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Impact of Tighter Controls on Japanese Chemical Exports to Korea

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Abstract

The Japanese Ministry of Economy, Trade and Industry announced recently that they will terminate preferential treatment in the licensing of specific chemical products for export to South Korea. This announcement evoked concern that the impact on Korean semiconductor and electronics industries, which rely heavily on imports from Japan, might cause a serious supply shortage in the global semiconductor market. To assess the economic impact of tighter export controls, this study simulates: (a) imposition of an export tax on chemical products; and (b) a productivity decline in the electronics sector in Korea, using a world trade computable general equilibrium model. The results of these simulations indicate that such a productivity decline would cause only slight harm to the Japanese and world economies, aside from the electronics sector in Korea, and that an export tax would significantly distort trade patterns and undermine the welfare of Japan and Korea in a similar magnitude. However, welfare loss normalized for GDP size would be far smaller in Japan than in Korea.

Keywords

Trade facilitation; economic integration; computable general equilibrium analysis

JEL Classification: F13, F15, F17, C68

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1. Introduction

In July of 2019, the Japanese Ministry of Economy, Trade and Industry (METI) (2019) announced that they would tighten implementation of export controls under the Foreign Exchange and Foreign Trade Act and would terminate preferential treatment in the licensing of specific chemical products, (fluorinated polyimides, hydrogen fluoride, and photoresists) for export to South Korea. These chemical products are essential intermediate inputs in the Korean semiconductor and electronics industries. Korea's dependency on imports of fluorinated polyimides, hydrogen fluoride, and photoresists from Japan has been as high as 94, 92, and 44%, respectively (Yang and Park (2019)). The METI announcement evoked concern that a disruption of the supply of those intermediate inputs could stall the output of the relevant Korean industries, affecting export supply and prices globally, as Korea accounts for 75% and 45% of global DRAM and NAND flash supply, respectively (Yang and Park (2019)).

Trade conflicts occur not only in traditional sectors such as agriculture and garments, but also in high-tech industries including semiconductors. For example, in 1980s and 90s, supercomputer exports were one of the major issues in US-Japan trade conflicts, and in 2018-2019 the US banned the use of communication devices made by Chinese companies Huawei and ZTE. Many trade conflicts have been brought about by the US; as it attempts to reduce its large trade deficits with these countries. There was also a trade conflict between Japan and Korea over high-tech industry issues: the Japanese government imposed countervailing duties on imports of DRAMs made by Hynix under subsidy by the Korean government between 2006 and 2009.

These actions against freer trade can be seen as a reversal of economic integration—whether they take the form of tariff or nontariff measures, motivated by national security reasons or political economic reasons. Similar problems can be seen globally, such as the UK's departure from the European Union (EU) (a.k.a. Brexit), renegotiations of the North American Free Trade Agreement (NAFTA), and the last moment withdrawal of the US from the Trans-Pacific Partnership (TPP) Agreement. General equilibrium models (including computable general equilibrium (CGE) models) have found use as a powerful tool for assessment of such instances of economic integration and de-integration. For example, using a GTAP-based CGE model, Kawasaki (2017) conducted alternative scenario analyses of US departures from existing and (at that time) ongoing regional and global trade deals. A number of studies have assessed the impact of Brexit, both before and after the UK referendum (e.g., PwC (2016), Dhingra et al. (2017), Hosoe (2018), and Jafari and Britz (2018)). These general equilibrium analyses quantified impacts of various instances of economic de-integration in detail, focusing on industrial output, trade, and consumer benefits by country, and from the results identified implications for policy making and evaluations.

This study follows the above strand of the literature, applying a CGE model to examination of the expected impacts of trade barriers between Japan and Korea. It should be noted that this study only quantifies the economic impacts of trade de-facilitation; it does not examine either the economic benefits of de-facilitation or its contributions to tighter export controls on chemical products with the potential for misuse in areas such as weapons manufacture—a concern voiced in METI (2019). We conduct a hypothetical simulation of the effects of tighter export controls in two cases: (a) a tax imposition on chemical exports to Korea and (b) a productivity decline in the Korean electronics sector owing to increased uncertainty and inefficiency evoked by the resumption of export controls. Our policy simulations demonstrate the extent of production and welfare losses in Korea and Japan that would arise and the extent to which global trade would be affected.

However, we can hardly predict the impact of such trade de-facilitation policy in terms of changes in quality and quantity. We therefore hypothetically assume a 50% export tax imposition on Japanese chemical exports to Korea and predict the impact of that tax on output in the Korean electronics sector. For a clean comparison, in another scenario, we calibrate productivity decline, which is shown later to be 0.14% in order to reproduce the same output fall in Korean electronics as that brought about by imposition of 50% export tax. Through examination of these two policy simulation scenarios, we find that if a policy change takes the form of a total factor productivity (TFP) decline, aside from the output change in the Korean electronics sector, there will only be a small impact on output, trade, and welfare in Japan and the world economy. The other scenario, with export tax imposition, indicates a more serious outcome in welfare for both Japan and Korea. Despite the abovementioned concern expressed by producers and users of Korean electronics products, the international electronics market would not be affected substantially by either shock.

This paper proceeds as follows. Section 2 below describes the CGE model used in these simulations. Section 3 explains our simulation scenarios and presents their numerical results. We conclude the paper in Section 4, mentioning limitations and future extensions of this study, and present policy implications derived from our simulations.

