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Abstract

Welfare gains achieved through international trade are a cornerstone of the literature on international economics. However, the data and research methods needed to empirically assess these welfare gains have only recently become available. Building on recently developed methodologies for estimating the elasticity of substitution and computing welfare gains from trade, we estimate Japan's welfare gains from liberalizing trade in the manufacturing sector. To do so, we estimate the elasticities of substitution using Harmonized System (HS) 9-digit product codes, for various periods of time. The analysis shows that the Japan's welfare gains from trade liberalization occurred especially from the 1990s onward, and reached eleven percent vis-à-vis the autarky situation.

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Abstract

Welfare gains achieved through international trade are a cornerstone of the literature on international economics. However, the data and research methods needed to empirically assess these welfare gains have only recently become available. Building on recently developed methodologies for estimating the elasticity of substitution and computing welfare gains from trade, we estimate Japan's welfare gains from liberalizing trade in the manufacturing sector. To do so, we estimate the elasticities of substitution using Harmonized System (HS) 9-digit product codes, for various periods of time. The analysis shows that Japan's welfare gains from trade liberalization occurred especially from the 1990s onward, and reached eleven percent vis-à-vis the autarky situation.

Keywords: Trade liberalization, Welfare gains, Japan
JEL classifications: F14

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1. Introduction

From the earliest days of research on international trade theory as introduced by Ricardo and Heckscher-Ohlin in the 19^{th} century, welfare improvement through trade has been a cornerstone of the literature. While the international trade literature has studied the various channels and mechanisms of the welfare impact of trade, including important contributions such as Krugman (1980), Eaton and Kortum (2002), Melitz (2003), and others, until recently empirical measurement of the welfare impact of trade has been infeasible. Now, because of the revolution in computational power due to increased computer processing speed and the recent availability of new, massive datasets, as well as new empirical methodologies developed by trade economists, estimating the welfare impact of trade has come to the forefront of the literature.

Since joining the General Agreement on Tariffs and Trade in 1955, Japan has been involved in and benefited from the system of world trade. However, for the reasons mentioned above, attempts to empirically assess the welfare impact from trade liberalization have been stymied. The aim of this paper is to make such an assessment using methodologies proposed by Arkolakis et al. (2012) and Ossa (2015). As participation in the Trans-Pacific Partnership has been a hotly debated political issue in Japan, it is important to look back at earlier forms of trade liberalization to assess the welfare gains Japan has realized from them. To our knowledge, this study is the first attempt to do such an analysis for Japan. To obtain reliable results, we estimate the elasticities of substitution at a highly disaggregated product category level, using 9-digit Harmonized System (HS) codes. We analyze data at this level using various time periods because elasticities of substitution may change over time. Our analysis shows that gains from trade liberalization in Japan's manufacturing sector increased gradually throughout the period 1970–2011, most notably from the 1990s onward, reaching approximately eleven percent vis-à-vis the autarky situation.

2. Literature and methodology review

The first attempt to measure welfare improvement through trade liberalization was likely Feenstra (1994), which derives the exact price index of the Constant Elasticity of Substition (CES) function and thereby provides a way to compute the welfare impact of goods that are newly available from imports. However, that study is not about the nationwide welfare impact of trade; it is limited to the welfare impact of someof new products that became available through imports. Building on Feenstra (1994), Broda and Weinstein (2006) compute the elasticities of substitutions for roughly 3,000 product groups and estimate the nationwide welfare improvement that the US enjoyed through trade liberalization in the previous 30 years. However, their methodology was based on the Dixit-Stiglitz model, and therefore the model's key property of the constant mark-up does not allow researchers to measure the welfare impact through the effect of competition, the so-called pro-competitive effect. Faced with this challenge, Feenstra and Weinstein (2017) argue that the translog function captures both variety effects and pro-competitive effects, and estimate the welfare impact through these two effects for the US. However, their methodology requires a highly detailed dataset that is typically not available for countries other than the US. Whereas Feenstra and Weinstein (2017) offer a detailed study on the welfare impact by its various channels, Arkolakis et al. (2012) show that if we are only interested in the total welfare impact of trade, not the individual impacts of the specific channels, this can be computed using only the domestic expenditure share (one minus the import penetration ratio) and elasticities of substitutions as follows:

$$\hat{W} = \hat{\lambda}^{1/\varepsilon}, \quad (1)$$

where W, λ, and ε represent the welfare, one minus the import penetration ratio (domestic expenditure share), and the elasticities of substitutions, respectively. In moving from autarky to the current level of domestic expenditure share, Equation (1) becomes

$$\hat{W} = \lambda^{1/\varepsilon} \quad (2)$$

because the initial level of λ equals 1 under autarky.

