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1. Introduction

Since the dawn of international trade theory by Ricardo and Heckscher-Ohlin in the 19th century, welfare improvement through trade has been a cornerstone of the literature. Whilst trade theories have studied the various channels and mechanisms of welfare impact of trade since the birth of the international trade literature by important contributions such as Krugman (1980), Eaton and Kortum (2002), Melitz (2003), among others, empirical measurement of the welfare impact through trade has been practically infeasible until recently. However, because of the revolution of computational power thanks to computers and the huge dataset which have recently become available, and moreover the empirical methodologies developed by trade economists, the estimation of the welfare impact of trade has come to the forefront of the literature.

Since its membership to GATT in 1955, Japan has been involved in and benefited from the world trade system. However, there has not been an empirical assessment of welfare impact from such trade liberalization because of the reasons mentioned above. The aim of this paper is simply to do that, using the methodologies proposed by Arkolakis et al. (2012) and Ossa (2015). As the participation into the Trans-pacific partnership (TPP) has been a hotly debated political issue in Japan, it is important to look back the past trade liberalization and see how much of welfare gains Japan has benefited from it. This paper is the first such attempt. To obtain reliable results, we estimate the elasticities of substitution at a highly aggregated product category level, Harmonised System (HS) 9-digit for various time periods because we cover a long period and the elasticities of substitution may change over long period of time. Our analyses show that Japan's estimated gains from trade from trade liberalization in manufacturing sector increased gradually throughout 1970-2011 and most notably from the 1990s, reached about eleven percent vis-à-vis the autarky situation.

2. Literature and methodologies

The first attempt of the measurement of welfare improvement was most probably Feenstra (1994). It derives the exact price index of CES function, and by doing so enables to compute the welfare impact of the newly available goods through imports. However, the study is not about the nationwide welfare impact of trade but limited to the welfare impact of some new products which became available through imports. Building on Feenstra (1994), Broda and Weinstein (2006) computes the elasticities of substitutions of about 3000 product groups and estimates the nationwide welfare improvement that the US enjoyed through trade liberalization in the past 30 years. However, the methodologies of Broda and Weinstein (2006) was based on Dixit-Stiglitz model and consequently the model's key property of the constant mark-up does not allow researchers to measure welfare impact through competition effects, so-called pro-competitive effect. Faced with this challenge, Feenstra and Weinstein (2010) argues that the translog function captures both of variety effects and pro-competitive effects, and estimates the welfare impact through these two effects for the US. However, its methodology requires highly detailed dataset, which usually could not be available for other countries. Whereas Feenstra and Weinstein (2010) makes a detailed study on the welfare impact by its channels, Arkolakis et al. (2012) shows that if we are only interested in total welfare impact of trade, not the channels, the impact can be computed only with domestic expenditure share (one minus import penetration ratio) and elasticities of substitutions as follows.

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

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

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

because the initial level of λ equals 1 under autarky.

However, the welfare impact of the US argued in Arkolakis et al. (2012) was nothing but a rough reference number because they used the import penetration ratio of the US as a whole and the average elasticity of substitution. Ossa (2015) pointed out that one needs to consider input-output structure of industries when he/she computes 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 for Japan's economy. Thus, oil imports should yield higher welfare gains. Ossa (2015) extends Arkolakis et al. (2012) to N industries and incorporate input-output structure.[1] Following the equation (2) derived in Ossa (2015), we compute Japan's welfare gains from trade liberalization in manufacturing sector.

$$\frac{\widehat{W}}{P} = \lambda^{-\left(\sum_{s=1}^{S}\sum_{t=1}^{S}\alpha_s\delta_t^s\frac{\log\lambda_t}{\log\lambda}\frac{1}{\sigma_t-1}\right)} \tag{2}$$

where P represents the price index, α_s the consumption expenditure share of industry s, σ elasticity of substitution. $\delta_t^s \equiv \gamma_t^s\left(1-\beta_s\right)$, where β_s the share of value added in gross production, γ_t^s the fraction of each downstream industry s ' s intermediate input expenditure which goes to a particular upstream industry t (element of Leontieff's inverse matrix.) Intuition is straight forward. The higher the expenditure share of industry s (a higher α_s), the more welfare gains the trade liberalization of industry s incurs. When industries that depend heavily on intermediate inputs (low β industries) have good access to their most important inputs (high γ industries), trade liberalization yields larger welfare gains.

