RIETI Discussion Paper Series 17-E-042

Factor Decomposition of Japan's Trade Balance

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The Research Institute of Economy, Trade and Industry
http://www.rieti.go.jp/en/

RIETI Discussion Paper Series 17-E-042

March 2017

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Abstract

Hit by the global financial crisis and a great earthquake followed by a tsunami, Japan's trade balance has turned to deficit, ending its 26 years of trade surplus. However, it is puzzling that its trade balance has remained long in deficit even during the sharp depreciation of the yen beginning at the end of 2012. We construct several alternative indices for price and quantity, decomposed at the country and industry level, for Japanese exports and imports between 1988 and 2014. Income elasticity, price elasticity, and pass-through elasticity are estimated at the country and industry disaggregated levels. The estimated results support that Japanese trade experienced a structural change both in income and exchange rate pass-through elasticity. After the crisis, exports became more unresponsive to exchange rate fluctuations, whereas import prices rose more proportionately with the depreciation of the yen and income elasticity of imports rose sharply. The difference in income elasticity between Japan and the rest of world is reminiscent of the Houthakker-Magee effect and suggests that the trade balance of Japan is likely to deteriorate. The decomposition of Japanese trade reveals that almost every element shifted, resulting in the deterioration of the external balance.

Keywords: Exchange rate pass-through, Great trade collapse, Income elasticity, International trade, Trade balance

JEL classification codes: F14, F32, E31

* This study is conducted as a part of the "Exchange Rate and International Currency (ERIC)" project undertaken at the Research Institute of Economy, Trade and Industry (RIETI). We thank Shugo Yamamoto and participants at the RIETI ERIC meeting for their comments on presentation of the earlier version of this paper. Both authors acknowledge financial support from KAKENHI 15K03557. Yoshida also acknowledges financial support from KAKENHI C26380295. +Yuri Sasaki, 1-2-37, Shiroganedai, Minato-ku, Tokyo, 108-8636 Japan. e-mail (yurissk@eco.meijigakuin.ac.jp). ++Yushi Yoshida (corresponding author), 1-1-1, Banba, Hikone, Shiga, 522-8522 Japan. e-mail (yushi.yoshida@biwako.shiga-u.ac.jp).

1. Introduction

Originating in the US housing market, financial turmoil rippled through the rest of the world, in particular affecting the Euro zone. The central banks responded to the global financial crisis with an unprecedented degree of monetary expansion, including the quantitative easing pursed by the Federal Reserve Board and capital injection to failing financial institutions by the European Central Bank. As an unintended result, the Japanese yen appreciated to the historical high of 75.55 yen per US dollar in October 2011 since the introduction of the Bretton Woods System. Japan's trade balance turned to deficit partly due to the weakened price competitiveness of Japanese exporters in the world market. Unfortunately, at the same time, Japan increased its degree of reliance on petroleum imports, reflecting a drastic shift from nuclear power plants (Figure A1 in Appendix A).

The momentum of the Japanese yen reversed when the new ruling party formulated Abenomics at the end of 2012. The Japanese yen depreciated to 100 yen per US dollar in 2013 and experienced another hike to 120 yen per US dollar at the end of 2014. However, the trade balance mostly remained in deficit between 2011 and 2015[1]. Numerous explanations are given for this ineffective depreciation channel to trade balance (Shimizu and Sato, 2015; Nawada, 2014; Koizumi, Morikawa, and Takahashi, 2014; Noguchi, 2015; Toma, Sato, and Nagauchi, 2013). Some indicate the existence of the ratchet effect, which was caused by Japanese multinationals accelerating their relocation of production facilities overseas under the appreciated Japanese yen during the global financial crisis, but then the increased overseas production ratio remained high after the Japanese yen depreciated recently. Another group argues that the combination of oil price hikes and the depreciation of the Japanese yen increased the amount of imports. A minor but subtle issue is that the effects of the denomination currency may affect the trade statistics.

In this paper, we follow Haddad, Harrison, and Hausman (2010) and Gopinath, Itskhoki, and Neiman (2012), who investigate the causes of the Great Trade Collapse by breaking up the international trade of the US into price and quantity components. We decompose Japanese trade into price and quantity components for the level of disaggregation at country-industry pairs. The price and quantity indices need to be constructed for this study because these indices at this level of disaggregation are not available. As the original data source from the Customs Office of Japan, the Ministry of Finance undergoes occasional changes in both codes and units. We suggest several alternative price (and implicit quantity) indices to circumvent the problems of code

[1] The estimated report from Japan Customs in January 2016 documents the monthly trade balance turned to surplus in March and October 2015.

changes and unit changes in the sample period[2].

After constructing appropriate price and quantity indices disaggregated at the country-industry level, we estimate exchange rate pass-through (ERPT, henceforth) elasticity, price elasticity, and income elasticity in the manner of Houthakker and Magee (1969). By splitting the entire sample between 1988 and 2014 into pre-crisis and post-crisis sub-periods, we find strong evidence that Japanese exports and imports experienced a structural change in ERPT and income elasticity. More precisely, we find that both exports and imports become more responsive to income changes in the post-crisis period. This is consistent with the well-documented puzzle of the Great Trade Collapse in which global international trade deteriorated to a much greater degree in comparison to the decline in global income. On top of that, the shifts in ERPT elasticities are asymmetric between exports and imports. The prices of exports have become more unresponsive to a change in exchange rate, whereas the prices of imports have become more sensitive to exchange rate fluctuations. Overall, the shifts in ERPT elasticities and income elasticities for both exports and imports all have converged to induce the Japanese trade balance to deteriorate. Moreover, the difference in income elasticity between Japan and the rest of the world has caused the Houthakker-Magee asymmetry effect, which implies that balanced growth among all countries in the world has led to the trade balance deterioration.

The structure of the rest of this paper is as follows. The next section reviews the literature on trade balance adjustment with respect to exchange rate changes and provides possible causes for the recent global trade collapse. Section 3 shows how our dataset is constructed from Japanese customs data. Section 4 examines behaviors of values, prices, and quantities of Japanese exports and imports. Section 5 describes our methodology to estimate income elasticity and exchange rate pass-through after disintegrating the trade balance into industries and partner countries. Sections 6 and 7 show the estimated results for income elasticity and exchange rate pass-through, respectively, for exports and imports. Section 8 examines the robustness of the results, and the last section concludes.

2. Great Trade Collapse and afterward

At the wake of the global financial crisis, world trade experienced a disproportionate fall (in comparison to the preceding periods) with respect to the decline in the world income and production[3]. The so-called 'Great Trade Collapse' in

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[2] The database constructed in this study will be made publicly available on the website of the Research Institute of Economy, Trade, and Industry (RIETI).

[3] We cite two figures in the literature. "Real world trade fell by approximately 15 percent between 2008:Q1 and 2009:Q1, exceeding the fall in real world GDP by a factor of roughly four." (Bems, Johnson, and Yi, 2010, p. 296) "During these quarters (*from 2008:Q3 to 2009:Q2*) global manufacturing production fell by 13 percent while global

international trade has been examined by numerous studies that attempt to find explanations for this unprecedented decline (Ahn, Amiti, and Weinstein, 2011; Alessandria, Kaboski, and Midrigan (2011); Amiti and Weinstein, 2011; Bems, Johnson, and Yi, 2011; Bussière et al., 2013; and a series of papers in the 2010 December issue of the IMF Economic Review). Bems, Johnson, and Yi (2011) argue that demand spillovers arising from intermediate trade in the global value chain have reinforced the link between demand and international trade. According to their estimates, 70 percent of the trade collapse can be attributed to the demand force alone. Alessandria, Kaboski, and Midrigan (2011) note that inventory adjustment played a crucial role in a sharp drop of automobile imports to the United States during the Great Trade Collapse. By reducing the level of inventory of foreign automobiles, sales in the US market did not drop proportionately to the sharp decline in the importation of foreign automobiles.

Amiti and Weinstein (2011) investigated whether the tightening of trade finance during the global financial crisis caused additional decline in international trade. Amiti and Weinstein (2011) find that exports of Japanese manufactures declined if their most associated bank's market-to-book value fell. Following Amiti and Weinstein's (2011) emphasis on the link between trade finance and trade flows, Ahn, Amiti, and Weinstein (2011) turned to transportation modes of international trade, i.e., by air, land, or sea. Trade finance has become more costly for trade, which takes a long time for transportation. In the case of the United States, international trade by sea transportation takes a longer time than by air or land. Ahn, Amiti, and Weinstein (2011) confirmed that prices of sea-borne traded goods were relatively higher than those of air or land-borne goods during the crisis period.

Gopinath, Itskhoki, and Neiman (2012) point to the fact that neither prices of total exports nor total imports fell significantly during the Great Trade Collapse. By breaking down trade products into differentiated and non-differentiated products, they find a sharp contrast in price changes between differentiated and non-differentiated products. The prices of differentiated products remained relatively stable, whereas the rate of decline in the prices of non-differentiated products matches that of the decline in trade values. The difference in price behaviors of differentiated and non-differentiated products is also noted by Haddad, Harrison, and Hausman (2010). Moreover, they decompose imports of Brazil, the European Union, Indonesia, and the US into extensive margins and intensive margins of trade and found that adjustment through extensive margins was greater during the Great Trade Collapse.

The decline in Japan's trade was as severe as that of the rest of the world while financial institutions were hit less severely, as was the case of those in the US and in

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trade in manufactures declined by an even larger 20 percent." (Eaton, Kortum, Neiman, and Romalis, 2016, p. 3407, italics added by the author.)

European countries. The other external factors for Japanese trade are the prolonged appreciation of the Japanese yen from 2007 to 2012, as shown in Figure A1, and the Great East Japan Earthquake in 2011. These detrimental factors contributed to delaying the recovery of Japanese exports while a higher reliance on external energy resources increased Japanese imports. Thus, the trade balance of Japan turned to deficit in 2011.

Led partly by the market expectation of more drastic measures pursued by the new governor of the Bank of Japan under the new prime minster Abe, the Japanese yen started to depreciate at the end of 2012. The Japanese yen depreciated approximately 50 percent from 2012 to 2015. The persistent deficit of the Japanese trade balance during this period despite the great magnitude of currency depreciation questioned the validity of the rebalancing mechanism of the terms of trade.

However, the unresponsiveness or even worsening of the trade balance with respect to the current depreciation of the national currency is not a new issue in international macroeconomics. This phenomenon is as well documented as the J-curve. Magee (1973) argues that prices of traded goods do not fully respond to exchange rate fluctuations because of the contract period and incomplete pass-through. Extending this earlier research, Backus, Kehoe, and Kydland (1994) account for the asymmetric pattern of cross-correlation, coined as the S-curve, between the trade balance and the terms of trade. The S-curve indicates that the (two to four quarters) past deterioration of the terms of trade is associated with an improvement in the trade balance, but the current or future deterioration of the terms of trade affects the trade balance in the opposite direction.

3. Construction of Price and Quantity Indices

The Ministry of Finance (MOF) constructs price and quantity indices of Japanese trade, and these are made available publicly. These indices are constructed relative to a base year. Indices relative to a base year can be constructed in two ways. The Laspeyres method uses the value of a base year as a weight whereas the Paasche method uses the value of the current period as a weight. Both methods are used by the MOF. The selection of traded products comprises the following three basic rules: 1) include those HS 9-digit categories with their share exceeding 0.001% in the base year; 2) include those HS 9-digit categories that have made an actual trade transaction at least 32 months of a three-year period, including during the base year in the middle; and 3) exclude 'basket products'. The MOF provide indices at the HS 2-digit level (97 industries) for the world. For the individual country level, they provide indices only for 10 aggregated sectors for China and the US. It is therefore imperative to construct appropriate price and quantity indices for Japan's trading partners at the more disaggregate industry level before we begin the empirical investigation of the Japanese trade balance.

3-1. Data Source

The GDP at the current PPP is obtained from the World Development Indicators, the World Bank. Bilateral exchange rates are obtained from International Financial Statistics, IMF. Exchange rates between partner countries and Japan are calculated by dividing the Japanese yen per US dollar by local currency per US dollar. Japanese trade data are obtained from Japan Customs, Ministry of Finance. The HS 2-digit codes are listed with a brief description in Appendix Table B1.

3-2. Japanese Trade Data

Japan Customs, Ministry of Finance, provides detailed international trade data with HS (Harmonized System) 9-digit codes. At the most aggregate level (2-digit codes), the number of industries is 97. For more disaggregate levels with 4-digit (6-digit) codes, the number of industries/products is approximately 1,200 (6,000). The international standard is only up to the 6-digit code, and the last 3 digits are only applicable to Japan. Only at the 9-digit code level are the value and quantity of exports (imports) available for each destination (source) country. By dividing value by quantity, we can also obtain the 'unit value' price, $P_{c,i,t}^{HS-9}$ for HS 9-digit commodity *i*, for partner country *c* and for time *t*.

$$P_{c,i,t}^{HS-9} = \frac{value_{c,i,t}}{quantity_{c,i,t}} \qquad (1)$$

We exclusively use subscript *i* for HS 9-digit products, so superscript 'HS-9' is not really necessary; however, we sometimes use it for clarity. Prices at more aggregate levels are defined as value weighted averages. For example, the price at HS 6-digit level *j* is denoted as $P_{c,j,t}^{HS-6}$. A detailed description for constructing the price and quantity indices is given in the following subsection.

3-3. Price and Quantity indices

Using price indices at the HS 9-digit level, we can also construct a more aggregated price index. The price index at HS 2-digit industry *k* for country *c* and time *t* is defined as follows. It is important for the reasons explained in the following section that we should explicitly indicate the set (or universe) of commodities by Ω_t^w where w denotes alternative definitions for the universe of commodities included in calculating indices.

$$P_{c,k,t}^{HS-2}(\Omega_t^w) = \sum_{i \in k} \left(\frac{value_{c,i,t}}{\sum_{i \in k} value_{c,i,t}} \right) \left(P_{c,i,,t}^{HS-9} \right), \text{ for any i} \in \Omega_t^w \tag{2}$$

We define quantity as an implicit index so that price times quantity is equal to value.

$$Q_{c,k,t}^{HS-2}(\Omega_t^w) \equiv \frac{value_{c,k,t}(\Omega_t^w)}{P_{c,k,t}^{HS-2}(\Omega_t^w)} \tag{3}$$

We obtain these indices for each industry (k) and destination country (c) pair.

All price and quantity indices are normalized by the previous year index and are transformed into logarithmic form when they are used in estimation equations. Therefore, prices and quantities with tilde are defined as follows.

$$\tilde{P}_{c,k,t}^{EX}(\Omega_t^w) = \ln \left(\frac{P_{c,k,t}^{EX}(\Omega_t^w)}{P_{c,k,t-1}^{EX}(\Omega_{t-1}^w)} \right) = \ln(P_{c,k,t}^{EX}(\Omega_t^w)) - \ln(P_{c,k,t-1}^{EX}(\Omega_{t-1}^w)) \tag{4}$$

$$\tilde{Q}_{c,k,t}^{EX}(\Omega_t^w) = \ln \left(\frac{Q_{c,k,t}^{EX}(\Omega_t^w)}{Q_{c,k,t-1}^{EX}(\Omega_{t-1}^w)} \right) = \ln(Q_{c,k,t}^{EX}(\Omega_t^w)) - \ln(Q_{c,k,t-1}^{EX}(\Omega_{t-1}^w)) \tag{5}$$

3-4. Alternative measures to overcome the problems with changes in codes and units

The price index constructed by using all HS 9-digit level products show an abnormal level of jumps in a few years. By carefully examining the original Customs Office dataset, a few severe problems are detected. First, some HS 9-digit codes stop being used and other HS 9-digit codes enter as new codes in the middle of the sample period. For many occasions, a new code replaces an old (dead) code with an only slight change in the product definition. This by itself does not cause a problem if both the old code and the new code use the same unit of measurement. However, the effect of change in codes is severe if a change in unit of measurement is accompanied. Second, the unit of measurement is sometimes replaced by an alternative unit of measurement for the continuing code. For example, a change of unit of measurement from kilograms to metric tons inflates a unit price by an order of 1,000-fold.

To ameliorate the effect of unit and code changes on price indices, we took two approaches. For a simple scale problem, we converted GT (gross tons), KL (kiloliters), MT (metric tons), or TH (thousands) into 1,000 kilograms, 1,000 liters, 1,000 kilograms, and 1,000 units, respectively, regardless of a change in code or unit of measurement. For a more complicated problem regarding code changes, we excluded those products that experience a change in codes. The exact definitions of these price indices are presented in Appendix C. Among the ALL, MOD, PARTC, WHOLEC, and NP indices, we have chosen the NP indices because of their balance between minimizing the number of products excluded and avoiding the unit change problem.

The NP indices are constructed by restricting the set of commodities that are consistently available in the consecutive years. Here, 'consistently' refers to the existence of codes and no change in the unit of measurement in two consecutive years for that code. In this manner, two price indices, over alternative sets, are constructed for each year. Indices based on NEXT sets are based on the set of commodities that are consistently available both for current and subsequent years, whereas PREV indices are based on the set of commodities that are available for previous and current years. In terms of equation (4), the commodity set in the first term is PREV in current year, Ω_t^{PREV}, and the set in the second term is NEXT in previous year, Ω_{t-1}^{NEXT}. These two sets are equal, i.e., $\Omega_t^{PREV} = \Omega_{t-1}^{NEXT}$. It is noteworthy that PREV and NEXT in the same year are not necessarily equal, i.e., $\Omega_t^{PREV} \neq \Omega_t^{NEXT}$. The NP index for export price is therefore constructed as shown in equation (6).

$$\tilde{P}_{c,k,t}^{EX}(\Omega_t^{PREV},\Omega_{t-1}^{NEXT}) = \ln\left(\frac{P_{c,k,t}^{EX}(\Omega_t^{PREV})}{P_{c,k,t-1}^{EX}(\Omega_{t-1}^{NEXT})}\right) = \ln(P_{c,k,t}^{EX}(\Omega_t^{PREV})) - \ln(P_{c,k,t-1}^{EX}(\Omega_{t-1}^{NEXT})) \quad (6)$$

Figure 1 shows the values of total exports and imports by alternative definitions. Because of its very strict method of excluding the products, the WHOLEC index is about half the size of the values of other indices[4]. Still, all indices show a similar pattern of fluctuations. Similarly, Figure 2 shows the prices of total exports and imports by alternative definitions. For both exports and imports, only a slight difference is observed among the ALL, PARTC, and MOD price indices. It is remarkable that the average prices of these imported products constituting the WHOLEC price index show only a small decrease over 27 years. In contrast, by looking at the price changes of the same import categories for two consecutive years, the NP price index shows a substantial rise over the same period. On the export side, the overall shapes of price movements are similar among all indices.

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[4] By definition, the product coverage of ALL and MOD is 100%. The product coverage of PARTC, WHOLEC, PREV, and NEXT for exports (imports) is 96.5 (97.1)%, 53.1 (49.7)%, 97.3 (96.6)%, and 97.9 (97.2)%, respectively, in terms of values during the total 27 years.

4. The Behavior of Export and Import Values, Prices, and Implicit Quantities

Figure 3 shows the value, price, and implicit quantity indices of Japanese exports and imports based on NP measures. Both exports and imports fell in value (solid lines) dramatically in 2009 as the world economy turned into a recession because of financial turmoil in the U.S. Japanese exports fell again in 2011 and 2012 because of the March 2011 earthquake and tsunami disaster; however, Japanese imports rose steadily to a level higher than in the pre-crisis level. The unprecedented large drop in world trade in 2009 is termed as the Great Trade Collapse and has been extensively investigated.

Gopinath, Itskhoki, and Neiman (2012) constructed price indices of US exports and imports and examined to what degree the price decline contributed to the drop in the value of US trade. By decomposing traded products into differentiated and non-differentiated product categories (and also by durables and non-durables), Gopinath et al. (2012) show that the sharp drops in 2009 trade was partly caused by a large fall in non-differentiated products. This is in sharp contrast to no declines observed in the prices of differentiated products in US imports and exports.

The price indices in Figure 3 reveal that for Japanese trade in 2009, a decline in import prices (longer broken line) was also substantial. Further investigation into which groups of imported products contributed to the fall in the overall import price index is necessary, as was performed in Gopinath et al. (2012). At this point, however, the price factor was seemingly the major cause of the trade collapse in Japanese imports. In contrast, the Japanese export price index actually increased slightly. As a result, the quantity of Japanese export should have fallen more than the value of exports. This result is in fact consistent with the findings by Alessandria, Kaboski, and Midrigan (2011), which discussed how US automobile imports in 2009 were mostly adjusted by reducing the inventories of US dealers. Their results imply that the Japanese automobile exporters on the other side must have reduced the number of automobile exports in 2009.

What is also puzzling with Japanese trade is that the trade deficit persisted in 2013 and 2014 despite the 50 percent depreciation of the Japanese yen since the introduction of the qualitative and quantitative easing in 2013 was targeted to two percent inflation. We continue to search for some explanations by further investigating value, price, and implicit quantity indices of exports and imports at the HS 2-digit industry level. This research strategy is in accord with Eaton, Kortum, Neiman, and Romalis (2016), who find the durable sector to be the major factor causing an unproportioned decline in trade by classifying HS 2-digit industries into durables and non-durables. A common theme in this paper and theirs is that aggregation (or disaggregation) at the HS 2-digit level can detect the difference in the price and quantity behaviors caused by industry characteristics.