However, the welfare impact in the US as proposed in Arkolakis et al. (2012) was only a rough approximation because they used the import penetration ratio for the US as a whole, and the average elasticity of substitution. Ossa (2015) pointed out that one must consider the input-output structure of individual industries when computing the welfare impact. Ossa (2015) argues "while imports in the average industry do not matter too much, imports in some industries are critical to the functioning of the economy." For example, oil imports are crucial to Japan's economy; therefore, oil imports should yield higher welfare gains than many other imports. Ossa (2015) extends Arkolakis et al. (2012) to N industries and incorporates an input-output structure.[1] Following Equation (3) in Ossa (2015), we compute Japan's welfare gains from trade liberalization in the manufacturing sector as

$$\frac{\widehat{W}}{P} = \lambda^{-\left(\sum_{s=1}^{S}\sum_{t=1}^{S}\alpha_s\delta_t^s\frac{\log\lambda_t}{\log\lambda}\frac{1}{\sigma_t-1}\right)} \quad (3)$$

where P is the price index, α_s is the consumption expenditure share of industry s, and σ is the elasticity of substitution. $\delta_t^s \equiv \gamma_t^s\left(1-\beta_s\right)$, where β_s is the share of value-added in gross production, γ_t^s is the fraction of each downstream industry s's

[1] One other refinement of Arkolakis et al. (2012) is Felbermayr et al. (2015), which incorporates tariff revenues. We use Ossa (2015) instead of Felbermayr et al. (2015) because Japan's tariff revenue is small whereas its input-output structure is becoming more important, especially due to the deepening global value chains (or supply chains).

intermediate input expenditure that goes to a particular upstream industry t (an element of Leontieff's inverse matrix.) The intuition is straight forward: the greater the expenditure share of a given industry s (a high α_s), the greater the welfare gains from trade liberalization for that industry. When industries that depend heavily on intermediate inputs (low β industries) have fairly easy access to their most important inputs (high γ industries), trade liberalization yields larger welfare gains.

3. Data and methodologies

This section describes the data and computing methodology used to estimate and calculate the parameters in Equation (3).

To compare the estimation results to Ossa (2015), we estimate Japan's welfare gains from trade liberalization in the manufacturing sector beginning in 1970. Then, we apply the input-output (IO) table from the Japan Industry Productivity (JIP) database[2], which provides annual IO tables separated into 52 manufacturing sectors and 56 non-manufacturing sectors from 1970 to 2012. The list of sectors is presented in the Appendix. Based on the JIP database, we calculate α_s, β_s, γ_t^s, δ_t^s, λ, and λ_t in Equation (3).

The JIP database does not record import data disaggregated at the country level. However, to estimate the elasticity of substitution (σ) we need panel data by sector and country. We apply import data for Japan at the HS 9-digit product codes from 1988 to 2011[3]. Since the HS code changes periodically (typically every five to six years), we compute the elasticities of substitution for each version of the HS product codes, namely,

[2] This database is compiled as a part of research project of the Research Institute for Economy, Trade and Industry (RIETI) and Hitotsubashi University. Specifically, we use JIP 2012 for this study. For more details, see: https://www.rieti.go.jp/jp/database/jip.html (last access 2019/11/18).

[3] HS data are available only from 1988.

HS88, HS96, HS02, and HS07. Import data for 1988–1995 are used to estimate elasticities of substitution using product codes in HS88, import data for 1996–2001 is used with the HS96 product codes, and so on. The estimated elasticities of substitution are aggregated with the JIP codes using import values as weights. In order to concord JIP codes with HS 9-digit product codes, we use an HS-IO-JIP concordance table[4]. The estimated elasticities of substitution using JIP codes are provided in the Appendix.

