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How Did the Japanese Exports Respond to Two Crises in the International Production Network?: The Global Financial Crisis and the East Japan Earthquake

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Abstract: This paper analyzes the impact of two massive shocks, the 2008-2009 Global Financial Crisis and the 2011 East Japan Earthquake, on Japanese exports, focusing on the characteristics of domestic/international production networks in machinery industries. Using monthly data of Japanese bilateral exports at the most disaggregated level, we decompose the fall and recovery of Japanese exports into intensive and extensive margins and also examine the exits and re-entries by applying logit estimation and survival analysis. Episodes of both shocks confirm the stability and robustness of production networks and the enhancing link with East Asia. On the other hand, differences between two shocks seem to generate differential impacts on corporate behavior.

***Keywords*:** The fragmentation theory, Intensive/extensive margins, Supply and demand shocks, Exchange rates, Survival analysis

***JEL Classification*:** F14, F23

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1. Introduction

Recent two massive shocks, the 2008-2009 Global Financial Crisis and the 2011 East Japan Earthquake, seriously affected the Japanese economy. In particular, international production/distribution networks, which are major sources of international competitiveness of Japan and East Asia, transmitted these negative shocks from the origin to all over the world, and thus some claimed that production networks revealed their vulnerability. As this paper demonstrates, however, international production/distribution networks rather presented their elasticity and resiliency against these two crises.[1]

The two shocks had similar and dissimilar features, which generated common and different adjustments in production networks and international trade. Both shocks were massive ones for the Japanese economy and generated distinctive falls and recoveries in international trade. The patterns of responses were similar; trade within production networks, particularly trade in machinery parts and components, presented distinctive stability and resiliency vis-à-vis trade in machinery final products and others. On the other hand, the magnitude and duration of shocks were different; the 2008-2009 Global Financial Crises had huge and prolonged impacts while the 2011 East Japan Earthquake had much smaller and temporary impacts. The former was primarily a demand shock due to drastic drops of demand in the US and EU markets while the latter was a supply shock

[1] As Ando (2010) demonstrates, international trade, particularly in East Asia, recovered with rapid re-activation of production/distribution networks from the Global Financial Crisis. East Asia itself became a major contributor to the recovery of East Asian trade, not only for machinery parts and components but also for machinery finished products. As for the Global Financial Crisis, also see Haddad and Shepherd (2011) for an interesting serious of analyses of trade and economies.

due to the devastation of production plants located in the disaster areas. These differences partially explain such a dissimilar response, with a perception of permanent or temporary shocks.

This paper sheds light on machinery industries with a distinction between machinery intermediate goods and machinery final products and examines how and to what extent the two crises affected Japanese exports, from the viewpoint of domestic/international production networks. More specifically, we first conduct detailed descriptive analysis on trade movements in these industries, using monthly data of Japanese bilateral exports at the most disaggregated level or exports at the country-product level. Then, we take a decomposition approach, which is proposed by Haddad *et al.* (2010), and decompose changes in exports into extensive and intensive margins, i.e., quantity effect, price effect, effect due to exiting products, and effect due to new products. With this decomposition analysis, we identify major factors of trade falls and recoveries at the crises for machinery parts and components and machinery final products. Moreover, we examine the probability of trade falls and recoveries by applying logit estimation, with a particular interest in differences between machinery intermediate goods and final products. In addition, the methodology of survival analysis is used to investigate the probability of trade recovery, considering the timing of recovery in a longer period.

The rest of the paper is organized as follows: section 2 presents descriptive analysis to capture the patterns of Japanese exports, particularly focusing on machinery exports. Sections 3 and 4 provide analyses of fall and recovery of machinery trade at the 2008-2009 Global Financial Crisis and the East Japan Earthquake in 2011, respectively.

The paper ends in section 5 with discussion on similarities and differences in two massive shocks and policy implications.

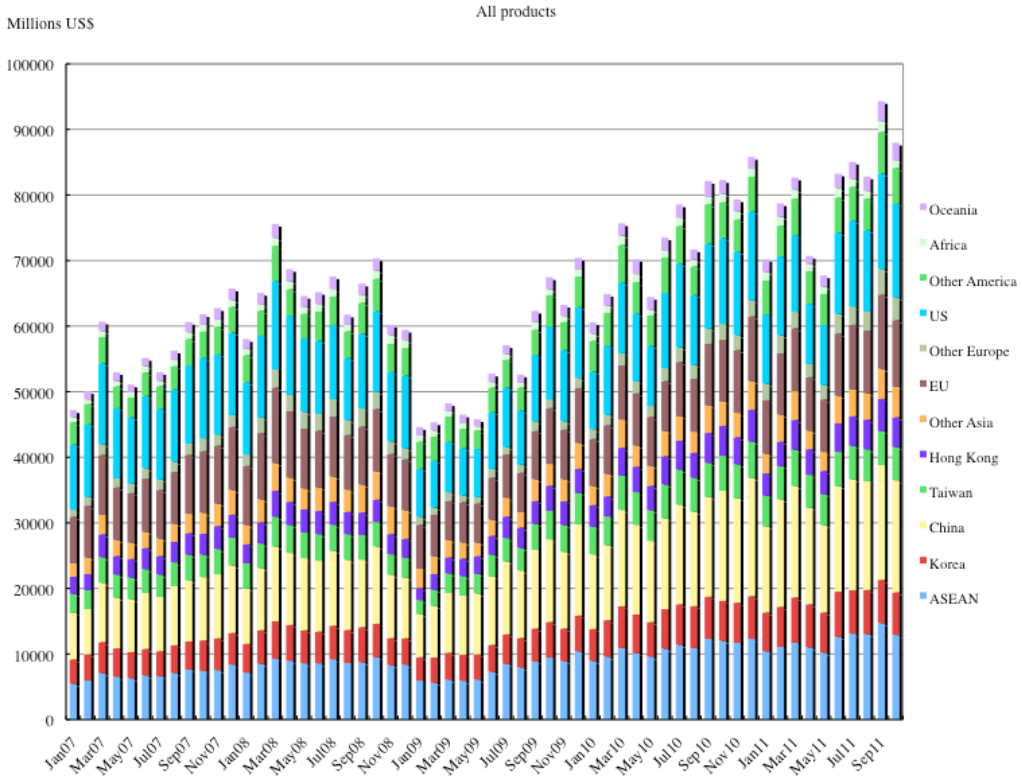
2. Patterns of Japanese Exports: Descriptive Analysis

