall in export prices is observed in products from the target country (Korea), particularly in those that experienced a significant decline in imports from the imposing country (Japan) following Japan's announcement of export controls.

Third, this paper contributes to the literature that uses trade policy shocks to identify the effects of scale economies. This literature demonstrates that trade policy can have significant, and sometimes unexpected, effects on production and exports. Juhàsz (2018) finds that temporary trade protection during the Napoleonic Wars boosted the French cotton spinning industry. Breinlich et al. (2023) show that trade normalization with China reduced US export growth in affected sectors. Fajgelbaum et al. (2024) highlight that third countries increased their global exports for products affected by the higher tariffs of the US-China Trade War. Similarly, this paper provides novel evidence that foreign export controls can, paradoxically, boost productivity and exports in the target country. This unintended consequence is driven by the presence of scale economies. The target country increases its domestic production to substitute away from the imposing country's goods, which triggers productivity gains via scale economies. This effect is most pronounced in sectors where the imposing country holds a higher market share.

Fourth, this paper is directly connected to the literature on the home-market effect, a key prediction of trade models with scale economies (Head and Ries (2001); Davis and Weinstein (2003); Costinot et al. (2019)). This effect posits that a larger domestic market for a good leads to increased exports of that same good. This paper documents a direct empirical demonstration of this channel. Specifically, it shows how an exogenous trade policy shock that restricts imports can generate a home-market effect by increasing demand for domestic goods, a process that in turn raises productivity, lowers prices, and ultimately expands exports.

Lastly, this paper extends the 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); Alessandria et al. (2024)). The analysis reveals that the mere threat of export controls—even without actual enforcement—can act as a catalyst for import substitution. This shift toward domestic producers, in turn, triggers the scale economies mechanism, leading to higher productivity and an increase in exports. Thus, this paper demonstrates that trade policy uncertainty can have unintended, and even beneficial, consequences by spurring a positive supply-side response.

Outline. The remainder of the paper is structured as follows. Section 2 provides the background on Japan's 2019 announcement of export controls on Korea. Section 3 presents empirical findings regarding changes in Korea's imports, domestic producers' revenue and exports following the event. Section 4 introduces a trade model that incorporates external economies of scale. Section 5 estimates the strength of scale economies, first for Korea and then for a broader cross-country sample. Section 6 uses these estimates to quantify the general equilibrium welfare effects of the trade dispute on Korea and Japan. Finally, Section 7 concludes the paper.

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 on the shipment of three chemicals—photoresist, fluorinated polyimide and hydrogen fluoride—to South Korea, 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 whether their future imports from Japan would be permitted. 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 would now be 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 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 implement 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, domestic producers' revenue and exports 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 (Fact 5). Furthermore, Korea's exports in these sectors also increased, accompanied by a decrease in export prices (Fact 6). These empirical findings motivate the analysis of 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

[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.

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. The original monthly data are aggregated to the quarterly level for this 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' refers to the HS-6 level, and 'sectors' refers to the KSIC-5 level.

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

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 $m^{kor}_{c,g,t}$ denotes the value of 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, both relative to the pre-event period and to imports from other countries. Time-varying coefficients β_t, estimated using an event-study, are also plotted in Panel (A) of Figure 2, along with 95 percentage confidence 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, both relative to the pre-event period and to exports to other countries. See Appendix A for details.

Fact 2: Non-exposed goods experienced a similar decline in imports from Japan to that of exposed goods.

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:

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

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 statistically 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 this finding, showing no statistical difference in the import trends between *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 decline in both categories. See Appendix A for details.

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

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:

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

where $Dominant_g$ is an indicator variable for goods for which Japan was the leading supplier during the pre-event period (July 2018 to June 2019), and $NonDominant_g$ is an

[4] *Exposed* goods are defined as items on a list compiled by the Korean Security Agency of Trade and Industry (KOSTI). This list identifies Japanese national strategic items at the HS-10 level that became subject to individual export approval after Japan removed Korea from its "White List" countries. See Appendix A for details.

indicator variable for goods for which Japan was not the leading supplier. 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 the decline in imports from Japan was larger in sectors where Japan had previously been dominant. 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. The time-varying coefficients, $\beta_{1,t}$ and $\beta_{2,t}$, plotted in Panel (C) of Figure 2, consistently show a larger decline for *Dominant* goods than for *NonDominant* goods. In addition, Japan's exports to Korea decreased disproportionately in goods for which Japan had been the leading supplier, 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 for which Japan had been the leading supplier did not increase relative to the pre-event period.

Building on the finding from Fact 3 that imports from Japan decreased disproportionately in *Dominant* goods, I use the following difference-in-differences specification to examine whether Korea's imports from the rest of the world in these goods increased to replace those from Japan:

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

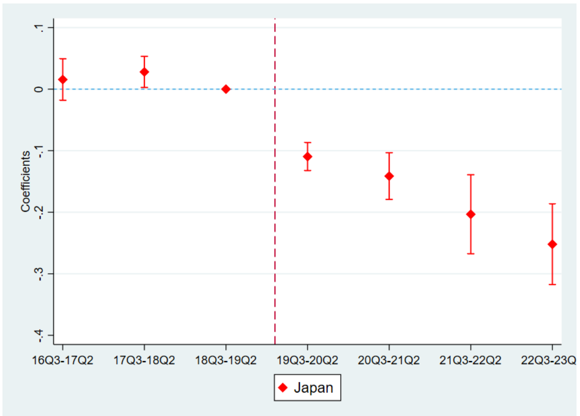
where RoW_c is an indicator variable for the rest of the world, and $\alpha_{c,t}$ denotes country-time fixed effects. Good-time fixed effects, $\alpha_{g,t}$, are excluded to investigate whether there are differential effects between Japan and the rest of the world in *Dominant* goods during the *Post* 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 for 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 increase, both relative to the pre-event period and to *NonDominant* goods. This also suggests that imports from Japan were not substituted with those from the rest of the world. The time-varying coefficients, $\beta_{1,t}$ and $\beta_{2,t}$, also support the absence of an increase in imports from the rest of world in *Dominant* goods, as plotted in Panel (D) of Figure 2.

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

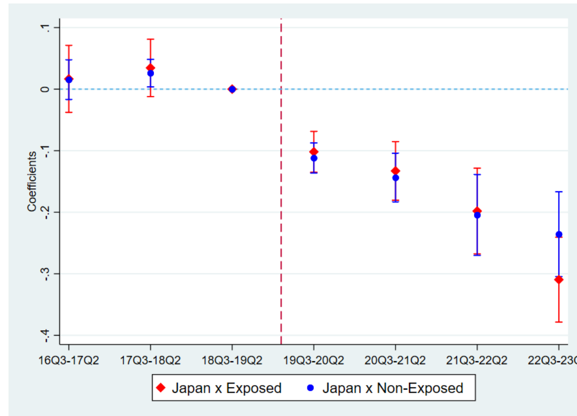
	Fact 1	Fact 2	Fact 3	Fact 4	Fact 5	Fact 6	Fact 6
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	$\ln m$	$\ln m$	$\ln m$	$\ln m$	$\ln R$	$\ln x^q$	$\ln x^p$
JP x Post	-0.190***						
	(0.025)						
JP x Post x Exposed		-0.200***					
		(0.031)					
JP x Post x NonExposed		-0.187***					
		(0.025)					
JP x Post x Dominant			-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
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

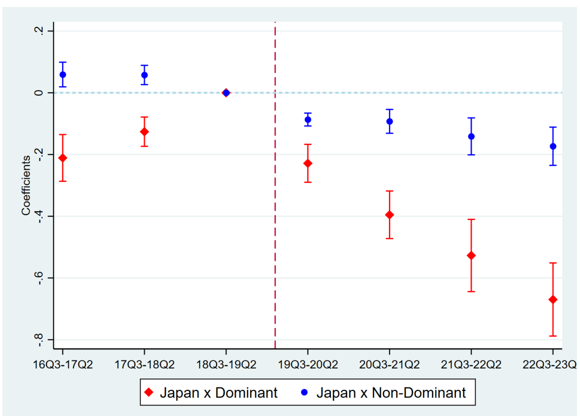
Notes: Table 1 presents the estimation results for the difference-in-differences specifications from Section 3. Columns (1) through (5) correspond to Facts 1 through 5. Columns (6) and (7) both relate to Fact 6, analyzing export quantity and export price, respectively. The dependent variable is the log of Korea's import value in Columns (1)-(4), the log of Korean producers' revenue in Column (5), and the log of Korea's export quantity and price in Columns (6) and (7). All estimations are at the HS-6 product level, except for Column (5), which is at the more aggregated KSIC-5 sector level.
Source: Korea Customs Service (2016-2023) and Statistics Korea (2016-2022).



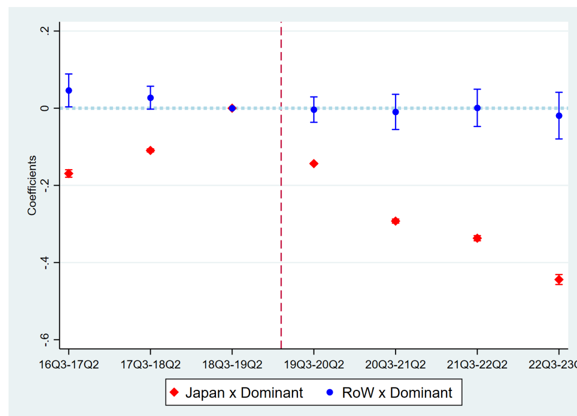
(A) Fact 1: Imports from Japan



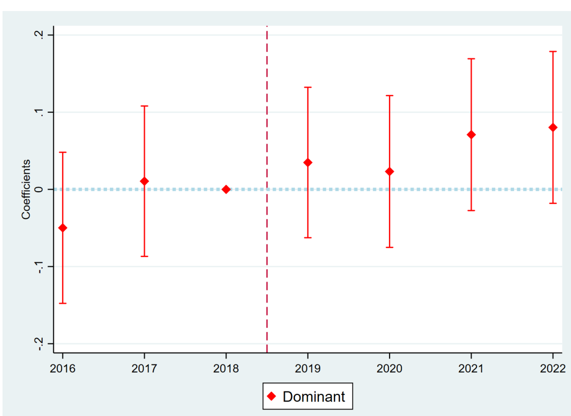
(B) Fact 2: Exposed vs. Non-Exposed



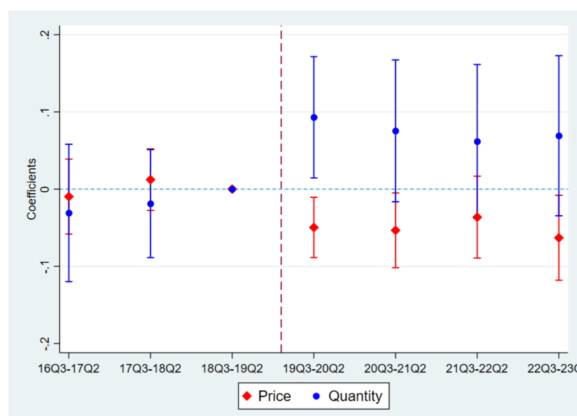
(C) Fact 3: Dominant vs. Non-Dominant



(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 from Section 3. Panels (A) through (F) correspond to Facts 1 through 6, respectively. All panels use HS-6 product-level data, with the exception of Panel (E), which uses more aggregated KSIC-5 sector-level data. Similarly, all panels use quarterly data for the period from Q3 2016 to Q2 2023, except for Panel (E), which uses annual data for the period from 2016 to 2022.
Source: Korea Customs Service (2016-2023) and Statistics Korea (2016-2022).

Fact 5: Korean producers' revenue increased in sectors where Japan had been the leading supplier, both relative to other sectors and to the pre-event period.

Building on Fact 3 and Fact 4, I now examine whether Korean producers' revenue increased in sectors where Japan had previously been dominant following Japan's 2019 announcement of export controls. To this end, I employ the following difference-in-differences specification:

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

where $R_{s,t}^{kor}$ 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 estimate for β is 0.065 (Column (5) of Table 1, suggesting that Korean producers' revenue in *Dominant* sectors increased by approximately 6.7%, both relative to other sectors and to the pre-event period. Combined with the findings from Fact 3 and Fact 4, this result indicates that the decline in Japanese imports was offset by an increase in domestic production—a sign of import substitution. The time-varying coefficients (β_t) plotted in Panel (E) of Figure 2 also confirm the revenue increase in *Dominant* sectors after the event.

Fact 6: Korea's export quantities of goods for which Japan had been the leading supplier increased, while their prices decreased.

Given the findings from Fact 3, Fact 4 and Fact 5, a plausible hypothesis is that Korea's exports of goods for which Japan had previously been the dominant supplier would decline. This is because the domestic production would likely be redirected to the domestic market to satisfy the demand previously met by Japanese imports. 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

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

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, contrary to the hypothesis, Korea's export quantities of *Dominant* goods increased by approximately 9.5%, both relative to *NonDominant* goods and to the pre-event period.