To estimate σ, we follow the methodology in Soderbery (2015), which is a refinement of the Feenstra (1994)/Broda and Weinstein (2006) (F/BW) framework. That framework is the most widely used method in modern economic research for estimating σ, the elasticity of substitution, when determining the welfare gains from trade as shown in the above section. Similar to having a common model of international trade, this way of estimating the elasticity of substitution is based on supply and import demand equations deriving from the CES utility function. Following Feenstra (1994), in order to address the endogeneity issue we eliminate any time- and product-specific unobservables from our export supply and import demand equations. We develop the equations for the structural model's demand and supply curves as follows:

$$\begin{aligned} \Delta^k \ln s_{vgt} &= -(\sigma_g - 1)\Delta^k \ln(p_{vgt}) + \varepsilon_{vgt}^k \\ \Delta^k \ln p_{vgt} &= -\left(\frac{\omega_g}{1+\omega_g}\right)\Delta^k \ln(s_{vgt}) + \delta_{vgt}^k \end{aligned} \qquad (4)$$

where *vgt* denotes the varieties *v* of good *g* available at time *t*, s_{vgt} is the market share for a given *vgt*, p_{vgt} is the market price for a given *vgt*, σ_g is the constant elasticity of

[4] IO is an Input-Output Table for Japan published by the Ministry of Internal Affairs and Communications. Concorded IO sector codes with HS9 is provided in the Appendix of the report. RIETI also provides a concordance table between IO sector code and JIP codes in the JIP database.

substitution for good *g*, ω_g is the inverse of the export supply elasticity for good *g*, Δ represents first differences, k is the reference country, ε_{vgt}^{k} is the error term capturing unobservable demand shocks for a given *vgt*, and δ_{vgt}^{k} is the error term reflecting unobservable supply shocks for a given *vgt*. Following Feensta (1994), we eliminate unobservable shocks[5] and convert the two equalities shown in Equation (4) into a single equation:

$$\begin{aligned} &Y_{vgt} = \theta_{1g} X_{1vgt} + \theta_{2g} X_{2vgt} + u_{vgt}, \text{ where} \\ &Y_{vgt} \equiv \left(\Delta^k \ln p_{vgt}\right)^2, \ X_{1vgt} \equiv \left(\Delta^k \ln s_{vgt}\right)^2, \\ &X_2 \equiv \left(\Delta^k \ln s_{vgt}\right)\left(\Delta^k \ln p_{vgt}\right), \ u_{vgt} = \frac{\varepsilon_{vgt}^{k}\delta_{vgt}^{k}}{(1-\rho_g)} \\ &\theta_{1g} = \frac{\rho_g}{(\sigma_g-1)^2(1-\rho_g)}, \text{ and } \theta_{2g} = \frac{2\rho_g - 1}{(\sigma_g-1)(1-\rho_g)} \end{aligned} \tag{5}$$

Here, u_{vgt} is the error term for a given *vgt*, and θ_{1g} and θ_{2g} are nonlinear functions identified with σ_g and ρ_g. In Equation (5), u_{vgt} is correlated with X_1 and X_2 as the prices and expenditure shares are correlated with the error terms, ε_{vgt}^{k} and δ_{vgt}^{k}. To obtain a consistent estimator, Equation (5) is rewritten by averaging the terms across all *t* as follows:

$$\bar{Y}_{vg} = \theta_{1g}\bar{X}_{1vg} + \theta_{2g}\bar{X}_{2vg} + \bar{u}_{vg} \tag{6}$$

Feenstra (1994) employs a two-stage least squared method (2SLS) to estimate θ_{1g} and θ_{2g} as defined by that methodology. However, Feenstra (1994)'s method

[5] Multiply ε_{vgt}^{k} and δ_{vgt}^{k} together, and define $\rho_g \equiv \frac{\omega_g(\sigma_g-1)}{1+\omega_g\sigma_g} \in \left[0, \frac{\sigma_g-1}{\sigma_g}\right)$, scale by $\frac{1}{(1-\rho_g)}$.

causes the 2SLS to produce some inconsistent estimators about θ due to violations of certain underlying assumptions[6]. Broad and Weinstein (2006) address this problem by proposing a constrained grid search (GRID) in the second stage to adjust and replace the estimation results if the first stage of the 2SLS produces infeasible estimators. Therefore, the F/BW framework is an estimation methodology constructed by 2SLS and GRID.