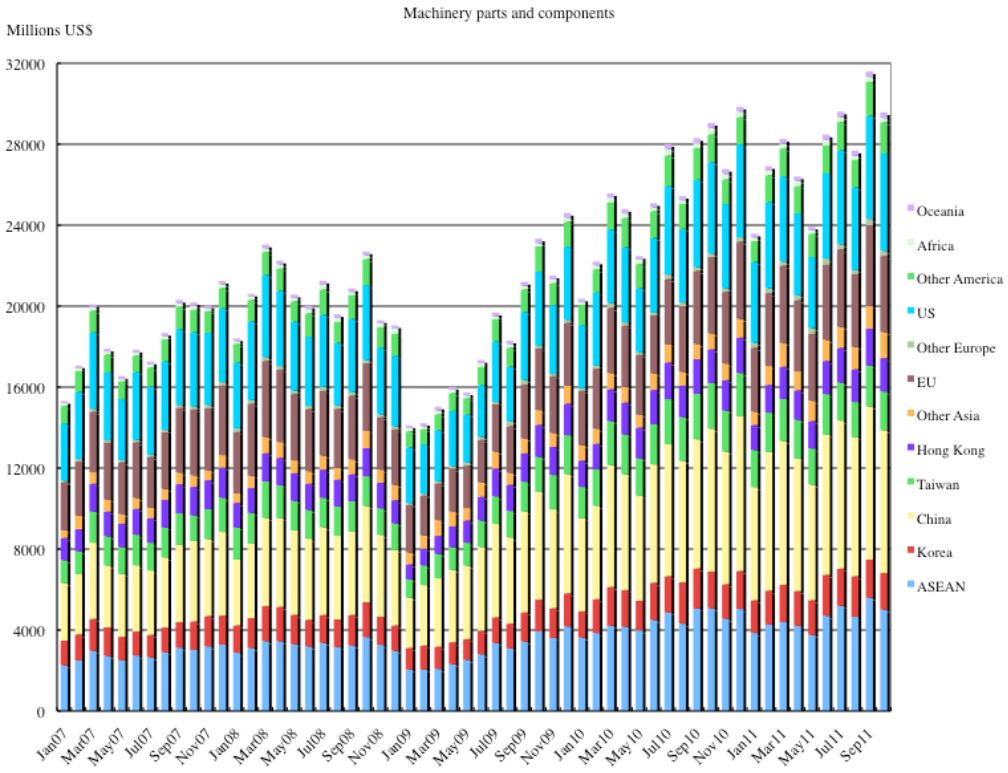
Figure 1 presents movements of Japanese real exports in US dollars by destination regions not only for all products but also for machinery final goods (total and only automobiles), machinery parts and components from January 2007 to October 2011.[2] The figure clearly shows the existence of significant negative impacts of the 2008-2009 Global Financial Crisis on Japanese exports. At the same time, the figure displays a V-shape recovery of exports by the end of 2009 for all products, with an initial peak in October 2008 and a bottom in January 2009, followed by a gradual growth until the East Japan Earthquake occurs in March 2011.[3]

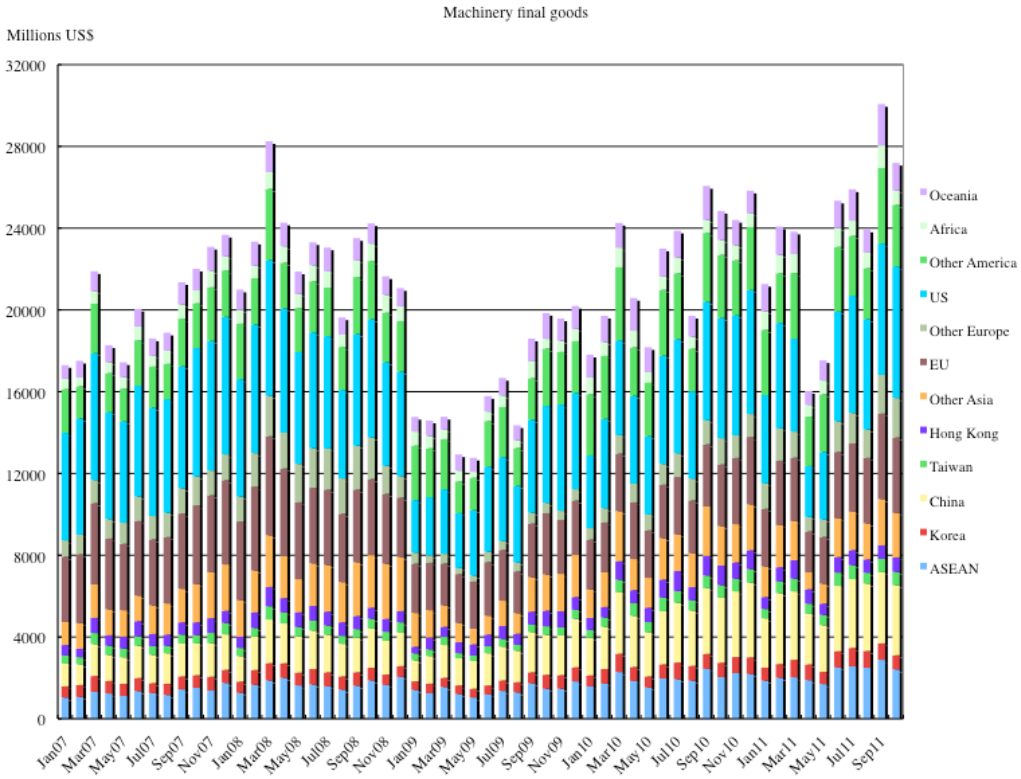
[2] Machinery goods are composed of general machinery, electric machinery, transport equipment, and precision machinery (Harmonized System (HS) 84-92) in this paper. The definition of machinery parts and components is based on Ando and Kimura (2005), which is adjusted to the 2007 version of HS classification (Table A.1). Machinery final products are defined as machinery goods other than machinery parts and components. Automobiles are final products only in HS87. See subsection 3.1.1 for the explanation to obtain the real export values in US dollars.