Exports at HS 2-digit industry level

In this subsection, we use the price indices aggregated at the HS 2-digit industry level, and we focus on the industries with the largest trade values in the sample years. The largest (by far in comparison to others) export industries are HS 84 (machinery and mechanical appliances), HS 85 (electrical machinery equipment), and HS 87 (vehicles). Their shares in the overall exports of Japan are 21%, 20%, and 21%, respectively. The following largest sectors are HS 29 (organic chemicals) with 3%, HS 39 (plastics) with 3%, HS 72 (iron and steel) with 4%, and HS 90 (optical and precision) with 6%.

Figure 4 (a) shows that the value of HS 29 (organic chemicals) had been steadily increasing up to a year before the global financial crisis erupted in 2008. A slight recovery in 2010 and 2011 was wiped out by another fall in the value of exports caused by a natural disaster in 2012. (Note that we deliberately removed 2003 price and quantity indices due to their extreme figures; therefore, they were re-set to equal 100 in 2004 again.) It is noteworthy that the average price of organic chemicals actually increased in 2009. Combined with the fact that the value in 2009 decreased, the implicit quantity dramatically dropped mid-crisis. The implicit quantity indices of organic chemicals were decreasing well before the global financial crisis. Figures 4 (b) through (f) similarly show values, prices, and quantities for major export industries.

Imports in the HS 2-digit industry

The industry with the largest trade share is HS 27 (mineral fuels and oils) with a 25.7% share, which is followed by HS 85 (electrical machinery equipment) with 10.7%; HS84 (machinery and mechanical appliances) with 8.5%; HS 26 (ores, slag and ash) and HS 90 (optical and precision), both with 3.2%; and HS 3 (fish), HS 44 (wood), and HS 87 (vehicles) with 2.7%. Similar to export industries, Figures 5 (a) through (c) show values, prices, and quantities for major import industries. It is noteworthy that the import values of HS 27 (mineral fuels and oils) peaked in 2008, and after the collapse in 2009, these values returned to the levels of 2008 only recently in 2013 and 2014. However, by considering the price and quantity components, it reveals that the import quantity has remained low since 2006; however, the price of oil imports nearly doubled those of 2008.

5. Methodology

Instead of using the total trade values in previous studies, we decompose trade values into price components and quantity components. Moreover, we disaggregate total trade into country and sector components. We construct the database from the most disaggregate trade data reported at the customs level, and we show our dataset has some advantage over the publicly available trade indices provided by the Ministry of Finance or the Bank of Japan. With this dataset, we estimate the price and income elasticity of the demand and exchange rate pass-through elasticity[5].

5-1. Trade Balance Decomposition

Trade balance is a macroeconomic concept that captures the difference between aggregate export value and aggregate import value. We define trade balance as follows: aggregate exports and imports are the sum of industry exports and imports in equation (7).

$$TB = EX - IM = \sum_{k \in K} EX_k - \sum_{k \in K} IM_k \, , \tag{7}$$

where EX_k and IM_k are the export value and import value of industry k and K is the total number of industries. Then, we decompose the value of industry exports (imports) into price components and quantity components so that multiplication of price and quantity equals export (import) value. For industry k, export value is decomposed as shown in equation (8).

$$EX_k = P_k^{EX}(s) \cdot Q_k^{EX}(P_k^{EX}, Y^*) \tag{8}$$

In equation (8), the price index is shown as a function of the exchange rate, s, and the quantity index as a demand function is the function of the price index and foreign income, Y^*. Note that the exchange rate is defined as the value of one unit of foreign currency in terms of the domestic currency, so an increase in s indicates depreciation. Using equation (8) for exports and a similar equation for imports (IM_k), the trade balance can be shown as in equation (9).

$$TB(s, P_1^{EX}, .., P_K^{EX}, P_1^{IM}, .., P_K^{IM}, Y, Y^*) = \sum_{k \in K} P_k^{EX}(s) \cdot Q_k^{EX}(P_k^{EX}, Y^*) - \sum_{k \in K} P_k^{IM}(s) \cdot Q_k^{IM}(P_k^{IM}, Y) \tag{9}$$

In total, differentiating the trade balance in equation (9) and rearranging the terms gives equation (10).

$$dTB = \sum_{k \in K} \left(Q_k^{EX} + P_k^{EX} \frac{\partial Q_k^{EX}}{\partial P_k^{EX}} \right) \frac{\partial P_k^{EX}}{\partial s} ds + \sum_{k \in K} \left(P_k^{EX} \right) \frac{\partial Q_k^{EX}}{\partial Y^*} dY^* - \sum_{k \in K} \left(Q_k^{IM} + P_k^{IM} \frac{\partial Q_k^{IM}}{\partial P_k^{IM}} \right) \frac{\partial P_k^{IM}}{\partial s} ds + \sum_{k \in K} \left(P_k^{IM} \right) \frac{\partial Q_k^{IM}}{\partial Y} dY \tag{10}$$

From equation (10), a change in the trade balance is decomposed into four parts. The first and third summation terms are the price effect and exchange rate pass-through channel,

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5 As an exchange rate pass-through study for Japan, we follow Ueda and Sasaki (1998), Takagi and Yoshida (2001), Yoshida (2010), and Sasaki and Yoshida (2015).

and the second and fourth summation terms are the income effect. Equation (10) can also be represented in an elasticity form, as shown in equation (11)

$$dTB = \sum_{k\in K} \frac{EX_k}{s}(1+e_k^{EX,p})e_k^{EX,s}ds + \sum_{k\in K} \frac{EX_k}{Y^*}e_k^{EX,Y^*}dY^*$$
$$-\sum_{k\in K} \frac{IM_k}{s}(1+e_k^{IM,p})e_k^{IM,s}ds + \sum_{k\in K} \frac{IM_k}{Y}e_k^{IM,Y}dY \quad (11)$$

where *e* with superscripts *p*, *s*, and *Y**(*Y*) denotes price elasticity, ERPT elasticity, and foreign (domestic) income elasticity, respectively. World income declined sharply during the global financial crisis, so the second and fourth terms, independent of exchange rate movement, should have played a major role in the great trade collapse. To explain Japan's persistent trade deficit despite the depreciation of the Japanese yen, we focus on the first and third terms in this paper. Noting the term in the brackets is price elasticity, we estimate both the exchange rate pass-through and price elasticity at the sector level.

5-2. Aggregate Income and Price Elasticities and Pass-through Elasticity

For the estimation of demand elasticity, we regress the industry-level quantity index on the industry-level price index and the income level of the destination countries. Specifically, a demand equation for Japanese exports in industry *k* is modeled as equation (12): for a fixed industry k,

$$\tilde{Q}^{EX}_{c,k,t} = \alpha_0 + \alpha_1 \tilde{P}^{EX}_{c,k,t} + \alpha_2 Y_{c,t} + \lambda_c + \varepsilon_{c,k,t}, \quad (12)$$

where dependent variable, $\tilde{Q}^{EX}_{c,k,t}$, is the log difference of quantity index of Japanese exports aggregated at HS 2-digit level industry *k* and destination country *c*; $\tilde{P}^{EX}_{c,k,t}$ is the log difference of price index of Japanese exports; $Y_{c,t}$ is the log difference of income of destination country *c*; λ_c is a vector of destination country fixed effects; and $\varepsilon_{c,k,t}$ is the disturbance term. The expected sign of the price coefficient is $\alpha_1 < 0$. Note that $\alpha_2 > 0$ for a normal goods industry, but α_2 can be negative for an inferior goods industry.

Similarly, a price equation for Japanese exports in industry *k* is defined as equation (13): for a fixed industry k,

$$\tilde{P}^{EX}_{c,k,t} = \beta_0 + \beta_1 S_{c,t} + \lambda'_c + \eta_{c,k,t}, \quad (13)$$

where dependent variable, $\tilde{P}^{EX}_{c,k,t}$, is the log difference of the price index of Japanese exports aggregated at HS 2-digit level industry *k* and destination country *c*; $S_{c,t}$ is the log difference of nominal bilateral exchange rate of Japanese yen in terms of the currency of the destination country; $\lambda_c^{'}$ is a vector of destination country fixed effect; and $\eta_{c,k,t}$ is the disturbance term. The exchange rate pass-through elasticity is β_1; complete pass-through occurs when $\beta_1 = 0$, and zero pass-through occurs when $\beta_1 = 1$.

Demand and price equations for Japanese imports are similarly defined in equations (14) and (15): for a fixed industry k,

$$\tilde{Q}^{IM}_{c,k,t} = \alpha_0 + \alpha_1 \tilde{P}^{IM}_{c,k,t} + \alpha_2 Y_{JPN,t} + \lambda_c + \varepsilon_{c,k,t}, \quad (14)$$

$$\tilde{P}^{IM}_{c,k,t} = \beta_0 + \beta_1 S_{c,t} + \lambda_c^{'} + \eta_{c,k,t}, \quad (15)$$

Note that the interpretation of exchange rate pass-through coefficients are the opposite in the imports case. The exchange rate pass-through elasticity is called complete pass-through when $\beta_1 = 1$ and zero pass-through when $\beta_1 = 0$.

6. Evidence on Japanese Exports

We constructed the panel dataset for Japanese trade covering all pairs of countries and industries; however, we focus on the major trading partners of Japan to avoid too many zero trades. This should not cause too severe a bias of the empirical results because of the great shares fall on only a small number of countries. In the following regression results, partner countries are restricted to the 19 major trading countries, which are listed in Appendix D. These countries comprise 85% of the overall exports.

6-1. Exchange Rate Pass-Through Elasticity of HS 2-Digit Exports

As a preliminary investigation, we estimated equation (13) for Japanese exports at the HS 2-digit level without any control variables. The estimated results are shown in Table 1 and Figure 6. At this aggregation level, the majority of industries seem to follow complete pass-through behavior. First, the estimated coefficients are unreliable for 20 industries. For these industries, the estimated coefficients cannot be rejected for either complete or zero pass-through. By the one-sided test on ERPT elasticity, 62 (of 76 reliable estimates) industries reject the null hypothesis of zero pass-through (i.e., $H_0 : \beta = 1$) at the 5 percent significance level[6]. From 62 industries, of which complete pass-through is rejected for 11 industries, 51 industries cannot be rejected for complete pass-through.

From this broad perspective at the HS 2-digit industry level, the overall export

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[6] The two-sided tests at the 10 percent significance level in Table 1 correspond with the one-sided test at the 5 percent significance level. For example, the ERPT estimate of the HS-4 industry is 1.763 and is rejected for the two-sided test for $\beta = 1$. However, the estimate lies on the right-hand side of the null and cannot be rejected for the one-sided null of $H_0 : \beta >= 1$.

price in the destination markets has been more likely to respond closely with the fluctuations in Japanese yen. The Japanese yen appreciation after 2009 should have been inductive to reduce the value of Japanese exports. This is consistent with a huge drop in Japanese exports in 2009, as was true of the exports of many other countries. However, this result comes back to the puzzle of unresponsive Japanese exports to the depreciation of the Japanese yen in more recent years. For ERPT to be an important factor consistently for Japanese export movements, a reduction in ERPT elasticity after the post-crisis period must be observed. Of course, other factors in addition to exchange rate movements may have contributed to the recent slow growth in Japanese exports.

Notably, all these arguments are based on the presumption that price elasticity of foreign demand for Japanese exports is greater than unity. We will inquire later whether this assumption holds for most Japanese exports.

6-2. Export ERPT before and after the Global Financial Crisis

Equation (13) is estimated for the following two subsamples: the ‘pre-crisis’ period from 1988 to 2008 and the ‘post-crisis’ period from 2009 to 2014. Figure 7 shows the distributions of estimated ERPT elasticities for both subsamples. The post-crisis distribution has a fatter tail on the right side. For the range of ERPT elasticities over the 0.8-1.0 bin and beyond, more industries are observed in the post-crisis period than in the pre-crisis period. It is not a perfectly clear-cut case in which the entire distribution moves to the right, but the estimated result in Figure 7 provides strong supporting evidence for the reduction in the ERPT of Japanese exports in the post-crisis period. The formal statistical tests also agree with the reduction in ERPT in the post-crisis period. From statistical testing for the null hypothesis of complete pass-through, the null cannot be rejected for 45 (of 68 reliable estimates) industries in the pre-crisis period and 26 (of 56 reliable estimates) industries in the post-crisis period. From the statistical testing for the null hypothesis of zero pass-through, we also find that ERPT is smaller in the post-crisis sample. The null cannot be rejected for 10 industries in the pre-crisis subsample and 17 industries in the post-crisis subsample. The evidence that export prices respond less to the depreciation in the Japanese yen exchange rate movements between 2012 and 2015 can partly account for the slow growth of Japanese exports.

6-3. Income Elasticity of HS 2-Digit Exports

Table 2 shows the estimated income elasticity of Japanese exports. Figure 8 shows the corresponding distribution of income elasticity estimates. A total of 45 industries reject the null of no foreign income effect on Japanese exports at the five percent significance level of the two-sided test. The majority of income elasticities fall in the range that is greater than unity. Let us focus on the seven major export industries. For HS 29 (organic chemicals), HS 39 (plastics), HS 72 (iron and steel), and HS 84 (machinery and mechanical appliances), the null of unit income elasticity cannot be rejected at the statistical significance level of 5 percent. HS 85 (electrical machinery equipment) has income elasticity greater than unity with statistical significance. However, exports for HS 90 (optical and precision) are unresponsive to foreign income; their estimated income elasticities are not significantly different from zero. Surprisingly, for HS 87 (vehicles), income elasticity is negative with statistical significance. The solution to this seemingly puzzling result is provided in Alessandria et al. (2010). They find that inventory adjustments aggravated US imports after the financial shocks, particularly for US automobile imports.

6-4. Export Income Elasticity before and after the Global Financial Crisis

Income elasticities are re-estimated for two subsample periods before and after the global financial crisis. Figure 9 demonstrates the shift in income elasticities between pre-crisis and post-crisis periods. The distribution of income elasticities shifted to the right in the post-crisis period. On the right of income elasticity of 2, there are only a few industries in the pre-crisis period; however, over 50 industries fall in this range. The number of industries rejecting the null hypothesis of no income effect also increased from 28 industries in the pre-crisis period to 43 industries in the post-crisis period at the five percent significance level. This evidence suggests that the income effect on the export side, i.e., transmission channel from the post-crisis recovery of the rest of world to Japanese export growth, must have functioned effectively.

6-5. Export Price Elasticity

Price elasticities of exports for the entire sample are summarized in Figure 10. Point estimates are shown in Table 2. The estimates of price elasticities of each industry are negative and correct in the sign as expected, partly owing to the way quantity is constructed as implicit index to the price index. On top of that, all point estimates are greater than 0.5 in absolute terms. Combined with estimates of import price elasticities also being higher than 0.5 in absolute terms (as will be shown in section 7-5), the classical Marshall-Learner condition holds for all industries in Japan. That is, if ERPT is complete (or 100%), the trade balance should improve by the depreciation of the domestic currency.

For the subsamples, Figure 11 shows evidence of a small difference between the pre-crisis and the post-crisis periods. The empirical distribution of the post-crisis period is flatter, but it can be attributed to a larger variance due to the smaller number of observations.

7. Evidence on Japanese Imports

Now we turn to the import side of Japan's trade balance. The same methodologies as those in the previous section for exports will be applied to import data.

Notably, in the regressions for imports, partner countries are also restricted to the 19 major trading countries, which are listed in Appendix D. The US, European countries, and China appear as Japan's major trading partners for both exports and imports. For Japanese imports, oil-exporting countries in the Middle East are also included in the sample.

7-1. Exchange Rate Pass-Through Elasticity of HS 2-Digit Imports

On the import side, equation (15) is similarly estimated for all HS 2-digit industries. Table 3 provides ERPT elasticities along test statistics for zero pass-through (i.e., $\beta_1 = 0$) and complete pass-through (i.e., $\beta_1 = 1$). Figure 12 summarizes the results. On the import side, the ERPT elasticities for many industries are found at the lower end. Of 96 industries, the estimated ERPT elasticities for 15 industries are unreliable in a sense that the null of neither $\beta_1 = 0$ nor $\beta_1 = 1$ can be rejected at the 10 percent significance level. Among the remaining 81 industries, the null of zero pass-through cannot be rejected for 40 industries in comparison to 14 industries on the export side. However, the null of complete pass-through cannot be rejected for 17 (of 81 reliable estimates) industries. The ERPT elasticities for the remaining 24 industries fall between zero and one. The lower responsiveness of ERPT on the import side is consistent with the findings of Takagi and Yoshida (2001), who examined the ERPT of Japanese exports and imports with respect to Asian developing countries during the Asian financial crisis.

7-2. Import ERPT before and after the Global Financial Crisis

Figure 13 shows distributions of estimated ERPT elasticities for the pre-crisis (1988-2008) and post-crisis (2009-2014) periods. The figure clearly shows that the post-crisis distribution has a fatter tail on the right end, which, for imports, means greater ERPT. The formal statistical tests also agree with the increase in ERPT in the post-crisis period. From the statistical testing for the null hypothesis of complete pass-through, the null cannot be rejected for 28 industries in the pre-crisis period and 75 industries in the post-crisis period. From the statistical testing for the null hypothesis of zero pass-through, the null cannot be rejected for 64 industries in the pre-crisis period and 35 industries in the post-crisis period. Noting that for more industries in the post-crisis period that the import price movements corresponds with the exchange rate fluctuations, the sharp depreciation in the Japanese yen must have reflected a jump in the import price denominated in Japanese yen for these industries. This result is in contrast to the result for exports that the export ERPT has declined.

7-3. Income Elasticity of HS 2-Digit Imports

Table 4 shows the estimated income elasticity of Japanese imports. Figure 14 shows the corresponding distribution of income elasticity estimates. A total of 61 industries rejects the null of no income effect on Japanese imports at the five percent significance level of the two-sided test. The empirical distributions of income elasticities are in contrast with the exports and imports of Japan. The empirical distribution of income elasticity on imports is skewed to the right whereas the shape of distribution for exports is symmetrically centered on the value of one. The estimated income elasticities of major import industries, namely, HS 26 (ores, slag and ash), HS 84 (machinery and mechanical appliances), HS 85 (electrical machinery equipment), and HS 87 (vehicles), are well beyond unity and are statistically significant. The income elasticity of HS 3 (fish), HS 27 (mineral fuels and oils), HS 44 (wood), and HS 90 (optical and precision) are not statistically significant.

7-4. Import Income Elasticity before and after the Global Financial Crisis

Income elasticities for the two subsamples are estimated and summarized in Figure 15. Unlike other effects, there seems no obvious change in the middle range before and after the crisis. In terms of the income effect on Japanese imports, however, industries with the extreme values exceeding 4 almost doubled, from 24 industries to 50 industries. After the crisis, approximately half of all industries show high responsiveness of import demand to a change in Japanese income. If Japan grows at one percent per year, Japanese imports in half of all industries will grow four percent annually.

7-5. Import Price Elasticity

The estimates of import price elasticity are shown in Table 4 along with income elasticities. They are summarized as an empirical distribution in Figure 16. As discussed in subsection 6-5, import price elasticities are greater than 0.5 in absolute value for all industries. Like export price elasticities, import price elasticities show a small difference in the empirical distribution between the two subsamples. Owing to a smaller sample, estimates in the post-crisis period show a wider range and thus show a flatter shape of distribution in Figure 17.

8. Discussions and Robustness checks

Our focus on income elasticity of trade shares the views of Engel and Wang (2011); Borin, Di Nino, Mancini, and Sbracia (2016); and Constantinescu, Mattoo, and Ruta (2015). Engel and Wang (2011) emphasize the importance of including durable sectors in the theoretical model to explain the well-documented correlation between income and trade. Constantinescu et al. (2015) find that the relationship between world trade and world income has undergone a structural change in the past 40 years. In particular, they find that long-term income elasticity rose sharply in the 1990s and declined in the 2000s even before the global financial crisis. Borin et al. (2016) calculate the annual ratio of trade growth to income growth for 161 countries. The cross-country average is 2.1 for OECD countries and 4.6 for 161 countries. Their theoretical model, which is an extended version of Bems, Johnson, and Yi's model (2013), gives income elasticity a cyclical component that fluctuates positively with income. Our study complements these studies by showing how income elasticities differ around the mean among industries and finding structural changes in income as well as ERPT elasticities at the industry level.

The prime emphasis of empirical sections is on the shifts in ERPT and income elasticity in the post-crisis period. However, it is also important to compare the relative magnitude of income elasticities between exports and imports. We find that the income elasticities of Japanese imports are higher than those of exports. By relatively high income elasticity of imports with respect to lower income elasticity of exports, a balanced growth of income in the world has induced the external balance of Japan to deteriorate, reminiscent of the Houthakker-Magee asymmetry effect in 1960s on the US external balance, as discussed in Houthakker and Magee (1969). This result has a decimal implication to the Japanese economy that Japan, ceteris paribus, has to grow at a slower speed than the rest of the world in order to return to balanced trade.