3. Data and methodologies

This section explains computation methodologies of elasticities of substitution and the dataset we use to compute the statistics explained in the previous section.

3.1. Elasticities of substitution

We show below the methodologies for the computation of elasticities of substitution. When estimating import demand elasticities, endogeneity issue should be addressed. However, it is practically impossible to find instrumental variable for each category of export product. Feenstra (1994) deals with the endogeneity issue by making use of the panel structure of import statistics of multiple import partner countries, and deriving export supply and import demand equations from CES utility function.

$$\begin{aligned}\Delta\ln s_{vt} &= \phi_t - (\sigma-1)\Delta\ln p_{vt} + \varepsilon_{vt}\\ \Delta\ln p_{vt} &= \omega\Delta\ln x_{vt} + \xi_{vt}\end{aligned} \tag{3}$$

where $v \in V_i$ is a set of varieties in industry i, t represents for time, and △ is difference from the period t-1 to t, s_{vt} import share of v, x_{vt} export to own countries (domestic sales), p_{vt} import price of v, ϕ_t random effect and ξ_{vt} error term. σ is

[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).

the elasticity of substitution of each good, ω inverse of export supply elasticity ($\omega \equiv 1/e^{f}$). Feenstra (1994) defines structural parameter $\rho \equiv \omega(\sigma-1)(1+\omega\sigma)^{-1}$ and derives the inverse export supply function as follows.

$$\Delta \ln p_{vt} = \psi_{vt} + \frac{\rho \varepsilon_{vt}}{\sigma - 1} + \delta_{vt}$$

where, ψ_{vt} is random effect, δ_{vt} error term. Feenstra (1994) addresses the endogeneity problem by adding several assumptions and derives the equation below.

$$Y_{vt} = \theta_1 X_{1vt} + \theta_2 X_{2vt} + u_{vt} \tag{4}$$

where $Y_{vt} \equiv (\Delta \ln p_{vt} - \Delta \ln p_{kt})^2, X_{1vt} \equiv (\Delta \ln s_{vt} - \Delta \ln s_{kt})^2, X_{2vt} \equiv (\Delta \ln p_{vt} - \Delta \ln p_{kt})(\Delta \ln s_{vt} - \Delta \ln s_{kt}), \theta_1 \equiv \rho(\sigma-1)^{-2}(1-\rho)^{-1}, \theta_2 \equiv (2\rho-1)(\sigma-1)^{-1}(1-\rho)^{-1}$, k benchmark variety, u_{vt} error term.

To obtain efficient estimator, Feenstra (1994) takes period-average of the equation (4) and estimate the following:

$$\bar{Y}_v = \theta_1 \bar{X}_{1v} + \theta_2 \bar{X}_{2v} + \bar{u}_v \tag{5}$$

The structural parameter ρ and the elasticity of substitution σ can be computed from the estimated parameters of (θ_1, θ_2). However, there may happen a problem where the structural parameter ρ may exceed the threshold (especially the upper one) and as a result, ω, the inverse of export supply elasticity may take a negative number. To address the problem, Broda and Weinstein (2006) deals with it by the grid search. Soderbery (2015) shows that the grid search method overestimates the elasticity of substitution due to the small sample bias by the Monte Carlo experiment and thus Broda and Weinstein (2006) underestimates the welfare impact, and thus proposes a solution based on Limited Information Maximum Likelihood, LIML). Following Soderbery (2015), we estimate (θ_1, θ_2) and compute the elasticity of substitution for each sub-group of goods. The whole estimation results are in the appendix B.

3.2. Data

Because we follow Ossa (2015) to examine the effect of globalization of the Japanese manufacturing sector, which started in the 1970s, the data we use comes from the Input-Output (IO) table of JIP database. This database is compiled as a part of research project of the Research Institute for Economy, Trade and Industry (RIETI) and Hitotsubashi University and it covers 108 sectors from 1970 to 2012. Among 108 sectors, it includes 52 manufacturing sectors and 56 non-manufacturing sectors. This database provides detailed information on sectoral output, input, capital, labor and total factor productivity at industry-level. It also contains an annual IO tables and thus input coefficients varies by years. The list of sectors is in the appendix A. Whereas the data other than the elasticities of substitution comes from JIP database, the import data to estimate the elasticities of substitution comes from Harmonised System 9-digit level for 1988-2011.[2]