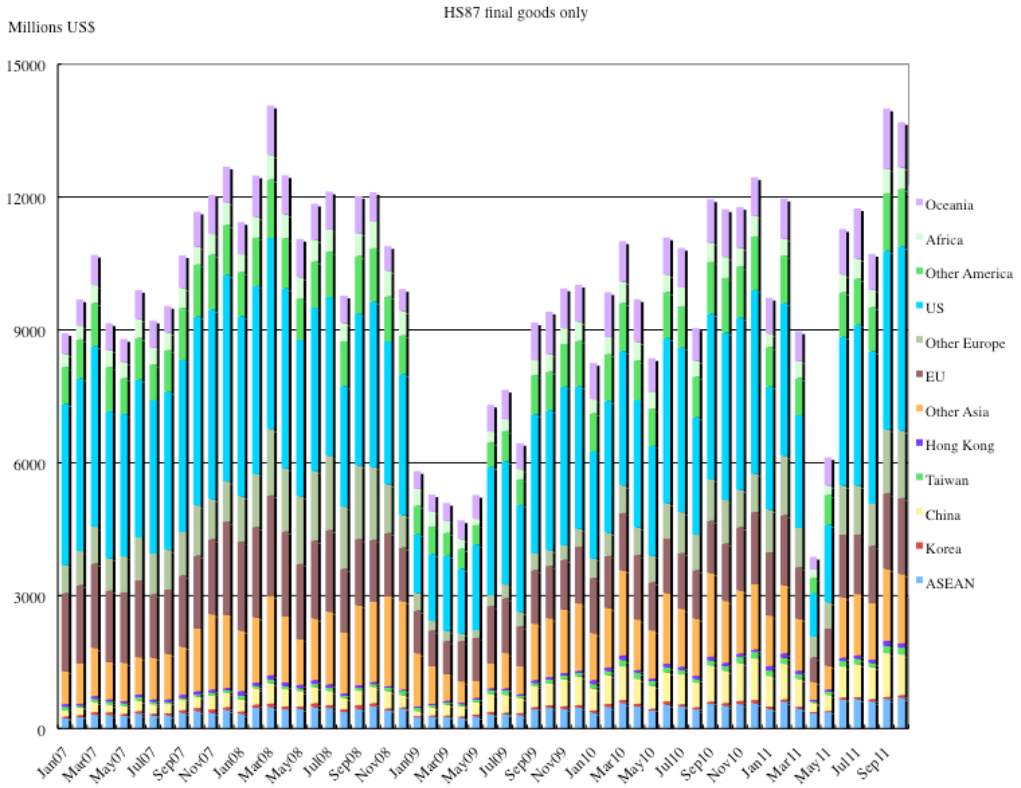
[3] The Japanese Yen tend to appreciate since the Global Financial Crisis (Figure A.1 in the Appendix). Therefore, the corresponding figure for exports in JP Yen demonstrates slightly different picture of the recovery from the global financial crisis (Figure A.2 in the Appendix); for instance, exports for all products in JP Yen finally return to the level of October 2008 in around March 2010.