2. Model and Data

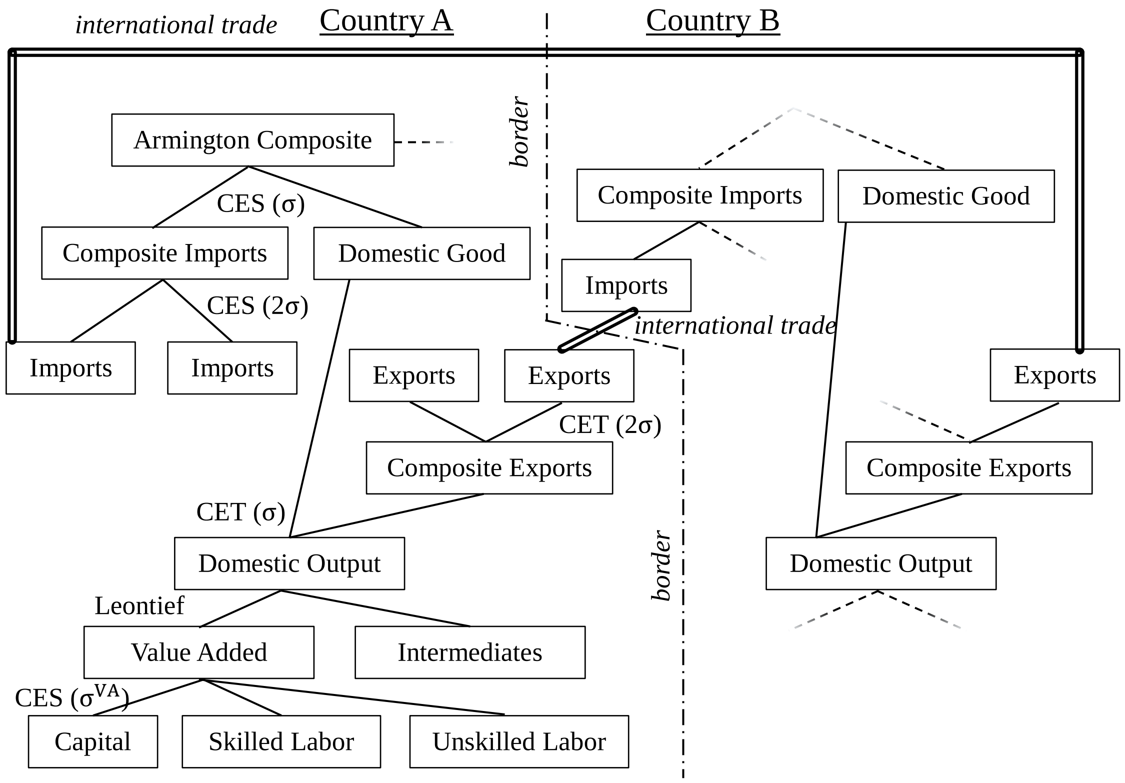
2.1 CGE Model

We employ an extended version of the single-country static CGE model developed by Hosoe et al. (2010). The model distinguishes eight regions: Japan, Korea, East Asia (other than Japan and Korea), Southeast Asia, NAFTA, EU28, Latin America, and the rest of the world; and nine industrial sectors, including chemical and electronics sectors, which are of interest here.[1] Each region uses capital, skilled and unskilled labor, and various intermediate inputs for production. Production technology is represented by constant-returns-to-scale functions, for simplicity. Departing from Hosoe et al. (2010), to describe a short run adjustment of economies we assume capital is not mobile across sectors. Both types of labor are assumed to be mobile.

Output is transformed into composite exports and domestic goods. The composite exports are further divided into exports to individual export destinations. For these transformation processes, we assume a constant elasticity of transformation (CET) function. Similarly, imports from various source countries are aggregated to composite imports, which are in turn combined with domestic goods to produce Armington's (1969) composite goods. For these aggregation processes, we assume a constant elasticity of substitution (CES) function. Armington's composite is used for consumption by a representative household and the government and for investment and intermediate input. The consumption goods purchased by the representative household are aggregated with a Cobb-Douglas type utility function, which measures welfare in each country.

[1] Details of our aggregation pattern of GTAP sectors into our nine sectors are provided in the Appendix.

Figure 2.1 World Trade CGE Model



Source: Modification of Hosoe et al. (2010, Figure 10.3)
Note: For simplicity, this figure ignores uses of Armington's composite goods. See Hosoe et al. (2010) for details of demand side and CES/CET functions.

The key model structures are: (1) the production function that links input and output; and (2) substitution between domestic goods and exports/imports, which is determined by relative competitiveness of the domestic and foreign suppliers. For example, imposition of a tax on chemical exports from Japan pushes up the imported material price in Korea, which induces substitution of domestic materials for imported ones. Not only the price hike on imports but also the relatively costly domestic inputs increase the input costs of the Korean industry. This undermines competitiveness of the Korean industry in the domestic and global markets and reduces Korean output and exports. When a productivity decline hits an industry, a similar outcome to that of export taxes is expected, since the productivity decline would raise production costs and thus harm that industry's output and exports.

Other modelling assumptions are as follows. Factor markets are assumed to be in full employment in each country; no international factor mobility is assumed. Current account deficits are fixed at the currency terms of the rest of the world. Walras' law requests us to choose a numeraire and fix its price. For this, we choose unskilled labor and fix its wage rate for each country. Following Hosoe et al. (2010), government consumption and investment uses of goods are determined in proportion to the government's total revenues and the total savings, respectively. Therefore, export tax revenues from the chemical trade between Japan and Korea are to be spent on government consumption and investment (through government savings); they are not to be transferred to the households.

2.2 Data

We calibrate this CGE model to the GTAP Database version 10 (2014 benchmark year) with its elasticity parameters for trade σ and for value added σ^{VA} (Hertel (1997)).[2] However, the sectoral classifications used in the GTAP database are not as detailed as the commodity classifications used by METI (2019) to define chemical products subject to policy change. Similarly, the electronics sector of GTAP includes the semiconductor sector but also some other sectors. To make sectoral classifications consistent, one option is to split the GTAP sector down to the tariff code level before developing a CGE model. However, given the premature nature of the current export control policy change, we use the most detailed GTAP sectoral classifications for the chemical and electronics sectors as is, but focus on policy simulations. Nevertheless, to examine potential penalties of this mismatch qualitatively, we compare within sectoral classifications below.

Table 2.1 shows the sectors in the GTAP Database and the corresponding sectors in the Korean input-output (IO) tables in producer's price (Bank of Korea (2019)). The three chemical products subject to the policy change should be included in the categories "basic chemical products," "synthetic resins and synthetic rubbers," and "other chemical products," but many other products also fall in these categories. Similarly, "semiconductor and related devices" accounts for only 29% of the output of the GTAP electronics sector, which is called "computer, electronic and optical products" in the GTAP Database.

[2] We use alternative elasticity parameter assumptions to confirm robustness of our simulation results with respect to the assumed parameters. Details are provided in the Appendix.

Table 2.1: Gross Output in GTAP Sectors and Korean IO Table Sectors

GTAP Sector/Korean IO Table Sector	mil. KRW	% in GTAP Sector
Chemical (GTAP)		
Basic chemical products	63,315,419	27.8
Synthetic resins and synthetic rubbers	40,175,178	17.7
Chemical fibers	3,388,906	1.5
Fertilizers and pesticides	4,807,758	2.1
Other chemical products	38,478,475	16.9
Plastic products	62,630,815	27.5
Rubber products	14,737,354	6.5
		100.0
Computer, Electronic and Optic (GTAP)		
Semiconductor and related devices	80,509,086	28.5
Electronic signal equipment	65,827,406	23.3
Other electronic components	23,636,299	8.4
Computer and peripheral equipment	7,528,911	2.7
Telecommunication, video, and audio equipment	75,333,738	26.7
Precision instruments	29,378,121	10.4
		100.0

Source: Bank of Korea (2019) *2015 Benchmark Input-output Tables*.

On the input side of the semiconductor sector, total chemical product inputs account for only 6% of total input (Table 2.2). This seems not to imply a serious impact of tighter export controls, unless chemical supplies are completely disrupted. The self-intermediate inputs have a large share, more than a quarter of total inputs. Import dependency of many intermediate inputs is high, reaching 40–80%, which implies high vulnerability to import disruption, especially when materials imported from other countries are hardly substitutable for those from Japan.