In the empirical section, the sample is split into the pre-crisis and post-crisis periods, and we compare the difference in the elasticities of price, income and ERPT. For ERPT elasticities, sub-period empirical distributions show a shift toward incomplete pass-through in the post-crisis period for exports in Figure 7 and a shift toward complete pass-through for imports in Figure 9. Income elasticities become higher in both exports and imports as shown in Figures 13 and 15. However, formal statistical testing should be conducted to see whether structural break really occurred for Japan's international trade in the post-crisis period. The F-tests based on the comparison of sum of squared residuals of subsample periods are shown under "F". The t-tests based on the interaction dummy variable, which takes the value of one in the post-crisis periods, are shown under "D". For the export price equation, 7 (18) industries are found to undergo a structural change by F-test (t-test), as shown in Table 1. For the import price equation, 10 (23) industries experienced a structural change according to F-test (t-test). For the quantity equation, 26 (22) industries show a structural change in exports (imports) in Table 2 (4). Income elasticities shifted with statistical significance in 25 (21) industries in exports (imports). Price elasticities show a shift in 32 (10) industries in exports (imports). In terms of the statistical tests, we should not emphasize the structural change too much, as to it did not occur in all industries. However, it is also true that for the substantial part of industries, we confirmed a structural change in the post-crisis period by formal statistical tests.

The empirical distribution of elasticities shown in Figures 6 through 17 are unweighted. In an unweighted distribution, a small-value traded industry exerts the same effect as a heavily traded industry. This type of distribution may obscure the effect of a large industry, e.g., petroleum imports, on the shift of elasticities on the Japanese trade imbalance. In Appendix E, Figures E1 through E6 show the value-weighted empirical distribution of elasticities. The qualitative results remain intact, although the shape is greatly distorted by the great shares of a few industries.

9. Conclusions

In this paper, we focused on the possible shifts in income, price, and exchange rate elasticities of the Japanese trade balance; however, we do not deny other important channels of macroeconomic changes affecting the trade balance. The long-lasting current account deficit of the US spurred macroeconomists to investigate the factors causing this persistent imbalance. Lane and Milesi-Ferretti (2001) suggest output per-capita, demographic indicators and government debt as key factors. Among these three factors, Ferrero (2010) suggests that output per-capita growth is the most important for the US external imbalance. These macroeconomic factors play important roles in forming the long-run trend for countries' external balance. Japan may have been under a gradual structural change mainly caused by demographic changes combining the lowered birth rate and longer life expectancy. Fujita and Fujiwara (2015) calibrate the heterogeneous agent model and conclude that the demographic change can solely account for 40% of the decline in real interest rates in the past three decades in Japan.

To account for the persistent deficit in the Japanese trade balance despite the sharp depreciation of the Japanese yen between 2012 and 2015, we suggest decomposing the trade balance at both the sector and partner-country level. We constructed trade indices for the price and quantity components at the country and sector levels. With these datasets, we estimated the income elasticity and price elasticity of demand for traded goods and the exchange rate pass-through for these goods. The analysis in this study highlights the importance of decomposing trade value into price and quantity components when investigating trade balance dynamics. Our preliminary investigation suggests that Japanese trade underwent a structural change during the global financial crisis and became less responsive to the fluctuations in the Japanese yen and incomes of foreign countries. Whether this structural change in Japanese trade is generated by long and irrevocable movements of macroeconomic factors such as demographic change in Japan is left for future research studies.

Acknowledgments

We would like to thank Shugo Yamamoto at the Japan Monetary Economics Conference and participants at the RIETI Exchange Rate and International Currency Research Project meeting for their comments on the presentation of an earlier version of this paper. Both authors acknowledge financial support from KAKENHI 15K03557. Yoshida also acknowledges financial support from KAKENHI C26380295.

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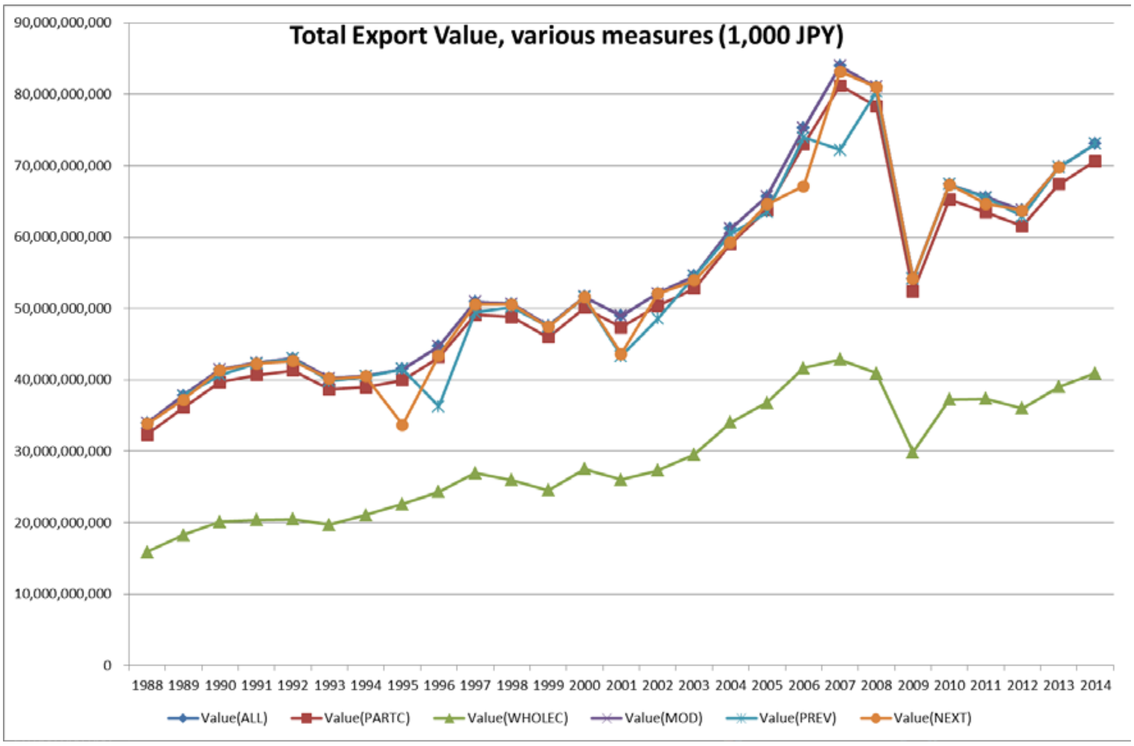
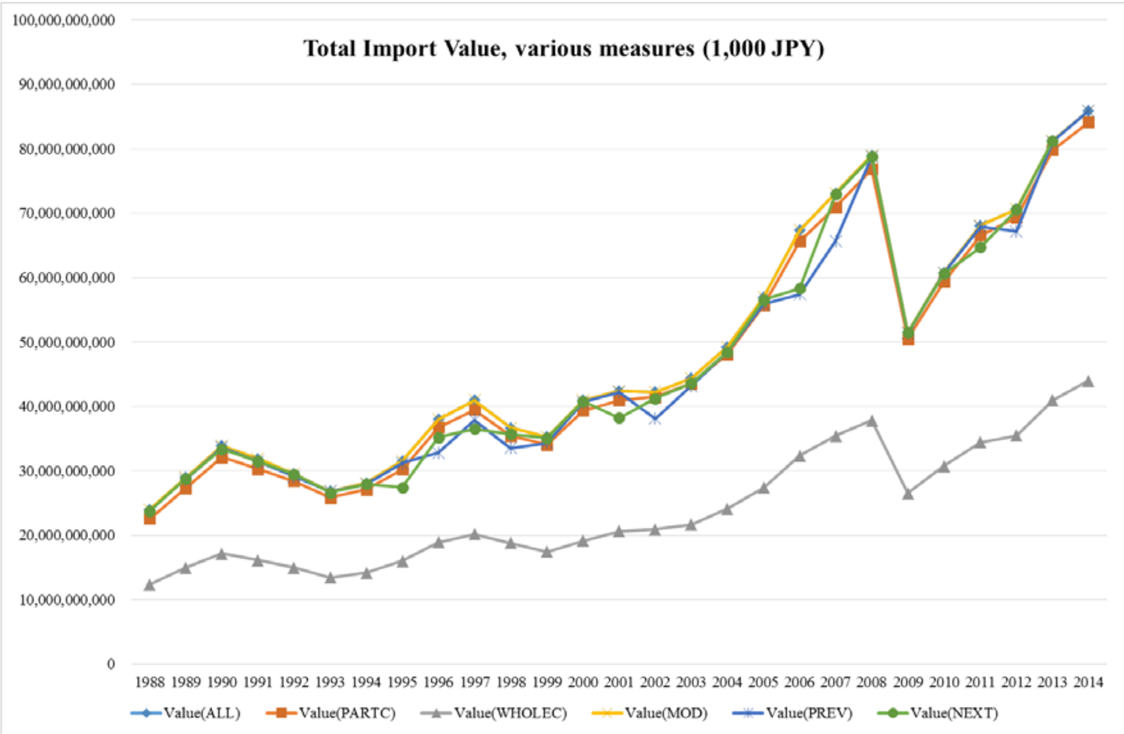
Figure 1. Aggregate export and import values by various measures (1,000 Japanese yen)

(a) exports



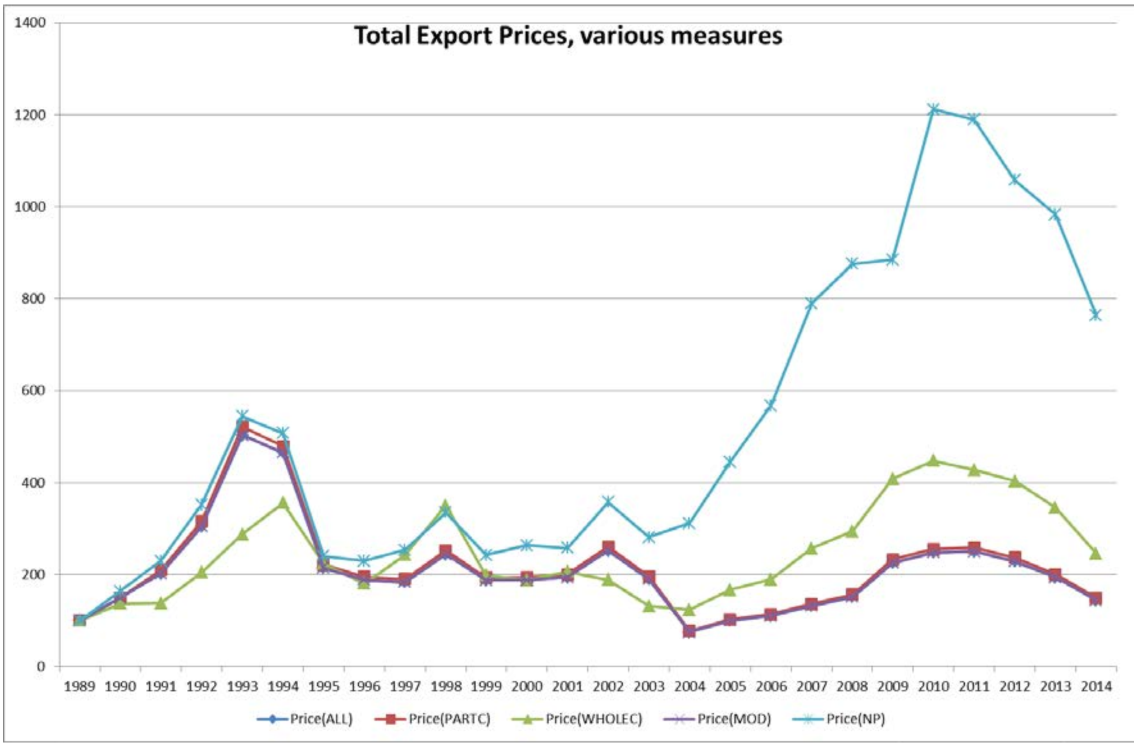
(b) imports



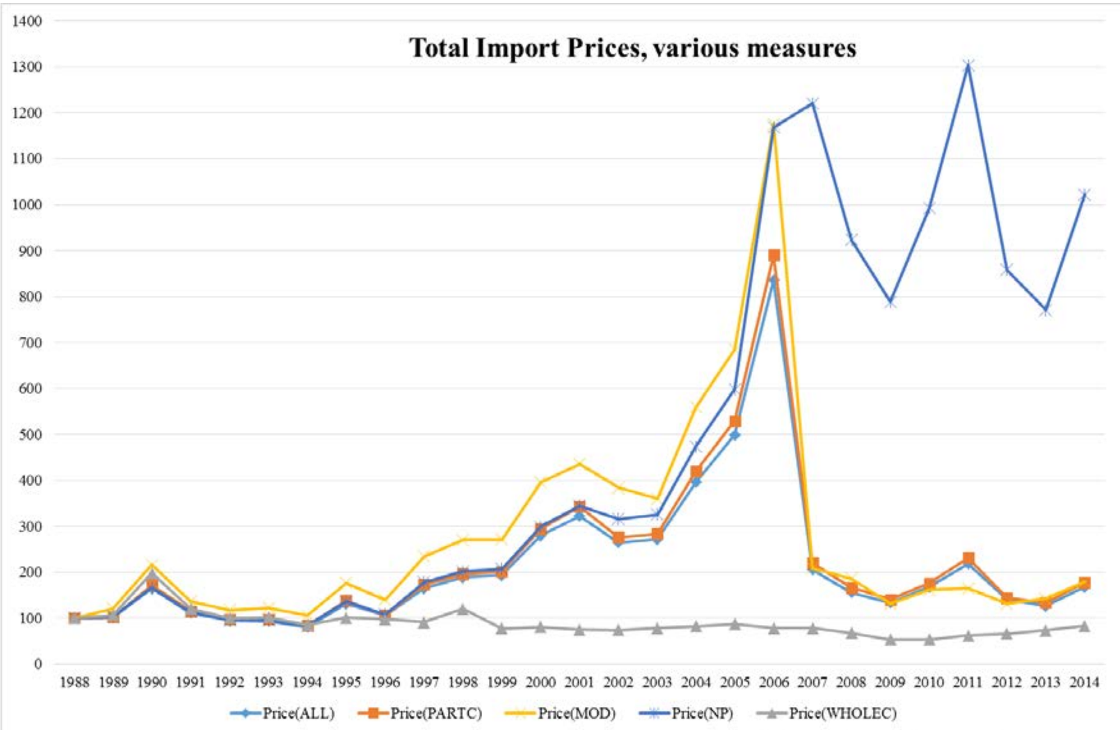
Note: The value of exports is calculated based on the products included in each index set. The detailed descriptions for each set are given in Appendix C.

Figure 2. Prices of aggregate exports and imports by various measures

(a) exports (1989=100)



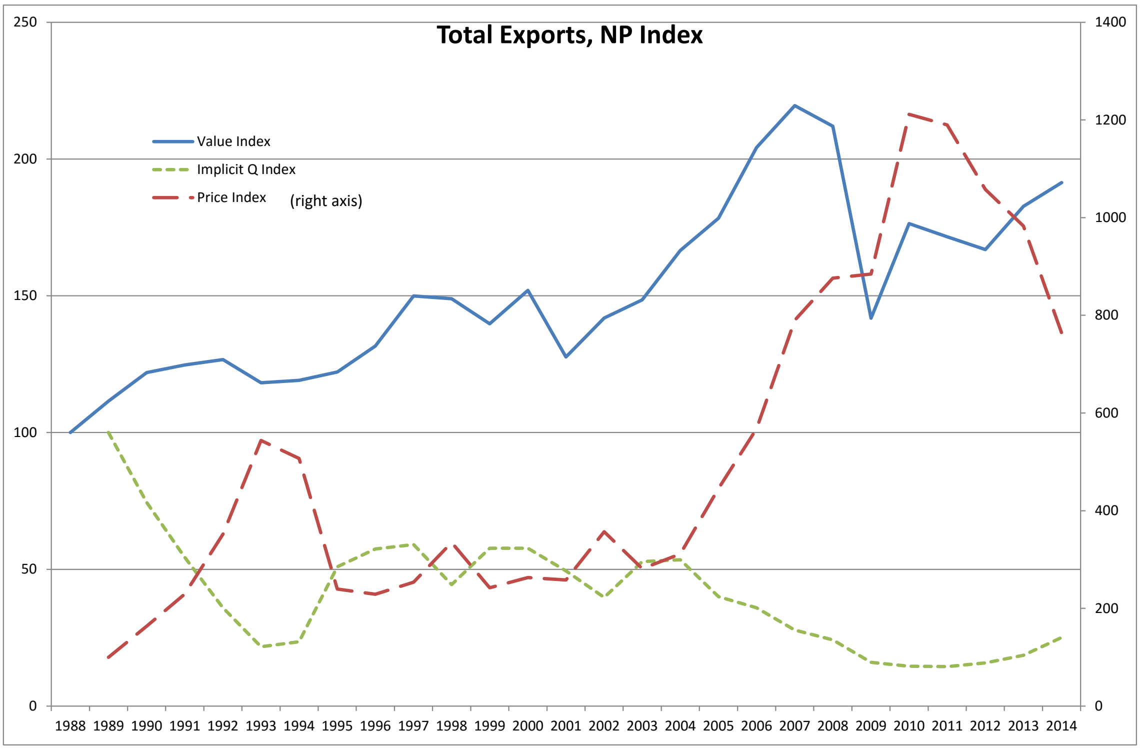
(b) imports (1988=100)



Note: The price of exports is calculated based on the various definitions of indices. The detailed descriptions for these indices are given in Appendix C.