On the other hand, Soderbery (2015) argues that the estimator in the F/BW framework is often biased by overweighting outlier observations, consistent with the small sample bias. As a method of overcoming this small sample bias, Soderbery (2015) presents a hybrid estimator that combines a limited information maximum likelihood (LIML) estimate with a constrained nonlinear LIML routine. Following Soderbery (2015), we estimate θ_{1g} and θ_{2g} from the data on HS9 products imported by Japan from 1988 to 2011 at a disaggregated level.

4. Computation results

The welfare gains computed according to Equation (3) using individually estimated elasticities of substitution (σ) are shown in Figure 1. To compute the welfare gains, the estimate of σ based on HS07 is used for the period 2007–2011, σ estimated from HS02 is used for the period 2002–2006, σ estimated from HS96 is used for the period 1996–2001, and σ estimated from HS88 is used for the period 1970–1995. The welfare gains are approximately 10 percent at the end of the period. This figure is much higher than the 0.7–1.4 percent range of welfare gains from trade for the United States shown in Arkolakis et al. (2012), but is lower than the 21.4 percent shown by Ossa (2015) as Japan's gains from trade.

The remarkable welfare gains that were generated from the 1990s may have

[6] Specifically, $\widehat{\theta_1} < 0 \Rightarrow \hat{\rho} < 0$ or $\hat{\rho} > 1 \Rightarrow \hat{\sigma} < 1$ or $\hat{\omega} < 0$

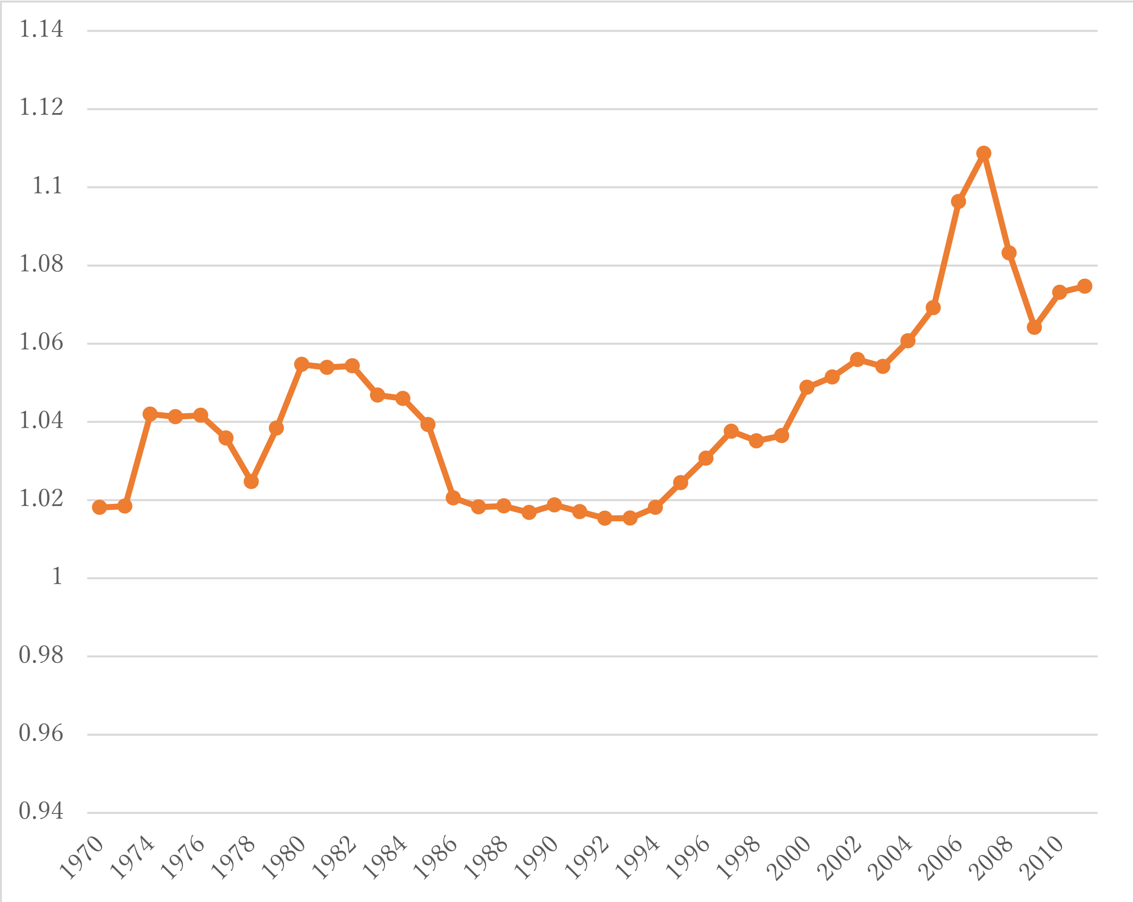
been caused by an increase in imports of intermediate goods due to expanding supply-chains, a trend that has become increasingly notable, especially in the 1990s. Figure 2 supports this hypothesis, at least partially. It shows the shares of imports of different types of goods over the period from 1980 to 2012, and the import share for Parts and Components increased substantially during the 1990s. As explained in Section 2, particularly by Equation (2), the more dependent production is on intermediate inputs, which equates to a smaller value-added share, the greater the impact of imports on welfare gains. To verify this, we computed the weighted value-added ratio each year from 1970 to 2011, as shown in Figure 3. Since there is no downward trend observed for this ratio over this time, we conclude that a change in the value-added share is not an underlying cause of the welfare gains that have been realized over this period.