4. Computation Results

To estimate the elasticities of substitution at disaggregated level, we use Japan's import data from all the origin countries at Harmonised System 9-digit level for 1988-2011. Since the HS code changes periodically (typically five to six years), we computed the elasticities of substitution for each HS version, namely HS88, HS96, HS02, HS07. Import data for 1988-1995 are used to estimate elasticities of substitution for HS88, the data for 1996-2001 for HS96 and so on. The estimated elasticities of substitution are aggregated into JIP code using import values as weight. The computed elasticities of substitution at JIP code is in the appendix A. The computed welfare gains as in the equation (2), using these estimated elasticities of substitution (σ), is shown in

[2] HS data are available only from 1988.

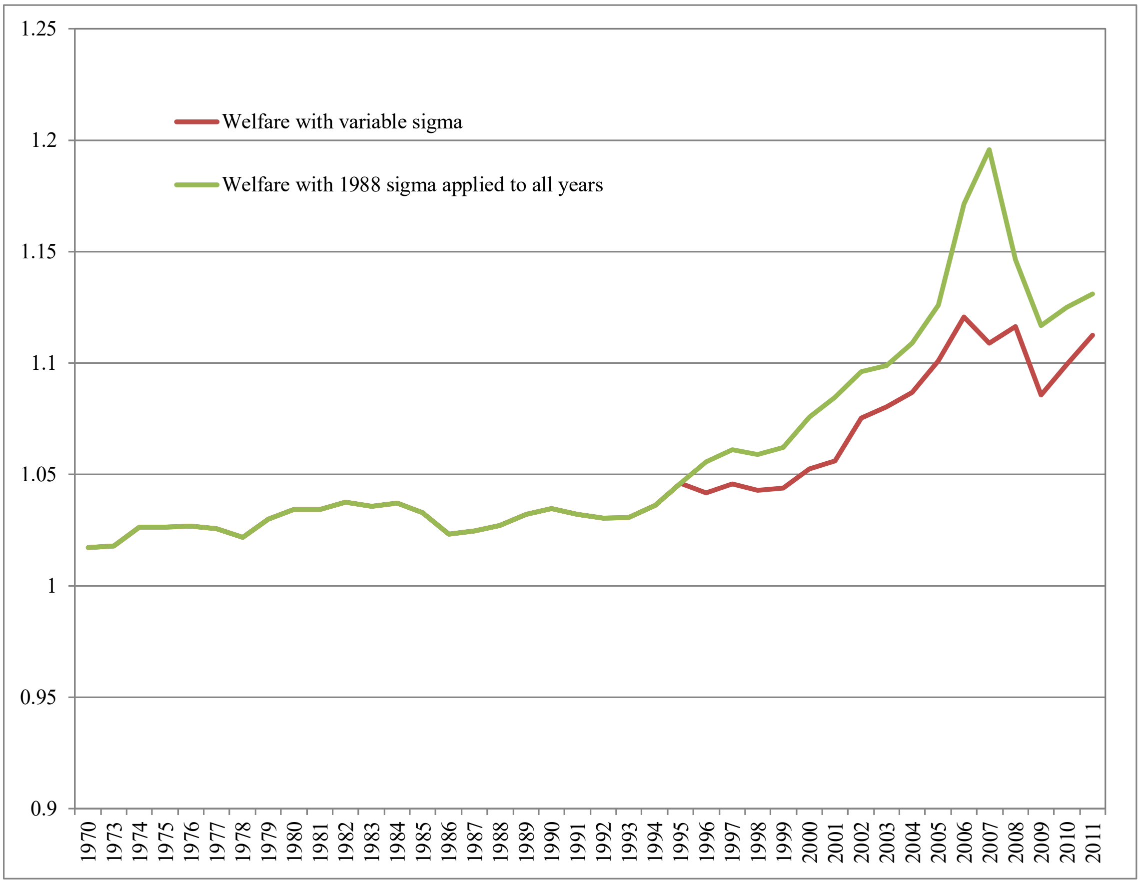
Figure 1. For the welfare gains computation, σ for HS07 is used for the years of 2007-2011, σ for HS02 is used for the years of 2002-2006, σ for HS96 is used for 1996-2001, σ for HS88 is used for the years of 1970-1995. The red line shows the welfare gains vis-à-vis the autarky situation. We can observe a gradual increase of welfare gains throughout the whole period, but especially a remarkable rise from the 1990s. As mentioned above, unlike the previous literature, we have estimated the elasticities of substitution for various periods. To see if this is important, we have computed the welfare gains using the HS88 elasticities of substitution for the whole period, shown by the green line. As the red line case (with variable sigma) uses HS88 for 1970-1995, the red and green lines are identical for that period. However, from 1996 there is clear difference between the two. In fact, more precisely measured welfare gains (red line) are slightly lower than that of a fixed (HS 88) sigma. The welfare gains are about 10 percent at the end of the whole period. This figure is much higher than 0.7-1.4 percent shown by Arkolakis et al. (2012) as the welfare gains from trade for the United States, but lower than 21.4 percent shown by Ossa (2015) as Japan's gains from trade. The remarkable welfare gains from the 1990s might have been caused by an increase of intermediate goods imports through deepening supply-chain, which gained pace especially in the 1990s. Figure 2 shows a supportive evidence for such hypothesis, at least partially. It shows the shares of imports of different types of goods for 1980-2012. The shares of Parts and Components increased from the 1990s. As explained in the Section 2, particularly by the equation (2), the more dependent the production is on the intermediate inputs, which is equivalent to a smaller value-added share, the higher the impact of imports on welfare gains. To check this, we have computed the weighted value-added ratio for 1970-2011, as shown in Figure 3. There is no downward tendency of value-added ratio. Thus, a change of the value-added ratio is not a part of the underlying causes. As mentioned in the introduction, we follow the methodology proposed by Ossa (2015), which essentially incorporates the input-output structure into