Furthermore, a standard economic prediction would be that Korea's export prices for *Dominant* goods would rise, driven by increased domestic demand and an upward-sloping supply curve. To test this hypothesis, the dependent variable $\log x_{g,t}^{kor}$ is replaced by the log of the export unit value. 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 further examines 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.

What, then, can explain this surprising export expansion and price decline, given that the increased domestic production was expected to be absorbed by import substitution? The answer lies in scale economies in production, characterized by a downward-sloping supply curve. If scale economies exist, an increase in production can enhance productivity, which in turn lowers 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 exports with a price decline in the target country. The model follows Kucheryavyy et al. (2023) and Bartelme et al. (2025).

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 sector features product differentiation by country of origin (the Armington assumption), meaning each country produces a unique variety. 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.

Preferences and Demand. 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 $P_{j,k} = \big(\sum_i p_{ij,k}^{-\theta_k} \big)^{-\frac{1}{\theta_k}}$.

Production and Pricing. The production technology exhibits external economies of scale, giving rise to increasing returns. 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—the *scale elasticity*—governs the strength of scale economies and is assumed to be common across all sectors. Note that if $\gamma = 0$, the production features 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 is a decreasing function of the sector size $L_{i,k}$, with an elasticity of $-\gamma$. 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), the price equation is given by:

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

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 next step is to apply the goods market clearing condition, $\beta_{j,k} w_j L_j = X_{j,k}$, 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 substitution 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 key term in this equation is the exponent on total sales, $\gamma\theta_k$, which represents the *output elasticity*: the elasticity of bilateral trade ($X_{ij,k}$) with respect to total sales ($Y_{i,k}$). This output elasticity arises from two channels. First, a 1% increase in total sales ($Y_{i,k}$) lowers price ($p_{ij,k}$) by γ percent; this is the scale elasticity channel from equation (3). Second, a 1% decrease in price increases sales in j ($X_{ij,k}$) by θ_k percent; this is the trade elasticity channel from equation (1). The product of these two effects, $\gamma\theta_k$, gives the total output elasticity. If $\gamma = 0$, indicating the absence of scale economies (the standard Armington model), an origin's total sales ($Y_{i,k}$) do not affect its sales in destination j ($X_{ij,k}$). In contrast, if $\gamma > 0$, indicating the presence of scale economies, an increase in $Y_{i,k}$ leads to an increase in $X_{ij,k}$.

4.3 General Equilibrium

The model's general equilibrium is defined by two market clearing conditions: the labor market and the goods market. First, the labor market clears when the total income in country i equals the country's total wage bill: $Y_i = w_i L_i$. Second, the goods market clears when the total output equals the country's total sales across all sectors and destinations: $Y_i = \sum_k \sum_j X_{ij,k}$. For the economy to be in equilibrium, both conditions must hold simultaneously. Combining these two yields the final market clearing condition:

$$w_i L_i = \sum_k \sum_j X_{ij,k}. \tag{5}$$

This condition must hold for all countries simultaneously. This system of equations can be formalized by defining an excess demand function for each country i as:

$$Z_i(\mathbf{w}) \equiv \frac{1}{w_i} \left(\sum_k \sum_j X_{ij,k} - w_i L_i \right). \tag{6}$$

The equilibrium is then the wage vector $\mathbf{w}^*$ that solves $Z_i(\mathbf{w}^*) = 0$ for all countries.

4.4 Application: Japan's 2019 Export Controls on Korea

This theoretical framework can rationalize the empirical findings presented in Section 3. To illustrate, I model Japan's announcement of export controls as a perceived increase in the bilateral trade cost, $\tau_{JP\,KR,k}$, where JP and KR denote Japan and Korea.

First, the model directly explains the effects on Korea's imports from Japan ($X_{JP\,KR,k}$). The bilateral trade equation (4) shows that an increase in $\tau_{JP\,KR,k}$ mechanically reduces $X_{JP\,KR,k}$, consistent with Fact 1 in Section 3. The model also predicts that this decline will be disproportionately larger for goods with a higher initial import share from Japan, which aligns with Fact 3 in Section 3.

Furthermore, the model explains the increase in Korean producers' revenue (Fact 5). The policy change, modeled as an increase in trade costs ($\tau_{JP\,KR,k}$), first raises the price of Japanese goods in Korea ($p_{JP\,KR,k}$), as shown in equation (3). This in turn raises the sectoral price index in Korea ($P_{KR,k}$), which directly increases expenditure on domestically produced goods ($X_{KR\,KR,k}$) as shown in the bilateral trade equation (4). This rise in domestic sales consequently increases total sales ($Y_{KR,k}$). Beyond the effect on domestic sales, the model also predicts that the increase in total sales leads to a decrease in Korea's export price, which in turn boosts its exports to all destinations (Fact 6). This occurs because the larger scale of production enhances productivity, which lowers the price of Korean goods in foreign markets ($p_{KR\,j,k}$), as shown in equation (3). This price decline boosts Korea's exports, as shown in the bilateral trade equation (4).

This entire mechanism is driven by the model's key feature: the presence of scale economies ($\gamma > 0$). In a standard model without this feature (i.e., $\gamma = 0$), the link between a country's domestic market size and its export performance is severed; an increase in total sales ($Y_{i,k}$) would have no impact on prices ($p_{ij,k}$) or exports ($X_{ij,k}$). Such a framework is therefore inconsistent with the empirical findings in Section 3. Thus, the model demonstrates that scale economies are the essential ingredient to explain how a negative shock on the import side can generate a positive expansion on the export side.

5 Estimation of Scale Elasticity

Motivated by the empirical findings from Section 3, this section structurally estimates the strength of scale economies based on the model presented in Section 4. First, I estimate the scale elasticity in Korea. Second, I extend the analysis to all other countries, excluding Korea and Japan. For these countries, an increase in sales to Korea to replace Japanese goods can enhance productivity through scale economies, thereby boosting their exports to all other destinations. The estimation results strongly support the presence of scale economies in both Korea and all other countries. These estimates then serve as key inputs for the quantitative analysis in Section 6.

Data. The empirical analysis uses three data sources. The first is bilateral trade data 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 across 227 countries. The sample spans annually from 2016 to 2022. The second source is Korean producer data from Statistics Korea. The data cover 478 mining and manufacturing 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 spans annually from 2016 to 2022. The third source is a concordance from Statistics Korea used to match the HS-6 goods to the KSIC-5 sectors. In this matching, a single KSIC-5 sector typically corresponds to multiple HS-6 goods. For the analysis, the sample is restricted observations from manufacturing sectors and from countries with a population of over one million.

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

$$\Delta \ln X_{ij,k} = \gamma\theta_k \Delta \ln Y_{i,k} - \theta_k(1+\gamma)\Delta \ln w_i + \Delta \ln \left(X_{j,k} P_{j,k}^{\theta_k}\right) + \theta_k \Delta \ln A_{i,k} - \theta_k \Delta \ln \tau_{ij,k}. \tag{7}$$

Changes in origin i's sales 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 exogenous productivity, $A_{i,k}$. $\Delta \ln X_{ij,k}$ also depends on changes in destination j's demand factors, $X_{j,k} P_{j,k}^{\theta_k}$, and trade costs from origin i to destination j, $\tau_{ij,k}$.

To obtain a direct estimate of the scale elasticity, γ, the baseline specification adjusts $\Delta \ln X_{ij,k}$ by the trade elasticity (θ_k) and includes a set of fixed effects as follows:

$$\frac{1}{\theta_k} \Delta \ln X_{ij,k} = \gamma \Delta \ln Y_{i,k} + \alpha_i + \alpha_{j,k} + \alpha_{i,k} + \varepsilon_{ij,k}. \tag{8}$$

The origin fixed effects, α_i, absorb any origin-specific changes, such as w_i in equation (7). The destination-sector fixed effects, $\alpha_{j,k}$, absorb demand shifts within each j and k, such as $X_{j,k} P_{j,k}^{\theta_k}$ in equation (7). The origin-sector fixed effects, $\alpha_{i,k}$, absorb other supply-side changes within each i and k, such as $A_{i,k}$ in equation (7). The error term, $\varepsilon_{ij,k}$, represents supply-side shocks not absorbed by these fixed effects.

5.1 Analysis 1: Korea Only

The first analysis focuses solely on Korea as the origin country. This provides the most direct setting in which to estimate the strength of scale economies, as Korea was directly targeted by the export controls and subsequently experienced a substantial increase in its total sales and exports (Fact 5 and Fact 6 in Section 3).

Specification. The estimation specification for Korea is adapted from the baseline equation (8), substituting KOR for i.

$$\frac{1}{\theta_k} \Delta \ln X_{KOR\,j,k} = \gamma \Delta \ln Y_{KOR,k} + \alpha_{KOR} + \alpha_{KOR\,j} + \alpha_{KOR\,K(k)} + \varepsilon_{KOR\,j,k}. \tag{9}$$

The estimation is performed using the difference in data between a pre-event period (2016-2018) and a post-event period (2020-2022), excluding the event year 2019. The dependent variable, $\frac{1}{\theta_k} \Delta \ln X_{KOR\,j,k}$ (defined as $\frac{1}{\theta_k} \ln X^{Post}_{KOR\,j,k} - \frac{1}{\theta_k} \ln X^{Pre}_{KOR\,j,k}$), is the log difference in Korea's exports of good k to destination j between the post-period and the pre-period, adjusted by the trade elasticity (θ_k). The same estimates for θ_k are used as in Bartelme et al. (2025), which in turn takes the values from Giri et al. (2021).[6] The independent variable, $\Delta \ln Y_{KOR,k}$, is the log difference in Korea's total sales in good k over the same periods. Due to the unavailability of domestic sales data at the HS-6 level, total sales are proxied by total exports. This limitation is addressed in a robustness check at a more aggregate 5-digit level; including domestic sales yields results consistent with the baseline findings at the 6-digit level.[7]

γ is the coefficient of interest, which measures the strength of scale economies and is referred to as the scale elasticity. The estimate of γ has two equivalent interpretations based on the model: (i) it is the elasticity of productivity with respect to total sales as defined by the production technology ($\tilde{A}_{i,k} = A_{i,k} L_{i,k}^{\gamma}$); and (ii) it is the elasticity of price with respect to total sales, as shown in equation (3).

The remaining terms in the specification (9) are a set of fixed effects that control for other sources of variation, with each effect corresponding to a theoretical term in equation (7). The origin fixed effects (α_{KOR}) absorb any aggregate shocks to Korea that are common across all js and ks, such as changes in the wage ($\Delta \ln w_{KOR}$) in equation (7). The Korea-destination fixed effects ($\alpha_{KOR\,j}$) absorb any shocks specific to destination j, such as changes in overall demand for Korean goods. To control for origin-sector specific shocks, fixed effects at the 5-digit sector level ($\alpha_{KOR,K(k)}$) are included, assuming a common effect for all 6-digit ks within the same 5-digit K. This level of aggregation is necessary because fixed effects at the 6-digit sector level ($\alpha_{KOR,k}$) are perfectly collinear with the independent variable, $\Delta \ln Y_{KOR,k}$. The destination-sector fixed effects $\alpha_{j,k}$ are not included in this Korea-only specification. This is because, with only a single origin country in the sample, these fixed effects are perfectly collinear with the dependent variable, $\Delta \ln X_{KOR\,j,k}$. This limitation is resolved in Section 5.2, where the inclusion of multiple origins allows $\alpha_{j,k}$ to be incorporated.

A key identification challenge is that the error term ($\varepsilon_{KOR\,j,k}$) in specification (9) contains shocks from the theoretical model (equation (7)) that are not fully absorbed by the fixed effects, including shocks to fundamental productivity ($\Delta \ln A_{KOR,k}$), destination-sector specific demand ($\Delta \ln X_{j,k} P_{j,k}^{\theta_k}$), and bilateral trade costs ($\Delta \ln \tau_{KOR\,j,k}$). The indepen-

[6] Giri et al. (2021) provide the estimates for manufacturing sectors at the SIC-2 level. As this analysis is conducted at the more disaggregated HS-6 level, it is assumed that all HS-6 products belonging to the same SIC-2 sector share a common trade elasticity.

[7] This consistency is also in line with the theoretical and empirical findings from Bartelme et al. (2025), which suggest that excluding domestic sales from the total sales yields estimates of scale economies similar to those obtained when they are included.

dent variable, the change in total sales ($\Delta \ln Y_{KOR,k}$), is likely to respond endogenously to these shocks, implying $E[\Delta \ln Y_{KOR,k} \times \varepsilon_{KOR\, j,k}] \neq 0$. Therefore, an instrumental variable that isolates exogenous demand-side variation is required to obtain an unbiased estimate of the scale elasticity, γ.

Instrumental Variable. To address the potential endogeneity of $\Delta \ln Y_{KOR,k}$, the estimation requires an instrument variable that is correlated with $\Delta \ln Y_{KOR,k}$ but uncorrelated with unobserved supply-side shocks. I therefore construct an instrument that captures the exogenous demand shock from the 2019 Korea-Japan Trade Dispute. The instrument is the product of the trade elasticity (θ_k) and Japan's pre-event (2018) import share in Korea for product k, denoted as $IV_{KOR,k}$:

$$IV_{KOR,k} = \theta_k Share^{2018}_{JPN\, KOR,k},$$

where $Share^{2018}_{JPN\, KOR,k} = \frac{X_{JPN\, KOR,k}}{\sum_{i \neq KOR} X_{i\, KOR,k}}$.