Table 2.2: Intermediate Inputs of Chemicals and Electronics by Semiconductor Sector

Korean IO Sector	Input		Imported Input	
	mil. KRW	% of Total Input	mil. KRW	% of Input
Basic chemical products	1,413,163	1.8	935,850	66.2
Synthetic resins and synthetic rubbers	605,789	0.8	375,469	62.0
Chemical fibers	0	0.0	0	-
Fertilizers and pesticides	12,865	0.0	527	4.1
Other chemical products	2,892,236	3.6	2,247,059	77.7
Plastic products	1,348,876	1.7	666,127	49.4
Rubber products	12,725	0.0	5,106	40.1
…				
Semiconductor and related devices	21,153,671	26.3	12,810,965	60.6
Electronic signal equipment	3,719	0.0	1,749	47.0
Other electronic components	3,255,321	4.0	867,005	26.6
Computer and peripheral equipment	3,161	0.0	1,518	48.0
Telecommunication, video, and audio equipment	49,456	0.1	9,619	19.4
Precision instruments	97,271	0.1	59,595	61.3

Source: Bank of Korea (2019) *2015 Benchmark Input-output Tables*.

3. Simulations

3.1 Two Simulation Scenarios

There is significant uncertainty as to how export control tightening affects the chemical and semiconductor sectors. We set up two scenarios to describe how export control tightening could affect the two economies. One scenario, an *export tax scenario*, assumes an export tax imposition on chemical exports from Japan to Korea, interpreting the policy change as a trade barrier.

The second scenario, a *TFP scenario*, assumes that the Korean electronics sector suffers a productivity decline due to increased uncertainty or inefficiency in production. To make material supply secure, producers may need to find alternative, less competitive suppliers outside Japan and/or increase their stockpiles as a buffer against temporary supply disruptions. In production planning, they may be forced to set conservative targets. These effects can be described as a TFP decline. As we cannot predict which type of effect will arise, we simulate both to model differences between the two.

The magnitude of these effects is also unknown. With observed data, we could measure tariff-equivalents of the trade barriers by estimating a gravity model, and productivity decline by estimating a production function. As we have no observations, in the export tax scenario we assume a hypothetical magnitude of 50% for the export tax on chemical exports from Japan to Korea. For the TFP scenario, we assume a 0.065% TFP decline in the Korean electronics sector. For convenience of comparison, this TFP shock is chosen so that the two scenarios yield the same output fall in the Korean electronics sector.[3] While the impacts of the two on output of this sector are the same, impacts would differ in other aspects, as demonstrated below.

3.2 Simulation Results

Running the CGE model with the two scenarios, we find sectoral output changes (Figure 3.1). In Korea, electronics sector output would fall by 0.14% in both scenarios, where the TFP shock is tuned to yield the same output fall as that from a 50% export tax. As the export tax would hinder chemical product imports from Japan, Japanese chemical sector sales would shift towards the domestic market, and Korean domestic chemical output would increase to meet Korean electronics sector demand. Output of petroleum and coal products would be stimulated through its input-output linkage with the chemical sector. The machinery sector would suffer from a supply shortage from the electronics sector, and thus would decrease output.

The impact on Japanese industries is a mirror image of that on Korean ones. The decline of chemical exports would affect Japanese chemical production negatively. The sourcing of chemicals would shift to the domestic electronics sector in Japan and thus would increase Japanese electronics output and exports. As discussed below, Japanese exports would fill the gap resulting from contraction of export the Korean electronics sector. This effect also increases domestic electronics production in Japan. In the TFP scenario, the impact on production in both Japan and Korea would be significantly smaller than that under the export tax scenario.

[3] They led to a fall of its output by 0.14%. The details are provided in the Appendix.

Figure 3.1: Impacts of Export Tax and TFP Decline on Domestic Output, by Sector

[Changes from the base, %]

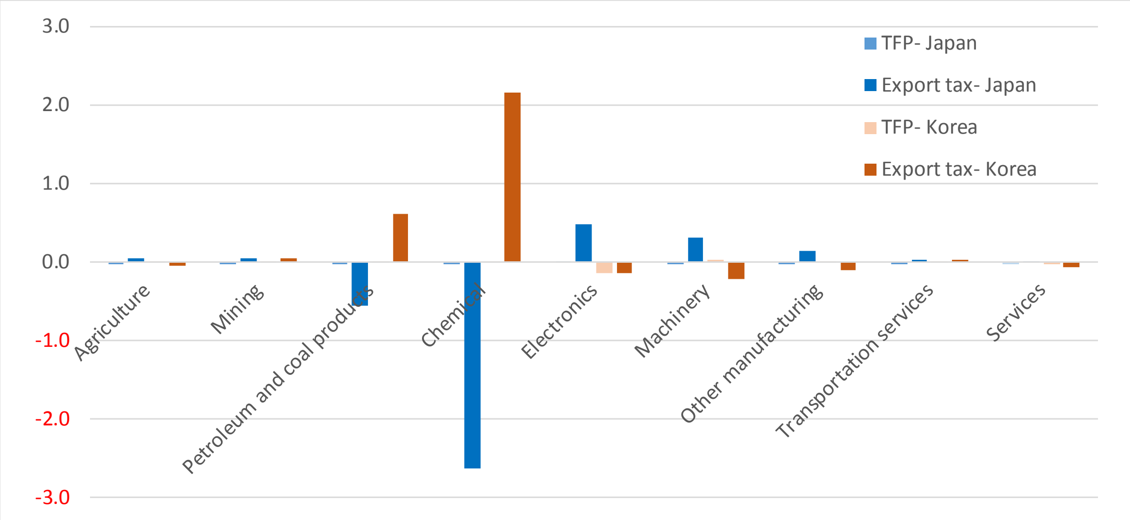
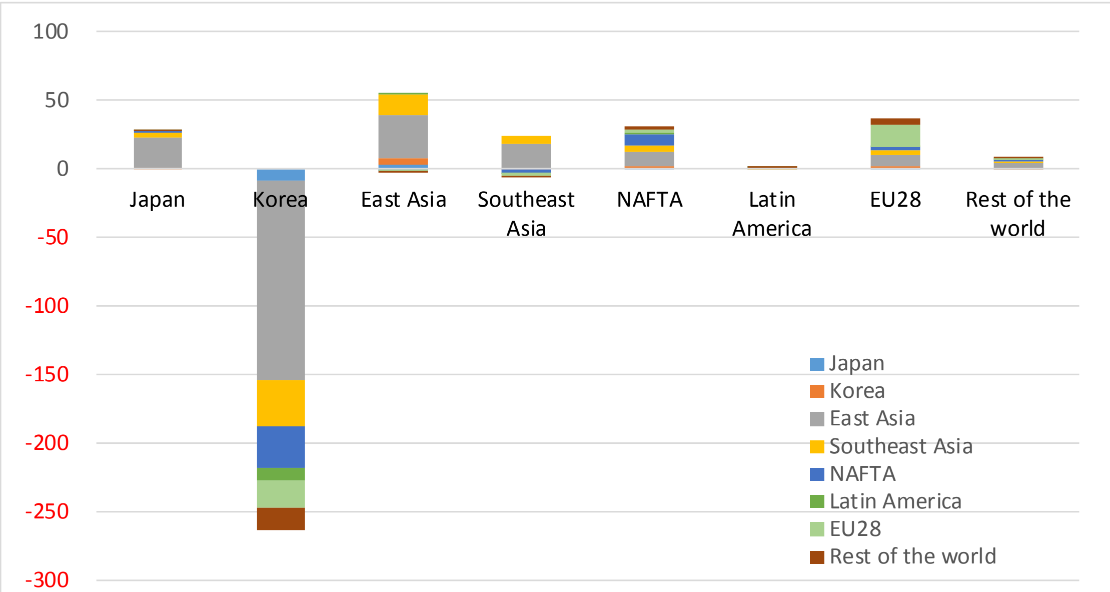


Figure 3.2 shows impact on electronics exports by country. The TFP shock would curb Korean production capacity and thus reduce exports by 262 million USD. This gap in the international market would be covered by increased exports from Japan and other major four regions, more or less evenly.