We also examine the role of the IO linkage in the welfare gain from trade by comparing the methodologies used by Ossa (2015) and Arkalakis et al. (2012). As mentioned in the introduction section, this study follows the methodology proposed by Ossa (2015), which essentially incorporates the IO structure into the welfare gain computation as proposed by Arkolakis et al. (2012). Ossa (2015) shows that the estimated welfare gain is much higher if the IO structure is taken into consideration, and this result also holds in this analysis. Figure 4 shows the estimated welfare gains computed following both Arkolakis et al. (2012) and Ossa (2015), and the estimated welfare gain for Japan is shown to be much higher using the methodology in Ossa (2015).

5. Concluding remarks

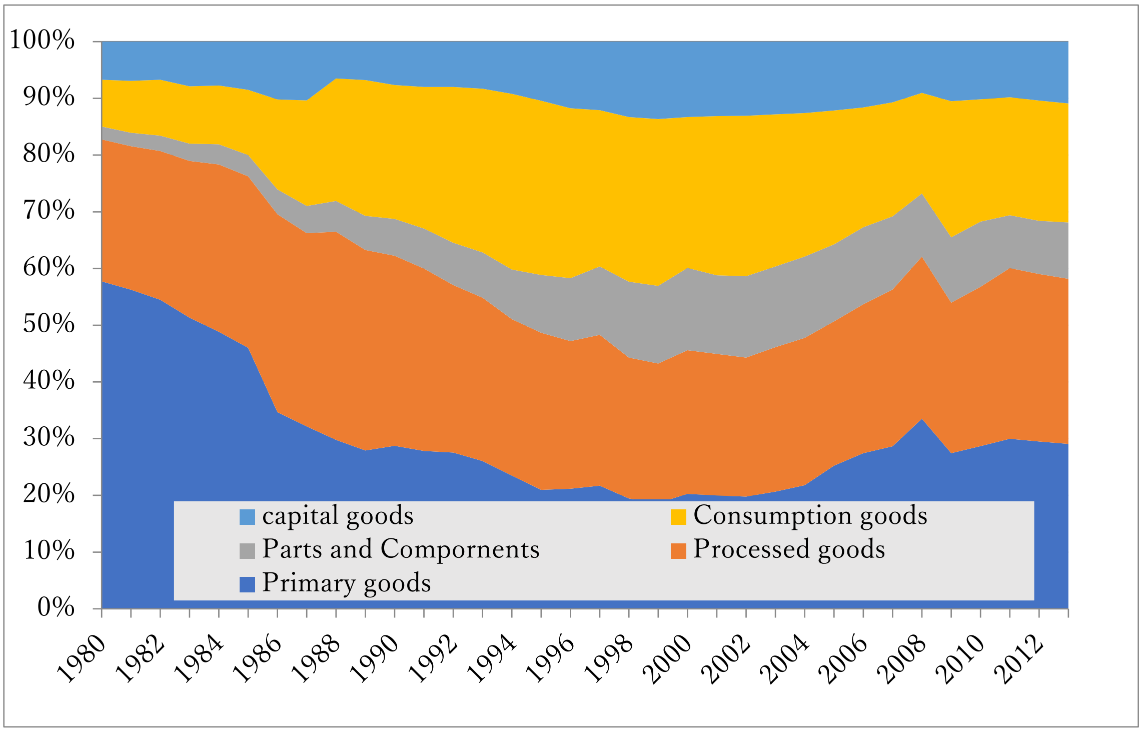
This empirical study analyses Japan's welfare gains from trade liberalization, the first study of its kind to focus exclusively on Japan, using the methodologies proposed by Arkolakis et al. (2012) and Ossa (2015). To measure the welfare gains from trade liberalization as precisely as possible, the elasticities of substitution based on HS 9-digit product code are estimated for various periods of time. The analysis shows that Japan's welfare gains from trade liberalization took place especially from the 1990s, and reached 11% vis-à-vis the state of autarky equilibrium.