Figure 3. Aggregate exports and imports by NP index

(a) exports



(b) imports

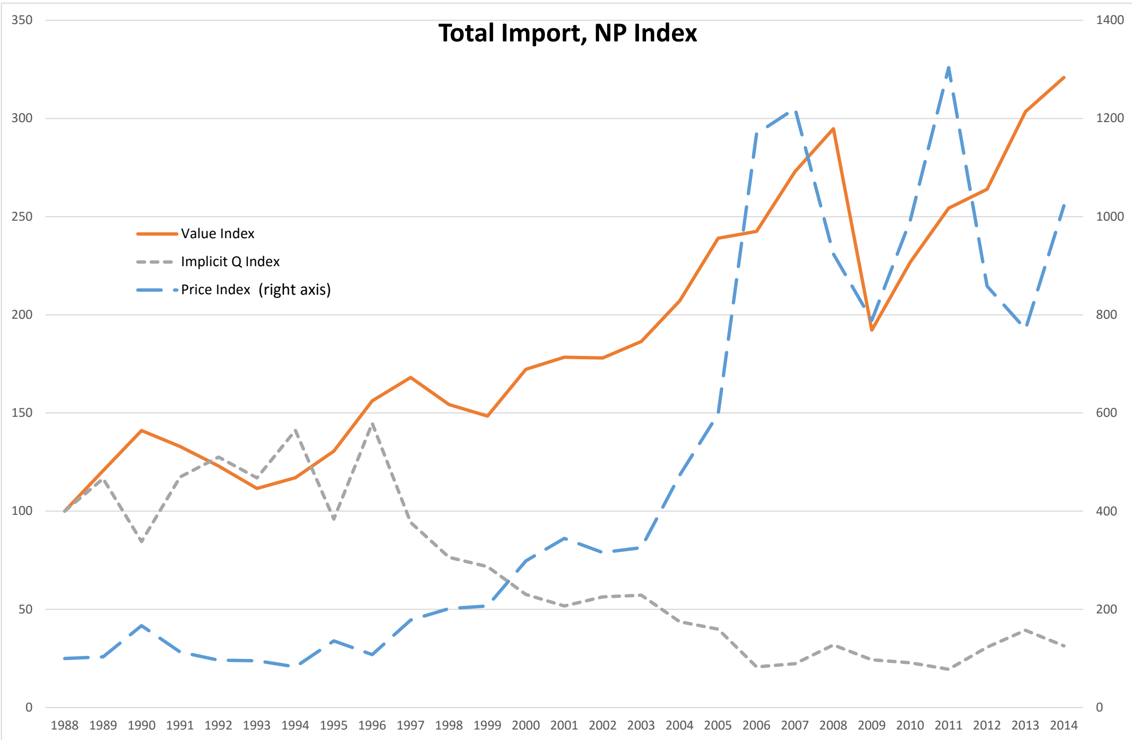
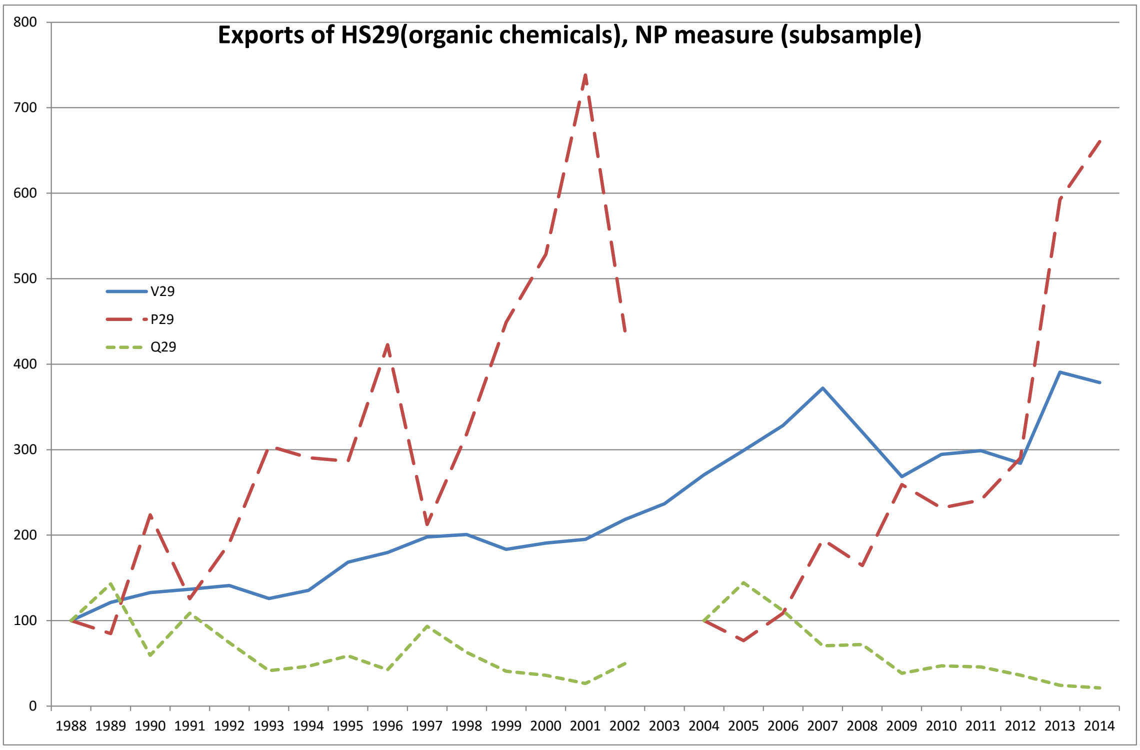
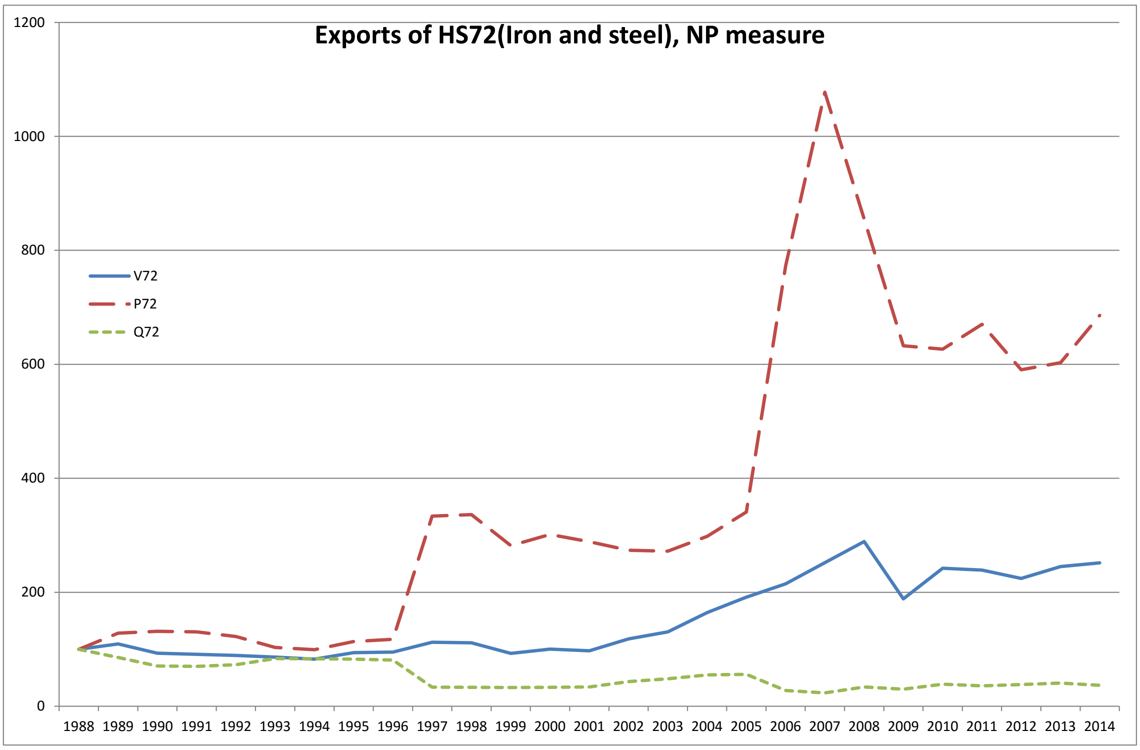


Figure 4. Major HS 2-digit exports by NP measure

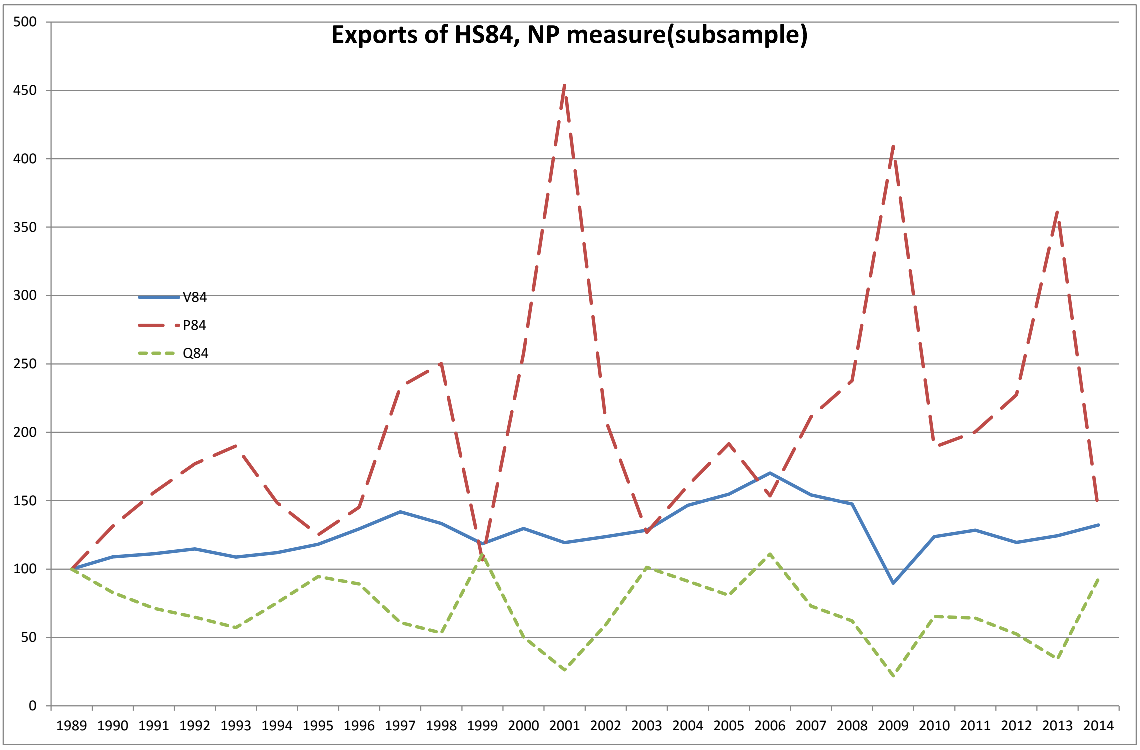
(a) HS29 (organic chemicals)



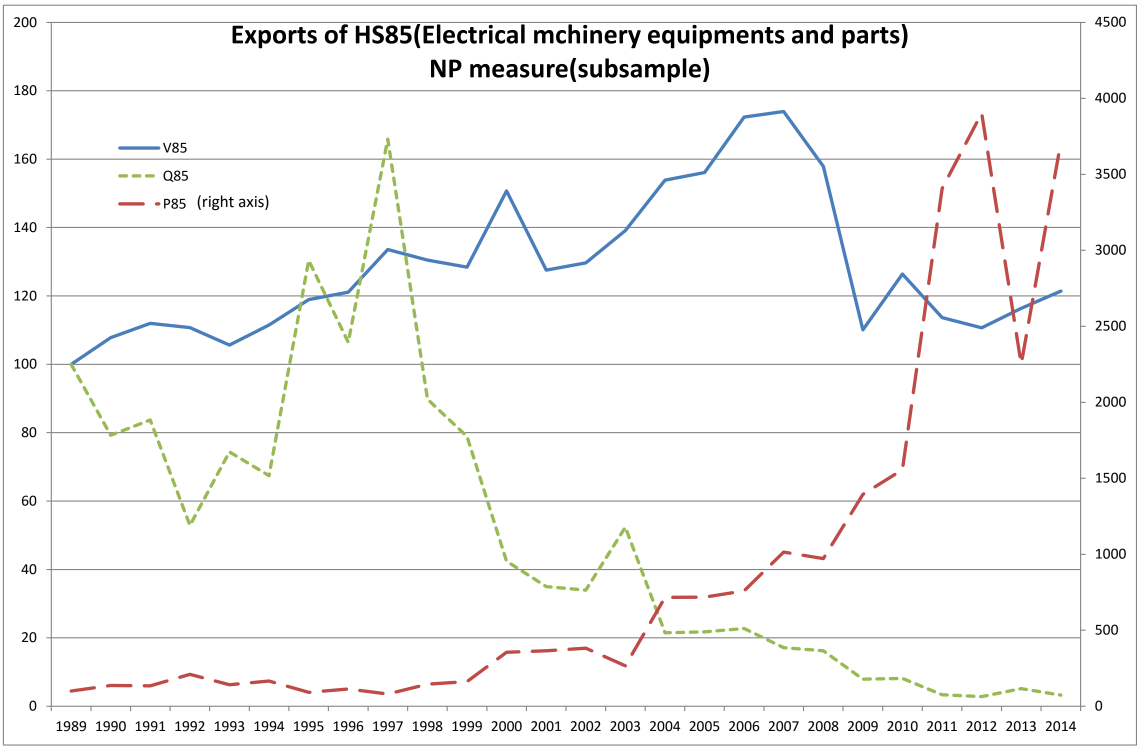
(b) HS72 (iron and steel)



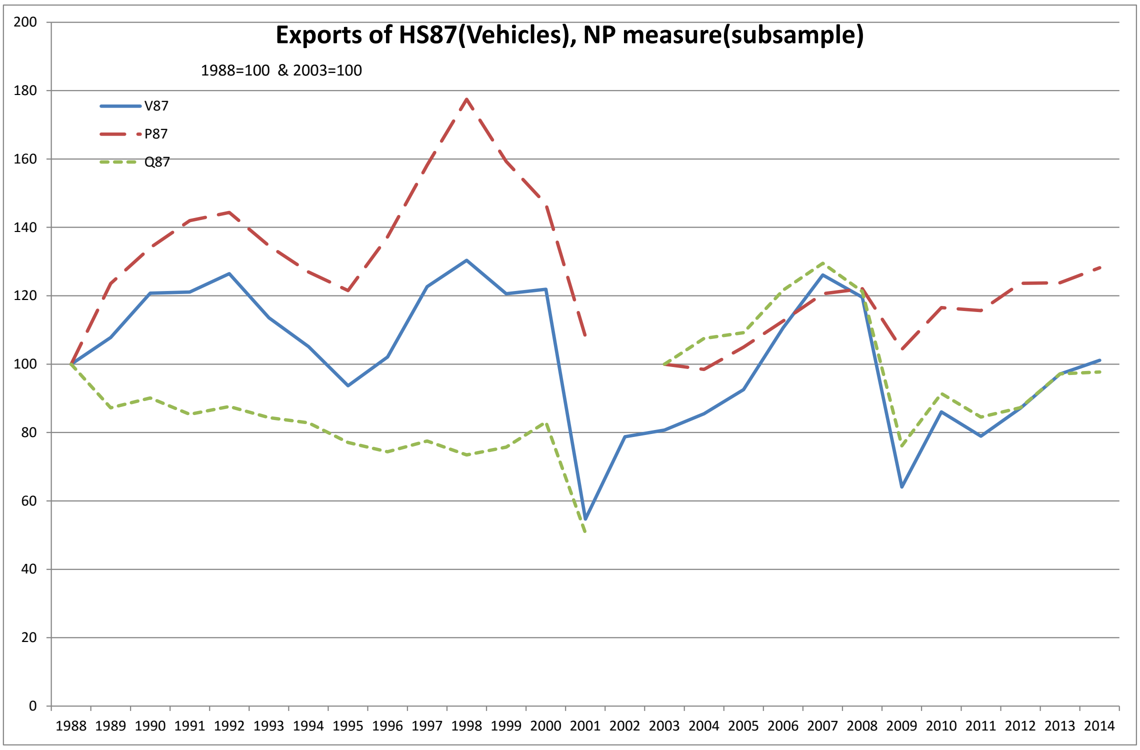
(c) HS84 (machinery and mechanical appliances)



(d) HS85 (electrical machinery equipment)



(e) HS87 (vehicles)



(f) HS90 (optical and precision)

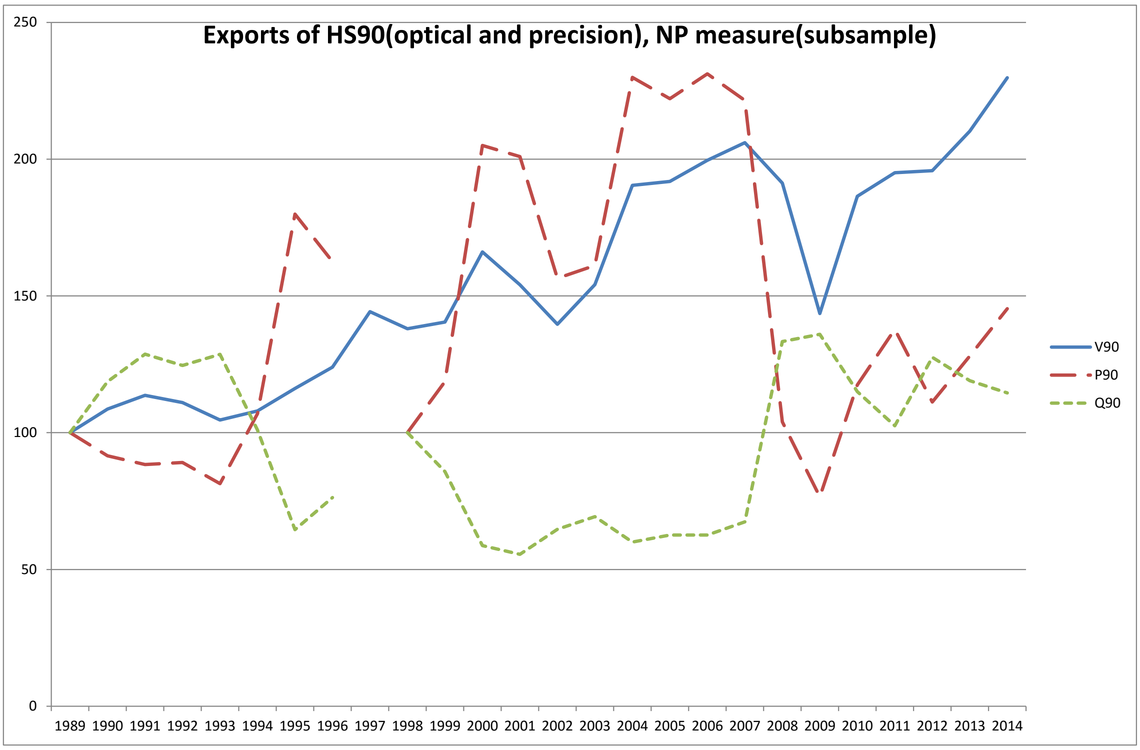
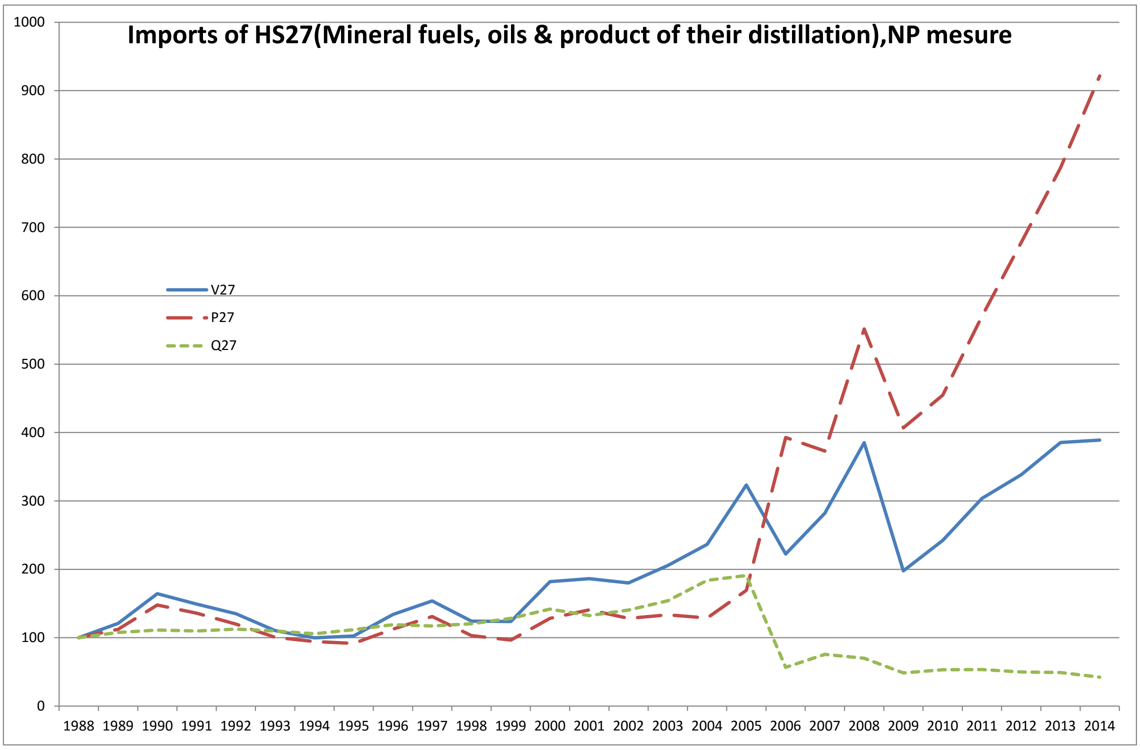
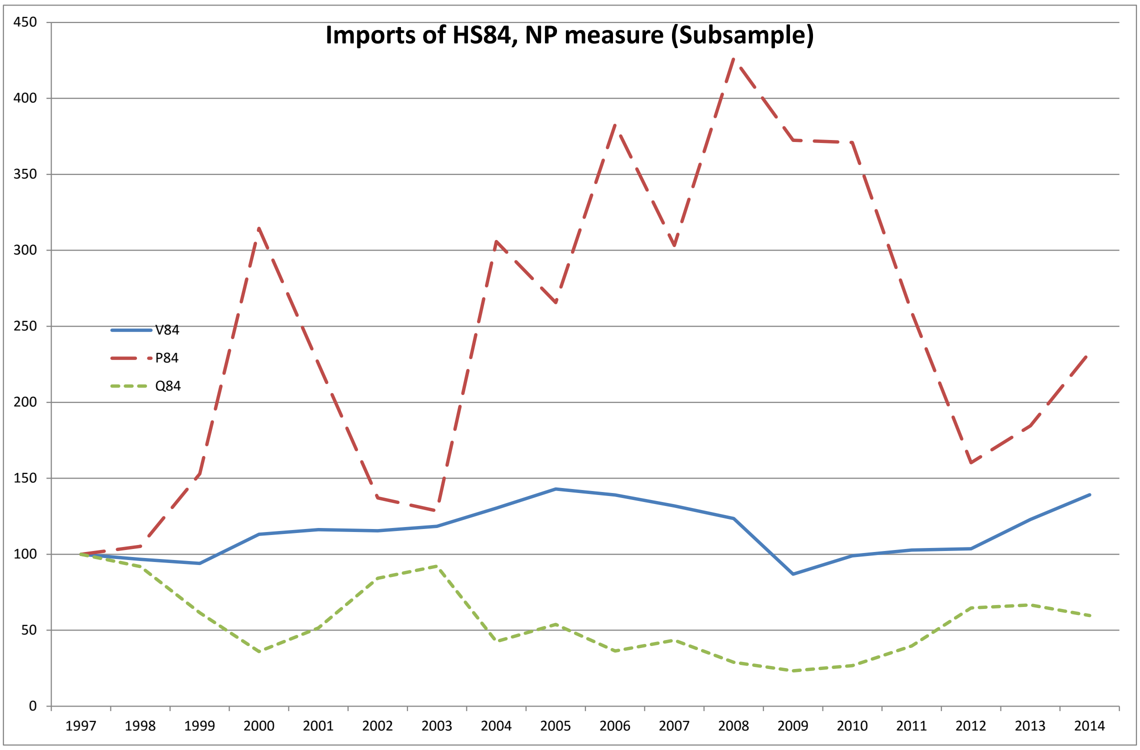


Figure 5. Major HS 2-digit imports by NP measure

(a) HS27 (mineral fuels and oils)



(b) HS84 (machinery and mechanical appliances)



(c) HS85 (electrical machinery equipment)