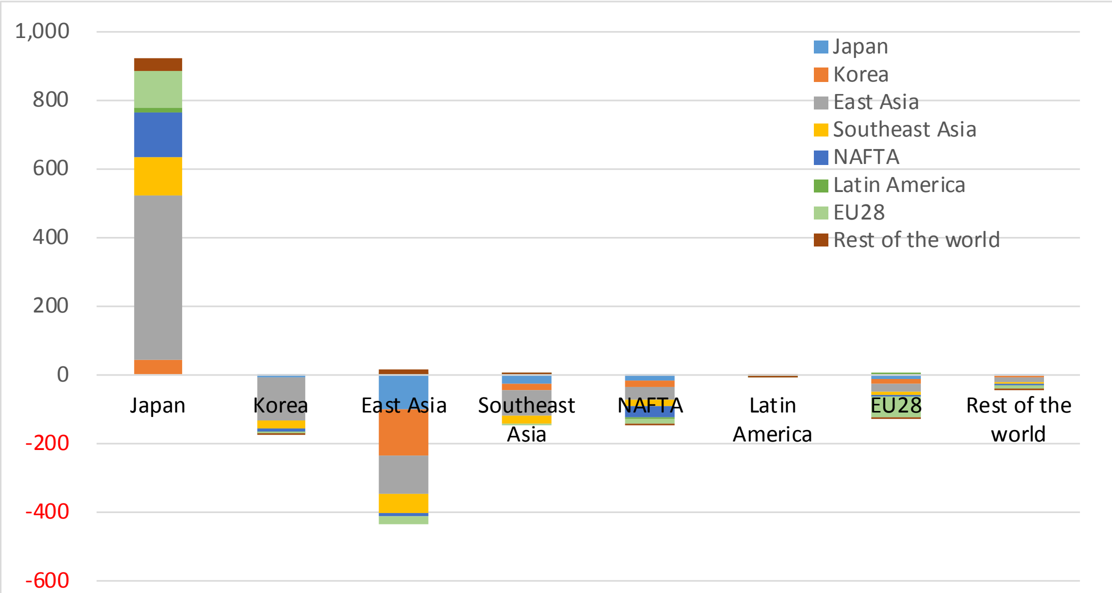
Figure 3.2: Impact of TFP Decline on Regional Electronics Exports with Breakdown by Export Destination [Unit: mil. USD]



Note: Values are evaluated with Laspeyres prices.

The export tax scenario presents a clear contrast to the TFP scenario. Korea would indeed reduce its exports by 174 million USD, which is much less than under the TFP scenario (Figure 3.3). Besides, East Asia, Southeast Asia, NAFTA, and EU28 would reduce exports by 100–400 mil. USD as a result of the marked increase in Japan's exports, which would be boosted by use of domestic chemical products, whose supply destination would shift from Korea as a result of the export tax.

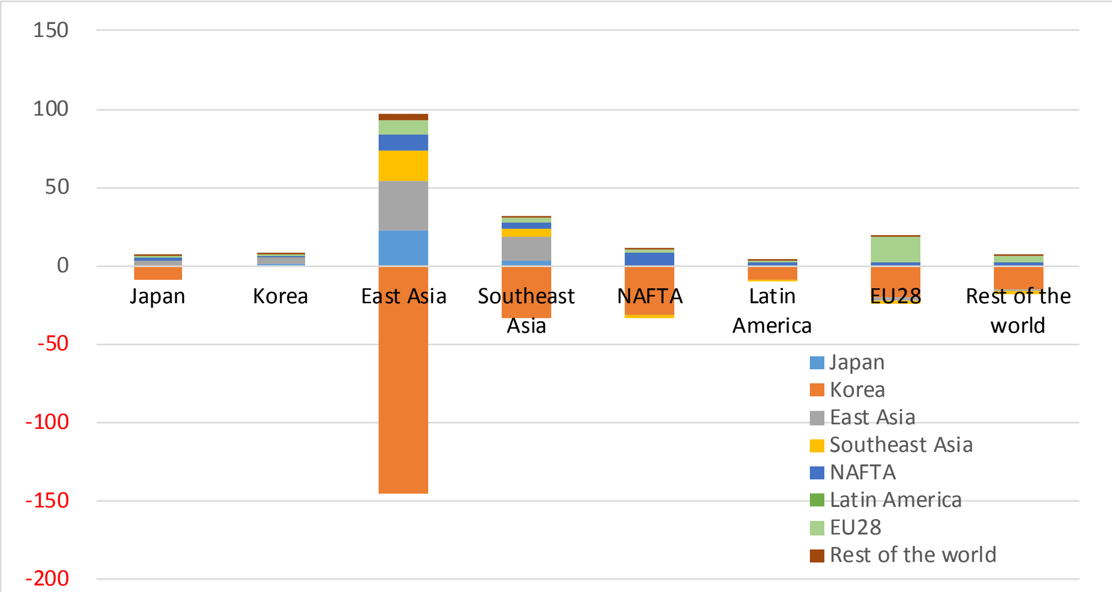
Figure 3.3: Impact of Export Tax on Regional Electronics Exports with Breakdown by Export Destination [Unit: mil. USD]



Note: Values are evaluated with Laspeyres prices.

As the international semiconductor market depends heavily on exports from Korea, suppliers and users of Korean electronics products have a serious concern about the consequences of the Japanese government policy change. To explore this issue, we examine trade pattern changes from the import side (Figure 3.4). The TFP scenario supports this concern, showing a huge loss of supply from Korea in all regions. However, a large part of the lost supply would be made up by Japan and four other major players; they would fill 29% of the gap experienced by NAFTA, 77% of EU28, and 67% of East Asia; Southeast Asia would successfully secure import supply as large as the lost Korean supply.