Figure 1: Welfare gain vis-à-vis the autarky situation for 1970–2011



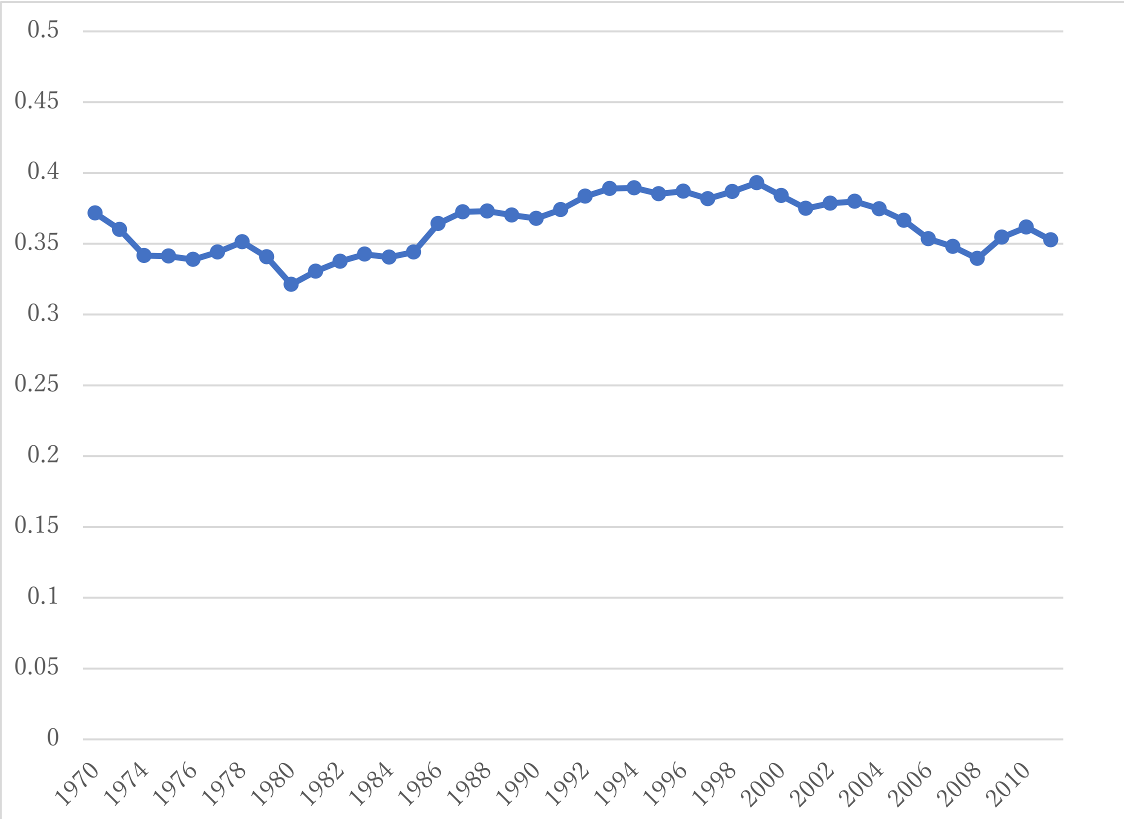
Source: Authors' computation

Figure 2: The share of Japan's imports by types of goods, 1980–2012



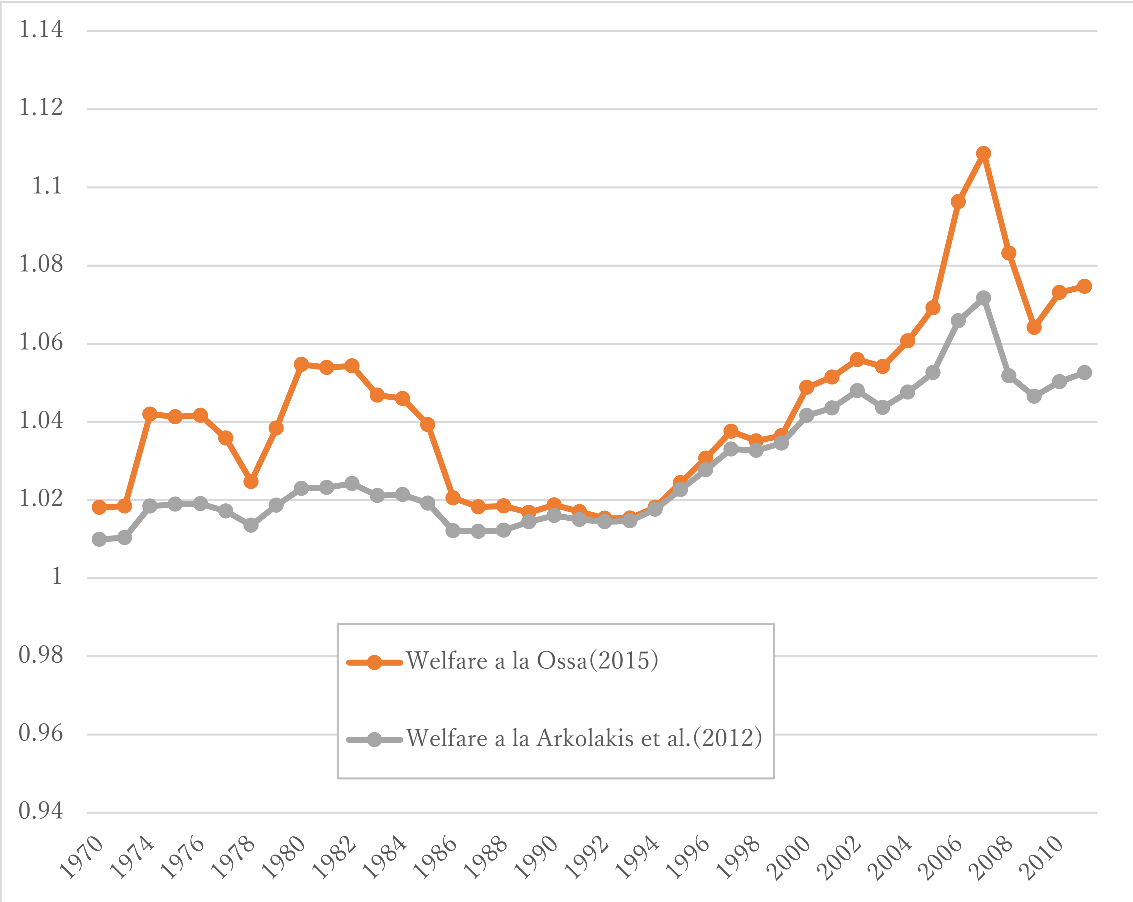
Source: Authors' computation from RIETI-TID database

Figure 3: Value-added share, 1970–2011



Source: Authors' computation

Figure 4: Welfare gains vis-à-vis the autarky situation, 1970–2011, Arkolakis et al. (2012) versus Ossa (2015)