This instrumental variable is designed to capture the sector-specific exposure to the 2019 Trade Dispute. The intuition is straightforward: sectors where Korea was more reliant on Japanese imports (i.e., a higher $Share^{2018}_{JPN\, KOR,k}$) were poised to experience a larger increase in demand for domestically produced goods following the shock. This increase in domestic demand should, in turn, lead to greater sales growth for Korean producers in the same sectors. This mechanism is strongly supported by the empirical evidence in Section 3. Fact 3 shows that the decline in imports from Japan was the largest in these high-share sectors and Fact 5 demonstrates that Korean producers' revenue also increased the most in precisely these sectors.

The structural model in Section 4 also provides a theoretical justification for this instrumental variable. Within this framework, the trade dispute is modeled as an exogenous shock to trade costs ($\tau_{JPN\, KOR,k}$).[8] This shock propagates purely through a demand-side channel: it raises the price of Japanese goods ($p_{JPN\, KOR,k}$), which increases Korea's overall price index ($P_{KOR,k}$) and shifts expenditure toward domestic goods ($X_{KOR\, KOR,k}$), ultimately increasing Korean producers' total sales ($Y_{KOR,k}$). This mechanism establishes the theoretical relevance of the instrument. Furthermore, because this channel is entirely demand-driven, the instrument is by construction uncorrelated with the unobserved supply-side shocks in the error term, satisfying the exclusion restriction. The formal

[8]This modeling choice is rationalized by the empirical finding in Fact 2 in Section 3: the decline in imports from Japan was not restricted to the officially targeted items but was similarly large for non-targeted goods as well. This suggests that the event created a broad-based, perceived increase in importing costs for all Japanese goods.

derivation of this mechanism is detailed in Appendix B.

Threats to the Exclusion Restriction. The exclusion restriction would be violated if there were productivity shocks during the post-event period that were correlated with $Share^{2018}_{JPN\,KOR,k}$. For instance, the Korean government might have subsidized sectors with high Japan's market shares to boost domestic production, in response to Japan's 2019 announcement of export controls. This would lead to an overestimate of the strength of scale economies.

To address this concern, I examine the Korean government's actual policy responses to the 2019 export controls. Immediately after Japan's announcement, the government provided support packages for domestic importers of Japanese goods. These packages focused on two main strategies: first, expediting imports from Japan before export controls could be fully enforced; and second, helping domestic firms shift their sources from Japan to alternative foreign suppliers. Thus, these immediate 2019 measures were not supply-side shocks, but rather responses to import-side challenges. While the government later introduced supply-side measures in 2020 to address COVID-19 disruptions, these policies were not designed based on the 2018 Japan's market share, $Share^{2018}_{JPN\,KOR,k}$. Therefore, neither the 2019 import-side policies nor the 2020 supply-side measures were systematically correlated with the instrument, which supports the validity of the exclusion restriction.

Additionally, the specification (9) includes Korea-sector fixed effects ($\alpha_{KOR,K(k)}$) to control for any potential supply-side shocks, such as sector-specific production subsidies that might be correlated with the instrument.[9] This level of fixed effects is particularly appropriate, as manufacturing data for Korea (e.g., production, investment) are reported at this same 5-digit (K) industry level. By absorbing any such sector-specific shocks, these fixed effects further ensure that the instrumental variable satisfies the exclusion restriction.

Results. Table 2 reports the estimation results for equation (9). Column (1) presents the Two-Stage Least Squares (2SLS) estimate, where the log change in total sales ($\Delta \ln Y_{KOR,k}$) is instrumented by the interaction of the trade elasticity and Japan's 2018 market share ($\theta_k Share^{2018}_{JPN\,KOR,k}$). The 2SLS estimate for the scale elasticity (γ) is 0.18 and is statistically significant. This result provides strong evidence for scale economies in Korea, implying that a 1% increase in a sector's total sales increases its productivity by 0.18%. The result

[9] k refers to a product at the HS-6 level, while K refers to the more aggregated 5-digit KSIC sector to which product k belongs. A single K sector typically contains multiple k products.

Table 2: Estimates of Scale Elasticity (HS-6)

	$\frac{1}{\theta_k}\Delta \ln X_{KOR\,j,k}$		
	2SLS	OLS	Reduced-form
	(1)	(2)	(3)
$\Delta \ln Y_{KOR,k}$	0.177^{***}	0.100^{***}	
	(0.053)	(0.002)	
$\theta_k Share^{2018}_{JPN\,KOR,k}$			0.006^{***}
			(0.002)
First-stage Coefficient	0.034		
First-stage F-statistic	375.91		
Destination Fixed Effects	Yes	Yes	Yes
Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Sectors	4,582	4,582	4,582
Observations	190,087	190,087	190,087

Standard errors in parentheses

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

Notes: Table 2 reports the estimation results for the scale elasticity (γ) at the HS-6 level using specification (9). Column (1) presents the main 2SLS estimate, with its corresponding first-stage coefficient and F-statistic reported below. For this 2SLS estimation, the log difference in total sales ($\Delta \ln Y_{KOR,k}$) is instrumented by the product of the trade elasticity and Japan's 2018 import share in Korea ($\theta_k Share^{2018}_{JPN\,KOR,k}$). Columns (2) and (3) show the OLS and reduced-form estimates, respectively. The independent variable ($\Delta \ln Y_{KOR,k}$) is proxied by the log difference in total exports. The trade elasticity (θ_k), as in Bartelme et al. (2025), is taken from Giri et al. (2021), assuming a common elasticity for all HS-6 products within the same SIC-2 sector. The sample is restricted to manufacturing sectors and countries with a population over one million.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

also supports the model's key mechanism—a demand-driven increase in sales enhancing productivity, which in turn lowers price and boosts exports—as documented in Fact 6 in Section 3. The first-stage result confirms the relevance of the instrument, showing a strong positive correlation with the endogenous variable.

The OLS estimate for the scale elasticity is 0.10 (Column (2) of Table 2), substantially smaller than the corresponding 2SLS estimate of 0.18. This downward bias suggests that the change in total sales ($\Delta \ln Y_{KOR,k}$) is negatively correlated with unobserved supply-side shocks ($\varepsilon_{KOR\,j,k}$). Such a bias is expected if sectors experiencing an increase in sales also faced negative supply-side shocks, such as rising production costs. Crucially, this finding alleviates the main threat to the exclusion restriction: if the dominant unobserved shock had been targeted government subsidies (a positive shock), we would expect an upward bias, not the downward bias observed in the data.

Column (3) of Table 2 presents the reduced-form estimate, showing the direct effect of the instrumental variable on exports. The coefficient is positive and significant, indicating that sectors with greater exposure to the shock (i.e., a higher instrument value) experienced greater subsequent export growth. The result is consistent with Fact 6 in Section 3 and provides direct, reduced-form evidence for the central mechanism in this paper: that export-control-induced positive shocks to domestic demand can enhance productivity through scale economies, which in turn expands exports. This finding also serves as a clear example of the home-market effect.

Comparison with the Literature. The estimate of the scale elasticity ($\gamma = 0.18$) is consistent with the findings of Bartelme et al. (2025). Although this study adopts their theoretical framework, the empirical strategy differs: Bartelme et al. (2025) estimate sector-specific elasticities (γ_k) using long-run demand variation, whereas this study estimates a single, common elasticity (γ) using a short-run trade policy shock. Despite these differences, the results are consistent: they report a median elasticity of 0.20 and an average of 0.21, which aligns closely with the estimate of 0.18 found in this paper. Moreover, the estimate from the cross-country analysis (Section 5.2) aligns even more closely, with a value of 0.22.

The findings in this paper are also consistent with those of Breinlich et al. (2023), which uses a theoretically similar model to study a different event: the 2001 permanent normalization of US trade relations with China. A key difference, however, is that their specification estimates the output elasticity ($\gamma\theta_k$), while the baseline in this paper estimates the scale elasticity (γ) directly. To create a direct comparison, I re-estimate the main specification (9) without adjusting the dependent variable by the trade elasticity.

This exercise yields an output elasticity of 0.87, which is consistent with the value of 0.82 used in the quantitative analysis of Breinlich et al. (2023).[10] The detailed results of this estimation are presented in Appendix B.

This close alignment with the findings of two recent studies, given the different identification strategies and events analyzed, strengthens the external validity of the estimated scale elasticity.

Robustness. To check the robustness of the main estimate reported in Table 2, the analysis is re-estimated at a more aggregated KSIC-5 sector level.[11] The specification is:

$$\frac{1}{\theta_k}\Delta \ln X_{KOR\,j,k} = \gamma \Delta \ln Y_{KOR,k} + \alpha_{KOR} + \alpha_{KOR\,j} + \delta \Delta \ln Z_{KOR,k} + \varepsilon_{KOR\,j,k}. \tag{10}$$

The primary motivation for this change in aggregation is the availability of domestic sales data at this level. This allows the endogenous variable, $\Delta \ln Y_{KOR,k}$, to be measured as the log change in total sales, rather than being proxied by total exports as in the main analysis. This change in aggregation, however, necessitates a different strategy for controlling for sector-specific shocks. At this 5-digit sector level, the Korea-sector fixed effects from the main analysis ($\alpha_{KOR,K(k)}$) become perfectly collinear with the endogenous variable, $\Delta \ln Y_{KOR,k}$. Therefore, they are replaced with a new control variable, $\Delta \ln Z_{KOR,k}$, which is the log change in the average annual wage (defined as the total wage bill divided by the number of employees) in each sector. The definitions of the remaining terms are the same as in the main analysis, though they are now applied at the 5-digit rather than the 6-digit level.

The estimation results for this robustness check, presented in Table 3, are highly consistent with the baseline findings. The 2SLS estimate for the scale elasticity (γ) is 0.17 (Column (1)), which is very close to the baseline estimate of 0.18. This confirms that the main finding is robust to both the change in aggregation level and the inclusion of domestic sales in the measure of total sales.[12] Furthermore, other key patterns from the main analysis also hold. The OLS estimate in Column (2) is 0.08, again substantially smaller than the 2SLS estimate of 0.17. This downward bias alleviates the threat to the

[10] Breinlich et al. (2023) report a structural estimate of 0.74 for the output elasticity (Table 5, column c). However, for their main quantitative analysis, they use a calibrated value of 0.82, which is chosen to match their simulated model with their reduced-form estimate.

[11] The total sales for Korean producers ($Y_{KOR,k}$) are sourced directly from the KSIC-5 data provided by Statistics Korea. The corresponding export data ($X_{KOR\,j,k}$) are aggregated from the HS-6 level to the KSIC-5 level using a concordance table.

[12] This finding is also consistent with Bartelme et al. (2025), who show that excluding domestic sales from total sales yields a similar estimate of scale elasticity.

Table 3: Estimates of Scale Elasticity (KSIC-5)

	$\frac{1}{\theta_k}\Delta \ln X_{KOR\,j,k}$		
	2SLS	OLS	Reduced-form
	(1)	(2)	(3)
$\Delta \ln Y_{KOR,k}$	0.166***	0.082***	
	(0.057)	(0.008)	
$\theta_k Share^{2018}_{JPN\,KOR,k}$			0.012***
			(0.004)
$\Delta \ln Z_{KOR,k}$	-0.200**	-0.091***	0.030
	(0.079)	(0.030)	(0.029)
First-stage Coefficient	0.070		
First-stage F-statistic	727.22		
Destination Fixed Effects	Yes	Yes	Yes
Number of Sectors	401	401	401
Observations	40,076	40,076	40,076

Standard errors in parentheses

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

Notes: Table 3 reports the estimation results for the scale elasticity (γ) at the KSIC-5 level using specification (10). Column (1) presents the 2SLS estimate, with its corresponding first-stage coefficient and F-statistic reported below. For this 2SLS estimation, the log difference in total sales ($\Delta \ln Y_{KOR,k}$) is instrumented by the product of the trade elasticity and Japan's 2018 import share in Korea ($\theta_k Share^{2018}_{JPN\,KOR,k}$). Columns (2) and (3) show the OLS and reduced-form estimates, respectively. The total sales for Korean producers ($Y_{KOR,k}$) are sourced directly from the KSIC-5 data provided by Statistics Korea. The corresponding export data ($X_{KOR\,j,k}$) are aggregated from the HS-6 level to the KSIC-5 level using a concordance table from Statistics Korea. The trade elasticity (θ_k), as in Bartelme et al. (2025), is taken from Giri et al. (2021), assuming a common elasticity for all KSIC-5 sectors within the same SIC-2 sector. The sample is restricted to manufacturing sectors and countries with a population over one million.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2016-2022)

exclusion restriction as in the main analysis. The reduced-form estimate in Column (3) is also positive and significant, aligning with the main analysis.