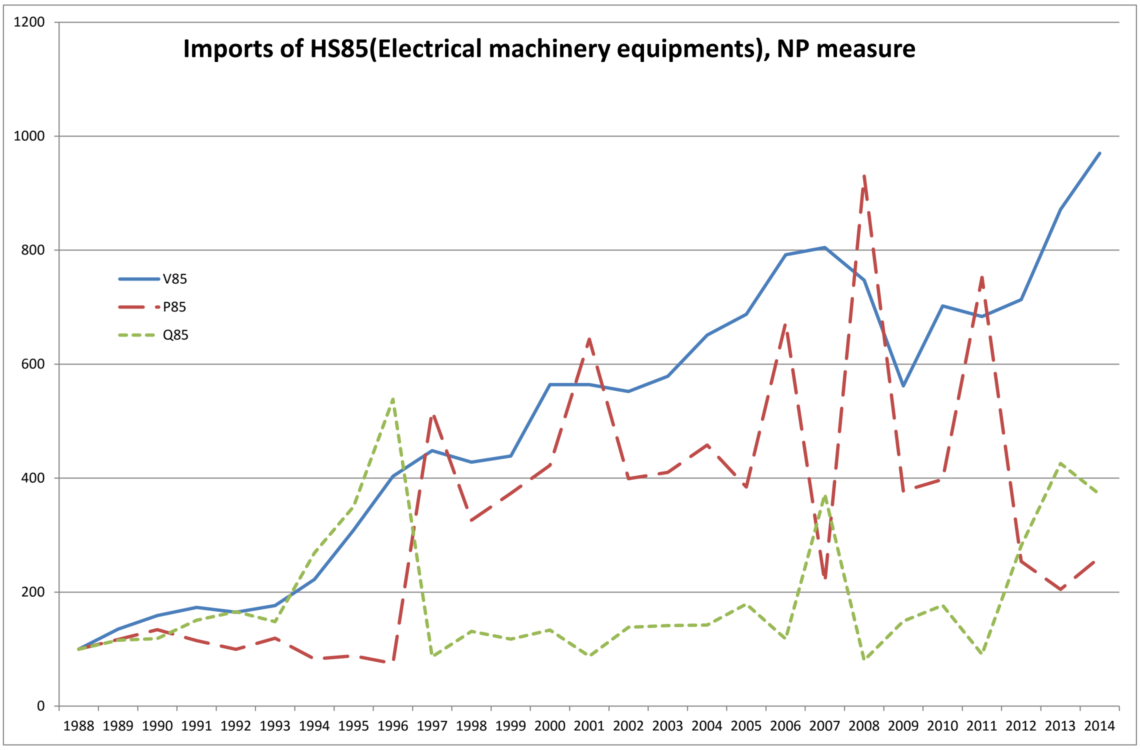
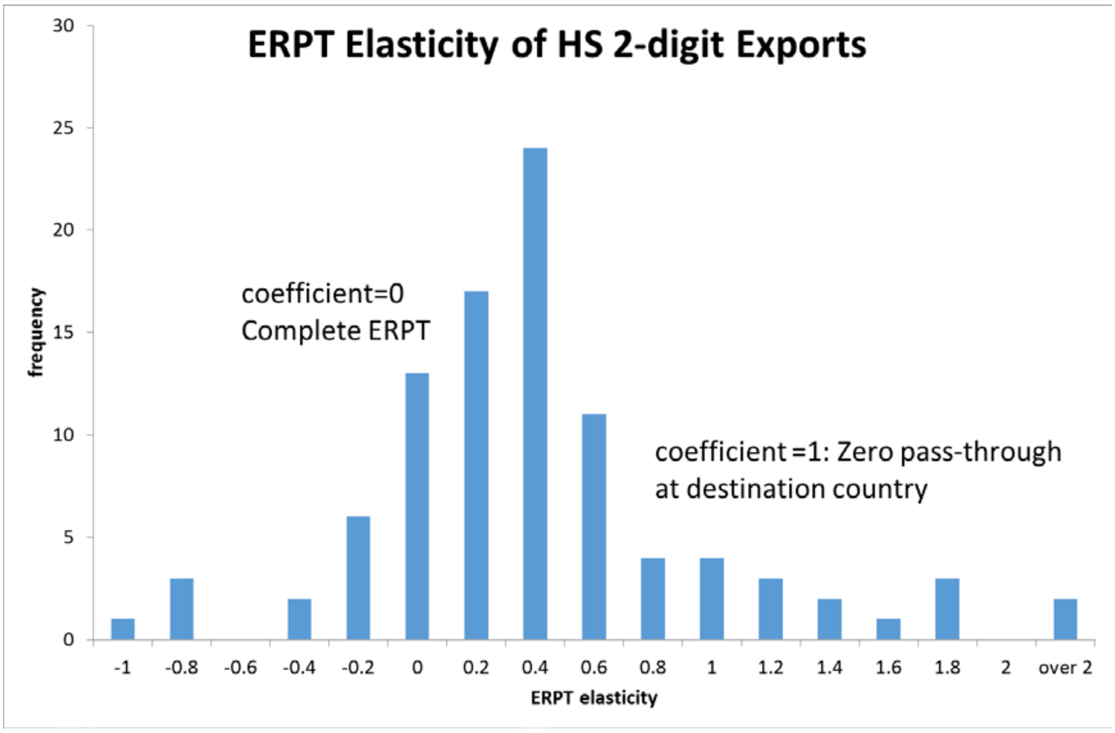
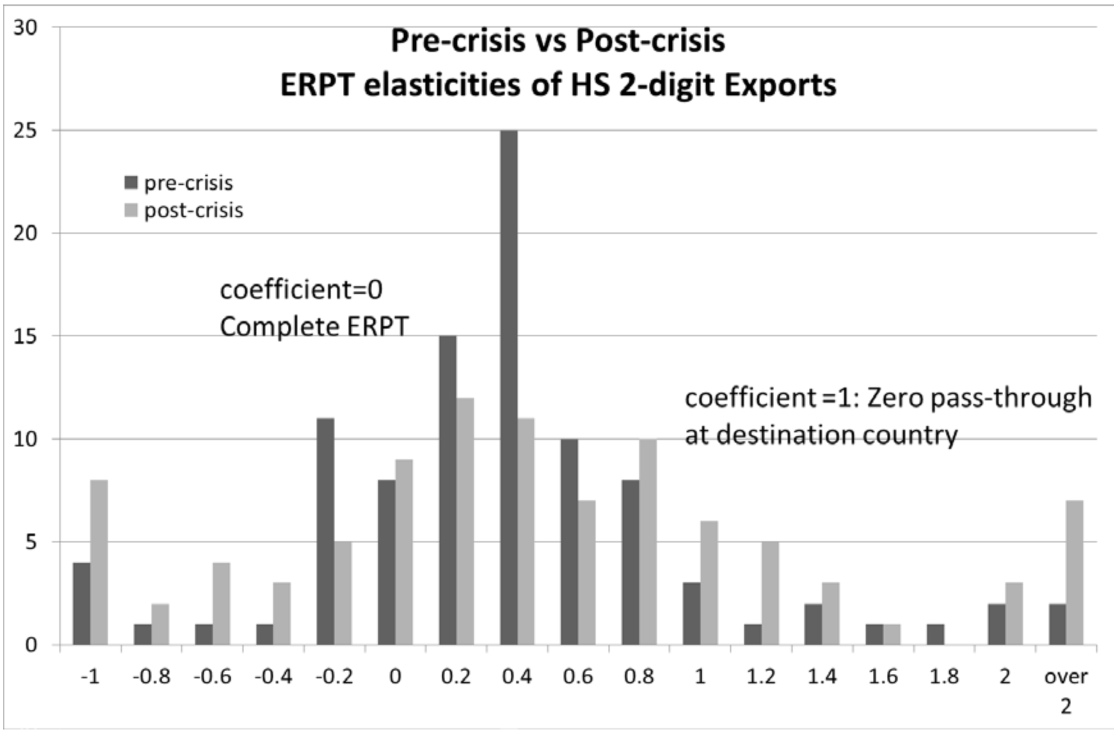


Figure 6. ERPT elasticity of HS 2-digit Exports (1988-2014)



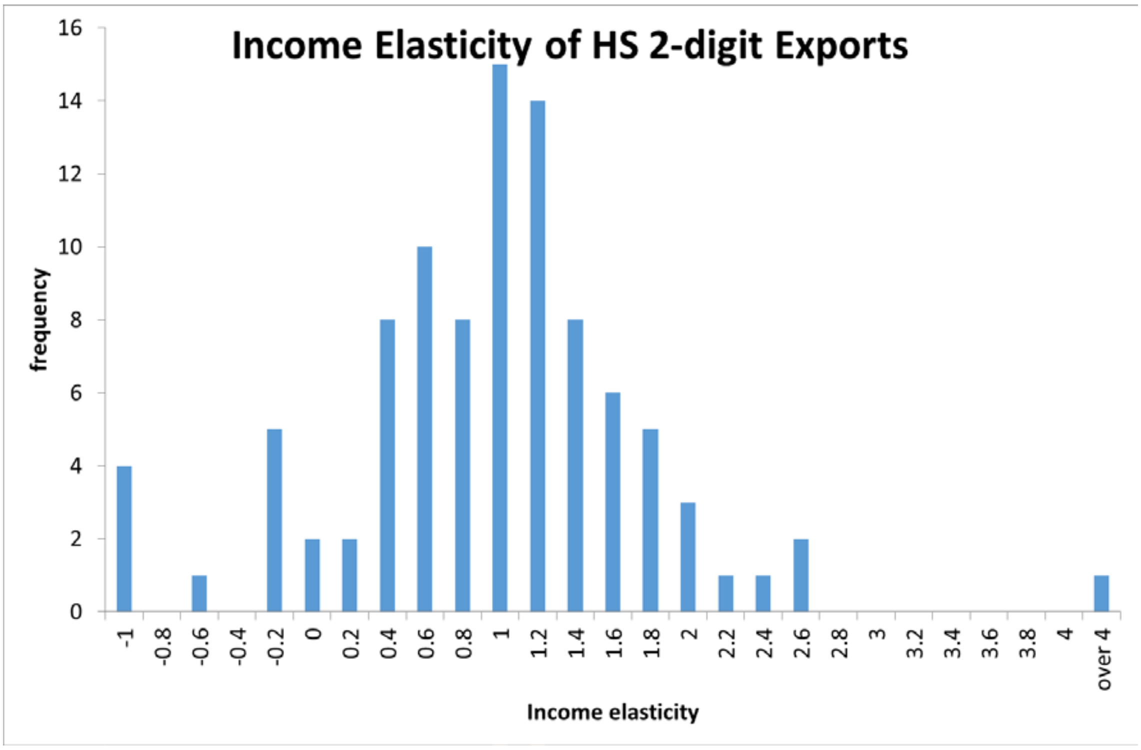
Note: The point estimates of ERPT elasticity coefficients of HS 2-digit Japanese exports are summarized. These estimates are also shown in Table 1.

Figure 7. Pre-crisis versus post-crisis, ERPT elasticity of HS 2-digit Exports



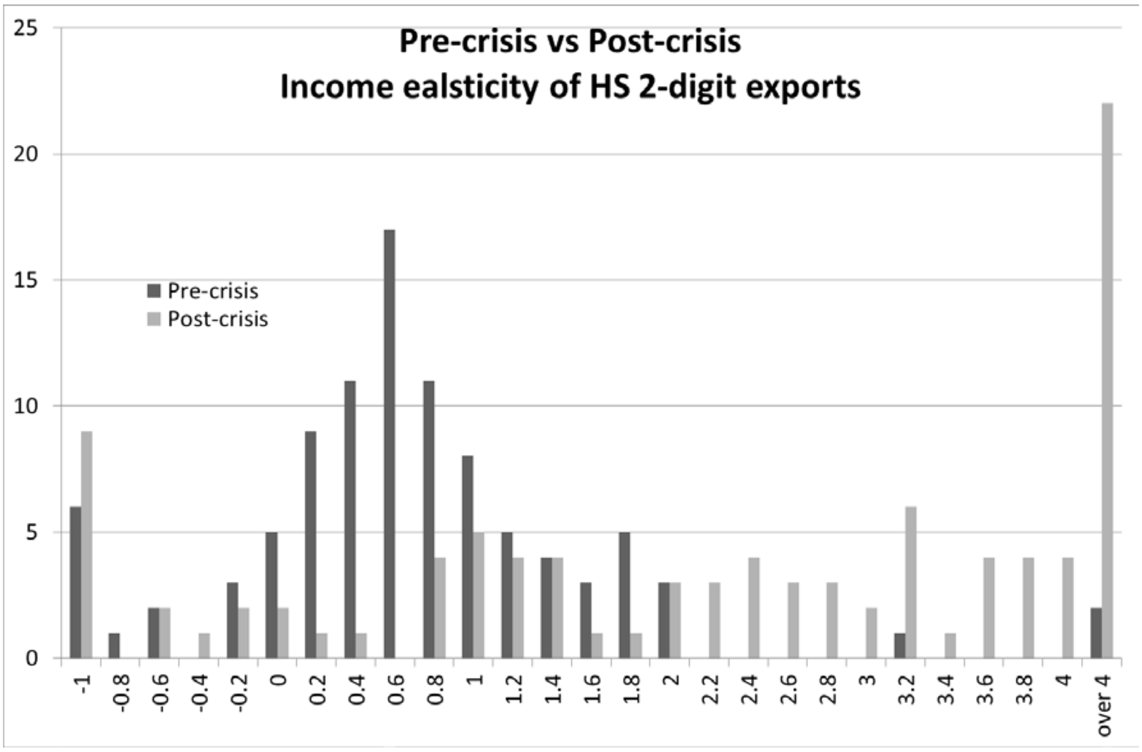
Note: The point estimates of ERPT elasticity coefficients of HS 2-digit Japanese exports are summarized for pre-crisis and post-crisis subsamples.

Figure 8. Income elasticity of HS 2-digit Exports (1988-2014)



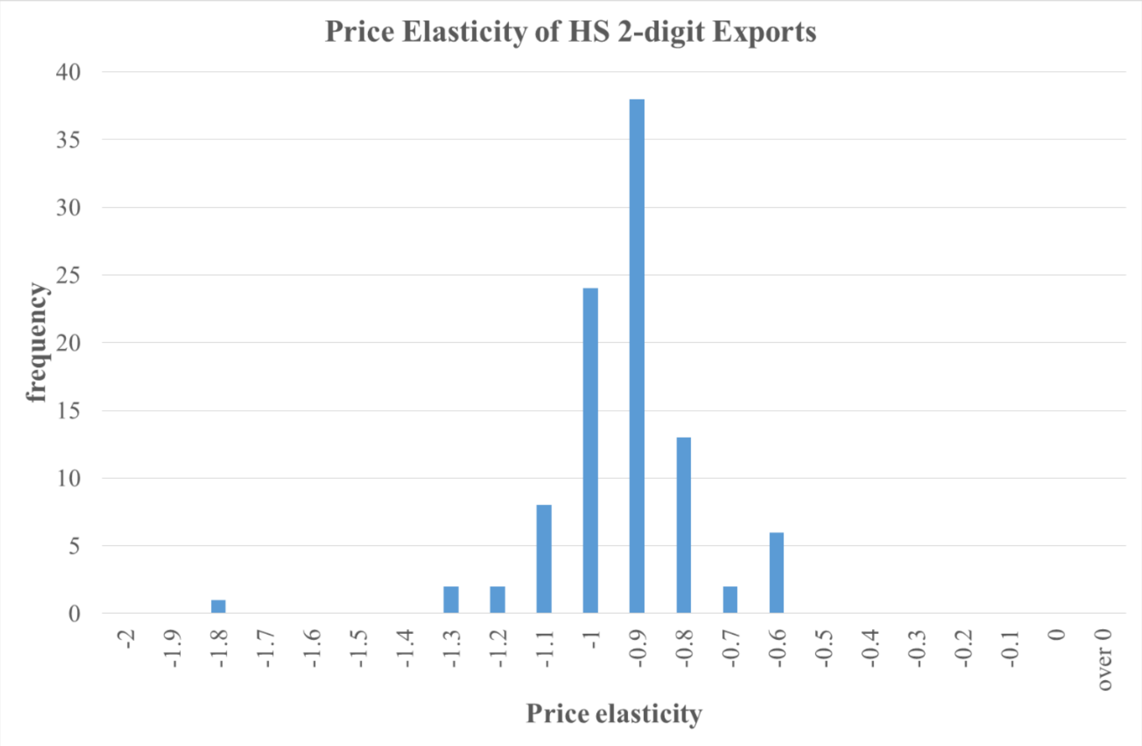
Note: The point estimates of income elasticity coefficients of HS 2-digit Japanese exports are summarized. These estimates are also shown in Table 2.

Figure 9. Pre-crisis versus post-crisis, income elasticity of HS 2-digit Exports



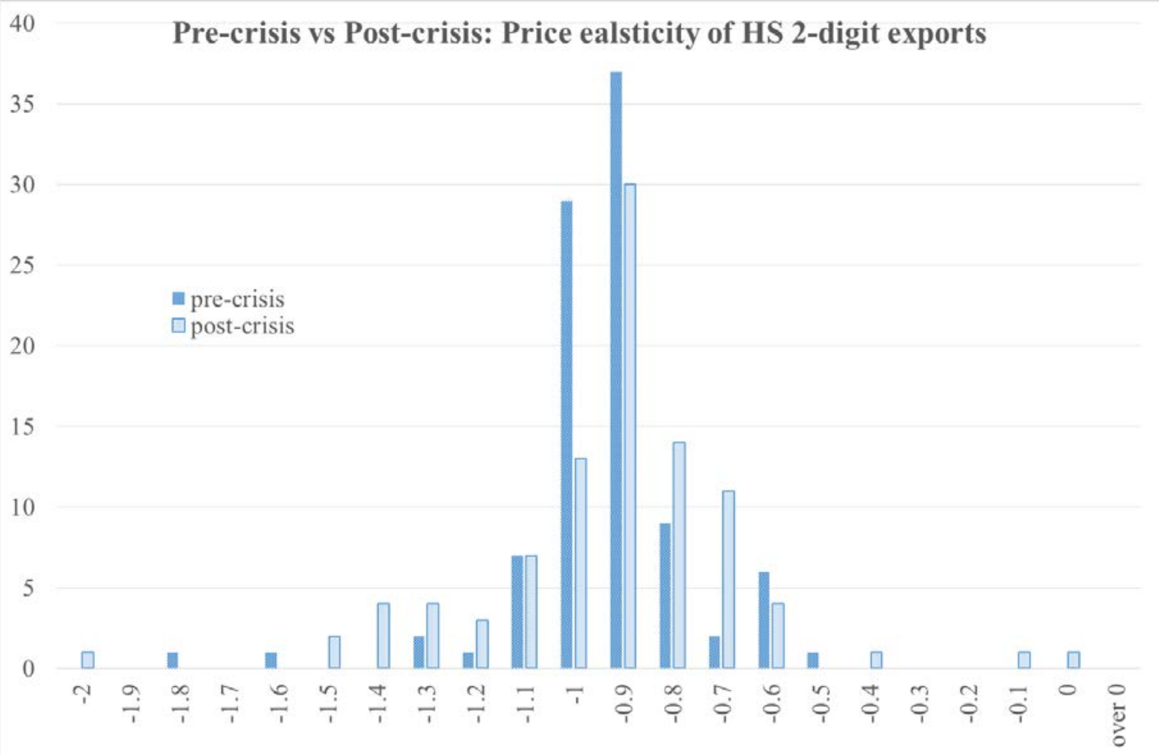
Note: The point estimates of income elasticity coefficients of HS 2-digit Japanese exports are summarized for pre-crisis and post-crisis subsamples.

Figure 10. Price elasticity of HS 2-digit Exports (1988-2014)



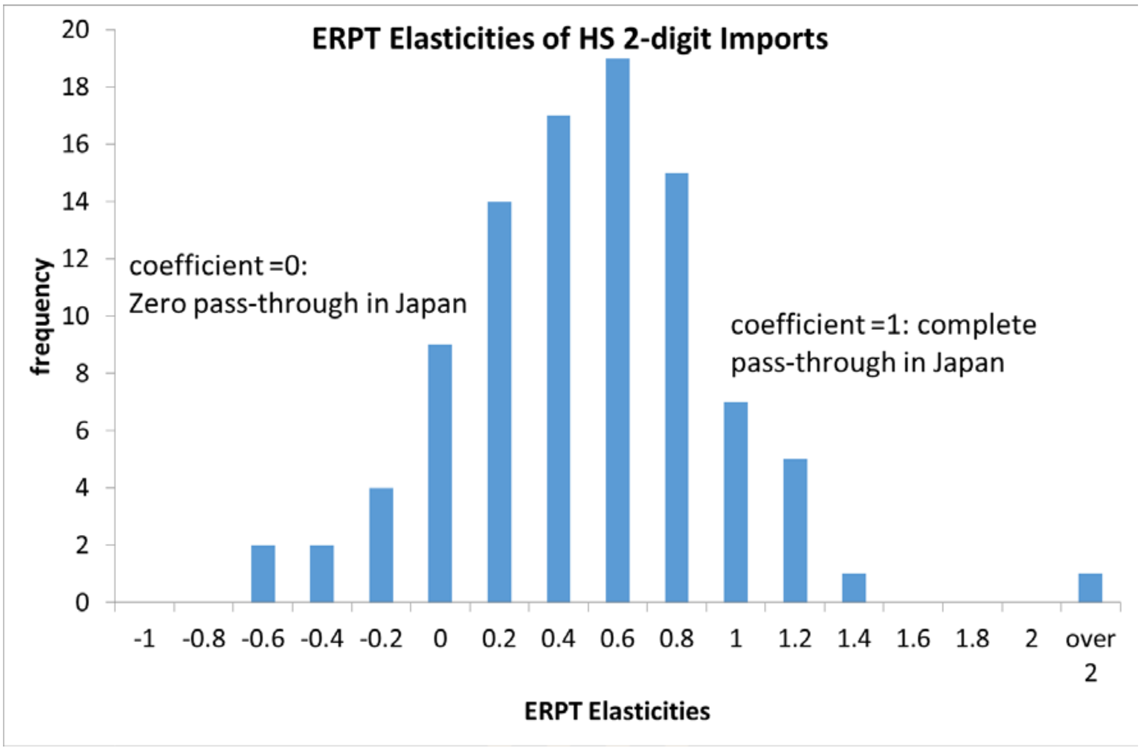
Note: The point estimates of price elasticity coefficients of HS 2-digit Japanese exports are summarized. These estimates are also shown in Table 2.