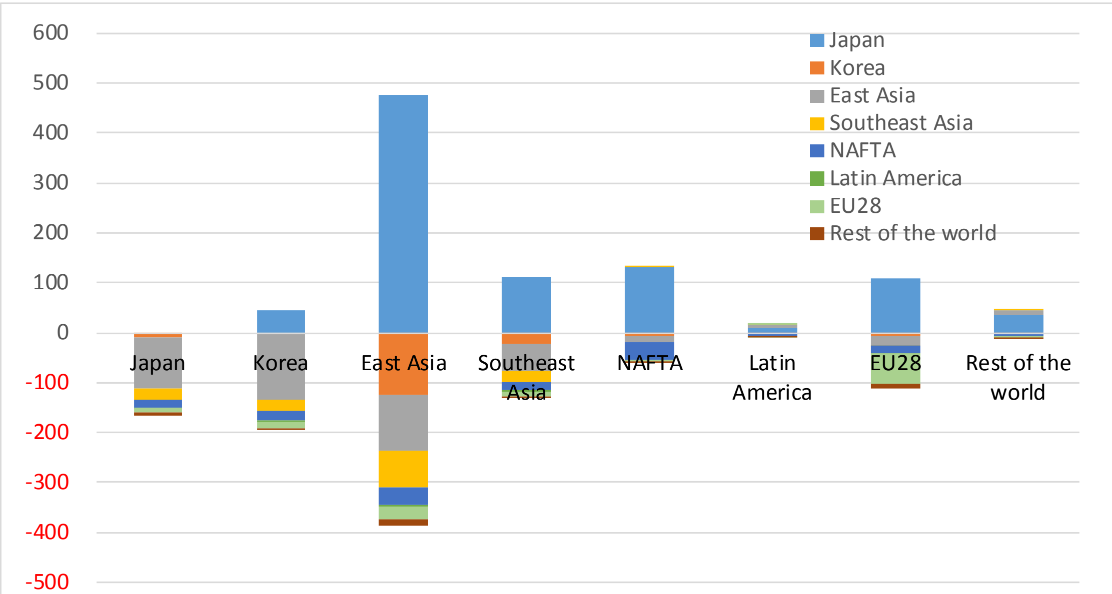
Figure 3.4: Impact of TFP Decline on Regional Electronics Imports with Breakdown by Import Source [Unit: mil. USD]



Note: Values are evaluated with Laspeyres prices.

In the export tax scenario, exports from Japan would substitute for supply not only from Korea but also from many other sources (Figure 3.5). Countries other than Japan and Korea would import a greater volume of electronics products than previously.

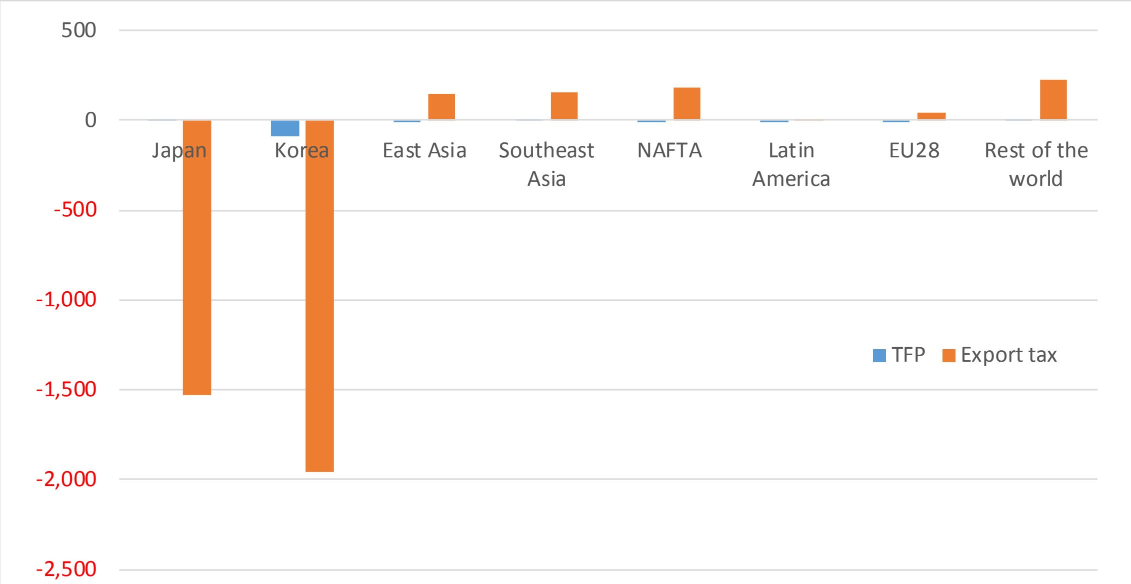
Figure 3.5: Impact of Export Tax on Regional Electronics Imports with Breakdown by Import Source [Unit: mil. USD]



Note: Values are evaluated with Laspeyres prices.

The welfare indicator of equivalent variations measures changes in total household consumption (Figure 3.6). The TFP shock would have a slightly negative welfare impact on Korea (0.00007% of GDP) but little on other countries. The export tax would have significantly larger impacts. Japan would suffer as much as Korea would. However, Japan's economy is much larger than that of Korea, so for a fair comparison, we normalize their welfare losses with GDP. Then Korea's welfare loss, 0.00152% of its GDP, is comparable to Japan's, which is only 0.00034% of its GDP. Other countries would experience a slight gain (less than 0.0001% of GDP) as a result of trade diversion.

Figure 3.6: Welfare Impacts of Export Tax and TFP Decline
[Equivalent Variations, mil. USD]



4. Concluding Remarks

This study uses a CGE model to examine impacts of tighter export controls on chemical exports from Japan to Korea. As the situation is highly fluid in coverage and depth, we run simulations of two hypothetical scenarios: imposition of export tax on chemical exports from Japan to Korea; and productivity decline in the electronics sector in Korea. Our simulation results show the impacts of the two shocks on global trade and on welfare in Japan and Korea. Though these two shocks are assumed to occur separately, they could occur jointly. Given the nature of the simulation method used here, interpretation of the simulation results should be cautious.

Our scenarios may not be capable of exact projection of the magnitude of these anticipated shocks, but it is possible to derive some policy implications qualitatively. If tighter export controls reduced the productivity of the Korean electronics sector, the adverse impact would be small in magnitude and range, and would not induce chaos in the global market. Rather, if the controls worked as an export tax, which is nothing like an export ban, the impacts would be markedly large, harming not only the Korean electronics sector but also the Japanese chemical sector and Japanese consumer welfare. There are two notable points regarding the latter scenario. First, that large 50% export tax would decrease Korean electronics output by only 0.14%. Second, the welfare loss in Japan would ultimately be much smaller than that in Korea because of the difference in the size of the two economies. The results suggest that Japan would likely not hesitate to tighten export controls, given the current coverage of policy change.

We conclude with some remarks about limitations of this study and directions for extension of the research. As noted earlier, this study does not rely on any empirical prediction of the direct effects of the aforementioned export controls. Such predictions can be only made by observing the actual unfolding of the event or similar events; only then could we validate the depth and breadth of the shocks predicted in our scenarios. In addition to the scenario issue, there are limitations inherent in our modeling method. While the chemical products subject to export controls are narrowly defined in practice, the chemical sector in our CGE model is defined on the basis of the GTAP sector, and thus is rather broader. This weak correspondence could lead to overestimation of the range of sectors assumed to be impacted. This issue could also be impacted by the assumed elasticity parameters in the CES/CET functions.

In the current policy context, a change in export control policy could affect a wider range of products, with deeper shocks. This is a subject of serious concern to the Korean government. CGE models can help us to assess the impacts of these broader policy changes. Our model is constructed with minimal features for simplicity, but it can be extended to take into account cross-border capital mobility in the form of foreign direct investment, such as that made by Japanese semiconductor companies in Korea and other Asian countries. A CGE model with FDI, à la Hosoe (2014), would capture longer-run impacts of the policy change on the Japanese and Korean economies.