A further robustness check tests whether the main estimate is sensitive to the aggregation level of the Korea-sector fixed effects ($\alpha_{KOR,K(k)}$). While the baseline specification uses the 5-digit sector level for K, I re-estimate equation (9) using more aggregated 3-digit and 2-digit sector definitions. The results, presented in Appendix Table A3 and Table A4, confirm that the estimate of the scale elasticity (γ) remains positive, significant, and of a similar magnitude across all specifications. This demonstrates that the main finding is not driven by the specific choice of the fixed effect level, further strengthening the robustness of the results. While the estimates are consistent, they tend to be slightly lower as the aggregation level of the sector fixed effects ($\alpha_{KOR,K(k)}$) becomes more disaggregated. This pattern is expected, as more granular fixed effects (e.g., 5-digit vs. 2-digit) absorb a greater amount of the unobserved sector-level variation.

5.2 Analysis 2: All Other Countries

The second part of the analysis extends the estimation to all other countries excluding Korea and Japan to test whether scale economies are also present in the cross-country analysis. These countries could have expanded their sales to the Korean market to meet the increased demand resulting from the decline in Japanese imports. This demand-driven increase in total sales, if scale economies are present, would in turn enhance their productivity and boost their exports.

Specification. The analysis uses the following specification, which builds upon the baseline equation (8):

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

This specification is different from equation (9) used in the Korea-only analysis in one key aspect: The inclusion of multiple origins now makes it possible to incorporate the destination-sector fixed effects ($\alpha_{j,k}$), allowing for a more robust control of demand-side factors.

The main variables are defined consistently with the Korea-only analysis. The dependent variable, $\frac{1}{\theta_k}\Delta \ln X_{ij,k}$, is the log difference in exports from origin i in sector k to destination j between the post-event period (2020-2022) and the pre-event period (2016-2018), adjusted by the trade elasticity (θ_k). The trade elasticity parameter is taken from

Giri et al. (2021), under the assumption that it is constant for all 6-digit sectors within the same 2-digit sector. The independent variable, $\Delta \ln Y_{i,k}$, is the log difference in origin i's total sales in sector k over the same periods. The total sales ($Y_{i,k}$) are proxied by total exports due to the unavailability of domestic sales data at the 6-digit level, as in the Korea-only analysis.

γ is the coefficient of interest, which measures the strength of scale economies and is referred to as the scale elasticity.[13] The set of fixed effects in specification (11) is designed to control for various sources of variation, mirroring the theoretical equation (7). The origin fixed effects (α_i) absorb aggregate shocks common to each origin i. The origin-destination fixed effects (α_{ij}) absorb shocks specific to a given trade partnership. The origin-sector fixed effects ($\alpha_{i,K(k)}$) are included at the 5-digit K-level to control for supply-side characteristics; as in the Korea-only analysis, a more granular 6-digit origin-sector fixed effect is excluded due to perfect collinearity with the independent variable ($\Delta \ln Y_{i,k}$).[14] The destination-sector fixed effects ($\alpha_{j,k}$) are now included, unlike the Korea-only analysis. The multiple origins in the sample make it possible to include this term, which was not identified in the single-origin analysis due to collinearity.

A key identification challenge is that the error term ($\varepsilon_{ij,k}$) in specification (11) contains unobserved shocks from the theoretical model (equation (7)) that are not fully absorbed by the fixed effects. These include shocks to fundamental productivity ($\Delta \ln A_{i,k}$), and bilateral trade costs ($\Delta \ln \tau_{ij,k}$). Since the independent variable ($\Delta \ln Y_{i,k}$) is likely to be correlated with these supply-side shocks, the OLS assumption is violated ($E[\Delta \ln Y_{KOR,k} \times \varepsilon_{ij,k}] \neq 0$). Therefore, an instrumental variable that isolates exogenous demand-side variation is required to obtain an unbiased estimate of the scale elasticity, γ.

Instrumental Variable. To address the potential endogeneity of $\Delta \ln Y_{i,k}$, the estimation of γ necessitates an instrumental variable that is correlated with $\Delta \ln Y_{i,k}$ but not correlated with unobserved supply-side shocks. I therefore construct an instrument that captures the exogenous demand shock from the 2019 Korea-Japan Trade Dispute specific to each origin i and sector k pair. The instrument is the product of three components: the trade elasticity (θ_k), Japan's pre-event (2018) import share in Korea, and the pre-event

[13] The estimate of γ has two equivalent interpretations based on the model: (i) it is the elasticity of productivity with respect to total sales as defined by the production technology; and (ii) it is the elasticity of price with respect to total sales.

[14] k denotes a product at the 6-digit HS level, while K denotes the corresponding 5-digit KSIC sector. The origin-sector fixed effects ($\alpha_{i,K(k)}$) are included to control for unobserved supply-side characteristics at the K level. This is the appropriate level of control, as key industrial data for most countries (e.g., production, investment, and employment) are typically reported at the K level.

share of sales to Korea in an origin i's total exports. Formally, it is defined as:

$$IV_{i,k} = \theta_k IMShare^{2018}_{JPN\,KOR,k} EXShare^{2018}_{i\,KOR,k},$$

where $IMShare^{2018}_{JPN\,KOR,k} = \frac{X_{JPN\,KOR,k}}{\sum_{i \neq KOR} X_{i\,KOR,k}}$ and $EXShare^{2018}_{i\,KOR,k} = \frac{X_{i\,KOR,k}}{\sum_{j \neq i} X_{ij,k}}$.

This instrumental variable is designed to capture the origin-sector (i-k) specific exposure to the demand shock in Korea by interacting two pre-event components: first, Japan's import share in Korea ($IMShare^{2018}_{JPN\,KOR,k}$) proxies for the magnitude of the shock in the Korean market; second, origin i's export share to Korea ($EXShare^{2018}_{i\,KOR,k}$) proxies for the origin's exposure to that shock. The intuition is that the positive impact on an origin's sales is greater for sectors that had both a high exposure to the Korean market (a high $EXShare^{2018}_{i\,KOR,k}$) and faced a larger demand shock (a high $IMShare^{2018}_{JPN\,KOR,k}$).

The structural model in Section 4 also provides a theoretical justification for the cross-country instrumental variable. Within this framework, the trade dispute is modeled as an exogenous shock to trade costs ($\tau_{JPN\,KOR,k}$). This shock propagates purely through a demand-side channel: it raises Korea's overall price index ($P_{KOR,k}$) and shifts expenditure toward goods from other countries ($X_{i\,KOR,k}$), which in turn increases other countries' total sales ($Y_{i,k}$). This mechanism establishes the theoretical relevance of the instrument. Furthermore, because this channel is driven by a demand shock external to origin i, the instrument is by construction uncorrelated with an origin i's own supply-side shocks, satisfying the exclusion restriction. The formal derivation of this mechanism is detailed in Appendix C.

Threats to the Exclusion Restriction. The validity of the instrument hinges on the exclusion restriction, which requires the instrument to be uncorrelated with unobserved supply-side shocks ($\varepsilon_{i\,j,k}$). A potential threat would be if foreign governments responded to the 2019 event by providing targeted subsidies to their domestic producers, particularly in sectors with high exposure to the Korean market opportunity. However, such a targeted subsidy response from numerous foreign governments is implausible for two practical reasons. First, the Korean market is not large enough to typically induce such coordinated, sector-specific policy on a global scale. Second, the shock itself was complex, directly affecting nearly a thousand distinct products, making a precisely tailored subsidy program difficult to implement. Even beyond these considerations, the model's specification is robust to such a threat. Any potential origin-sector specific subsidies would be absorbed by the origin-sector fixed effects ($\alpha_{i,K(k)}$) included in the estimation.[15] Therefore, both the practical implausibility of a coordinated subsidy response and the model's specification validate the exogeneity of the instrument.

Results. Table 4 presents the cross-country estimation results for equation (11). Column (1) reports the Two-Stage Least Squares (2SLS) estimate, where the log change in total sales ($\Delta \ln Y_{i,k}$) is instrumented by the product of the trade elasticity, Japan's import share, and the origin's export share. The 2SLS estimate for the scale elasticity (γ) is 0.22 and is statistically significant, which indicates that a 1% increase in total sales raises productivity by 0.22%. This result is consistent with the baseline estimate of 0.18 from the Korea-only analysis. Additionally, the first-stage result, reported below the 2SLS estimate, confirms the relevance of the instrument. These findings suggest that scale economies are also present in the cross-country sample, which supports the core mechanism in the paper: a demand-driven increase in sales can increase productivity, which in turn lowers price and expands exports.

The OLS estimate in Column (2) is smaller than the 2SLS estimate, indicating a downward bias. This suggests that the log change in total sales ($\Delta \log Y_{i,k}$) is negatively correlated with unobserved supply-side shocks. This is plausible under a scenario where high-growth sectors also encountered rising production costs. In line with the Korea-only analysis, this downward bias alleviates the threat to the exclusion restriction; if the unobserved supply-side shock had been coordinated subsidies, we would expect an upward bias. Column (3) reports the reduced-form estimate, which captures the direct effect of the instrument on the dependent variable ($\Delta \ln X_{ij,k}$). The coefficient is positive and significant, providing direct evidence for the main mechanism. This result indicates that origin-sector experienced greater export growth when they had a higher pre-event export share to Korea (a high $EXShare^{2018}_{i\,KOR,k}$) and when that market experienced a larger demand shock (a high $IMShare^{2018}_{JPN\,KOR,k}$).

Robustness. To test the robustness of the estimate of scale elasticity in Table 4, I re-examine the specification (11) by varying the level of aggregation for K in the origin-sector fixed effects ($\alpha_{i,K(k)}$), following the same approach as in Section 5.1. While the baseline uses the 5-digit sector level for K, this exercise re-estimates the specification using more aggregated 3-digit and 2-digit sector definitions.[16] The estimation results,

[15] This 5-digit (K) level is appropriate, as key manufacturing data for most countries (e.g., production, investment, and employment) are typically reported at this same level of aggregation.

[16] k denotes a product at the 6-digit HS level, while K denotes the corresponding aggregated KSIC sector.

Table 4: Estimates of Scale Elasticity (HS-6)

	$\frac{1}{\theta_k}\Delta \ln X_{ij,k}$		
	2SLS	OLS	Reduced-form
	(1)	(2)	(3)
$\Delta \ln Y_{i,k}$	0.224^{***}	0.107^{***}	
	(0.055)	(0.001)	
$\theta_k IMShare^{2018}_{JPN\,KOR,k} EXShare^{2018}_{i\,KOR,k}$			0.030^{***}
			(0.006)
First-stage Coefficient	0.134		
First-stage F-statistic	13.79		
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 Sectors	4,636	4,636	4,636
Observations	9,227,647	9,227,647	9,227,647

Standard errors in parentheses

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

Notes: Table 4 reports the cross-country estimation results for the scale elasticity γ at the HS-6 level using specification (11). Column (1) presents the main 2SLS estimate, with its corresponding first-stage coefficient and F-statistic reported below. For this 2SLS estimation, the log difference in total sales ($\Delta \ln Y_{i,k}$) is instrumented by the product of the trade elasticity, Japan's 2018 import share in Korea, and origin i's 2018 export share to Korea ($\theta_k IMShare^{2018}_{JPN\,KOR,k} EXShare^{2018}_{i\,KOR,k}$). Columns (2) and (3) show the OLS and reduced-form estimates, respectively. The independent variable ($\Delta \ln Y_{i,k}$) is proxied by the log difference in total exports. The trade elasticity (θ_k), as in Bartelme et al. (2025), is taken from Giri et al. (2021), assuming a common elasticity for all HS-6 products within the same SIC-2 sector. The sample is restricted to manufacturing sectors and countries with a population over one million. Standard errors, reported in parentheses, are clustered at the origin-good level.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

presented in Table A5 (3-digit) and Table A6 (2-digit), are highly consistent with the baseline 5-digit results from Table 4. Across all specifications, the key estimates—2SLS, OLS and reduced-form—remain stable in both sign, significance and magnitude. This confirms that the main finding is robust and not sensitive to the aggregation level of the origin-sector fixed effects ($\alpha_{i,K(k)}$). Furthermore, this stability across specifications strengthens the validity of the identification strategy in two ways. First, the inclusion of the origin-sector fixed effects itself controls for any origin-sector supply shocks that could be correlated with the instrument. Second, the stability of the γ estimate across the different aggregation levels of these fixed effects suggests that no such problematic correlation exists.

6 Quantitative Analysis

This section quantifies the welfare effects of the 2019 Korea-Japan Trade Dispute, using the structural model from Section 4 and the scale elasticity estimated in Section 5. The central exercise is to compare the welfare outcomes in two scenarios: (i) one without scale economies ($\gamma = 0$) and (ii) one with scale economies ($\gamma > 0$). The results show that the presence of scale economies mitigates the negative welfare impact of the export controls in the target country (Korea), while exacerbating it in the imposing country (Japan).

6.1 Solving for Equilibrium Changes

To quantify the general equilibrium effects of the trade shock, the model is solved in proportional changes using exact hat algebra, as in Dekle et al. (2008). This approach defines the relative change in any variable x as the ratio of its counterfactual value (x') to its initial value (x), denoted as $\hat{x} = x'/x$.