Figure 1. Japanese Exports by Region







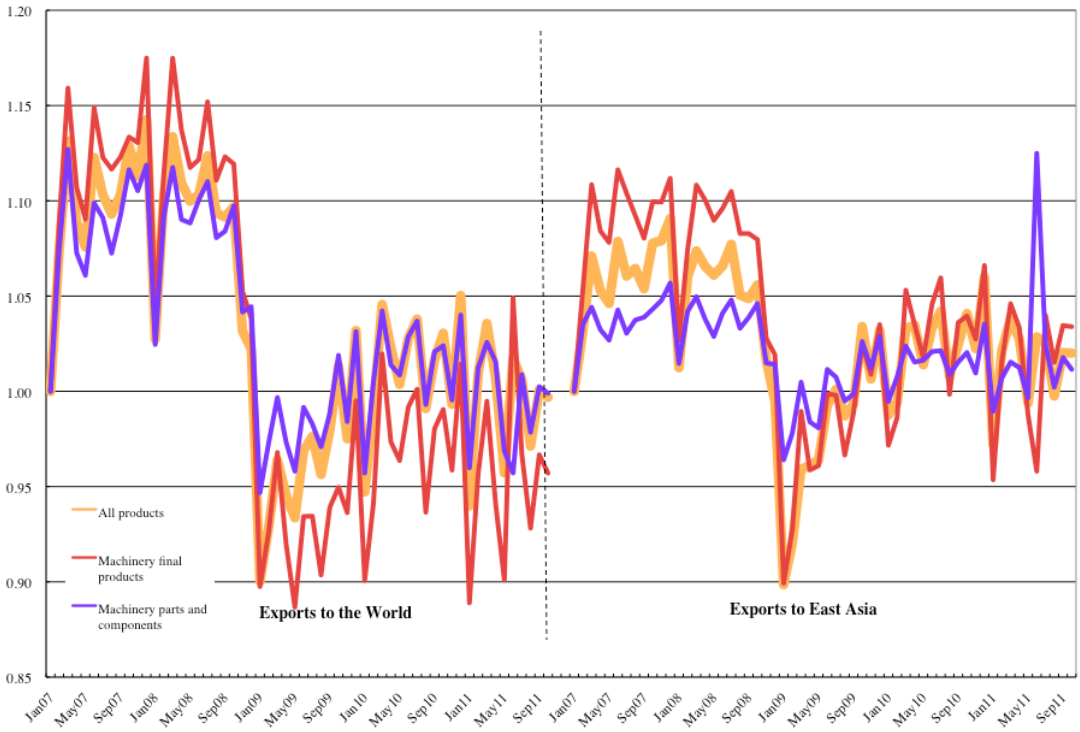


Data: Authors' preparation, using data available from the websites of the Ministry of Finance and the Bank of Japan.

We, however, observe a permanent change in extensive margins of machinery exports. The number of exported products tallied by partner country (i.e., the number of product-country pairs for exports) for all products exported to the world significantly dropped in the 2008-2009 Global Financial Crisis, with a bottom in January 2009 (Figure 2).[4] Although the number of exported products has a tendency to increase since January 2009, it does not return to the level of 2007 or 2008. Figure 2 also presents the number of product-country pairs for exports to East Asian countries only; it shows a significant drop of the number of exported products for East Asia as well, though the decline is not so serious as the case of exports to all countries in the world. These reflect the fact that geographical distribution of activities by Japanese firms, including those in East Asia, is reshuffled and the basis of Japanese exports is narrowed down with the Global Financial Crisis as a trigger.

[4] The number of exported product-country pairs is expressed as an index based on the number in January 2007; the number of exported product-country pairs for all products exported to the world is 66,119.

Figure 2. The Number of Exported Products (Tallied by Partner Country), Indexed to Januarv 2007=1



Data: Authors' calculation, using data available from the website of the Ministry of Finance.

The effects of the East Japan Earthquake are reflected in exports particularly in April and May 2011. Exports decline from the previous month in April and May 2011, while exports in April are more or less at the same level in the same month of the previous year, and exports in May are greater than the previous year. Interestingly, exports rapidly increase in June, achieving a positive growth in terms of both changes from the previous month and the previous year; exports in June 2011 are greater by more than 10 percent of exports in June 2010.[5] Compared with the 2008-2009 Global Financial Crises, overall

[5] Again, exports for all products in JP Yen demonstrate slightly different picture; exports in both April and May are still less than those in the corresponding month of the previous year. Exports in June finally catch the level of the previous year.

trade fall and recovery are much smaller and more rapid, and no distinctive change in extensive margins of exports is observed.[6]

Let us discuss features of sectoral exports. For machinery final products, major markets include developed countries such as the US and European Union (EU).[7] Since the Global Financial Crisis, the value of exports to the US and EU has not returned to the level in 2007 (Table 1). On the other hand, East Asia is growing in terms of the value of exports as well as the share in total exports: the value in 2010 is by 1.6 times as high as that in 2007, and the share increases from 22 percent in 2007 to 30 percent in 2010.[8] If we focus on only automobiles (final products), the corresponding value and share in 2010 are doubled from those in 2007. With the Global Financial Crisis as a trigger, East Asia is gaining the importance as the market of machinery final products, though the US and EU remain as important markets.

[6] For Japanese exports in agriculture and food industries, not only the earthquake itself but also the Tsunami by the earthquake resulting in the Fukushima nuclear disaster has been bringing significant negative impacts. Many importing countries introduced additional safety inspections and trade restrictions for imports in agriculture and food products produced in Japan in various ways. As a result, the number of exported products in agriculture and food industries significantly dropped particular in April-June 2011 in some countries such as China, Korea, EU, and the Middle East.

[7] EU refers to EU27 in this paper.

[8] East Asia in this paper includes the following 14 countries/economies: Association of South-East Asian Nations (ASEAN) 10 (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam), China, Korea, Hong Kong, and Taiwan.

Table 1. By-region Value and Share of Exports

	The value of exports, indexed to 2007=1				Share in total exports (%)			
	2007	2008	2009	2010	2007	2008	2009	2010
All products								
East Asia	1.00	1.18	1.09	1.53	47	48	53	54
US	1.00	1.01	0.78	1.01	20	18	16	15
EU	1.00	1.10	0.82	1.00	15	14	12	11
World	1.00	1.16	0.97	1.31	100	100	100	100
Machinery parts and components								
East Asia	1.00	1.13	1.06	1.54	56	56	59	62
US	1.00	1.04	0.85	1.13	18	17	16	15
EU	1.00	1.11	0.83	1.13	15	15	13	13
World	1.00	1.11	0.99	1.38	100	100	100	100
Machinery final products								
East Asia	1.00	1.19	1.02	1.55	22	23	28	30
US	1.00	0.97	0.66	0.86	29	24	23	22
EU	1.00	1.06	0.69	0.78	18	16	15	12
World	1.00	1.15	0.81	1.12	100	100	100	100
HS87 final goods only								
East Asia	1.00	1.38	1.20	2.00	7	8	12	14
US	1.00	0.96	0.64	0.86	37	31	34	31
EU	1.00	1.01	0.62	0.76	17	15	15	12
World	1.00	1.14	0.70	1.02	100	100	100	100

Data: Authors' calculation, using data available from the websites of the Ministry of Finance and the Bank of Japan.
Note: Export values are in US$.