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Appendix

A.1 Sensitivity Analysis

As is the case with other modeling methods, our simulation results are dependent on many assumptions made in the construction of our model. Simulation results of CGE models are often affected by assumptions about elasticity of substitution among goods. In this sensitivity analysis, we examine the robustness of our simulation results by perturbing: (1) Armington's (1969) elasticity of substitution σ between imports and domestic goods, which is also used to set the elasticity of transformation between exports and domestic goods and the elasticity of substitution/transformation among import sources/export destinations by means of the "rule of two" (Liu et al. (2004)); and (2) the elasticity of substitution among factor inputs σ^{VA}. We run the model under the export tax scenario, doubling and halving the elasticity values for the chemical and electronics sectors in all regions assumed in the main body (Table A.1).

Table A.1: Elasticity of Substitution/Transformation Assumed in the Main Body

	Armington σ	Factor input σ^{VA}
Agriculture	2.35	0.25
Mining	5.70	0.20
Petroleum and coal products	2.10	1.26
Chemical	3.30	1.26
Electronics	4.40	1.26
Machinery	3.54	1.26
Other manufacturing	3.26	1.23
Transportation services	1.90	1.68
Other services	1.95	1.36

Source: GTAP Database version 10
Note: Elasticity values are assumed to be common across countries.

As different elasticity values lead to different output changes in the Korean electronics sector, the TFP scenario in this sensitivity analysis assumes a TFP decline that produces exactly the same output change in the export tax scenario. That is, we assume a different TFP decline in each elasticity case (Table A.2). Therefore, while the simulation results for cases under the same export tax scenario are comparable, comparison of cases under the TFP scenario demands great care.

Table A.2: Assumed TFP Changes and Resulting Output Changes in the Korean Electronics Sector with Alternative Elasticity Values

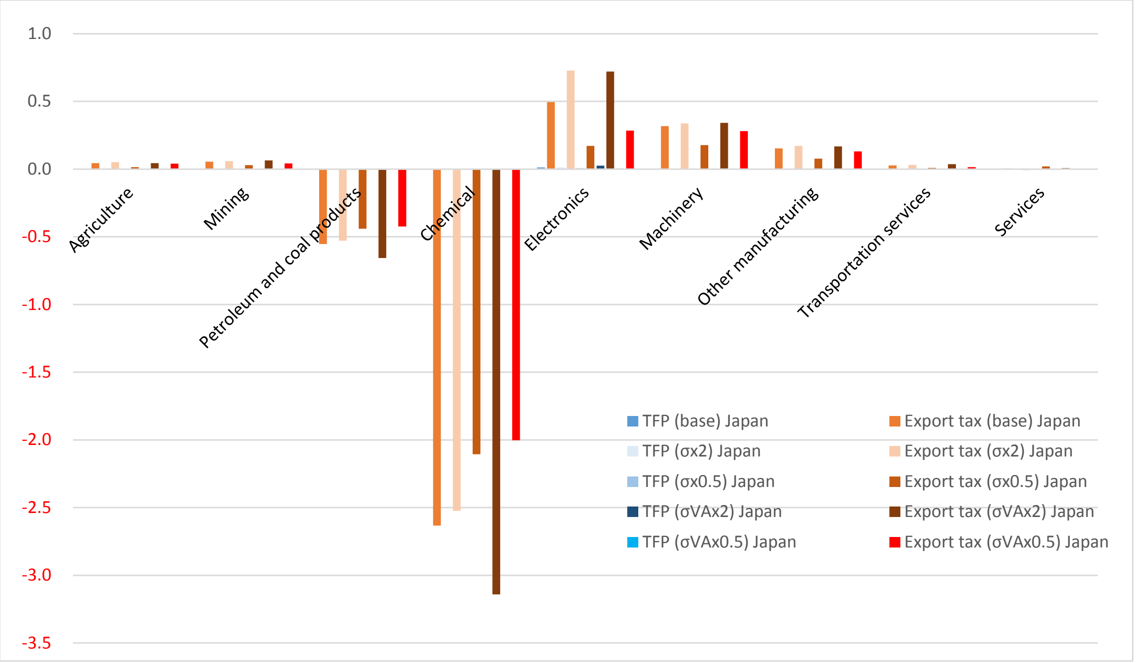
	Assumed TFP Change [%]	Output Change [%]
Base	−0.065	−0.137
σ x2	−0.064	−0.151
σ x0.5	−0.034	−0.061
σ^{VA} x2	−0.095	−0.261
σ^{VA} x0.5	−0.036	−0.059

Note: In the base case, presented in the main body, the TFP decline yields the same output decline (0.14%) in the Korean electronics sector that would be brought about by imposition of a 50% export tax on chemical exports from Japan to Korea.

Our results are qualitatively the same for output (Figure A.1), exports (Figure A.2), and imports (Figure A.3). Welfare impacts are also found robust (Figure A.4). Generally, larger elasticity leads to larger trade reactions, but its effects on output and welfare are not necessarily straightforward. While larger elasticity gives rise to larger reactions to a shock, it also allows more flexible adjustments to the shock in an economy.

Figure A.1: Impacts of Export Tax and TFP Decline on Domestic Output
[Changes from the base, %]

- Japan



- Korea

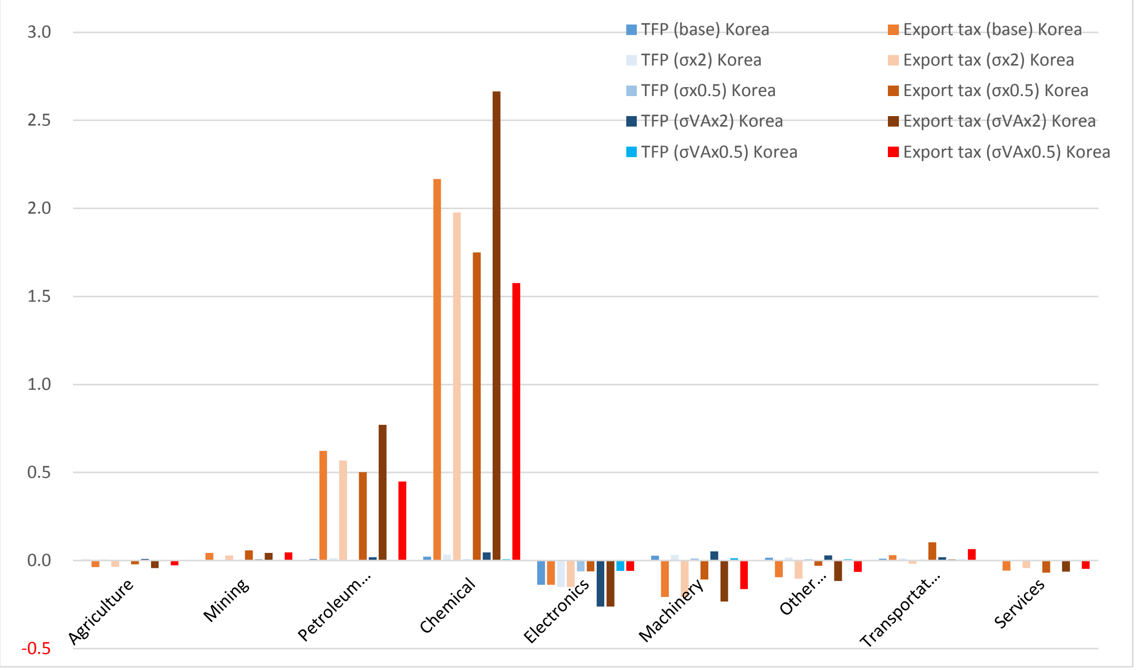
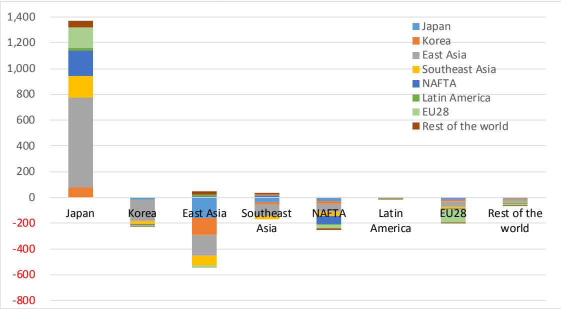
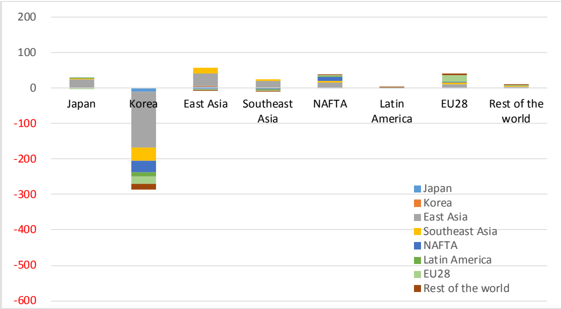