Source: Authors' computation

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Appendix

A. JIP sector code

JIP code	Sector name
7	Mining
8	Livestock products
9	Seafood products
10	Flour and grain mill products
11	Miscellaneous foods and related products
12	Prepared animal foods and organic fertilizers
13	Beverages
14	Tobacco
15	Textile products
16	Lumber and wood products
17	Furniture and fixtures
18	Pulp, paper, and coated and glazed paper
19	Paper products
20	Printing, plate making for printing and bookbinding
21	Leather and leather products
22	Rubber products
23	Chemical fertilizers
24	Basic inorganic chemicals
25	Basic organic chemicals
26	Organic chemicals
27	Chemical fibers
28	Miscellaneous chemical products
29	Pharmaceutical products
30	Petroleum products
31	Coal products
32	Glass and its products
33	Cement and its products
34	Pottery
35	Miscellaneous ceramic, stone and clay products
36	Pig iron and crude steel
37	Miscellaneous iron and steel
38	Smelting and refining of non-ferrous metals
39	Non-ferrous metal products
40	Fabricated constructional and architectural metal products
41	Miscellaneous fabricated metal products
42	General industry machinery
43	Special industry machinery
44	Miscellaneous machinery
45	Office and service industry machines
46	Electrical generating, transmission, distribution and industrial apparatus
47	Household electric appliances
48	Electronic data processing machines, digital and analog computer equipment and accessories
49	Communication equipment
50	Electronic equipment and electric measuring instruments
51	Semiconductor devices and integrated circuits
52	Electronic parts
53	Miscellaneous electrical machinery equipment
54	Motor vehicles
55	Motor vehicle parts and accessories
56	Other transportation equipment
57	Precision machinery & equipment
58	Plastic products
59	Miscellaneous manufacturing industries

B. Estimated elasticities of substitution

JIP code	1988–1995	1996–2001	2002–2006	2007–2011
7	10.78	51.97	8.35	856.23
8	8.16	17.03	15.89	11.78
9	51.57	27.00	11.09	6.84
10	41.65	37.34	13.07	14.44
11	39.75	41.10	21.35	70.44
12	16.82	3.42	4.13	4.56
13	4.99	123.52	4.16	19.17
14	3.04	1.56	4.64	1.64
15	21.03	79.34	29.69	49.41
16	984.87	6.29	14.19	47.61
17	3.66	10.83	2.32	5.66
18	7.17	21.51	84.04	5.71
19	5.98	3.11	3.82	11.78
20	12.00	2.31	4.25	4.39
21	4.37	6.27	9.89	5.71
22	12.51	4.57	31.10	38.06
23	4.90	12.36	5.78	186.22
24	15.21	171.69	12.22	178.02
25	2.05	11.76	5.26	10.41
26	6.27	11.27	129.25	67.22
27	2.81	2.66	4.36	4.12
28	6.57	69.94	4.06	51.54
29	7.05	62.75	5.43	4.27
30	5.86	4.76	10.26	25.27
31	3.59	6.10	5.88	17.07
32	12.86	7.79	4.27	12.59
33	18.14	2.76	5.49	33.50
34	2.89	3.21	6.57	4.96
35	4.19	8.57	10.14	16.32
36	10.84	14.11	51.48	14.31
37	18.53	5.09	6.43	36.91
38	7.98	13.64	121.09	10.20
39	8.93	83.73	4.11	8.04
40	2.36	3.06	31.08	3.04
41	3.52	6.35	11.44	7.10
42	4.95	3.80	4.82	6.57

JIP code	1988–1995	1996–2001	2002–2006	2007–2011
43	20.73	15.66	6.69	29.13
44	7.70	4.08	2.54	10.11
45	6.12	119.32	10.15	35.88
46	2.39	3.75	2.55	101.72
47	19.48	3.82	5.27	3.32
48	3.85	6.92	2.01	3.43
49	3.27	27.69	110.03	20.51
50	14.26	3.30	5.84	44.14
51	4.15	1.50	2.34	6.39
52	2.47	4.42	438.33	35.40
53	36.29	2.60	15.37	16.54
54	15.06	4.00	6.97	10.76
55	30.47	4.51	6.43	2.40
56	10.89	23.16	5.42	43.67
57	22.75	215.76	3.35	9.47
58	3.87	4.04	2.28	4.54
59	25.58	4.56	3.98	25.46