Exports in machinery final products suffered from the severe negative impacts of the Global Financial Crisis, with a bottom in April/May 2010, which is later than the average. Furthermore, the 2011 East Japan Earthquake brought a serious damage to their exports because critical small and medium-sized enterprises (SMEs) are located in the disaster areas and negative supply shocks affect exports through production chains; exports sharply declined in April resulting in the level much lower than the previous year. In particular, exports in automobiles experienced the most serious impacts; exports in April at the bottom are even lower than exports at the bottom in the 2008-2009 Global Financial Crisis. Exports in machinery final products, including automobiles, however, rapidly

recover since May and even exceed the level of the previous year in June. Permanent changes in the export pattern are barely observed here.

For machinery parts and components, East Asia occupies around 60 percent of their exports to the world. The share of East Asia slightly increases after the Global Financial Crisis, and the value in 2010 becomes by 1.5 times as large as that in 2007. East Asia is the most important destination of Japanese exports in machinery parts and components because Japanese firms are active in the region as one of the major players in production/distribution networks. While exports significantly dropped in the Global Financial Crisis, they recovered by October 2009, with a drastic recovery of exports to East Asia, and they continue to grow partially reflecting an increase in the price in US dollars due to the appreciation of JP Yen. In the 2011 East Japan Earthquake, exports decline in April and May, but exports in US dollars are still greater than the level of the previous year even in April and May. Moreover, as is the case of other products, exports in June increase. As a result, exports in June recover the level of previous year even in terms of both US dollars and JP Yen, though exports in JP Yen were lower than the level of previous year in April and May. Note that the number of exported product-country pairs for machinery parts and components sharply rises in July, while the number drastically increases in June for all products/machinery final products; interestingly the number of product-country pairs only for machinery parts and components exported to East Asia sharply increases in June as well, probably reflecting the importance of maintaining supply chains in regional production networks (Figure 2).

3. Analysis of the Effects of the 2008-2009 Global Financial Crisis

This section first investigates patterns of trade fall and recovery, using the decomposition approach and logit estimation, and then examines patterns of trade recovery by applying survival analysis, considering the timing of trade recovery with a further time horizon.

3.1. Decomposition of Trade Changes

In this subsection, we decompose the fall and recovery in exports into external and internal margins, i.e., quantity effect, price effect, effect due to exiting products, and effect due to new products. For this analysis, we set the period of trade fall as the one from October 2008 to January 2009 and the period of trade recovery as the one from January 2009 to October 2009.[9]

3.1.1. Methodology and Data

Let us briefly explain the decomposition approach, which is proposed by Haddad *et al.* (2010).[10] The first step is to identify the category of a product exported to a given partner country: "continuing", "entry", and "exit". If a product is exported to a given

[9] The month at the minimum level of exports is January 2009 for most products, while the corresponding month is May 2009 for machinery final products (April 2009 for automobiles only). To see whether there exist any differences among products, however, we analyze patterns of export changes in the same period. We also define the period of trade recovery as from January to October, rather than from January to December, to exclude the effects of the crisis in calculating changes during the same period of the previous year.

[10] Their approach is inspired by the earlier work by Bernard *et al*. (2009), who analyze the 1997 Asian crisis using trade data of U.S. firms.

country in both period $t-1$ and period t, the category of the product for the corresponding country (the product-country pair) is defined as "continuing". Similarly, the category of a product for a given country is defined as "entry" if the product is exported only in t, and the category is defined as "exit" if the product is exported to the corresponding country only in $t-1$.

The second step is to decompose changes in export values from period $t-1$ to period t into external and internal margins, based on the categories defined above. The total value in t, v_t, can be written as the sum of the value of each product i:

$$v_t = \sum_{i=1}^{I} p_t^i q_t^i, \tag{1}$$

where p_t^i and q_t^i denote price and quantity of product i in t, and I is the total number of products. The percentage change in the total value, dv_t / v_{t-1}, is expressed as follows:

$$dv_t / v_{t-1} = (v_t - v_{t-1}) / v_{t-1} = \left(\sum_{i=1}^{I} p_t^i q_t^i - \sum_{i=1}^{I} p_{t-1}^i q_{t-1}^i \right) / v_{t-1}. \tag{2}$$

Internal margin is composed of effects due to changes in quantity and price; changes in export values for products (country-product pairs) classified into "continuing" due to changes in quantity (quantity effect) and changes in price (price effect). External margin consists of an effect due to exiting products (exit effect hereafter) and an effect due to new products (entry effect hereafter); changes in export values resulting from a decrease in export values due to no export in t for products (product-country pairs) classified into "exit" and an increase in export values due to new exports in t for products (product-country pairs) classified into "entry". By rewriting the equation (2), the

percentage change in the total value of exports can be expressed as the sum of quantity effect, price effect, entry effect, and exit effect:

$$\frac{dv_t}{v_{t-1}} = \frac{\sum_{c=1}^{C} \frac{p_t^c + p_{t-1}^c}{2} \Delta q_t^c}{v_{t-1}} + \frac{\sum_{c=1}^{C} \Delta p_t^c \frac{q_t^c + q_{t-1}^c}{2}}{v_{t-1}} + \frac{\sum_{n=1}^{N} p_t^n q_t^n}{v_{t-1}} - \frac{\sum_{x=1}^{X} p_{t-1}^x q_{t-1}^x}{v_{t-1}}$$

$$(I = C + N + X) \qquad (3)$$

where c for products that are traded in both $t-1$ and t (in the category "continuing"), n for products that are traded only in t (in the category "entry"), x for products that are traded only in $t-1$ (in the category "exit"), C expresses the total number of products in the category "continuing", N the total number of products in the category "entry", and X the total number of products in the category "exit".[11]