Figure A.2: Impacts of Export Tax and TFP Decline on Regional Electronics Exports with Breakdown by Export Destination
[Unit: mil. USD]

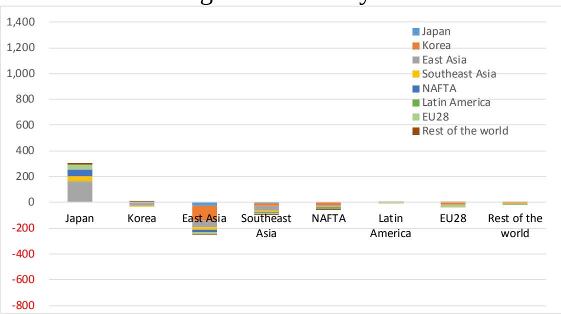
[Export Tax Scenario] [TFP Scenario]

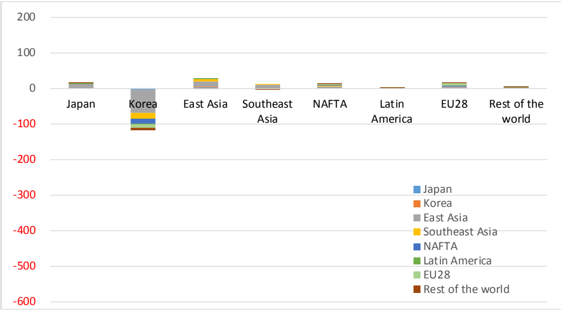
- Doubled Armington’s Elasticity



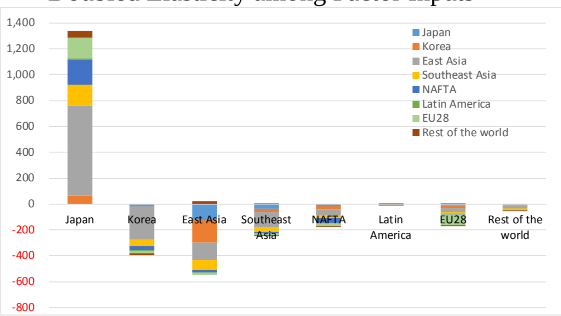


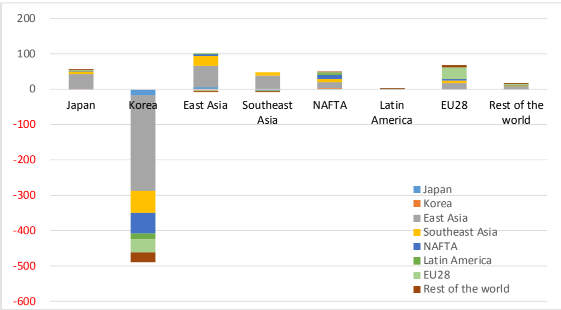
- Halved Armington’s Elasticity



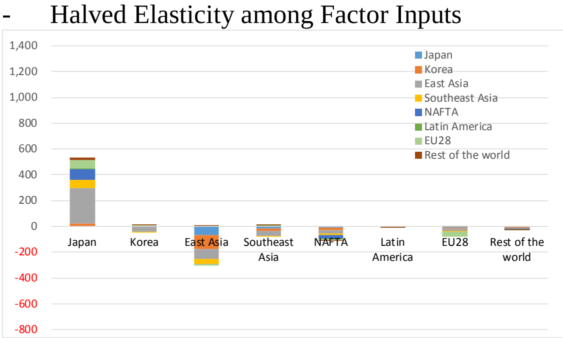


- Doubled Elasticity among Factor Inputs





- Halved Elasticity among Factor Inputs



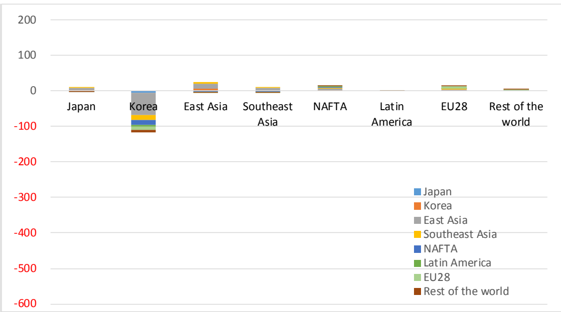
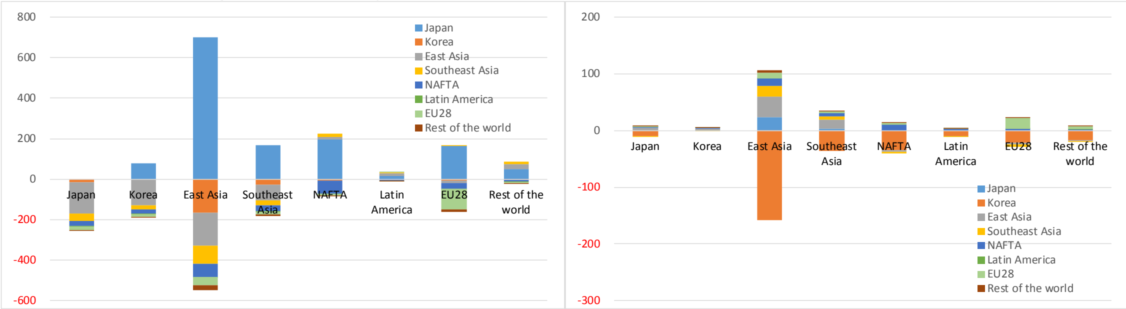