the welfare gain computation proposed by Arkolakis et al. (2012). Ossa (2015) shows that the estimated welfare gain is much higher if the input-output structure is taken into consideration. This also applies to our case. We have computed the estimated welfare gains following both Arkolakis et al. (2012) and Ossa (2015). As Figure 4 shows, the estimated welfare gain of Japan is much higher in the case of Ossa (2015).

5. Concluding remarks

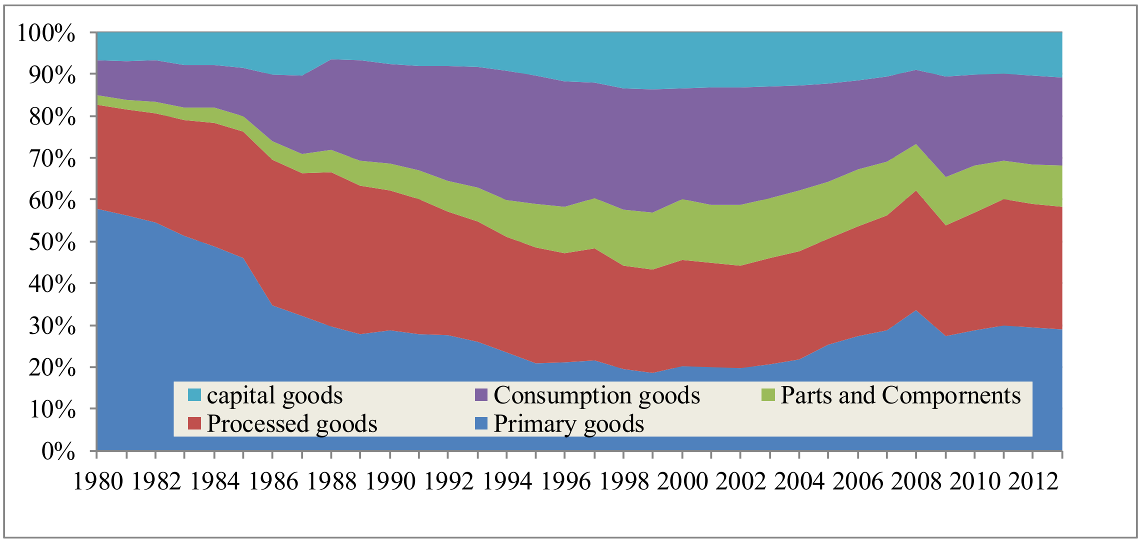
Japan's welfare gains from trade liberalisation is empirically studied, the first such attempt for the case of Japan using Japanese data, following the methodologies proposed by Arkolakis et al. (2012) and Ossa (2015). To measure the welfare gains from trade liberalisation as precisely as possible, the elasticities of substitution for HS 9-digit product code are estimated for various periods of time. The analyses show that Japan's welfare gains from trade liberalisation took place especially from the 1990s, and reached eleven percent vis-à-vis the autarky situation.