To decompose changes in values of Japanese exports by applying this method, the paper employs monthly data of Japanese bilateral exports at the most disaggregated level or the Harmonized System (HS) 9-digit level. The monthly data of Japanese exports at the product-country level in Japanese Yen is available from the Trade Statistics of Japan, the Ministry of Finance, Japan.[12] In order to convert exports in JP Yen on the nominal term into exports in US dollars on the real term, we use export price index, available from the Bank of Japan[13], and exchange rates that are monthly average of public rates announced by Japan Customs, available from the Ministry of Finance, Japan.[14] Note that prices for some products in the category "continuing" are missing due to the lack of

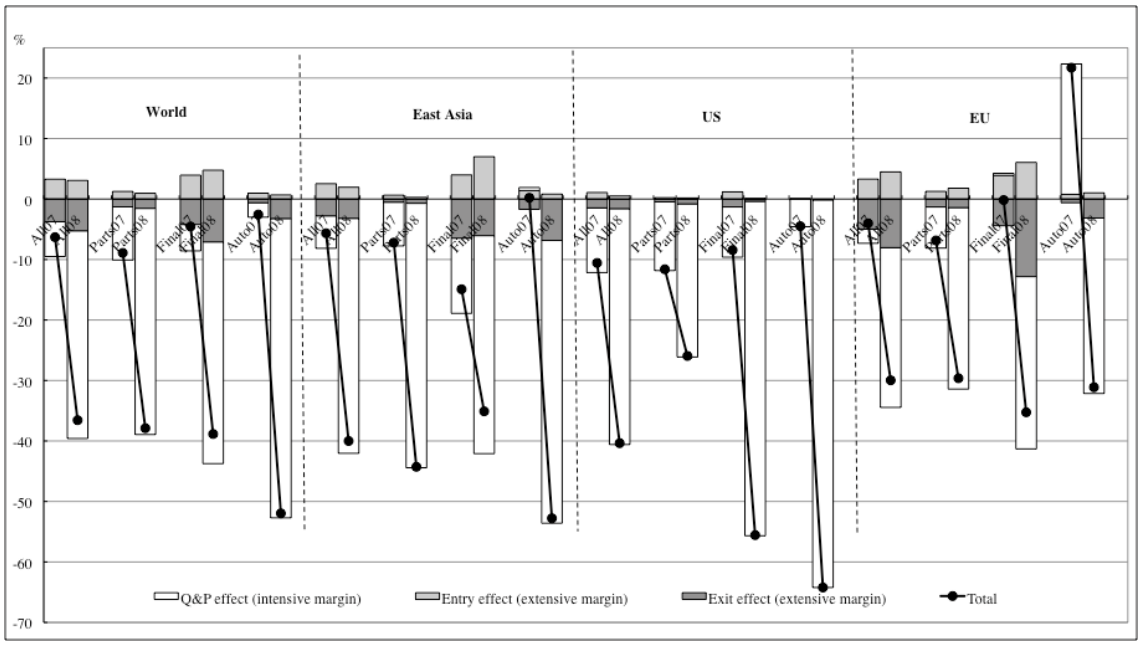
[11] Haddad *et al.* (2010) provide detailed explanation of how to obtain equation (3) by rewriting equation (2).
[12] http://www.customs.go.jp/toukei/info/index.htm.
[13] http://www.boj.or.jp/statistics/pi/index.htm/.
[14] http://www.customs.go.jp/tetsuzuki/kawase/index.htm.

quantity data. We regard changes in exports due to these product-countries pairs as the "unidentified effect" in order not to underestimate internal margins.

3.1.2. Results

Figure 3 and Table 2 represent changes in total exports during the period of trade fall due to the crisis (October 2008 to January 2009) and the decomposition for all products, machinery intermediate goods, machinery final products, and automobiles only. They also show the results in the same period of the previous year to partially consider seasonal fluctuations. Similarly, Figure 4 and Table 3 present corresponding figures for changes in total exports during the period of trade recovery from the crisis (January to October 2009) and the decomposition.

Figure 3. Export Decline in the 2008-2009 Crisis by Region: Decomposition of Real Changes in Exports (US$)



Data: See Table 2.

Notes: Q&P effect is the sum of quantity effect, price effect, and unidentified effect. All08 (All07), for instance, denotes all products in the period from October 2008 (2007) to January 2009 (2008). Parts, Final, and Auto denote machinery parts and components, machinery final goods, and automobiles (HS87 final only).

Table 2. Export Decline in the 2008-2009 Crisis: Decomposition of Real Changes in Exports (US$)

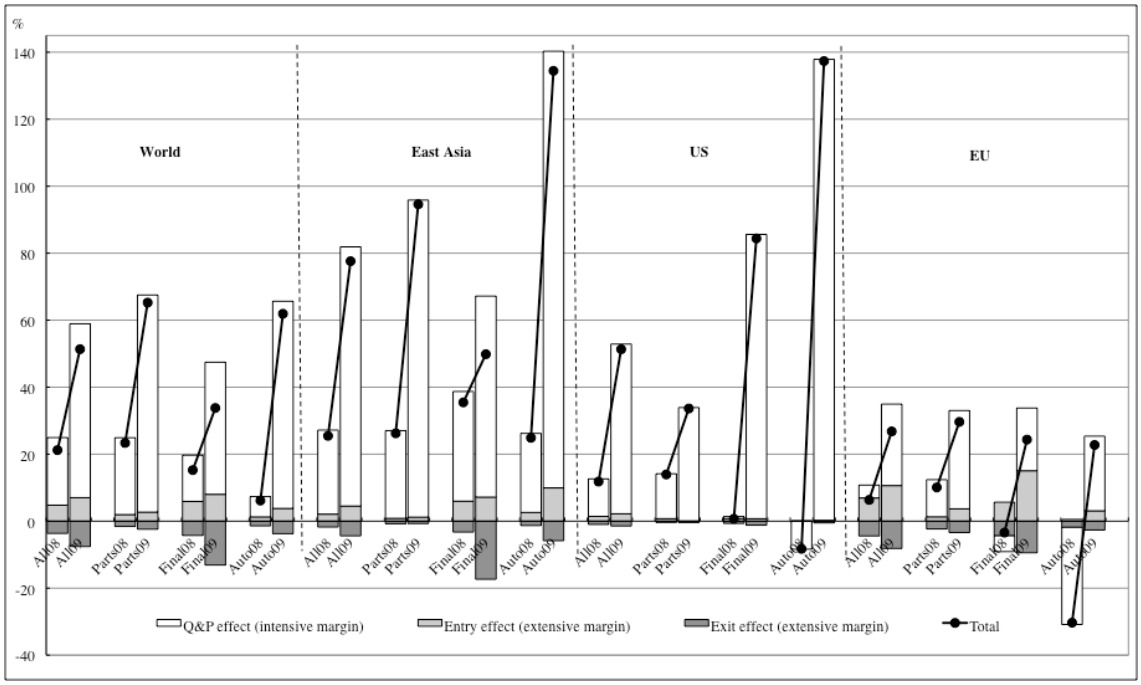
(%)