Figure A.3: Impacts of Export Tax and TFP Decline on Regional Electronics Imports with Breakdown by Import Source

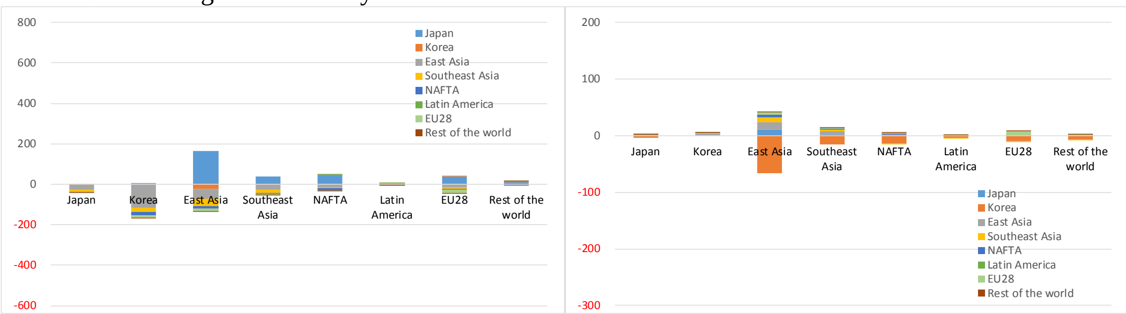
[Unit: mil. USD]

[Export Tax Scenario] [TFP Scenario]

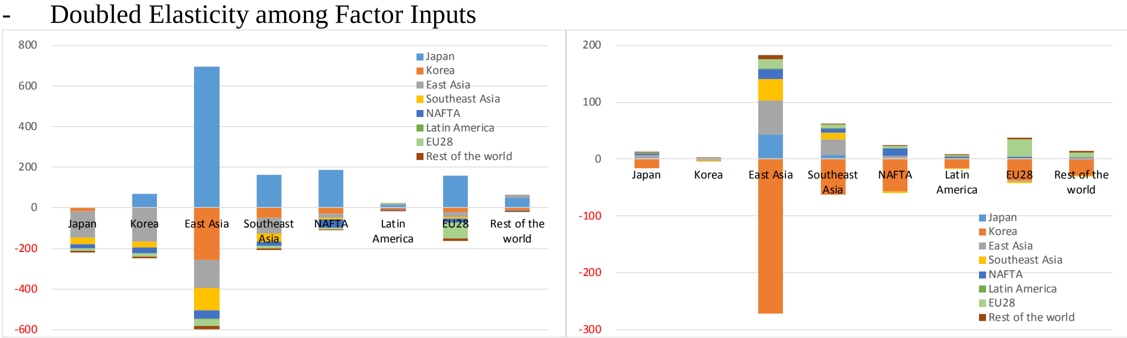
- Doubled Armington's Elasticity



- Halved Armington's Elasticity



- Doubled Elasticity among Factor Inputs



- Halved Elasticity among Factor Inputs

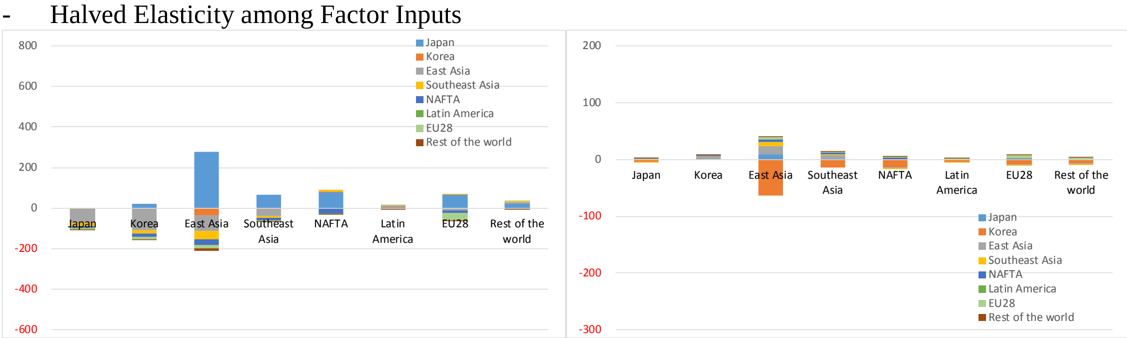
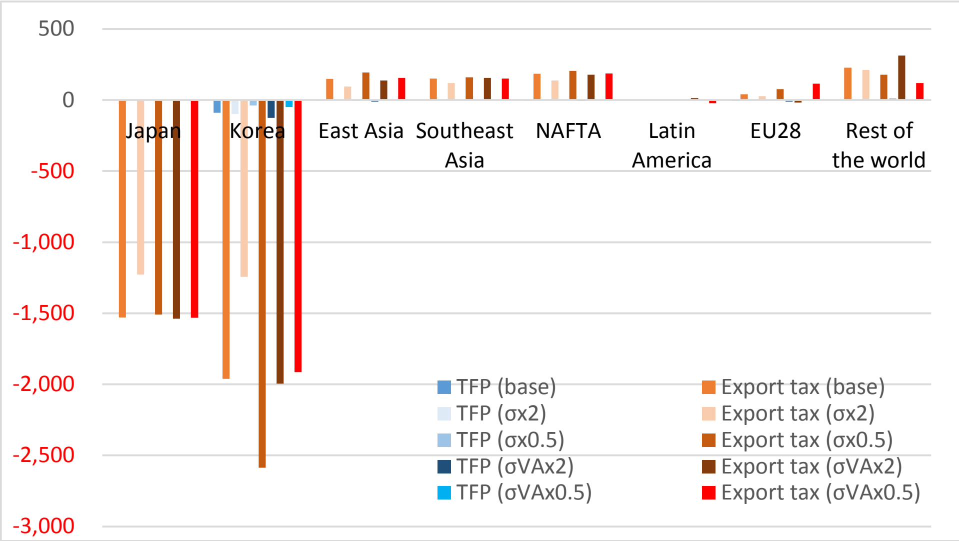


Figure A.4: Welfare Impacts of Export Tax and TFP Decline
[Equivalent Variations, mil. USD]



A.2 GTAP Sectoral Aggregation

Sector	GTAP Sector Abbreviation
Agriculture	prd, wht, gro, v_f, osd, c_b, pfb, ocr, ctl, oap, rmk, wol, frs, fsh
Mining	coa, oil, gas, oxt
Petroleum and coal products	p_c
Chemical	chm, rpp
Electronics	ele
Machinery	ome, mvh, otn
Other manufacturing	cmt, omt, vol, mil, pcr, sgr, ofd, b_t, tex, wap, lea, lum, ppp, bph, nmm, i_s, nfm, fmp, eeq, omf
Transportation services	otp, wtp, atp
Services	ely, gdt, wtr, cns, trd, afs, whs, cmn, ofi, ins, rsa, obs, ros, osg, edu, hht, dwe

Factor	GTAP Factor Abbreviation
Skilled labor	tech_aspros, clerks, off_mgr_prs
Unskilled labor	service_shop, ag_othlowsk
Capital	Land, Capital, NatlRes