Applying the hat algebra approach to the general equilibrium condition (5) yields the central equation for the change in each country's wage ($\hat{w}_i$). This equation depends on the change in expenditure shares ($\hat{\lambda}_{ij,k}$), which in turn depends on the change in sectoral labor allocation ($\hat{L}_{i,k}$). The equilibrium is therefore determined by simultaneously solving the following system of three equations:

$$\hat{w}_i = \frac{1}{Y_i} \sum_k \sum_j \lambda_{ij,k} X_{j,k} \hat{\lambda}_{ij,k} \hat{w}_j, \tag{12}$$

$$\hat{\lambda}_{ij,k} = \frac{\hat{\tau}_{ij,k}^{-\theta_k} \hat{L}_{i,k}^{\gamma\theta_k} \hat{w}_i^{-\theta_k}}{\sum_\ell \lambda_{\ell j,k} \hat{\tau}_{\ell j,k}^{-\theta_k} \hat{L}_{\ell,k}^{\gamma\theta_k} \hat{w}_\ell^{-\theta_k}}, \tag{13}$$

$$\hat{L}_{i,k} = \frac{1}{Y_{i,k} \hat{w}_i} \sum_j X_{ij,k} \hat{\lambda}_{ij,k} \hat{w}_j, \tag{14}$$

where $\lambda_{ij,k}$ is the initial share of origin i in destination j's expenditure on goods from sector k, $\lambda_{ij,k} = X_{ij,k}/X_{j,k}$. The detailed derivation of this system is provided in Appendix D.

This system of equations can be solved numerically for the changes in the endogenous variables ($\hat{w}_i$, $\hat{\lambda}_{ij,k}$, $\hat{L}_{i,k}$) given three inputs: data from the initial equilibrium (Y_i, $\lambda_{ij,k}$, $X_{j,k}$, $Y_{i,k}$, $X_{ij,k}$), the model's parameters (γ, θ_k), and an exogenous shock to trade costs ($\hat{\tau}_{ij,k}$).

6.2 Model Calibration

Data and Initial Equilibrium. The initial equilibrium for the quantitative analysis is constructed to be consistent with the preceding estimation in Section 5. The analysis uses bilateral trade values ($X_{ij,k}$) at the HS-6 product level from the CEPII BACI (Gaulier and Zignago (2010)) for the pre-shock period (2016-2018). From these bilateral trade values, all other variables required for the simulation are constructed by summing the values over the pre-shock period. These include total output (Y_i), total sectoral output ($Y_{i,k}$), total sectoral expenditure ($X_{j,k}$), and expenditure shares ($\lambda_{ij,k}$).

A key challenge is that the CEPII BACI dataset lacks information on domestic sales ($X_{ii,k}$). This variable is therefore imputed using a proportionality assumption, which posits that the domestic sales share of a 6-digit sector is identical to that of its corresponding aggregate 2-digit sector.[17] The aggregate sector-level data required to calculate these shares are sourced from the International Trade and Production Database for Simulation (Borchert et al. (2024)). The detailed procedure for this imputation is provided in Appendix E.

The sample for the quantitative analysis is restricted to manufacturing sectors and

[17]Formally, the assumption is expressed as $\frac{X_{ii,k}}{Y_{i,k}} = \frac{X_{ii,K(k)}}{Y_{i,K(k)}}$ for all $k \in K$, where k is an HS-6 product and K is its corresponding aggregate SIC-2 sector.

countries with a population over one million, to ensure consistency with the estimation analysis in Section 5. For computation tractability, this sample is consolidated into 28 country units: Korea, Japan, their 25 major trading partners, and a "Rest of the World (RoW)." The full list of countries included in the analysis is provided in Appendix E.

Key Parameters. The scale elasticity, γ, is calibrated directly from the main 2SLS estimates presented in the structural estimation in Section 5. Specifically, for Korea, the scale elasticity is set to $\gamma = 0.177$, which is the estimate from the Korea-only analysis (Table 2); and for all other countries (excluding Japan), it is set to $\gamma = 0.224$, the estimate from the cross-country analysis (Table 4). For Japan, the scale elasticity is set to $\gamma = 0.177$ in the baseline analysis, mirroring the estimate for Korea. This is motivated by the similar industrial and export structures between the two economies. Alternative calibrations for this parameter are examined in the sensitivity analysis.

Another key parameter is the trade elasticity, θ_k. To maintain consistency with the preceding estimation section, the values are sourced from Giri et al. (2021), as in Bartelme et al. (2025). This application requires the assumption that the 2-digit sector-level estimates apply uniformly to all underlying disaggregated 6-digit sectors.

Shock Calibration. The final key input for the quantitative analysis is the magnitude of the trade cost shock to Korea's imports from Japan ($\hat{\tau}_{JPN\,KOR,k}$).[18] Since this shock is unobserved, it is calibrated by inverting the model in Section 4. Specifically, $\hat{\tau}_{JPN\,KOR,k}$ is calibrated to a value that makes the model's predicted change in imports ($\hat{X}_{JPN\,KOR,k}$) exactly match the change observed in the actual data ($\hat{X}^{obs}_{JPN\,KOR,k}$). This calibration is performed for each sector k using the following equation:

$$\log \hat{\tau}_{JPN\,KOR,k} = \frac{1}{-\theta_k(1-\lambda_{JPN\,KOR,k})} \log \hat{X}^{obs}_{JPN\,KOR,k}. \tag{15}$$

This equation is derived from the model and captures the total effect of the shock on Korea's imports from Japan. This total effect is composed of a partial equilibrium effect and a first-order general equilibrium effect that incorporates the shock's impact on Korea's sectoral price index ($P_{KOR,k}$). The details are provided in Appendix E.

The inputs for this equation are sourced as follows. The observed change in imports ($\hat{X}^{obs}_{JPN\,KOR,k}$) is calculated directly from pre-shock (2016-2018) and post-shock (2020-2022)

[18] To isolate the effect of the 2019 Korea-Japan Trade Dispute, the counterfactual exercise assumes that all other trade costs remain unchanged ($\hat{\tau}_{ij,k} = 1$ for all $(i,j) \neq (JPN, KOR)$).

Table 5: Welfare Effects under Scale Economies

	Benchmark (1)	Baseline (2)	Case 1 (3)	Case 2 (4)	Case 3 (5)
A. Welfare Change (%)					
Japan	-0.052	-0.061	-0.070	-0.065	-0.048
Korea	-0.278	-0.237	-0.232	-0.235	-0.242
B. Scale Elasticity (γ)					
Japan	0	0.177	0	0.148	0.224
Korea	0	0.177	0.177	0.177	0.177
Other Countries	0	0.224	0.224	0.224	0.224

Notes: Table 5 reports the welfare effects of the 2019 Trade Dispute under the five scenarios detailed below. Panel A shows the percentage change in welfare for Japan and Korea, calculated as $(\hat{U}_j - 1) \times 100$, where $\hat{U}_j$ is the change in real income. Panel B details the scale elasticity (γ) values assumed for each country group in each scenario. Column (1) presents the benchmark scenario without scale economies ($\gamma = 0$). Column (2) is the baseline, using the main estimates from Section 5, with Japan's elasticity set to match Korea's. Columns (3)-(5) present alternative calibrations for Japan's scale elasticity: set to zero (Column 3); based on a direct estimate (Column 4); and using the highest value by equating it with the "Other Countries" group (Column 5).

data; this is the sole instance where post-shock data is used in the quantitative analysis.[19] The other inputs are the scale elasticity (γ) from the preceding structural estimation, the trade elasticity (θ_k) from the literature, and the initial shares ($\lambda_{JPN\,KOR,k}$) constructed from the pre-shock data.

6.3 Results

The quantitative results are presented in Table 5. Panel A reports the percentage change in welfare relative to the initial equilibrium. This change is derived from the model's measure of real income change, defined as $\hat{U}_j = \hat{w}_j / \hat{P}_j$.[20] This value is computed by substituting the solved equilibrium changes for the endogenous variables, as detailed in the full derivation in Appendix F. Panel B specifies the scale elasticity (γ) values used for each country group in each case.

[19]Two adjustments are made to ensure the calibrated shocks are economically plausible. First, for any sectors where imports increased, which would counterintuitively imply a trade cost reduction, the calibrated shock is floored at one. Second, to prevent a large decrease in imports from generating an implausibly large shock, the distribution of the calibrated shock is winsorized at the 95th percentile.

[20]This definition assumes constant total labor ($\hat{L}_j = 1$), so the change in nominal income is equal to the change in the wage ($\hat{w}_j$).

The first two columns of Table 5 enable a direct comparison that reveals the crucial role of scale economies in shaping the welfare outcomes. Column (1) presents the benchmark scenario, assuming a standard model without scale economies ($\gamma = 0$). Column (2) shows the baseline results, incorporating the scale elasticity estimates from Section 5. For Japan, the baseline assumes the same scale elasticity as Korea, motivated by their similar industrial and export structures. Quantitatively, the presence of scale economies exacerbates Japan's welfare loss, while mitigating Korea's. Specifically, Japan's welfare loss increases from -0.052% to -0.061%, representing a 17% amplification of the benchmark decline in Column (1). Conversely, Korea's welfare loss is reduced from -0.278% to -0.237%, offsetting 15% of the benchmark decline.

To examine the sensitivity of the baseline results, three alternative calibrations for Japan's scale elasticity are considered. Case 1 (Column (3)) assumes the most conservative value of zero; Case 2 (Column (4)) uses an intermediate estimate derived specifically for Japan; and Case 3 (Column (5)) applies the highest value by equating Japan with the "Other Countries" group. The central qualitative finding—that scale economies exacerbate Japan's welfare loss while mitigating Korea's—proves to be highly robust, holding under both the conservative assumption in Case 1 and the direct estimates in Case 2. This consistency is particularly noteworthy for Case 2; while the estimate for Japan's scale elasticity is sensitive to specifications (ranging from 0.148 to 0.210), all of these estimates consistently yield the same qualitative welfare implications.[21] The only exception to this robust finding is Case 3, which assumes the highest value for Japan's scale elasticity. While the mitigating effect for Korea still holds, Japan's welfare loss is slightly lessened compared to the benchmark.

Furthermore, the results reveal a systematic pattern across the scenarios. Holding the scale elasticities for Korea and other countries fixed, a higher value for Japan's scale elasticity weakens the overall "backfire" effect: the amplification of Japan's welfare loss becomes smaller and the offsetting effect for Korea's welfare loss also becomes smaller. A higher scale elasticity for Japan allows for greater productivity enhancements in its non-exposed sectors, as inputs are reallocated from its exposed sectors (i.e., those where Japan was a dominant supplier to Korea). This greater productivity gain in the expanding sectors partially offsets the losses from the contracting sectors, thereby dampening the negative effect of scale economies on Japan's welfare. This dynamic also explains the weakening of the positive effect of scale economies on Korea's welfare. With Japan's

[21] In contrast to the stable estimates from the Korea-only and cross-country analyses, the estimate for Japan's scale elasticity is sensitive to the aggregation K-level of the sector fixed effects ($\alpha_{JPN,K(k)}$). However, all of these estimates robustly yield the same qualitative welfare finding. See Appendix F for details.

assumed scale elasticity being higher than Korea's, Korean firms faced intensified competition from Japan in the non-exposed sectors in third-country markets. This competitive effect grows stronger as Japan's scale elasticity increases, thereby eroding Korea's welfare gains from scale economies in the exposed sectors.

7 Conclusion

Can export controls backfire by increasing productivity and exports in the target country? Does this response in turn exacerbate the welfare loss for the imposing country? I answer these questions in the context of the 2019 Korea-Japan Trade Dispute. In September 2019, amid heightened political tensions, Japan announced it would impose export controls on all national strategic items shipped to Korea. For Korean firms, this created immediate uncertainty, as each individual import now required a specific approval that could be denied at the discretion of Japanese officials. Although no formal export restrictions were ever enforced, the mere threat of disruption triggered substantial shifts in Korea's imports, domestic production, and exports.

The empirical analysis first documents a significant decline in Korea's imports from Japan, affecting both exposed and non-exposed goods. This decline was disproportionately larger in sectors where Japan had been the primary supplier. Korean producers' revenue increased most sharply in these sectors, suggesting import substitution. The most striking finding relates to exports: in these very sectors, Korea's export volumes expanded while its export prices simultaneously fell. This combination provides direct evidence of productivity growth, spurred by the increased demand for domestic products (caused by Japan's export controls).

Motivated by these empirical findings, I structurally estimate the strength of scale economies based on a trade model. To address the potential endogeneity, the estimation employs an instrumental variable strategy to isolate the exogenous demand-side variation generated by the trade dispute. The results strongly support the presence of scale economies in Korea, indicating that a 1% increase in total sales leads to a 0.18% increase in productivity. The quantitative analysis, parameterized by these estimates, confirms the crucial role of scale economies in shaping the welfare outcomes: their presence mitigates the welfare loss in Korea while exacerbating it in Japan. Quantitatively, this amounts to offsetting 15% of Korea's welfare loss and amplifying Japan's loss by 17%, relative to a scenario without scale economies.