	October 2008-January 2009					October 2007-January 2008				
	Total	Quantity effect	Price effect	Entry effect	Exit effect	Total	Quantity effect	Price effect	Entry effect	Exit effect
All products										
World	-36.6	-79.4	45.1	3.1	-5.3	-6.3	-16.1	10.3	3.3	-3.8
East Asia	-40.0	-110.7	71.9	1.9	-3.2	-5.7	-19.2	13.9	2.5	-2.8
US	-40.4	-54.8	15.9	0.5	-1.6	-10.6	-16.0	5.3	1.1	-1.5
EU	-30.0	-60.4	34.0	4.5	-8.1	-4.0	-13.0	10.7	3.3	-5.0
Machinery parts and components										
World	-37.9	-59.5	22.1	0.9	-1.6	-8.9	-17.5	8.7	1.3	-1.3
East Asia	-44.3	-63.7	20.0	0.3	-0.7	-7.2	-20.9	13.7	0.6	-0.6
US	-25.9	-41.6	16.3	0.2	-0.8	-11.6	-14.1	2.7	0.2	-0.5
EU	-29.6	-70.3	40.3	1.8	-1.4	-6.8	-13.2	6.4	1.3	-1.3
Machinery final goods										
World	-38.8	-55.4	18.8	4.8	-7.1	-4.5	-14.9	10.5	3.9	-4.2
East Asia	-35.1	-69.6	33.6	7.0	-6.1	-14.9	-28.7	16.3	4.0	-6.5
US	-55.6	-68.8	13.6	0.1	-0.4	-8.4	-14.4	6.1	1.2	-1.3
EU	-35.3	-38.0	9.5	6.0	-12.8	-0.2	-12.3	12.6	3.9	-4.4
HS87 final goods only										
World	-52.0	-60.8	11.4	0.7	-3.3	-2.6	-9.6	7.2	1.0	-0.6
East Asia	-52.8	-58.4	11.7	0.8	-6.8	0.2	-7.0	7.5	1.4	-1.7
US	-64.2	-73.3	9.3	0.0	-0.2	-4.5	-9.8	5.3	0.1	0.0
EU	-31.1	-41.5	12.5	1.0	-3.1	21.7	10.5	11.0	0.8	-0.6

Data: Authors' calculation, using data available from the websites of the Ministry of Finance and the Bank of Japan.

Notes: The category of "unidentied" is omitted since the values for this category is zero or pretty close to zero. Export changes are calculated, using data at the country-product level. Export changes in the same period of the previous year are also presented to partially consider the seasonality. Changes in exchange rates (JPYen/US$) are -12.7% in October 2008-January 2009 and -4.6% in October 2007-January 2008.

Figure 4. Export Recovery in the 2008-2009 Crisis by Region: Decomposition of Real Changes in Export (US$)



Data: See Table 3.

Notes: Q&P effect is the sum of quantity effect, price effect, and unidentified effect. All09 (All08), for instance, denotes all products in the period from January to October 2009 (2008). Parts, Final, and Auto denote machinery parts and components, machinery final goods, and automobiles (HS87 final only).

Table 3. Export Recovery in the 2008-2009 Crisis: Decomposition of Real Changes in Exports (US$)

(%)

	January 2009-October 2009					January 2008-October 2008				
	Total	Quantity effect	Price effect	Entry effect	Exit effect	Total	Quantity effect	Price effect	Entry effect	Exit effect
All products										
World	51.3	66.6	-14.7	7.0	-7.6	21.2	65.9	-45.7	4.8	-3.7
East Asia	77.6	101.5	-24.1	4.5	-4.4	25.5	136.3	-111.2	2.1	-1.8
US	51.3	43.6	7.0	2.2	-1.4	11.8	-1.2	12.3	1.4	-1.0
EU	26.8	45.6	-21.3	10.6	-8.1	6.4	-5.0	8.8	6.9	-4.4
Machinery parts and components										
World	65.2	74.5	-9.6	2.7	-2.4	23.4	20.7	2.3	2.0	-1.6
East Asia	94.6	104.2	-9.6	1.2	-0.7	26.2	25.3	0.9	0.8	-0.8
US	33.6	12.1	21.8	0.0	-0.3	13.9	0.3	13.1	0.8	-0.2
EU	29.6	85.6	-56.2	3.7	-3.4	10.1	5.1	6.0	1.3	-2.3
Machinery final goods										
World	33.8	44.6	-5.2	8.0	-13.1	15.2	10.9	2.9	5.9	-4.3
East Asia	49.9	85.9	-25.8	7.2	-17.3	35.5	48.5	-15.8	6.0	-3.3
US	84.4	85.5	-0.6	0.7	-1.2	0.7	-7.4	8.0	0.8	-0.7
EU	24.3	18.0	0.8	15.0	-9.4	-3.4	-1.4	-3.2	5.7	-4.4
HS87 final goods only										
World	61.9	58.1	3.8	3.8	-3.7	6.1	-1.7	7.7	1.3	-1.4
East Asia	134.4	128.3	2.1	9.9	-5.8	24.9	10.9	12.7	2.6	-1.3
US	137.4	134.6	3.1	0.2	-0.5	-8.3	-17.2	8.8	0.1	0.0
EU	22.7	17.6	4.7	3.1	-2.6	-30.3	-28.9	-0.1	0.5	-1.8

Data: Authors' calculation, using data available from the websites of the Ministry of Finance and the Bank of Japan.