Figure 11. Pre-crisis versus post-crisis, price elasticity of HS 2-digit Exports



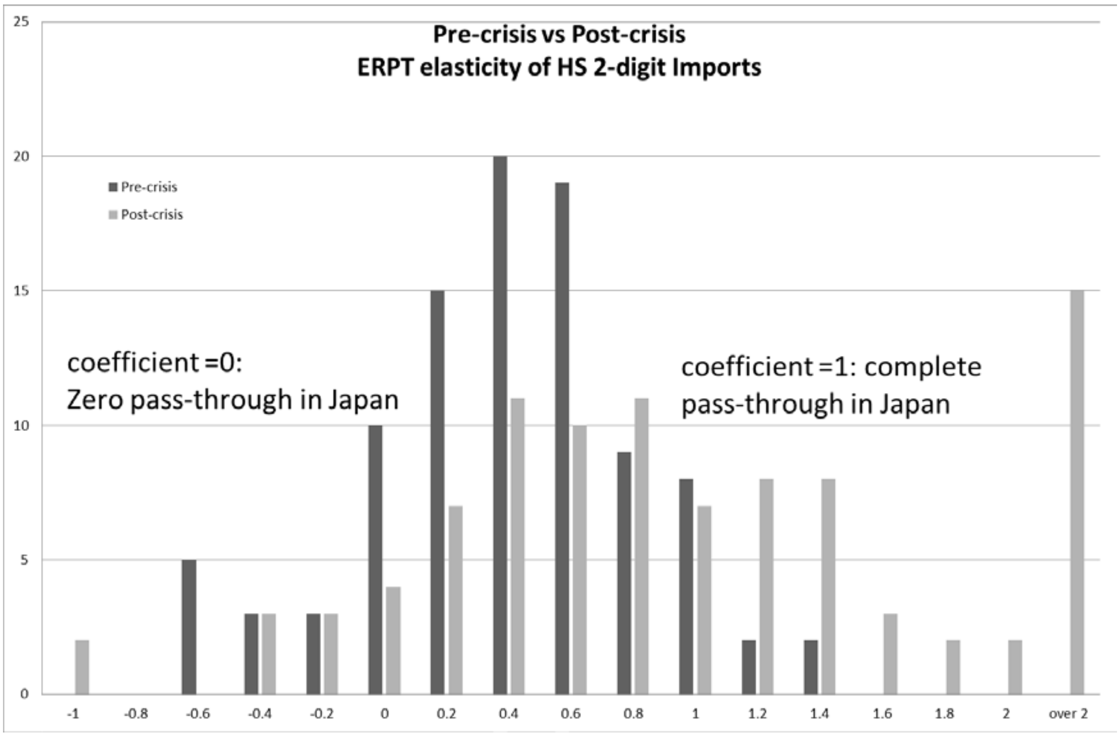
Note: The point estimates of price elasticity coefficients of HS 2-digit Japanese exports are summarized for pre-crisis and post-crisis subsamples.

Figure 12. ERPT elasticity of HS 2-digit Imports (1988-2014)



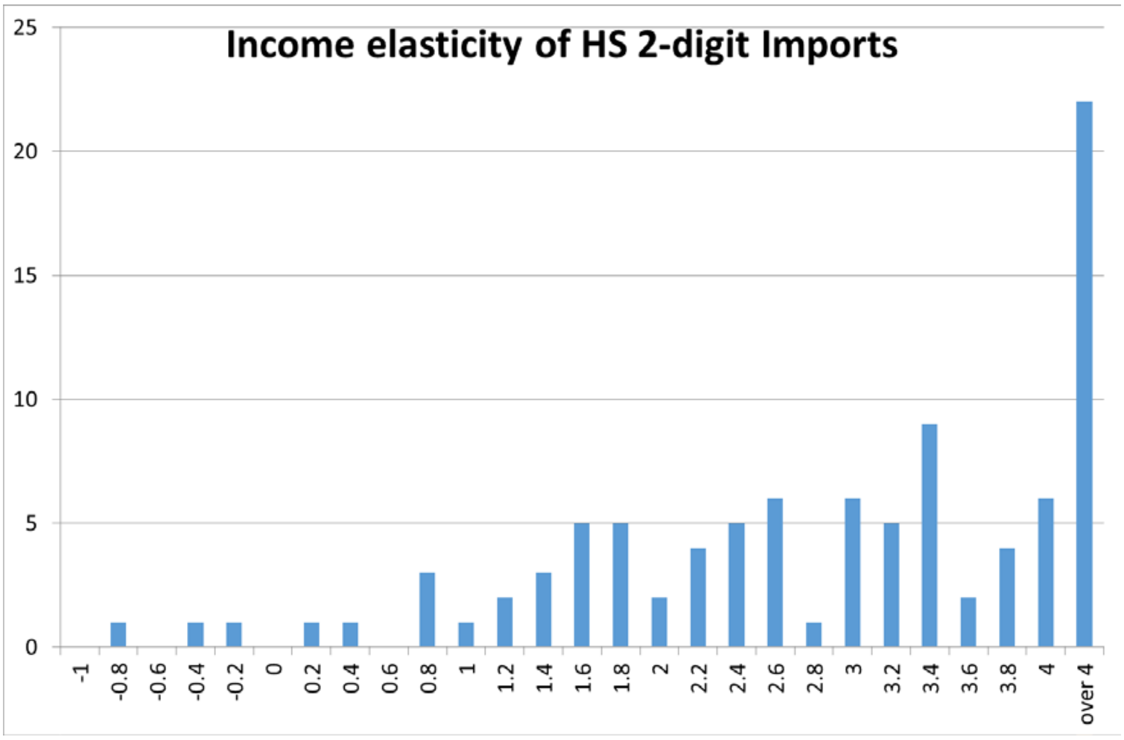
Note: The point estimates of ERPT elasticity coefficients of HS 2-digit Japanese imports are summarized. These estimates are also shown in Table 3.

Figure 13. Pre-crisis versus post-crisis, ERPT elasticity of HS 2-digit Imports



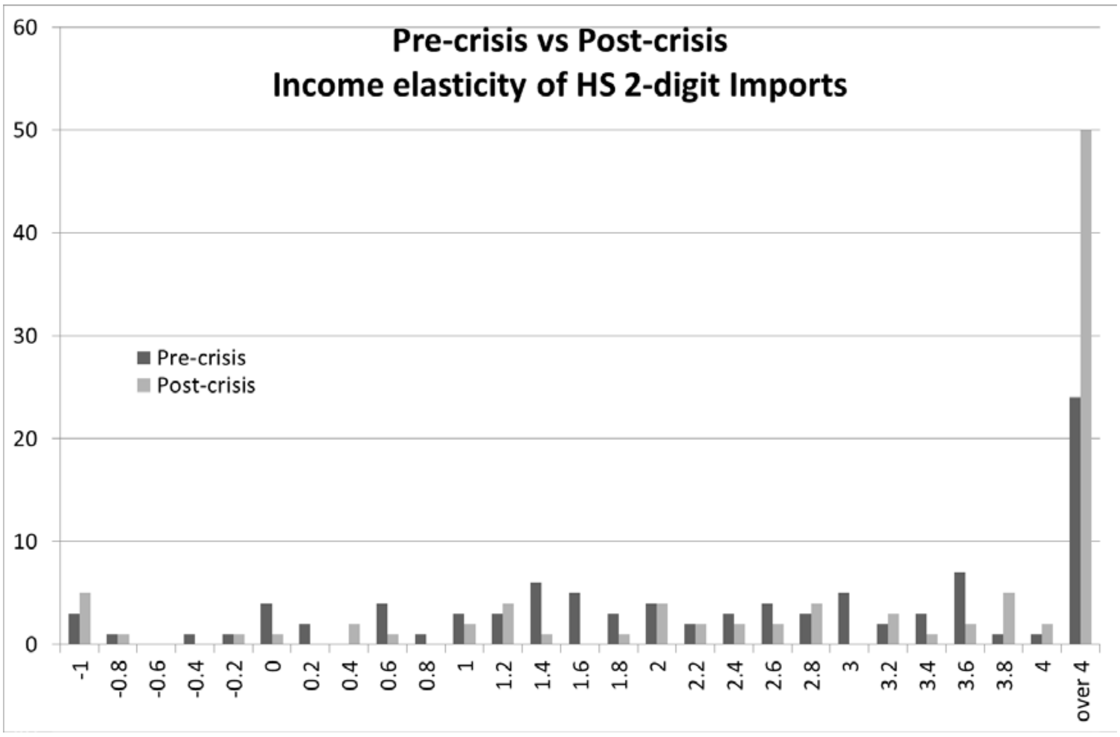
Note: The point estimates of ERPT elasticity coefficients of HS 2-digit Japanese imports are summarized for pre-crisis and post-crisis subsamples.

Figure 14. Income elasticity of HS 2-digit Imports (1988-2014)



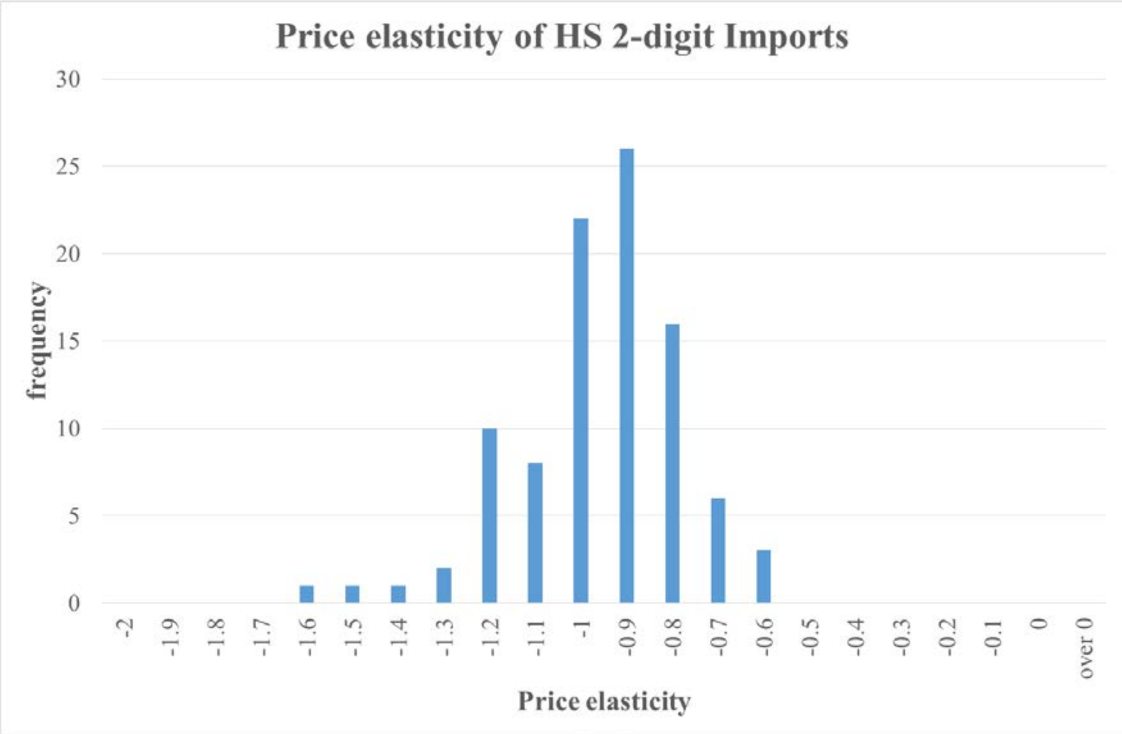
Note: The point estimates of income elasticity coefficients of HS 2-digit Japanese imports are summarized. These estimates are also shown in Table 4.

Figure 15. Pre-crisis versus post-crisis, income elasticity of HS 2-digit Imports



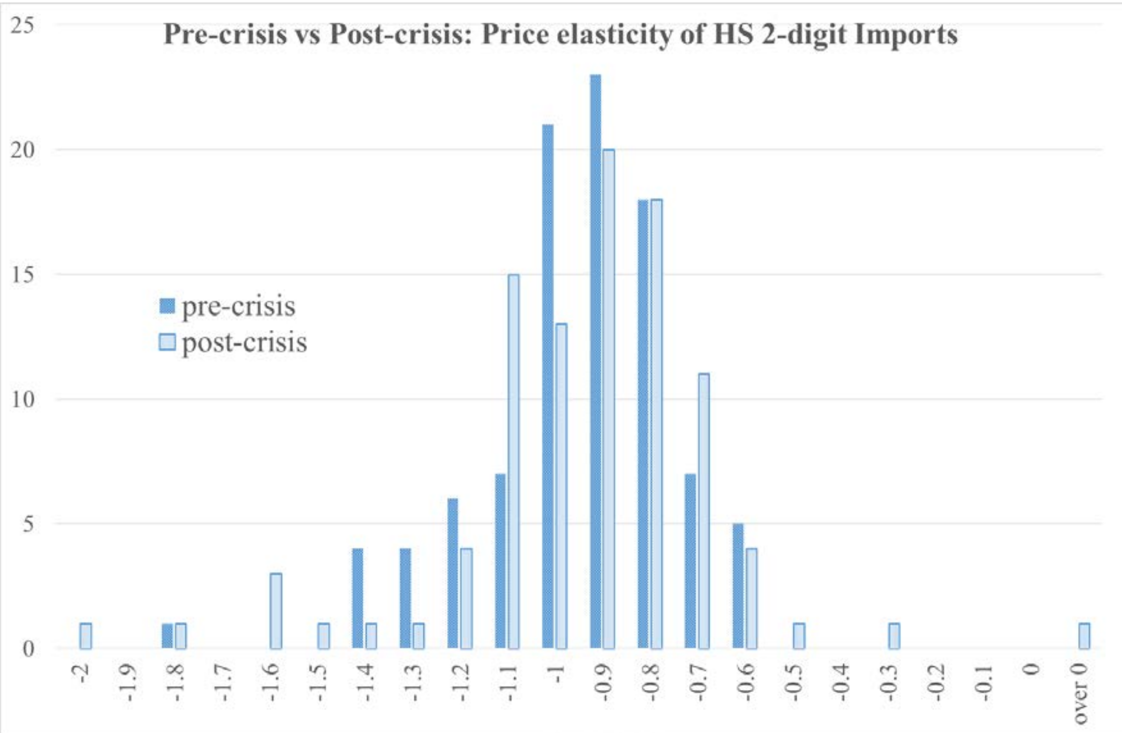
Note: The point estimates of income elasticity coefficients of HS 2-digit Japanese imports are summarized for pre-crisis and post-crisis subsamples.

Figure 16. Price elasticity of HS 2-digit Imports (1988-2014)



Note: The point estimates of price elasticity coefficients of HS 2-digit Japanese imports are summarized. These estimates are also shown in Table 4.

Figure 17. Pre-crisis versus post-crisis, price elasticity of HS 2-digit Imports



Note: The point estimates of price elasticity coefficients of HS 2-digit Japanese imports are summarized for pre-crisis and post-crisis subsamples.

Table 1. ERPT elasticities of HS 2-digit Exports (1988-2014)

HS2	ERPT elasticity	H0: complete pass-through t-stat (β=0)	H0: zero pass-through t-stat (β=1)	Structural break F	Structural break D	HS2	ERPT elasticity	H0: complete pass-through t-stat (β=0)	H0: zero pass-through t-stat (β=1)	Structural break F	Structural break D
1	0.366	1.23	-2.12**			51	0.134	0.38	-2.43**		
2	1.718	0.98	0.41		**	52	0.403	2.08**	-3.09***		
3	0.359	0.46	-0.82			53	-0.142	-0.81	-6.50***		
4	1.763	5.47***	2.37**	***	***	54	0.390	1.58	-2.48**		
5	0.165	0.31	-1.57			55	-0.006	-0.03	-5.39***		**
6	0.285	0.31	-0.78			56	0.138	1.18	-7.37***		**
7	0.192	0.24	-0.99	**	***	57	0.373	3.08***	-5.18***		*
8	0.792	1.29	-0.34			58	-0.476	-1.21	-3.76***		
9	0.862	2.63***	-0.42		***	59	0.166	0.75	-3.80***		
10	0.400	2.76***	-4.13***			60	0.234	1.33	-4.34***		
11	1.625	3.27***	1.26			61	0.342	1.09	-2.10**		
12	0.253	0.42	-1.23			62	0.251	1.35	-4.05***		
13	0.168	0.37	-1.83*		**	63	0.557	2.70***	-2.15**		
14	0.189	0.51	-2.17**			64	0.441	1.31	-1.66*		
15	-1.124	-1.73*	-3.28***			65	-0.056	-0.30	-5.64***	*	***
16	0.791	1.11	-0.29			66	0.121	0.42	-3.05***		
17	0.832	2.96***	-0.60	***	***	67	-0.241	-0.30	-1.56		
18	-0.883	-1.92*	-4.10***			68	-0.071	-0.11	-1.65		
19	0.353	1.91*	-3.52***			69	-0.097	-0.54	-6.08***		
20	0.080	0.73	-8.45***			70	-0.418	-1.02	-3.47***		*
21	-0.248	-1.50	-7.57***			71	0.217	0.98	-3.52***		
22	0.118	1.04	-7.80***			72	0.452	0.66	-0.80		
23	0.287	1.59	-3.96***		*	73	0.395	2.52**	-3.86***		
24	0.421	1.68*	-2.31**			74	0.184	0.98	-4.34***		
25	0.052	0.18	-3.34***	**	***	75	0.423	1.84*	-2.51**		
26	-0.838	-2.17**	-4.75***			76	1.000	1.65	0.00		
27	-0.089	-0.11	-1.31			78	-0.312	-0.94	-3.97***		
28	0.122	0.27	-1.94*			79	0.486	0.87	-0.92	**	
29	0.730	1.82*	-0.67			80	0.319	0.84	-1.79*		
30	0.327	0.66	-1.36			81	-0.256	-0.68	-3.36***		
31	0.267	1.12	-3.07***		*	82	-0.148	-0.53	-4.09***		
32	0.309	1.03	-2.31**			83	-0.216	-0.82	-4.62***		***
33	0.090	0.40	-4.09***			84	-0.045	-0.36	-8.34***		**
34	0.204	1.97**	-7.69***			85	1.263	1.85*	0.38		
35	-0.005	-0.03	-5.74***		**	86	1.300	2.08**	0.48		
36	-0.208	-0.97	-5.66***			87	2.640	1.86*	1.16		
37	-0.058	-0.13	-2.37**			88	0.970	3.65***	-0.11		
38	-0.066	-0.13	-2.07**			89	2.411	2.81***	1.65		
39	0.232	0.74	-2.45**			90	1.416	1.01	0.30		
40	0.083	0.83	-9.19***	*		91	1.177	2.85***	0.43		
41	0.560	2.68***	-2.10**			92	0.777	2.62***	-0.75		
42	0.430	1.22	-1.62			93	0.847	4.02***	-0.72		
43	0.417	1.02	-1.43			94	-0.014	-0.02	-1.69*		
44	-0.183	-0.28	-1.78*			95	0.236	0.58	-1.89*		
45	1.061	2.14**	0.12			96	0.352	1.78*	-3.28***		
46	0.182	0.15	-0.66			97	0.223	1.48	-5.14***	*	
47	-0.969	-1.57	-3.20***								
48	0.337	0.69	-1.37								
49	0.203	1.13	-4.42***		***						
50	0.119	0.30	-2.22**								

Note: The log of the export price index is regressed on the first difference of the log of the exchange rate. Both null hypotheses of complete pass-through (β =0) and zero pass-through (β =1) are tested. F is the structural break test by Chow-test, and D is the post-crisis dummy that interacts with the exchange rate. The asterisks *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

Table 2. Income and price elasticity of HS 2-digit Exports (1988-2014)