This paper demonstrates how export controls can "backfire": by spurring a scale-driven productivity increase in the target country, such policies can lead to unintended and detrimental welfare consequences for the imposing country. As export controls have become a prominent tool for addressing geopolitical issues, this paper thus serves as a cautionary tale about the arbitrary use of trade policy for political ends.

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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: Japan's exports to Korea significantly decreased, both relative to the pre-event period and to exports to other countries.

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

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

where $x^{jp}_{c,g,t}$ is the value of 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, both relative to the pre-event period and to exports to other countries. Time-varying coefficients β_t, estimated using an event-study, are also plotted in Panel (A) of Figure A1, along with 95 percentage confidence intervals for the estimates. This event-study analysis confirms a 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: Non-exposed goods experienced a similar decline in exports to Korea to that of exposed goods.

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:

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

where $Exposed_g$ is an indicator variable for goods that were directly exposed to the announcement of export controls on Korea, and $NonExposed_g$ is an indicator variable 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 statistically 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 this finding, showing no statistical difference in exports trends 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. This finding also provides further support to the interpretation that Korean firms' concerns about potential restrictions on their imports from Japan extended to *NonExposed* goods.

Fact 3: Japan's exports to Korea decreased disproportionately in goods for which Japan had been the leading supplier.

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:

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

where $Dominant_g$ is an indicator variable for goods for which Japan was the leading supplier in 2018, and $NonDominant_g$ is an indicator variable for goods for which Japan was not the leading supplier. 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 the decline in Japan's exports to Korea was larger in sectors where Japan had previously been dominant in the Korean market. The time-varying coefficients, $\beta_{1,t}$ and $\beta_{2,t}$, plotted in Panel (C) of Figure A1, consistently show a larger decline for *Dominant* goods than for *NonDominant* goods. These results align well with Korea's imports from Japan, as in Fact 3 in Section 3.

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

Building on the finding from Fact 3 that exports to Korea decreased disproportionately in *Dominant* goods, I use the following difference-in-differences specification to examine whether Japan's exports to the rest of the world in these goods increased:

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

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 increase, both relative to the pre-event period and to *Non-Dominant* goods. This also suggests that the decrease in exports to Korea did not lead to an increase in exports to the rest of the world. The time-varying coefficients, β_t, also support the absence of an increase in exports to the rest of world in *Dominant* goods, as plotted in Panel (D) of Figure A1.

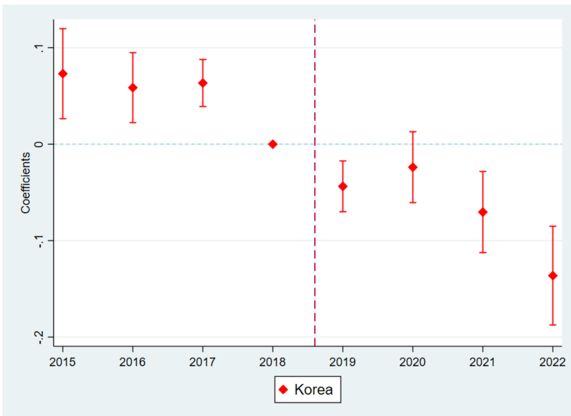
Table A1: Empirical Facts (Difference-in-Differences)

	Fact 1 (1) $\ln x$	Fact 2 (2) $\ln x$	Fact 3 (3) $\ln x$	Fact 4 (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

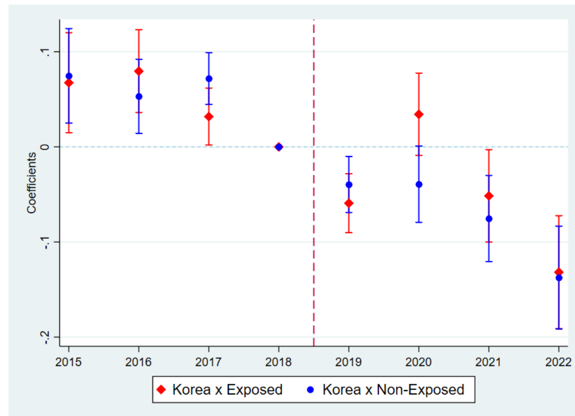
Standard errors in parentheses

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

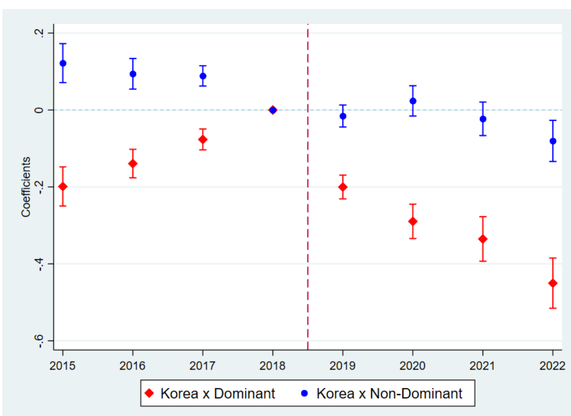
Notes: Table A1 presents the estimation results for the difference-in-differences specifications discussed in Section A.1. Columns (1) through (4) correspond to the appendix versions of Facts 1 through 4, respectively. The dependent variable in all four columns is the log of Japan's export value. The analysis uses annual Japanese export data at the HS-6 product level from 2015 to 2022. Columns (1)-(3) cover all destination countries, while Column (4) excludes Korea to isolate exports to the rest of the world. Standard errors, shown in parentheses, are clustered by country and good.
Source: CEPII BACI (Gaulier and Zignago (2010))



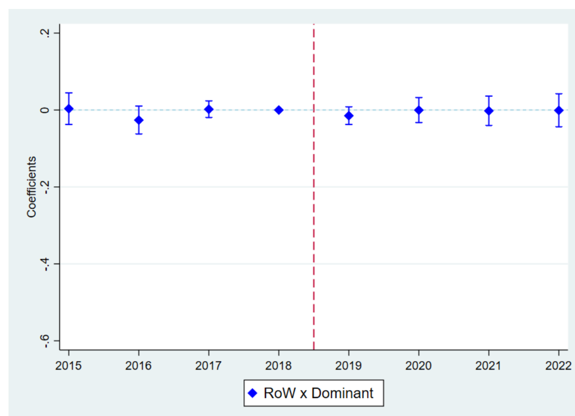
(A) Fact 1: Exports to Korea



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



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



(D) Fact 4: Exports to RoW

Figure A1: Empirical Facts (Event Study)

Notes: Figure A1 illustrates the estimation results for the event-study specifications from Section A.1. Panels (A) through (D) correspond to the appendix versions of Facts 1 through 4, respectively. The analysis uses annual Japanese export data at the HS-6 product level from 2015 to 2022. Panels (A)-(C) cover all destination countries, while Panel (D) excludes Korea to isolate exports to the rest of the world. Standard errors are clustered by country and good.
Source: CEPII BACI (Gaulier and Zignago (2010))

A.2 Identification of Goods Exposed to Japan's 2019 Announcement of Export Controls

B Appendix to Section 5.1

B.1 Theoretical Foundation of the Instrumental Variable

This section details the theoretical mechanism through which a shock to importing costs from Japan ($\Delta \ln \tau_{JPN\,KOR,k}$) affects Korea's total sales ($\Delta \ln Y_{KOR,k}$). The total elasticity can be decomposed using the chain rule as follows:

$$\frac{\Delta \ln Y_{KOR,k}}{\Delta \ln \tau_{JPN\,KOR,k}} = \frac{\Delta \ln p_{JPN\,KOR,k}}{\Delta \ln \tau_{JPN\,KOR,k}} \frac{\Delta \ln P_{KOR,k}}{\Delta \ln p_{JPN\,KOR,k}} \frac{\Delta \ln X_{KOR\,KOR,k}}{\Delta \ln P_{KOR,k}} \frac{\Delta \ln Y_{KOR,k}}{\Delta \ln X_{KOR\,KOR,k}}.$$

Each term on the RHS is derived below.

The first term of the RHS is the elasticity of the price of Japanese goods in Korea with respect to its trade cost. From equation (3), holding all other variables constant, this elasticity is equal to one:

$$\frac{\Delta \ln p_{JPN\,KOR,k}}{\Delta \ln \tau_{JPN\,KOR,k}} = \frac{\Delta \ln \left(\frac{\tau_{JPN\,KOR,k} w_{JPN}^{1+\gamma}}{A_{JPN,k} Y_{JPN,k}^{\gamma}} \right)}{\Delta \ln \tau_{JPN\,KOR,k}} = 1.$$

The second term of the RHS is the elasticity fo Korea's sectoral price index ($P_{KOR,k}$) with respect to the price of Japanese goods in Korea ($p_{JPN\,KOR,k}$). Holding all other prices constant, this elasticity is equivalent to Japan's market share in Korea for good k:

$$\frac{\Delta \ln P_{KOR,k}}{\Delta \ln p_{JPN\,KOR,k}} = \frac{\Delta \ln \left(\sum_i p_{i\,KOR,k}^{-\theta_k} \right)^{-\frac{1}{\theta_k}}}{\Delta \ln p_{JPN\,KOR,k}} = \frac{\left(p_{JPN\,KOR,k}\right)^{-\theta_k}}{\sum_i \left(p_{i\,KOR,k}\right)^{-\theta_k}} = \frac{X_{JPN\,KOR,k}}{\sum_i X_{i\,KOR,k}}.$$

The third term of the RHS is the elasticity of Korea's domestic sales ($X_{KOR\,KOR,k}$) with respect to its sectoral price index ($P_{KOR,k}$). From the bilateral trade equation (4), holding all other variables constant, this elasticity is equal to the trade elasticity (θ_k):

$$\frac{\Delta \ln X_{KOR\,KOR,k}}{\Delta \ln P_{KOR,k}} = \frac{\Delta \ln \left(\left(\frac{\tau_{KOR\,KOR,k} w_{KOR}^{1+\gamma}}{A_{KOR,k}} \right)^{-\theta_k} Y_{KOR,k}^{\gamma\theta_k} X_{KOR,k} P_{KOR,k}^{\theta_k} \right)}{\Delta \ln P_{KOR,k}} = \theta_k.$$

The fourth term of the RHS is the elasticity of Korea's total sales ($Y_{KOR,k}$) with respect to its domestic sales ($X_{KOR\,KOR,k}$). Holding sales to other destinations constant, this elasticity is equivalent to the share of domestic sales in Korea's total sales for good k:

$$\frac{\Delta \ln Y_{KOR,k}}{\Delta \ln X_{KOR\,KOR,k}} = \frac{X_{KOR\,KOR,k}}{Y_{KOR,k}} = \frac{X_{KOR\,KOR,k}}{\sum_j X_{KOR\,j,k}}.$$

Finally, combining these four terms, the total elasticity of Korea's total sales ($Y_{KOR,k}$) with respect to the shock to importing costs from Japan ($\tau_{JPN\,KOR,k}$) is given by:

$$\begin{aligned}\frac{\Delta \ln Y_{KOR,k}}{\Delta \ln \tau_{JPN\,KOR,k}} &= \frac{\Delta \ln p_{JPN\,KOR,k}}{\Delta \ln \tau_{JPN\,KOR,k}} \frac{\Delta \ln P_{KOR,k}}{\Delta \ln p_{JPN\,KOR,k}} \frac{\Delta \ln X_{KOR\,KOR,k}}{\Delta \ln P_{KOR,k}} \frac{\Delta \ln Y_{KOR,k}}{\Delta \ln X_{KOR\,KOR,k}} \\ &= 1 \times \frac{X_{JPN\,KOR,k}}{\sum_i X_{i\,KOR,k}} \times \theta_k \times \frac{X_{KOR\,KOR,k}}{\sum_j X_{KOR\,j,k}} \\ &= \theta_k \times \frac{X_{JPN\,KOR,k}}{\sum_i X_{i\,KOR,k}} \times \frac{X_{KOR\,KOR,k}}{\sum_j X_{KOR\,j,k}}.\end{aligned}$$

This total effect is therefore the product of three components: the trade elasticity, Japan's share of the Korean market, and the share of domestic sales in Korea's total sales.

In summary, the structural model provides a clear justification for the instrumental variable used in Section 5.1. The derivation demonstrates that the instrument is a core component of the demand-side mechanism through which the trade cost shock propagates to affect Korean producers' total sales. This channel theoretically establishes the instrument's relevance. Moreover, its demand-side nature ensures it is uncorrelated with the supply-side shocks, thus satisfying the exclusion restriction.

B.2 Estimation of the Output Elasticity

This appendix section presents the estimation of the output elasticity, which allows for a direct comparison with the findings of Breinlich et al. (2023). The specification is identical to the main specification (9) with the sole exception that the dependent variable is not adjusted by the trade elasticity (θ_k). The estimating equation is therefore:

$$\Delta \ln X_{KOR\,j,k} = \beta \Delta \ln Y_{KOR,k} + \alpha_{KOR} + \alpha_{KOR\,j} + \alpha_{KOR\,K(k)} + \varepsilon_{KOR\,j,k}. \tag{A1}$$

The data, sample, endogenous variable, instrumental variable, and fixed effects are the same as those used in the main analysis in Section 5.1.