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



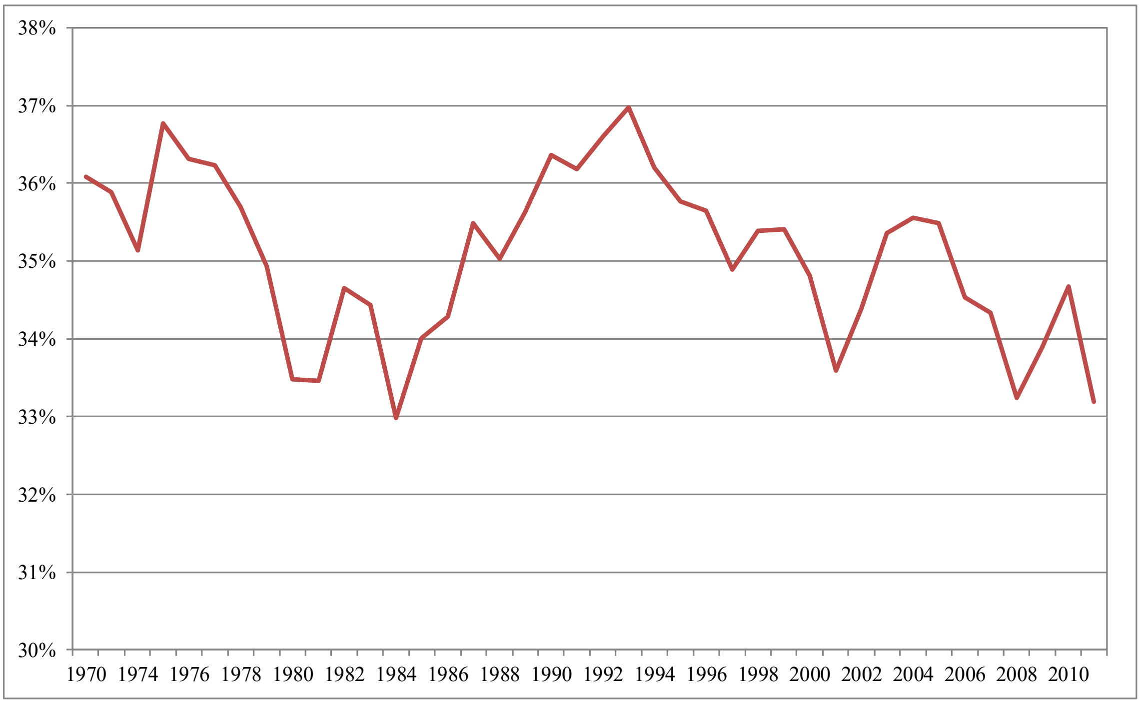
Source: Authors' computation

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



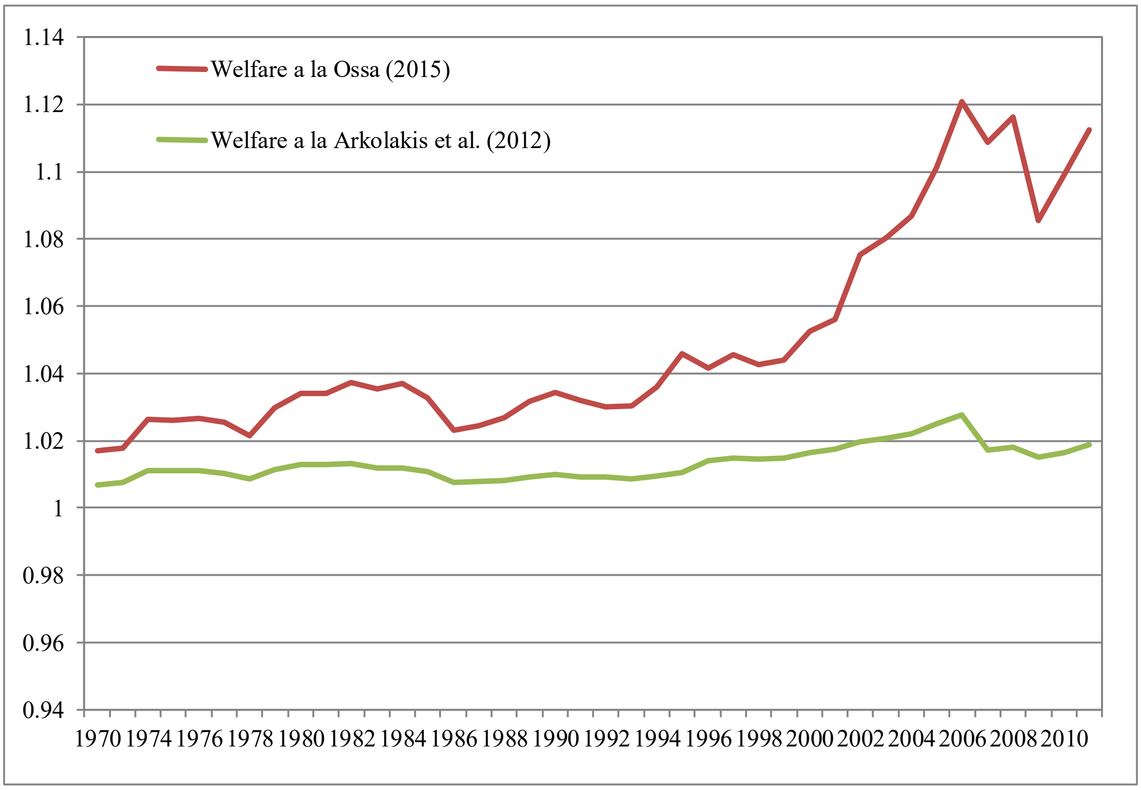
Source: Authors' computation from RIETI-TID database

Figure 3: Value-added share in 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

Appendix B. Estimated elasticities of substitution

JIP code	1988	1996	2002	2007
7	10.02	29.84	10.91	14.63
8	12.24	8.10	5.18	30.30
9	8.89	4.17	41.04	163.52
10	6.09	5.14	2.55	2.00
11	6.65	9.42	7.53	13.36
12	12.35	2.06	3.87	2.03
13	2.71	3.27	2.72	2.27
14	2.85	1.61	1.53	2.11
15	42.84	6.26	4.15	4.10
16	5.15	3.29	1.89	6.94
17	3.19	2.51	2.04	4.28
18	6.84	12.08	5.02	30.94
19	4.08	2.36	2.90	21.99
20	32.10	10.71	3.91	2.27
21	2.23	6.60	3.70	5.63
22	4.40	4.14	2.47	3.85
23	4.63	2.43	7.33	5.30