HS2	income elasticity	price elasticity	Structural break		
			F	Dummy income	Dummy price
1	0.795***	-0.946***			
2	1.486	-0.681***			
3	0.389	-1.023***	*		
4	0.537	-1.138***	***		
5	-1.241	-0.905***			
6	0.468	-0.937***			
7	-0.299	-0.936***	***		
8	0.567	-0.887***			*
9	0.209	-1.081***			
10	0.602	-0.799***			
11	8.222***	-1.367***			
12	0.417	-0.999***			
13	0.131	-0.988***	**		
14	1.008	-0.871***			
15	1.398	-0.966***			
16	-1.393**	-0.971***			
17	0.468	-1.150***			
18	-0.072	-0.899***			
19	0.770	-0.978***			
20	-0.231	-0.653***			
21	0.363	-1.099***			
22	0.501	-0.639***			
23	0.916**	-0.888***			*
24	-0.223	-0.917***			
25	1.990	-1.874***			
26	1.258**	-1.067***			
27	1.677	-0.957***			
28	2.106*	-1.339***			
29	1.389***	-0.934***	**	***	***
30	0.815***	-0.949***	***		
31	-0.317	-0.876***			**
32	2.463***	-1.116***		*	**
33	1.235***	-0.979***		***	**
34	0.528*	-0.683***			
35	0.784**	-1.210***			
36	1.015***	-1.024***		**	
37	1.625	-0.903***			
38	0.397*	-1.006***	**		**
39	0.858***	-0.985***	***	***	***
40	1.028***	-1.100***	***	***	***
41	1.025***	-0.963***	***	***	***
42	0.354	-0.977***			*
43	0.754	-0.977***			
44	0.445	-1.050***			
45	1.365**	-0.866***		*	*
46	0.819	-0.998***			
47	1.006	-1.054***			
48	2.230	-1.240***			
49	0.638***	-0.983***			***
50	1.044***	-0.950***	**	**	***
51	-0.267	-0.913***			
52	0.304	-0.843***			
53	0.909*	-1.006***			
54	0.151	-0.914***			
55	1.044***	-0.985***	***		
56	0.679**	-1.042***			
57	1.099***	-0.824***	***		*
58	0.342	-1.024***			
59	1.079**	-1.084***			
60	0.997***	-0.935***		**	
61	0.897	-1.058***			
62	1.932***	-1.083***			
63	2.550***	-1.064***			
64	1.018**	-1.021***			
65	1.746**	-1.050***			
66	1.972***	-0.877***		*	
67	0.993	-0.972***			
68	-0.712	-0.871***			
69	0.825***	-1.052***	***	***	***
70	1.654***	-0.911***		**	
71	1.146***	-1.001***			
72	1.459**	-0.977***		*	**
73	1.546***	-1.163***	***	***	***
74	0.832***	-1.077***	**	***	***
75	1.294***	-1.011***	***	***	***
76	1.495	-0.980***			
78	1.248***	-1.059***		**	**
79	1.787	-1.114***			*
80	0.583	-1.161***	***		***
81	1.458	-0.981***			
82	0.230	-1.167***	**	***	***
83	0.889**	-1.095***			
84	1.070***	-0.973***	***	***	***
85	1.530***	-0.983***	***	***	***
86	1.273***	-0.989***	***	***	***
87	-4.489**	-0.832***			*
88	1.030***	-0.898***		***	**
89	0.958	-0.832***			
90	-1.179	-0.609***	*		**
91	0.767***	-0.961***	*	***	**
92	0.418	-0.964***	**		
93	0.972***	-0.993***	***		
94	-0.093	-0.720***			
95	1.113***	-0.949***		***	***
96	0.976	-0.697***			
97	0.860***	-1.043***			

Note: Implicit quantity indices are regressed on the destination countries' income and price indices along destination fixed effects. F is the structural break test by Chow-test, and income and price under D are the post-crisis dummies that interact with income and price, respectively. The asterisks *,**, *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

Table 3. ERPT elasticities of HS 2-digit Imports (1988-2014)

HS2	ERPT elasticity	H0: zero pass-through t-stat (β=0)	H0: complete pass-through t-stat (β=1)	Structural break F	Structural break D	HS2	ERPT elasticity	H0: zero pass-through t-stat (β=0)	H0: complete pass-through t-stat (β=1)	Structural break F	Structural break D
1	0.250539	0.97	-2.90***			51	0.827217	4.24***	-0.88		
2	2.308405	2.98***	1.69*		***	52	0.418684	1.58	-2.20**		**
3	0.615954	2.18**	-1.36			53	0.345721	1.46	-2.76***		
4	0.321611	3.28***	-6.92***	***	***	54	0.77192	3.09***	-0.91		
5	0.412089	1.10	-1.57			55	0.379775	1.82*	-2.97***		**
6	-0.156146	-0.36	-2.66***			56	0.498978	1.63	-1.64		
7	0.550757	2.29**	-1.87*		***	57	0.632664	3.15***	-1.83*		
8	-0.259647	-0.69	-3.36***			58	0.131434	0.65	-4.29***		
9	0.138637	0.97	-6.05***	***	***	59	0.462771	1.54	-1.78*		
10	0.121506	0.58	-4.22***		*	60	0.350329	1.68*	-3.12***		
11	0.824496	2.35**	-0.50	***	***	61	0.832906	2.47**	-0.49		
12	1.153839	2.26**	0.30			62	0.080184	0.55	-6.31***		*
13	0.383058	1.61	-2.59**			63	0.652741	3.55***	-1.89*		
14	0.248317	1.18	-3.59***			64	0.498281	3.39***	-3.41***	**	
15	0.130249	0.41	-2.77***			65	0.380366	2.91***	-4.73***		
16	0.60576	3.20***	-2.08**			66	-0.008416	-0.04	-4.89***		
17	0.273025	1.46	-3.89***	***	***	67	0.47864	2.01**	-2.19**		
18	1.179065	2.98***	0.45	**	**	68	-0.199848	-0.55	-3.29***		
19	0.376649	3.67***	-6.07***			69	-0.010462	-0.03	-3.29***		
20	0.654857	4.91***	-2.59**	**		70	-0.247138	-0.81	-4.09***		
21	0.852392	6.20***	-1.07			71	0.128236	0.57	-3.90***		
22	0.605068	2.83***	-1.85*			72	0.167453	0.32	-1.60		
23	-0.17117	-0.73	-5.01***		**	73	0.446046	1.84*	-2.28**		
24	0.646807	3.47***	-1.90*			74	-0.618684	-2.13**	-5.57***		
25	0.103972	0.46	-3.96***			75	0.137424	0.81	-5.08***	***	***
26	0.172694	1.21	-5.79***			76	0.266871	0.74	-2.05**		*
27	0.591672	1.47	-1.01			78	0.370758	2.51**	-4.26***		**
28	0.43145	1.81*	-2.38**			79	0.905681	1.28	-0.13		
29	-0.268559	-0.64	-3.04***			80	1.126114	1.95*	0.22		
30	-0.195662	-0.49	-3.01***			81	0.502522	1.43	-1.41		
31	1.182395	2.68***	0.41			82	-0.041116	-0.07	-1.82*		**
32	0.34256	2.03**	-3.89***		*	83	0.609116	1.72*	-1.10		
33	0.391987	1.09	-1.69*			84	0.142139	0.86	-5.16***		
34	0.338285	1.88*	-3.67***			85	-0.414518	-1.41	-4.81***		***
35	0.341903	0.90	-1.74*		**	86	0.534856	1.20	-1.04		
36	0.609948	1.12	-0.72			87	0.157866	0.37	-2.00**		
37	0.827849	1.44	-0.30			88	-0.57564	-1.59	-4.36***		
38	0.503751	1.02	-1.01			89	0.441072	1.15	-1.45		
39	-0.683168	-1.45	-3.58***			90	0.619545	0.57	-0.35		**
40	1.206426	4.59***	0.79			91	-0.256918	-0.82	-4.00***		
41	-0.029814	-0.11	-3.72***	**		92	0.135248	0.29	-1.82*		*
42	0.604376	1.50	-0.98			93	0.891785	3.33***	-0.40		
43	0.541654	1.97**	-1.67*			94	1.166748	2.26**	0.32		
44	0.766665	2.49**	-0.76	***	*	95	0.557986	2.44**	-1.93*		
45	0.765388	3.78***	-1.16			96	0.780418	3.78***	-1.06		
46	0.527454	0.68	-0.61			97	0.108779	0.35	-2.87***		
47	-0.080309	-0.20	-2.66***								
48	0.509585	2.82***	-2.72***								
49	0.412259	1.82*	-2.59***								
50	0.399219	0.87	-1.31		**						

Note: The log of the export price index is regressed on the first difference of the log of the exchange rate. Both null hypotheses of zero pass-through (β =0) and complete pass-through (β =1) are tested. F is the structural break test by Chow-test, and D is the post-crisis dummy that interacts with the exchange rate. The asterisks *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

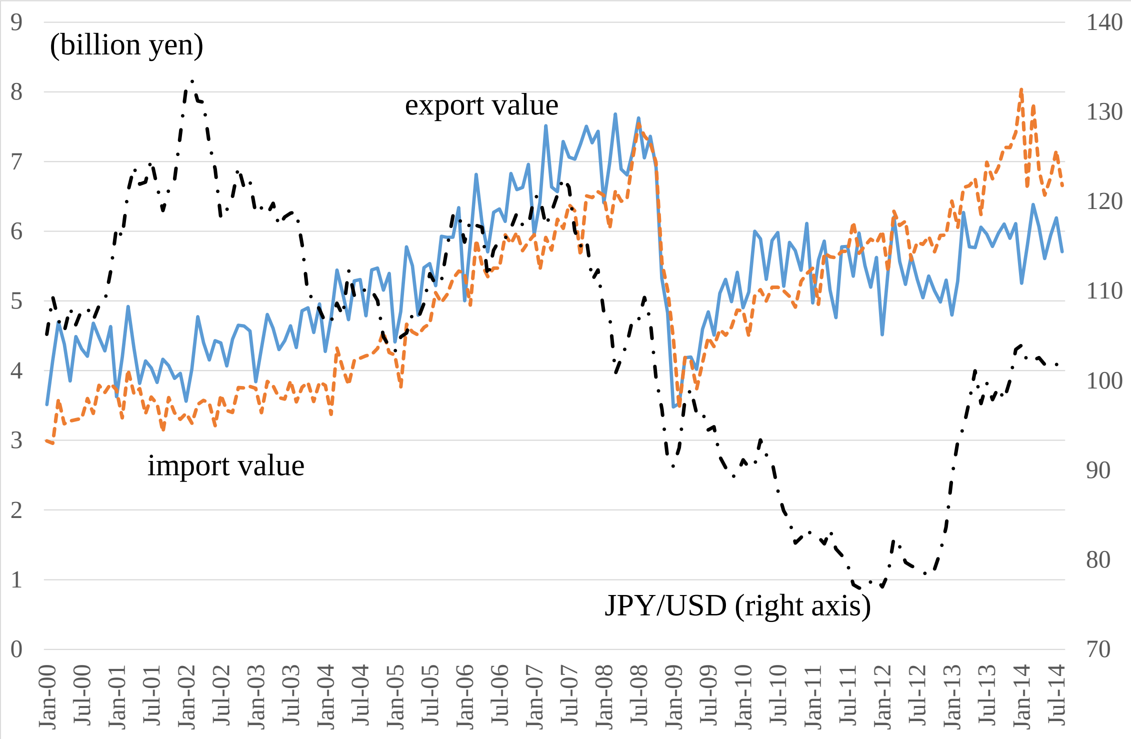
Table 4. Income elasticity of HS 2-digit Imports (1988-2014)

			Structural break						Structural break		
				Dummy						Dummy	
HS2	income elasticity	price elasticity	F	income	price	HS2	income elasticity	price elasticity	F	income	price
1	1.987**	-0.831***				51	3.336**	-1.210***			
2	1.529	-0.805***	***		***	52	3.050*	-1.065***			*
3	3.271	-1.641***	***			53	4.376***	-1.412***			
4	2.156**	-1.355***		**		54	0.707	-1.057***		**	
5	1.717	-1.000***				55	4.971***	-1.202***			
6	-0.390	-0.998***				56	3.566***	-1.329***			
7	3.139***	-0.961***				57	3.800***	-1.211***			
8	1.882*	-0.936***				58	3.939***	-0.773***			
9	0.207	-1.204***				59	3.556***	-1.147***			
10	3.284***	-0.920***	**			60	3.017**	-1.090***	*		***
11	3.293	-1.229***				61	4.129***	-0.953***			
12	3.796***	-1.026***				62	4.823***	-0.752***			
13	1.523	-0.927***				63	5.160***	-0.916***			
14	2.580**	-0.857***				64	1.072	-0.848***	***	*	
15	0.734	-1.167***	***		**	65	4.086***	-0.910***			
16	2.029**	-1.259***	*	**		66	2.963***	-0.796***			
17	2.640***	-0.960***				67	6.323***	-1.237***			*
18	1.421**	-0.941***				68	2.979**	-0.907***			
19	1.273	-1.209***				69	3.174***	-1.030***			
20	2.594***	-1.179***	*			70	2.977***	-0.823***		***	
21	2.312***	-0.913***				71	3.919***	-1.177***			
22	1.343	-0.890***	***			72	1.027	-0.977***		**	
23	0.045	-1.063***				73	3.906***	-1.074***		***	
24	1.763*	-1.014***				74	3.624**	-0.908***			**
25	1.614	-1.565***	**			75	6.240***	-1.195***	***	***	
26	2.097**	-0.879***				76	3.363**	-1.057***		***	
27	2.391	-0.821***				78	3.351***	-0.951***	***	***	
28	4.381***	-1.154***	***		***	79	3.248	-1.048***	**		
29	2.586**	-1.024***				80	3.359*	-0.970***			
30	2.565***	-1.053***	***	***	***	81	5.787***	-0.715***	*	***	
31	-0.962	-0.979***				82	2.939*	-0.873***	***	***	
32	3.033**	-1.273***	**	***		83	4.119***	-0.971***			
33	4.730***	-1.119***				84	5.147***	-0.921***		*	
34	1.785*	-1.095***			**	85	3.611***	-0.993***		**	
35	2.202**	-1.026***			*	86	3.851***	-0.902***			
36	1.509	-1.033***				87	8.601***	-0.635***		*	
37	1.520	-0.966***				88	4.189***	-0.852***			
38	-0.424	-0.932***				89	1.215	-0.632***			
39	1.795*	-1.014***	***			90	2.502	-0.877***			
40	2.240***	-1.114***	***	**		91	4.394***	-0.850***			
41	2.993***	-1.215***		**		92	5.298***	-0.840***			
42	2.251***	-0.877***		**		93	4.221***	-0.824***			
43	4.078***	-0.737***	***	***		94	3.846*	-1.036***			
44	0.920	-1.001***				95	4.338***	-1.008***			
45	2.586***	-1.013***				96	4.143***	-0.788***			
46	3.786**	-0.985***				97	2.146***	-0.976***	*		
47	4.062***	-1.014***									
48	3.339*	-0.631***									
49	0.645	-0.879***									
50	2.901***	-0.904***									

Note: Implicit quantity indices are regressed on Japanese income and price indices along exporters' fixed effects. F is the structural break test by Chow-test, and income and price under D are the post-crisis dummies that interact with income and price, respectively. The asterisks *, **, and *** indicate statistical significance at the 10, 5, and 1 percent levels, respectively.

Appendix A. Recent Dynamics of Japanese Trade Balance

Figure A1. Monthly Exports, Imports and Exchange Rate



Source: Bank of Japan and Japan’s Customs. Monthly.

Appendix B. Description of 2-digit HS industries

Table B1. Description of 2-digit HS industries

(1)Live animals.
(2)Meat and edible meat offal.
(3)Fish & crustacean, mollusc & other aquatic invertebrate
(4)Dairy prod; birds' eggs; natural honey; edible prod nes
(5)Products of animal origin, nes or included.
(6)Live tree & other plant; bulb, root; cut flowers etc
(7)Edible vegetables and certain roots and tubers.
(8)Edible fruit and nuts; peel of citrus fruit or melons.
(9)Coffee, tea, mat・and spices.
(10)Cereals.
(11)Prod mill indust; malt; starches; inulin; wheat gluten
(12)oil seed, oleagi fruits; miscell grain, seed, fruit etc
(13)Lac; gums, resins & other vegetable saps & extracts.
(14)Vegetable plaiting materials; vegetable products nes
(15)Animal/veg fats & oils & their cleavage products; etc
(16)Prep of meat, fish or crustaceans, molluscs etc
(17)Sugars and sugar confectionery.
(18)Cocoa and cocoa preparations.
(19)Prep of cereal, flour, starch/milk; pastrycooks' prod
(20)Prep of vegetable, fruit, nuts or other parts of plants
(21)Miscellaneous edible preparations.
(22)Beverages, spirits and vinegar.
(23)Residues & waste from the food indust; prepr ani fodder
(24)Tobacco and manufactured tobacco substitutes.
(25)Salt; sulphur; earth & ston; plastering mat; lime & cem
(26)ores, slag and ash.
(27)Mineral fuels, oils & product of their distillation; etc
(28)Inorgn chem; compds of prec met, radioact elements etc
(29)organic chemicals.
(30)Pharmaceutical products.
(31)Fertilizers.
(32)Tanning/dyeing extract; tannins & derivs; pigm etc
(33)Essential oils & resinoids; perf, cosmetic/toilet prep
(34)Soap, organic surface-active agents, washing prep, etc
(35)Albuminoidal subs; modified starches; glues; enzymes.
(36)Explosives; pyrotechnic prod; matches; pyrop alloy; etc
(37)Photographic or cinematographic goods.
(38)Miscellaneous chemical products.
(39)Plastics and articles thereof.
(40)Rubber and articles thereof.
(41)Raw hides and skins (other than furskins) and leather.
(42)Articles of leather; saddlery/harness; travel goods etc
(43)Furskins and artificial fur; manufactures thereof.
(44)Wood and articles of wood; wood charcoal.
(45)Cork and articles of cork.
(46)Manufactures of straw, esparto/other plaiting mat; etc
(47)Pulp of wood/of other fibrous cellulosic mat; waste etc
(48)Paper & paperboard; art of paper pulp, paper/paperboard
(49)Printed books, newspapers, pictures & other product etc
(50)Silk.
(51)Wool, fine/coarse animal hair, horsehair yarn & fabric
(52)Cotton.
(53)other vegetable textile fibres; paper yarn & woven fab
(54)Man-made filaments.
(55)Man-made staple fibres.
(56)Wadding, felt & nonwoven; yarns; twine, cordage, etc
(57)Carpets and other textile floor coverings.
(58)Special woven fab; tufted tex fab; lace; tapestries etc
(59)Impregnated, coated, cover/laminated textile fabric etc
(60)Knitted or crocheted fabrics.
(61)Art of apparel & clothing access, knitted or crocheted.
(62)Art of apparel & clothing access, not knitted/crocheted
(63)other made up textile articles; sets; worn clothing etc
(64)Footwear, gaiters and the like; parts of such articles.
(65)Headgear and parts thereof.
(66)Umbrellas, walking-sticks, seat-sticks, whips, etc
(67)Prepr feathers & down; arti flower; articles human hair
(68)Art of stone, plaster, cement, asbestos, mica/sim mat
(69)Ceramic products.
(70)Glass and glassware.
(71)Natural/cultured pearls, prec stones & metals, coin etc
(72)Iron and steel.
(73)Articles of iron or steel.
(74)Copper and articles thereof.
(75)Nickel and articles thereof.
(76)Aluminium and articles thereof.
(78)Lead and articles thereof.
(79)Zinc and articles thereof.
(80)Tin and articles thereof.
(81)other base metals; cermets; articles thereof.
(82)Tool, implement, cutlery, spoon & fork, of base met etc
(83)Miscellaneous articles of base metal.
(84)Nuclear reactors, boilers, mchy & mech appliance; parts
(85)Electrical mchy equip parts thereof; sound recorder etc
(86)Railw/tramw locom, rolling-stock & parts thereof; etc
(87)Vehicles o/t railw/tramw roll-stock, pts & accessories
(88)Aircraft, spacecraft, and parts thereof.
(89)Ships, boats and floating structures.
(90)optical, photo, cine, meas, checking, precision, etc
(91)Clocks and watches and parts thereof.
(92)Musical instruments; parts and access of such articles
(93)Arms and ammunition; parts and accessories thereof.
(94)Furniture; bedding, mattress, matt support, cushion etc
(95)Toys, games & sports requisites; parts & access thereof
(96)Miscellaneous manufactured articles.
(97)Works of art, collectors' pieces and antiques.
(98)Special Classification Provisions
(99)Special Transaction Trade.

Note: Descriptions are from OECD International Trade by Commodity Statistics

Appendix C. Detailed Description of Constructing Price and Quantity indices

[Units of measurement actually used in the Customs Office of Japan dataset, 1988-2014]

CM (cubic meters), CT (carats), DZ (dozens), GR (grams), GT (gross tons), KG (kilograms), KL (kiloliters), L (litters), M (meters), MT (metric tons), NO (numbers), SM (square meters), ST (sets), TH (thousands), PR (pairs)

[Indices based on the ALL set]

For the indices based on the ALL set, Ω_{ALL}, we used all products and maintained the unit of measurement as it was reported. We used the first unit of measurement whenever available, but the majority of HS 9-digit categories have only the second unit of measurement. Unit prices were calculated for all HS 9-digit categories. We ignored the possibility of problems caused by unit changes and code changes.