In this specification, the coefficient of interest, β, captures the output elasticity. As derived in equation (7), this is the total elasticity of bilateral trade ($X_{ij,k}$) with respect to total sales ($Y_{i,k}$). This output elasticity arises from two channels. First, an increase in total sales lowers prices via the scale elasticity channel (γ). Second, this price decline increases sales in destination j via the trade elasticity channel (θ_k). The product of these two effects ($\gamma\theta_k$) is the output elasticity, which corresponds to the coefficient β in equation (A1).

The 2SLS estimate for the output elasticity (β) is 0.87 and is statistically significant, as reported in Table A2. This estimate is consistent with the value of 0.82 used in the main quantitative analysis of Breinlich et al. (2023).

Table A2: Estimates of Output Elasticity (HS-6)

	$\Delta \ln X_{KOR\,j,k}$		
	2SLS	OLS	Reduced-form
	(1)	(2)	(3)
$\Delta \ln Y_{KOR,k}$	0.869^{***}	0.400^{***}	
	(0.207)	(0.009)	
$\theta_k Share^{2018}_{JPN\,KOR,k}$			0.030^{***}
			(0.007)
First-stage Coefficient	0.034		
First-stage F-statistic	375.91		
Destination Fixed Effects	Yes	Yes	Yes
Sector (KSIC-5) Fixed Effects	Yes	Yes	Yes
Number of Sectors	4,582	4,582	4,582
Observations	190,087	190,087	190,087

Standard errors in parentheses

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

Notes: Table A2 reports the estimation results for the output elasticity (β) using HS-6 product-level data, based on specification (A1). Column (1) presents the main 2SLS estimate, with its corresponding first-stage coefficient and F-statistic reported below. For this 2SLS estimation, the log difference in total sales ($\Delta \ln Y_{KOR,k}$) is instrumented by the product of the trade elasticity and Japan's 2018 import share in Korea ($\theta_k Share^{2018}_{JPN\,KOR,k}$). Columns (2) and (3) show the OLS and reduced-form estimates, respectively. The dependent variable ($\Delta \ln X_{KOR\,j,k}$) is not adjusted by the trade elasticity (θ_k). The independent variable ($\Delta \ln Y_{KOR,k}$) is proxied by the log difference in total exports. The sample is restricted to manufacturing sectors and countries with a population over one million.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

B.3 Robustness: Varying the Aggregation Level of Fixed Effects

Table A3: Estimates of Scale Elasticity (KSIC-3 Fixed Effects)

	$\frac{1}{\theta_k}\Delta \ln X_{KOR\,j,k}$		
	2SLS (1)	OLS (2)	Reduced-form (3)
$\Delta \ln Y_{KOR,k}$	0.181^{***} (0.067)	0.105^{***} (0.002)	
$\theta_k Share^{2018}_{JPN\,KOR,k}$			0.004^{***} (0.002)
First-stage Coefficient	0.024		
First-stage F-statistic	201.09		
Destination Fixed Effects	Yes	Yes	Yes
Sector (KSIC-3) Fixed Effects	Yes	Yes	Yes
Number of Sectors	4,582	4,582	4,582
Observations	190,089	190,089	190,089

Standard errors in parentheses

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

Notes: Table A3 reports the estimation results from re-estimating the main specification (9). The sole difference from the main analysis is that the Korea-sector fixed effects ($\alpha_{KOR,K(k)}$) are defined at the 3-digit sector level, rather than the 5-digit level. Column (1) presents the 2SLS estimate, with its corresponding first-stage coefficient and F-statistic reported below. For this 2SLS estimation, the log difference in total sales ($\Delta \ln Y_{KOR,k}$) is instrumented by the product of the trade elasticity and Japan's 2018 import share in Korea ($\theta_k Share^{2018}_{JPN\,KOR,k}$). Columns (2) and (3) show the OLS and reduced-form estimates, respectively. The independent variable ($\Delta \ln Y_{KOR,k}$) is proxied by the log difference in total exports. The trade elasticity (θ_k), as in Bartelme et al. (2025), is taken from Giri et al. (2021), assuming a common elasticity for all HS-6 products within the same SIC-2 sector. The sample is restricted to manufacturing sectors and countries with a population over one million.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

Table A4: Estimates of Scale Elasticity (KSIC-2 Fixed Effects)

	$\frac{1}{\theta_k}\Delta \ln X_{KOR\,j,k}$		
	2SLS	OLS	Reduced-form
	(1)	(2)	(3)
$\Delta \ln Y_{KOR,k}$	0.226***	0.110***	
	(0.067)	(0.002)	
$\theta_k Share^{2018}_{JPN\,KOR,k}$			0.005***
			(0.002)
First-stage Coefficient	0.024		
First-stage F-statistic	196.23		
Destination Fixed Effects	Yes	Yes	Yes
Sector (KSIC-2) Fixed Effects	Yes	Yes	Yes
Number of Sectors	4,582	4,582	4,582
Observations	190,089	190,089	190,089

Standard errors in parentheses

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

Notes: Table A4 reports the estimation results from re-estimating the main specification (9). The sole difference from the main analysis is that the Korea-sector fixed effects ($\alpha_{KOR,K(k)}$) are defined at the 2-digit sector level, rather than the 5-digit level. Column (1) presents the 2SLS estimate, with its corresponding first-stage coefficient and F-statistic reported below. For this 2SLS estimation, the log difference in total sales ($\Delta \ln Y_{KOR,k}$) is instrumented by the product of the trade elasticity and Japan's 2018 import share in Korea ($\theta_k Share^{2018}_{JPN\,KOR,k}$). Columns (2) and (3) show the OLS and reduced-form estimates, respectively. The independent variable ($\Delta \ln Y_{KOR,k}$) is proxied by the log difference in total exports. The trade elasticity (θ_k), as in Bartelme et al. (2025), is taken from Giri et al. (2021), assuming a common elasticity for all HS-6 products within the same SIC-2 sector. The sample is restricted to manufacturing sectors and countries with a population over one million.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

C Appendix to Section 5.2

C.1 Theoretical Foundation of the Instrumental Variable

The derivation for the cross-country instrumental variable is analogous to the one detailed for the Korea-only case in Appendix B. The logic of the chain rule and the derivation of each component are the same. The final elasticity of an origin i's total sales ($Y_{i,k}$) with respect to the shock to Korea's importing costs from Japan ($\tau_{JPN\,KOR,k}$) simplifies to:

$$\begin{aligned}
\frac{\Delta \ln Y_{i,k}}{\Delta \ln \tau_{JPN,KOR,k}} &= \frac{\Delta \ln p_{JPN\,KOR,k}}{\Delta \ln \tau_{JPN\,KOR,k}} \frac{\Delta \ln P_{KOR,k}}{\Delta \ln p_{JPN\,KOR,k}} \frac{\Delta \ln X_{i\,KOR,k}}{\Delta \ln P_{KOR,k}} \frac{\Delta \ln Y_{i,k}}{\Delta \ln X_{i\,KOR,k}} \\
&= 1 \times \frac{X_{JPN\,KOR,k}}{\sum_i X_{i\,KOR,k}} \times \theta_k \times \frac{X_{i\,KOR,k}}{\sum_j X_{i\,j,k}} \\
&= \theta_k \times IMShare_{JPN,KOR,k} \times EXShare_{i,KOR,k}.
\end{aligned}$$

This shows that the total effect is the product of three components: the trade elasticity, Japan's market share in Korea, and the share of sales to Korea in origin i's total sales. The instrument used in Section 5.2 is almost identical to this total effect, as it is composed of the following three empirical counterparts to the three components of the total effect: the trade elasticity, Japan's import share in Korea, and the share of sales to Korea in origin i total exports. This structural similarity establishes the relevance of the instrument.[22] The only difference is not total sales but total imports or total exports, because each i's domestic sales are missing at the HS-6 level. establishing its relevance based on the structural model. Furthermore, its demand-side mechanism ensures the instrument is uncorrelated with the supply-side shocks, thus meeting the exclusion restriction.

[22] A minor discrepancy is that the share variables are calculated using total imports or exports, rather than the theoretically ideal total sales, due to data limitations.

C.2 Robustness: Varying the Aggregation Level of Fixed Effects

Table A5: Estimates of Scale Elasticity (KSIC-3 Fixed Effects)

	$\frac{1}{\theta_k}\Delta \ln X_{ij,k}$		
	2SLS	OLS	Reduced-form
	(1)	(2)	(3)
$\Delta \ln Y_{i,k}$	0.226^{***}	0.108^{***}	
	(0.058)	(0.001)	
$\theta_k IMShare^{2018}_{JPN\,KOR,k} EXShare^{2018}_{i\,KOR,k}$			0.030^{***}
			(0.006)
First-stage Coefficient	0.132		
First-stage F-statistic	12.68		
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 Sectors	4,636	4,636	4,636
Observations	9,231,547	9,231,547	9,231,547

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

Notes: Table A5 reports the estimation results from re-estimating the main specification (11) for the cross-country analysis. The sole difference from the main analysis is that the origin-sector fixed effects ($\alpha_{i,K(k)}$) are defined at the 3-digit sector level, rather than the 5-digit level. Column (1) presents the 2SLS estimate, with its corresponding first-stage coefficient and F-statistic reported below. For this 2SLS estimation, the log difference in total sales ($\Delta \ln Y_{i,k}$) is instrumented by the product of the trade elasticity, Japan's 2018 import share in Korea, and origin i's 2018 export share to Korea ($\theta_k IMShare^{2018}_{JPN\,KOR,k} EXShare^{2018}_{i\,KOR,k}$). Columns (2) and (3) show the OLS and reduced-form estimates, respectively. The independent variable ($\Delta \ln Y_{i,k}$) is proxied by the log difference in total exports. The trade elasticity (θ_k), as in Bartelme et al. (2025), is taken from Giri et al. (2021), assuming a common elasticity for all HS-6 products within the same SIC-2 sector. The sample is restricted to manufacturing sectors and countries with a population over one million. Standard errors, reported in parentheses, are clustered at the origin-good level.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

Table A6: Estimates of Scale Elasticity (KSIC-2 Fixed Effects)

	$\frac{1}{\theta_k}\Delta \ln X_{ij,k}$		
	2SLS	OLS	Reduced-form
	(1)	(2)	(3)
$\Delta \ln Y_{i,k}$	0.222^{***}	0.109^{***}	
	(0.058)	(0.001)	
$\theta_k IMShare^{2018}_{JPN\,KOR,k} EXShare^{2018}_{i\,KOR,k}$			0.029^{***}
			(0.006)
First-stage Coefficient	0.131		
First-stage F-statistic	12.67		
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 Sectors	4,636	4,636	4,636
Observations	9,232,070	9,232,070	9,232,070

Standard errors in parentheses

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

Notes: Table A6 reports the estimation results from re-estimating the main specification (11) for the cross-country analysis. The sole difference from the main analysis is that the origin-sector fixed effects ($\alpha_{i,K(k)}$) are defined at the 2-digit sector level, rather than the 5-digit level. Column (1) presents the 2SLS estimate, with its corresponding first-stage coefficient and F-statistic reported below. For this 2SLS estimation, the log difference in total sales ($\Delta \ln Y_{i,k}$) is instrumented by the product of the trade elasticity, Japan's 2018 import share in Korea, and origin i's 2018 export share to Korea ($\theta_k IMShare^{2018}_{JPN\,KOR,k} EXShare^{2018}_{i\,KOR,k}$). Columns (2) and (3) show the OLS and reduced-form estimates, respectively. The independent variable ($\Delta \ln Y_{i,k}$) is proxied by the log difference in total exports. The trade elasticity (θ_k), as in Bartelme et al. (2025), is taken from Giri et al. (2021), assuming a common elasticity for all HS-6 products within the same SIC-2 sector. The sample is restricted to manufacturing sectors and countries with a population over one million. Standard errors, reported in parentheses, are clustered at the origin-good level.
Source: CEPII BACI (Gaulier and Zignago (2010)) and Statistics Korea (2019)

D Appendix to Section 6.1

D.1 Derivation of Equation (12)

The bilateral trade equation (4) can be expanded as follows:

$$
\begin{aligned}
X_{ij,k} &= \left(\frac{\tau_{ij,k} w_i^{1+\gamma}}{A_{i,k}}\right)^{-\theta_k} Y_{i,k}^{\gamma\theta_k} X_{j,k} P_{j,k}^{\theta_k} \\
&= \left(\frac{\tau_{ij,k} w_i^{1+\gamma}}{A_{i,k}}\right)^{-\theta_k} \left(w_i L_{i,k}\right)^{\gamma\theta_k} P_{j,k}^{\theta_k} X_{j,k} \\
&= \left(\frac{\tau_{ij,k} w_i}{A_{i,k} L_{i,k}^{\gamma}}\right)^{-\theta_k} \frac{X_{j,k}}{\sum_\ell p_{\ell j,k}^{-\theta_k}} \\
&= \frac{p_{ij,k}^{-\theta_k}}{\sum_\ell p_{\ell j,k}^{-\theta_k}} \beta_{j,k} w_j L_j.
\end{aligned} \tag{A2}
$$

The second line is obtained by substituting the labor market clearing condition, $w_i L_{i,k} = Y_{i,k}$. The third line incorporates the definition of the CES price index, $P_{j,k} = (\sum_\ell p_{\ell j,k}^{-\theta_k})^{-1/\theta_k}$. The last line is derived by substituting the goods market clearing condition ($X_{j,k} = \beta_{j,k} w_j L_j$) and equation (3).