24	4.31	3.99	5.52	3.83
25	2.00	9.03	3.88	1.77
26	5.17	3.57	4.63	5.15
27	2.98	7.52	11.26	4.46
28	3.54	5.80	3.60	7.25
29	3.30	15.80	5.37	3.60
30	7.92	1.84	2.12	2.68
31	2.46	5.68	3.38	17.49
32	2.29	2.22	5.48	3.90
33	12.11	3.18	1.76	19.48
34	1.95	2.32	4.80	3.69
35	2.93	3.23	2.88	2.13
36	14.05	9.11	32.86	3.24
37	2.66	5.85	3.42	3.17
38	20.67	12.88	20.72	7.48
39	5.73	5.90	2.38	4.20
40	2.78	8.07	1.80	2.56
41	2.69	6.48	3.11	2.38
42	4.13	5.06	2.56	3.75
43	6.66	3.49	8.01	3.38
44	2.45	3.32	2.35	1.79
45	5.83	2.08	7.32	6.22
46	3.25	3.83	2.26	3.71
47	3.72	2.75	3.50	2.54
48	2.31	3.29	2.48	2.51
49	3.60	2.63	2.13	3.10
50	3.58	2.57	3.41	9.60
51	1.21	4.99	3.00	7.94
52	2.09	3.26	81.15	3.25
53	4.35	2.34	16.75	2.53
54	2.54	2.52	2.47	11.40
55	3.76	3.49	7.20	11.54
56	3.44	18.52	2.64	6.75
57	6.91	3.73	3.65	5.43
58	2.77	2.74	2.53	232.78
59	4.99	4.12	10.27	4.26