[Indices based on the MOD set]

'MOD' stands for 'modified units'. For the indices using the MOD set, C_{MOD}, the sample of selected HS 9-digit categories is the same as that of ALL measures (i.e., $\Omega_{MOD} = \Omega_{ALL}$). However, for the MOD measure, the quantities are multiplied by 1,000 if their units of measurement are either GT (gross tons), KL (kiloliters), MT (metric tons), or TH (thousands).

[Indices based on the PARTC set]

'PARTC' stands for commodities with 'partly continuous units'. For the PARTC set, HS 9-digit categories are included if their units of measurement are not altered during the sample period. This definition does not exclude those appearing as new codes or those terminated in the middle of the sample period. Obviously, $\Omega_{PART} \subset \Omega_{ALL}$.

[Indices based on the WHOLEC set]

'WHOLEC' stands for 'continuous units for whole sample period'. For the WHOLEC set, HS 9-digit categories are included only if their units of measurement are always the same during the entire sample period. This measure drastically reduces the number of HS 9-digit categories that constitute the price index, $\Omega_{WHOLE} \subset \Omega_{PART}$.

[PN Index based on the PREV and NEXT sets)]

'PREV' stands for 'consistent with previous period' and 'NEXT' stands for 'consistent with next period'. The 'PREV' set and the 'NEXT' set are used together, and their sets of included HS 9-digit categories vary with time. For the 'PREV' set, HS 9-digit categories are included if their units of measurement are not altered from the previous period. For the 'NEXT' set, HS 9-digit categories are included if their units of measurement are not altered in the next period. Therefore, $\Omega_{PREV,t-1} = \Omega_{NEXT,t-1}$, but $\Omega_{PREV,t}$ is not necessarily equal to $\Omega_{NEXT,t}$. For any t, $\Omega_{WHOLEC} \subset \Omega_{PREV}$ and $\Omega_{WHOLEC} \subset \Omega_{NEXT}$.

[Examples]

The following table provides an example of codes denoting changes codes in terms of the units of measurement (code A), a new code (code C) and a disappearing code (code D).

HS 9-digit	1988	1989	1990	1991	…	2013	2014
code A	KG	KG	KG	MT	…	MT	MT
code B	KG	KG	KG	KG	…	KG	KG
code C			KG	KG	…	KG	KG
code D	MT	MT	MT				

The ALL uses all codes as they are. The MOD multiplies the units of code A by 1,000 from 1991 onward. The PARTC excludes code A. The WHOLEC uses only code B. The NEXT proceeds as follows: codes A, B and D are used in 1988 and 1989; codes B and C are used in 1990; and codes A, B, and C are used in 1991 through 2013. The PREV proceeds as follows: codes A, B, and D are used in 1989 and 1990; codes B and C are used in 1991; and codes A, B, and C are used in 1992 through 2014. The following table summarizes the commodities included in the corresponding sets.

HS 9-digit	1988	1989	1990	1991	…	2013	2014
$\Omega_{ALL}, \Omega_{MOD}$	ABD	ABD	ABCD	ABC	…	ABC	ABC
Ω_{PARTC}	BD	BD	BCD	BC	…	BC	BC
Ω_{WHOLEC}	B	B	B	B	…	B	B
Ω_{PREV}		ABD	ABD	BC	…	ABC	ABC
Ω_{NEXT}	ABD	ABD	BC	ABC	…	ABC	

Appendix D. Selected partner countries

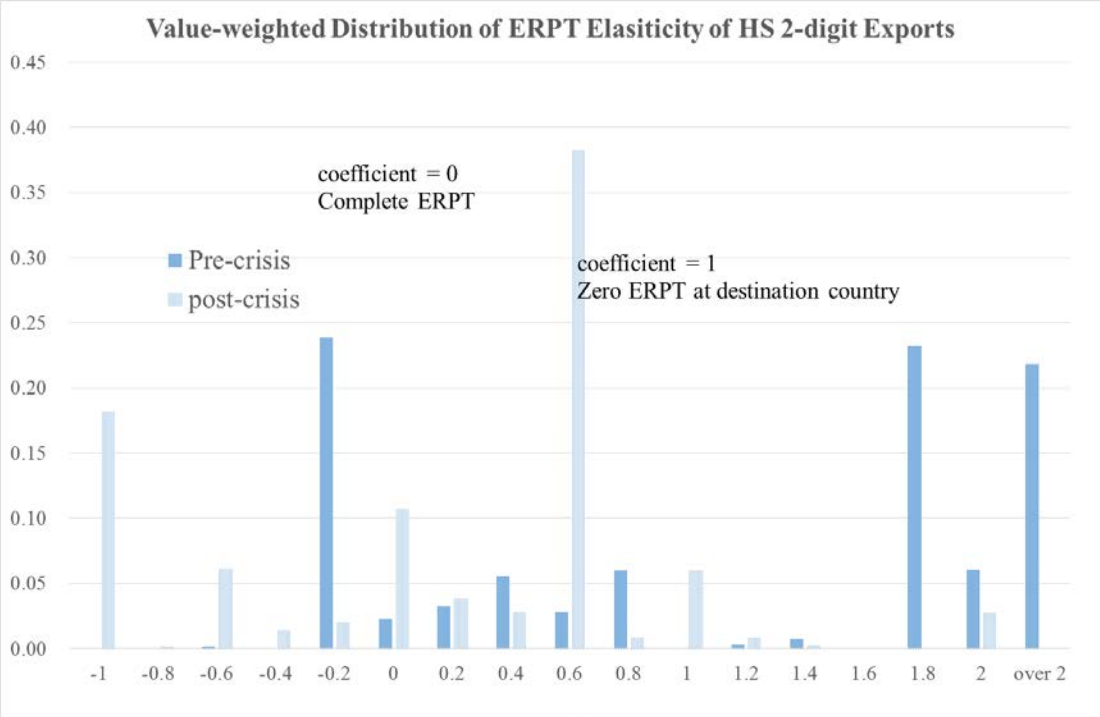
For Japanese exports, the following 19 countries were selected on the basis of the largest shares during 1988-2014: Korea, China, Hong Kong, Thailand, Singapore, Malaysia, the Philippines, Indonesia, the UK, Netherlands, Belgium, France, Germany, Italy, Canada, the US, Mexico, Panama, and Australia. These countries comprise 85% of the total exports.

For Japanese imports, the following 19 countries were selected on the basis of the largest shares during 1988-2014: Korea, China, Thailand, Singapore, Malaysia, the Philippines, Indonesia, Iran, Saudi Arabia, Qatar, the UAE, the UK, France, Germany, Italy, Russia, Canada, the US, and Australia. These countries comprise 83% of the total imports.

Notably, Taiwan was not included in either exports or imports due to the lack of data from WDI and IFS. For Russia, the exchange rate was only available after 1993.

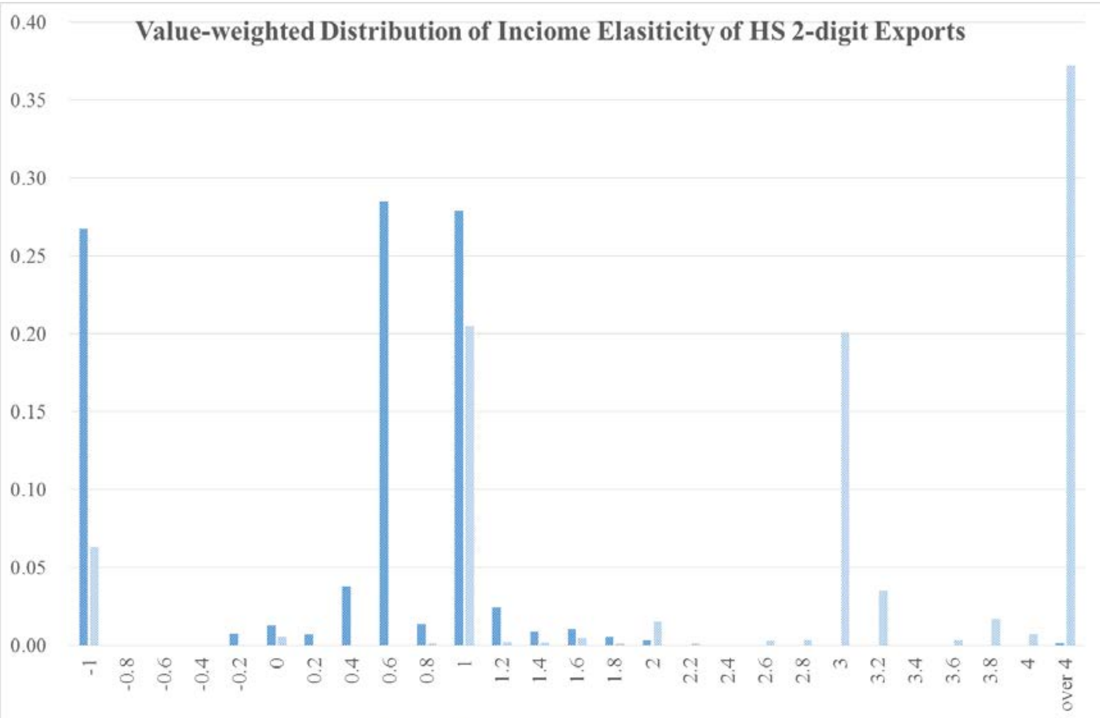
Appendix E. Value-weighted Distribution of Estimated Elasticities

Figure E1. Pre-crisis versus post-crisis, ERPT elasticity of HS 2-digit Exports



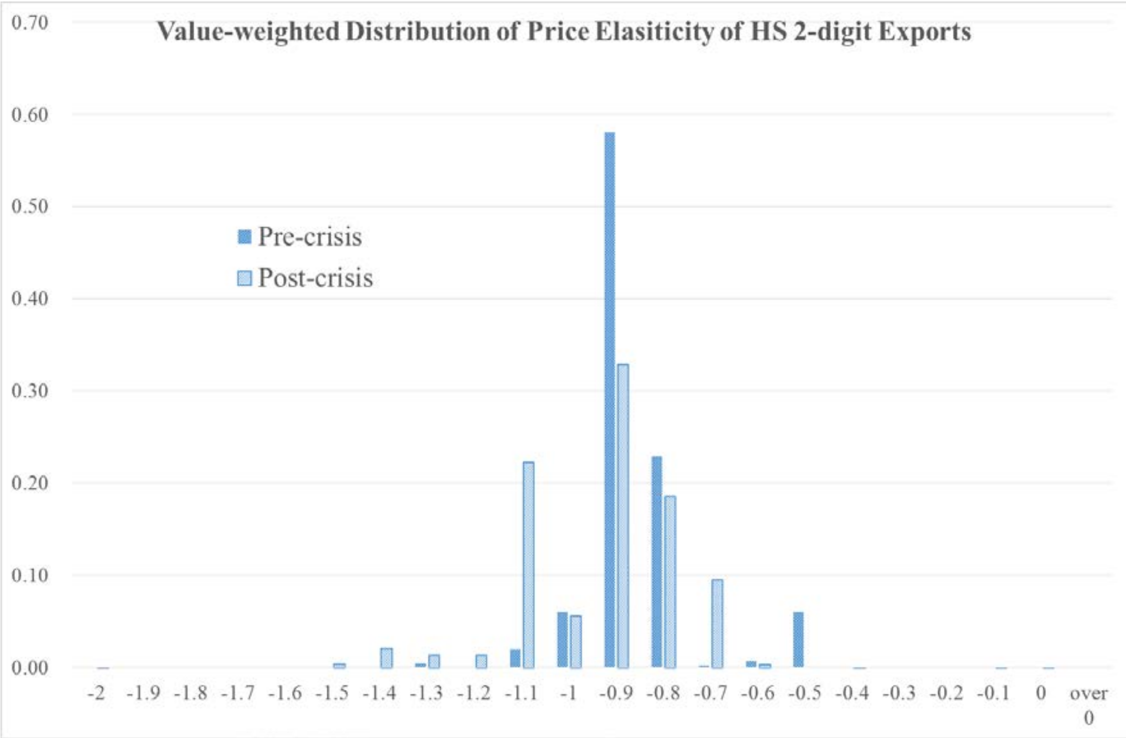
Note: The point estimates of ERPT elasticity coefficients of HS 2-digit Japanese exports are weighted by the trade share for pre-crisis and post-crisis subsamples.

Figure E2. Pre-crisis versus post-crisis, income elasticity of HS 2-digit Exports



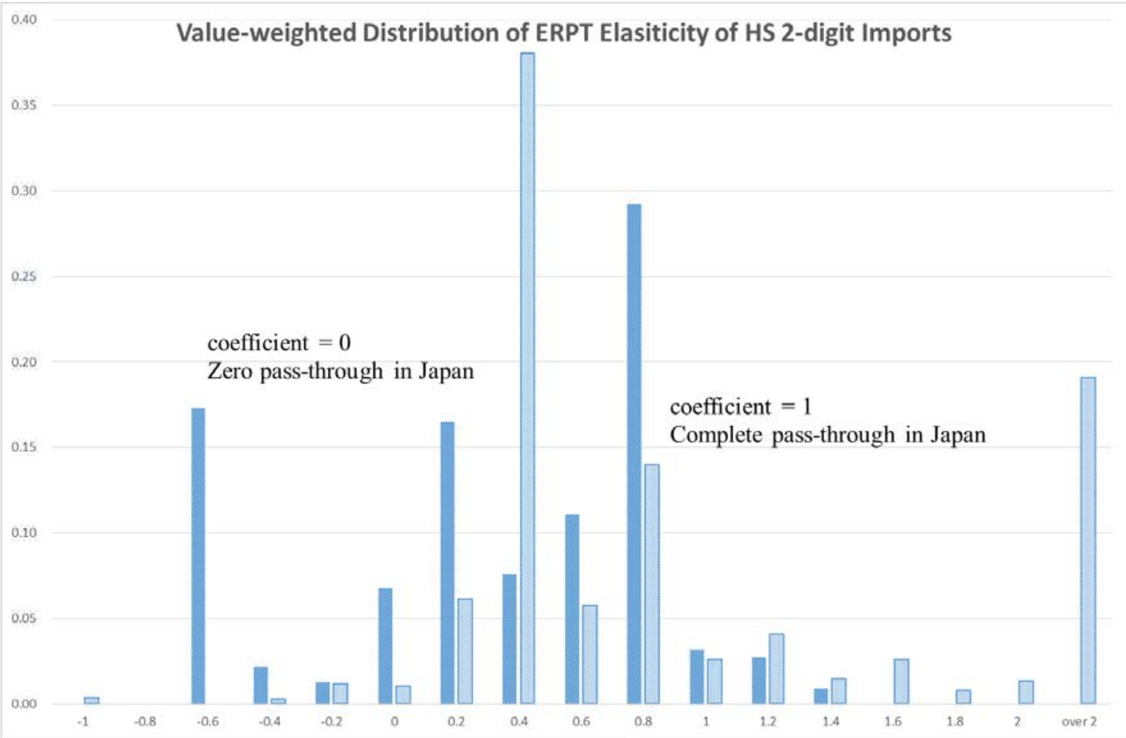
Note: The point estimates of income elasticity coefficients of HS 2-digit Japanese exports are weighted by the trade share for pre-crisis and post-crisis subsamples.

Figure E3. Pre-crisis versus post-crisis, Price elasticity of HS 2-digit Exports



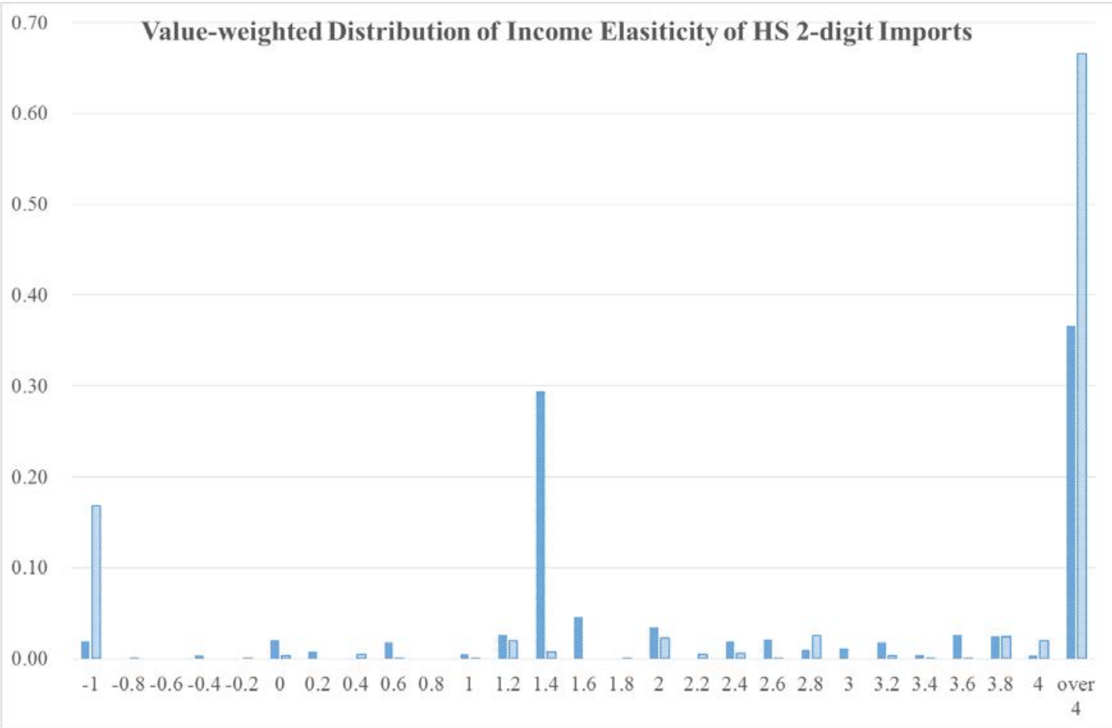
Note: The point estimates of price elasticity coefficients of HS 2-digit Japanese exports are weighted by the trade share for pre-crisis and post-crisis subsamples.

Figure E4. Pre-crisis versus post-crisis, ERPT elasticity of HS 2-digit Imports



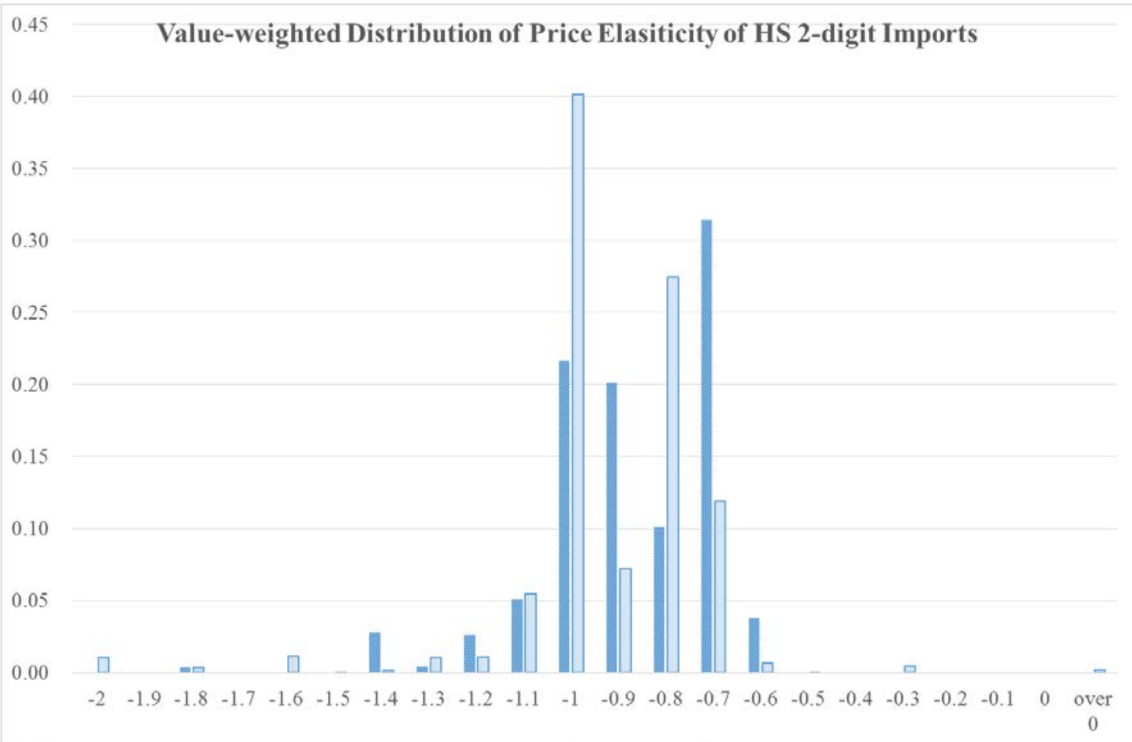
Note: The point estimates of ERPT elasticity coefficients of HS 2-digit Japanese imports are weighted by the trade share for pre-crisis and post-crisis subsamples.

Figure E5. Pre-crisis versus post-crisis, Income elasticity of HS 2-digit Imports



Note: The point estimates of income elasticity coefficients of HS 2-digit Japanese imports are weighted by the trade share for pre-crisis and post-crisis subsamples.

Figure E6. Pre-crisis versus post-crisis, Price elasticity of HS 2-digit Imports



Note: The point estimates of price elasticity coefficients of HS 2-digit Japanese imports are weighted by the trade share for pre-crisis and post-crisis subsamples.