The general equilibrium condition (5) can be expressed in terms of expenditure shares ($\lambda_{ij,k}$) by substituting equation (A2) as follows:

$$
\begin{aligned}
w_i L_i &= \sum_k \sum_j X_{ij,k} \\
&= \sum_k \sum_j \frac{p_{ij,k}^{-\theta_k}}{\sum_\ell p_{\ell j,k}^{-\theta_k}} \beta_{j,k} w_j L_j \\
&= \sum_k \sum_j \frac{X_{ij,k}}{X_{j,k}} \beta_{j,k} w_j L_j \\
&= \sum_k \sum_j \lambda_{ij,k} \beta_{j,k} w_j L_j.
\end{aligned} \tag{A3}
$$

The third line is obtained by a standard property of CES demand systems, where a variety's expenditure is equivalent to its relative price term. The last line applies the definition of $\lambda_{ij,k}$.

Denoting the proportional change in any variable x as $\hat{x}$ (the ratio of its new value to its initial value), equation (A3) can be re-written as follows:

$$
\begin{aligned}
w_i L_i \hat{w}_i \hat{L}_i &= \sum_k \sum_j \lambda_{ij,k} \beta_{j,k} w_j L_j \hat{\lambda}_{ij,k} \hat{\beta}_{j,k} \hat{w}_j \hat{L}_j, \\
\hat{w}_i &= \frac{1}{w_i L_i} \sum_k \sum_j \lambda_{ij,k} \beta_{j,k} w_j L_j \hat{\lambda}_{ij,k} \hat{w}_j \\
&= \frac{1}{Y_i} \sum_k \sum_j \lambda_{ij,k} X_{j,k} \hat{\lambda}_{ij,k} \hat{w}_j. \qquad \text{(A4)}
\end{aligned}
$$

The second line is derived from the first line by dividing by $w_i L_i$ and assuming both constant total labor ($\hat{L}_i = \hat{L}_j = 1$) and fixed preference shifters ($\hat{\beta}_{j,k} = 1$). The last line is obtained by substituting the labor and goods market clearing conditions ($w_i L_i = Y_i$ and $\beta_{j,k} w_j L_j = X_{j,k}$). This completes the derivation of equation (12).

D.2 Derivation of Equation (13)

By applying the CES property, the expenditure share of origin i in destination j's market for sector k ($\lambda_{ij,k}$) can be expressed as follows:

$$\lambda_{ij,k} = \frac{X_{ij,k}}{X_{j,k}} = \frac{p_{ij,k}^{-\theta_k}}{\sum_\ell p_{\ell j,k}^{-\theta_k}}.$$

Expressing this expenditure share in proportional changes ($\hat{x}$) yields the following derivation:

$$\begin{aligned}
\hat{\lambda}_{ij,k} &= \frac{p_{ij,k}^{-\theta_k}\hat{p}_{ij,k}^{-\theta_k}}{\lambda_{ij,k}\sum_\ell p_{\ell j,k}^{-\theta_k}\hat{p}_{\ell j,k}^{-\theta_k}} \\
&= \frac{\hat{p}_{ij,k}^{-\theta_k}}{\sum_\ell \frac{p_{\ell j,k}^{-\theta_k}}{\sum_m p_{mj,k}^{-\theta_k}}\hat{p}_{\ell j,k}^{-\theta_k}} \\
&= \frac{\hat{p}_{ij,k}^{-\theta_k}}{\sum_\ell \lambda_{\ell j,k}\hat{p}_{\ell j,k}^{-\theta_k}} \\
&= \frac{\left(\frac{\hat{\tau}_{ij,k}\hat{w}_i}{\hat{A}_{i,k}\hat{L}_{i,k}^{\gamma}}\right)^{-\theta_k}}{\sum_\ell \lambda_{\ell j,k}\left(\frac{\hat{\tau}_{\ell j,k}\hat{w}_\ell}{\hat{A}_{\ell,k}\hat{L}_{\ell,k}^{\gamma}}\right)^{-\theta_k}} \\
&= \frac{\hat{\tau}_{ij,k}^{-\theta_k}\hat{L}_{i,k}^{\gamma\theta_k}\hat{w}_i^{-\theta_k}}{\sum_\ell \lambda_{\ell j,k}\hat{\tau}_{\ell j,k}^{-\theta_k}\hat{L}_{\ell,k}^{\gamma\theta_k}\hat{w}_\ell^{-\theta_k}}.
\end{aligned} \tag{A5}$$

The derivation begins by expressing the change in share ($\hat{\lambda}_{ij,k}$) as a function of the change in relative prices ($\hat{p}_{ij,k}$). Equation (3), also in proportional changes, is then substituted for $\hat{p}_{ij,k}$ to express $\hat{\lambda}_{ij,k}$ in terms of the underlying cost shifters. Assuming that fundamental productivity is unchanged ($\hat{A}_{i,k} = 1$), this yields the final expression for the change in expenditure shares. This completes the derivation of equation (13).

D.3 Derivation of Equation (14)

The derivation for the change in sectoral labor allocation ($\hat{L}_{i,k}$) begins with the combined labor and goods market clearing condition for an origin i in sector k:

$$w_i L_{i,k} = Y_{i,k} = \sum_j X_{ij,k}.$$

Expressing this condition in proportional changes yields the following:

$$w_i L_{i,k} \hat{w}_i \hat{L}_{i,k} = Y_{i,k} \hat{Y}_{i,k} = \sum_j X_{ij,k} \hat{X}_{ij,k}.$$

The change in bilateral sales ($\hat{X}_{ij,k}$) can be further expressed as $\hat{X}_{ij,k} = \hat{\lambda}_{ij,k} \hat{w}_j$. This expression is derived from the goods market clearing condition ($X_{ij,k} = \lambda_{ij,k} \beta_{j,k} w_j L_j$), under the assumptions of constant total labor ($\hat{L}_j = 1$) and fixed preference shifters ($\hat{\beta}_{j,k} = 1$). Substituting $\hat{X}_{ij,k} = \hat{\lambda}_{ij,k} \hat{w}_j$ into the equation above and solving for $\hat{L}_{i,k}$ gives the final expression:

$$\hat{L}_{i,k} = \frac{1}{Y_{i,k} \hat{w}_i} \sum_j X_{ij,k} \hat{\lambda}_{ij,k} \hat{w}_j.$$

This completes the derivation of equation (14).

E Appendix to Section 6.2

E.1 Data Imputation for Domestic Sales

The primary dataset (CEPII BACI; Gaulier and Zignago (2010)) lacks information on domestic sales ($X_{ii,k}$), which is a necessary component for the quantitative analysis. This appendix section details the procedure used to impute this missing variable.

The procedure begins by sourcing aggregate industry data from the International Trade and Production Database for Simulation, Release 1.1 (ITPD-S; Borchert et al. (2024)). This data is first aggregated to the pre-shock period of 2016–2018. Using the concordance tables provided with the ITPD-S, the data's original industry classifications are then mapped to the SIC 2-digit level. From this prepared dataset, the domestic sales share for each country at the SIC 2-digit level (K) is calculated. Finally, a proportionality assumption is applied to impute the domestic sales shares for the more granular HS 6-digit level (k). This assumption posits that the domestic sales share of any specific 6-digit k is identical to the share of its corresponding aggregate 2-digit K. Formally, this is expressed as:

$$\frac{X_{ii,k}}{Y_{i,k}} = \frac{X_{ii,K(k)}}{Y_{i,K(k)}} \quad \text{for all } k \in K.$$

E.2 Country Sample for Quantitative Analysis

This appendix section details the construction of the 28 country units used in the quantitative analysis.

To ensure computational tractability while capturing the most relevant trade partners, the sample is constructed based on 2018 trade data from the CEPII BACI database. First, the total trade values (exports plus imports) are calculated for every country with both Korea and Japan. The top 25 trading partners common to both lists are then selected. The 25 selected trading partners are:

> Australia, Brazil, Canada, Chile, China, France, Germany, Hong Kong, Indonesia, Italy, Malaysia, Mexico, Netherlands, Philippines, Russia, Saudi Arabia, India, Singapore, Vietnam, Spain, Thailand, United Arab Emirates, United Kingdom, United States, and Taiwan.

Together with Korea, Japan, and a single "Rest of the World" (RoW) entity that aggregates all other countries, these 25 partners form the 28 country units used in the quantitative analysis. Trade data for Taiwan are proxied using the data for ‘Asia, not elsewhere specified’ (ISO code 490), following the CEPII documentation. This is a reliable proxy as, in practice, this category almost exclusively contains trade data for Taiwan.

E.3 Shock Calibration

This appendix section details the derivation of equation (15), which is used to calibrate the unobserved trade cost shock to Korea's imports from Japan ($\hat{\tau}_{JP\,KR,k}$).

The derivation starts by taking the total derivative of the log of bilateral trade equation (4) with respect to the log of the trade cost. Using the chain rule, this total effect can be decomposed into a partial equilibrium (PE) effect and a first-order general equilibrium (GE) effect. The PE effect captures the direct impact of the shock through its own price ($p_{JP\,KR,k}$), while the GE effect captures the indirect impact of the shock through Korea's sectoral price index ($P_{KR,k}$). This decomposition is expressed in elasticities as follows:

$$\begin{aligned}\frac{\Delta \log X_{JP\,KR,k}}{\Delta \log \tau_{JP\,KR,k}} &= \frac{\Delta \log X_{KR,k}}{\Delta \log p_{JP\,KR,k}} \frac{\Delta \log p_{JP\,KR,k}}{\Delta \log \tau_{JP\,KR,k}} + \frac{\Delta \log X_{JP\,KR,k}}{\Delta \log P_{KR,k}} \frac{\Delta \log P_{KR,k}}{\Delta \log p_{JP\,KR,k}} \frac{\Delta \log p_{JP\,KR,k}}{\Delta \log \tau_{JP\,KR,k}} \\ &= -\theta_k + \theta_k \frac{X_{JP\,KR,k}}{\sum_i X_{i\,KR,k}} \\ &= -\theta_k \left(1 - \lambda_{JP\,KR,k}\right),\end{aligned}$$

The second line is derived by substituting the elasticities from the price equation (3) and a standard property of CES demand systems. The last line applies the definition of $\lambda_{ij,k}$. This equation is rearranged to solve for the change in trade cost ($\Delta \log \tau_{JP\,KR,k}$) as a function of the change in imports ($\Delta \log X_{JP\,KR,k}$). Finally, expressing this in "hat" notation ($\log \hat{x} = \Delta \log x$) yields equation (15).

F Appendix to Section 6.3

F.1 Derivation of the Welfare Change Equation

This appendix section details the derivation of the welfare change equation used in the quantitative analysis. The change in welfare for country j ($\hat{U}_j$) is defined as the change in its real income. This is the change in the nominal income ($\hat{w}_j \hat{L}_j$) divided by the change in the aggregate price index ($\hat{P}_j$):

$$\hat{U}_j = \frac{\hat{w}_j \hat{L}_j}{\hat{P}_j}. \tag{A6}$$

The change in the aggregate price index ($\hat{P}_j$) is a Cobb-Douglas combination of the change in the sectoral price index ($\hat{P}_{j,k}$):

$$\hat{P}_j = \prod_k \hat{P}_{j,k}^{\beta j,k}.$$

The change in the sectoral price index ($\hat{P}_{j,k}$) is a CES aggregate of the price changes of individual varieties from each origin i ($\hat{p}_{ij,k}$), weighted by their initial expenditure shares ($\lambda_{ij,k}$):

$$\hat{P}_{j,k} = \left(\sum_i \lambda_{ij,k} \hat{p}_{ij,k}^{-\theta_k} \right)^{-\frac{1}{\theta_k}}.$$

The price change of an individual variety ($\hat{p}_{ij,k}$) is derived from the model's supply side (equation (3)), which is a function of changes in trade costs ($\hat{\tau}_{ij,k}$), wages ($\hat{w}_i$), exogenous productivity ($\hat{A}_{i,k}$), and labor ($\hat{L}_{i,k}$):

$$\hat{p}_{ij,k} = \frac{\hat{\tau}_{ij,k} \hat{w}_i}{\hat{A}_{i,k} \hat{L}_{i,k}^{\gamma}}.$$

Substituting each of these components into the initial welfare definition (equation (A6)) yields the full expression used for the quantitative analysis:

$$\hat{U}_j = \frac{\hat{w}_j \hat{L}_j}{\prod_k \left[\left(\sum_i \lambda_{ij,k} \left(\frac{\hat{\tau}_{ij,k} \hat{w}_i}{\hat{A}_{i,k} \hat{L}_{i,k}^{\gamma}} \right)^{-\theta_k} \right)^{-\frac{1}{\theta_k}} \right]^{\beta_{j,k}}}.$$

F.2 Direct Estimation of Japan's Scale Elasticity