Notes: The category of "unidentied" is omitted since the values for this category is zero or pretty close to zero. Export changes are calculated, using data at the country-product level. Export changes in the same period of the previous year are also presented to partially consider the seasonality. Changes in exchange rates (JPYen/US$) are -0.7% in January 2009-October 2009 and -6.2% in January 2008-October2008.

The results provide five notable findings. First, exports declined from October 2008 to January 2009 by almost 40 percent for all products, machinery final products, and machinery parts. Even in usual years, Japanese exports tend to fall from October to January; for instance, exports declined in the same period of the previous year by five to 10 percent. A 40 percent drop, however, is certainly far beyond a drop due to seasonality.

In particular, exports of automobiles dropped by more than 50 percent, which is much larger than the decline in the same period of the previous year (three percent). There is no doubt that the 2008-2009 Global Financial Crisis had significant negative impacts on Japanese exports.

Second, the exit effect for machinery parts and components is much smaller in absolute value than other products including machinery final products; the exit effect is only -1.6 percent for the world, and is even smaller for East Asia with -0.7 percent. Moreover, the exit effect for machinery parts and components is more or less at the same low level in the same period of the previous year. Although internal margins are large and exports significantly declined, particularly for East Asia, it suggests the robustness of trade relationships for machinery parts and components within dense production/distribution networks in the region.

Third, the major factors of a decrease in exports in machinery final goods are different between the US and EU. Almost all the decline in exports to the US (-56 percent) can be explained by the serious negative quantity effect (-69 percent). The corresponding figures are more serious when we focus only on automobiles: -64 percent (total changes) and -73 percent (the quantity effect). In other words, the quantity effect is the major factor of the decline of exports in machinery final goods to the US. On the other hand, in the case of exports to EU, the quantity effect (-38 percent) is less serious than the one for other regions, and the exit effect (-13 percent) is more serious than the ones for other regions in the same year and the one for EU in the same period of the previous year. Although internal margins are still larger than external margins in term of

the magnitude, the exit effect is relatively a major factor for the decline in machinery final goods to EU.

Fourth, the price effects are positive in the period from October 2008 to January 2009. The US$-based price effect is 13.6 percent for machinery final products exported to the US and 9.5 percent for those exported to EU. The corresponding figures for machinery parts and components are 16.3 percent and 40.3 percent, respectively. Since the shock was initiated by a demand decline in the US and EU market, we may usually expect a negative price effect. Nonetheless, we can think of several factors to explain the positive price effect. During the sample period from October 2008 to January 2009, Japanese Yen appreciated by 12.7 percent (US dollars depreciated by the same amount), which at least partially explains the positive price effect if the appreciation of Japanese Yen is largely passed through to the price in the US. Another factor would be a shift in the composition of export goods toward highly valued products.[15]

Fifth, the trade recovery shows a symmetric picture to the trade fall. The features reversal to those discussed above can be applied to the recovery of trade. For machinery parts and components exported to East Asia, extensive margin is quite small, and large positive quantity effect is observed. Regarding major factors of a rise in exports in machinery final goods, the positive quantity effect is the major factor for the US and intensive margins are large for EU. As for price effects, again, we may expect a positive price effect due to the recovery of demand, but there exist both positive and negative; the

[15] Ahn *et al.* (2011) posit a hypothesis that the increase in import prices in the US would be explained by the dis-functioning of trade finance. However, it does not seem to explain the case of Japanese exports because no major malfunctioning in trade finance did not occur in Japan.

price effect is positive as expected for automobiles and also for most cases of the US.

3.2. Probability of Trade Fall and Recovery

This subsection investigates probability of fall and recovery of machinery exports at the 2008-2009 Global Financial Crisis, using logit estimation, and formalizes the features of machinery exports in responding to the crisis.

3.2.1. Methodology

We again focus on the period of trade fall from October 2008 to January 2009 and the period of trade recovery from January 2009 to October 2009. For the analysis of trade fall, those product-country pairs at the HS 9-digit level with exports in October 2008 (and/or one-month before and after) are employed to examine whether their exports exist in January 2009 or not. For the analysis of trade recovery, on the other hand, those product-country pairs at the HS 9-digit level with exports in October 2008 (and/or one-month before and after) and no exports in January 2009 are used to investigate whether their exports recover by October 2009.

The equation for our logit estimation analyses is as follows:

$$EXchange_{i,j} = \beta_0 + \beta_1 \ln Dist_i + \beta_2 Parts_j + \sum_n^N \alpha_n Country_n + \varepsilon,$$

where $EXchange_{i,j}$ is binary variable representing fall/recovery of exports; $EXchange_{i,j}$ is 1 if no export of product j to country i is observed in January 2009 and 0 otherwise for the analysis of trade fall. In contrast, $EXchange_{i,j}$ is 1 if exports of product

j to country i are observed in October 2009 and 0 otherwise for the analysis of trade recovery. $\ln Dist_i$ denotes the distance between Japan and country i in the form of natural logarithm. $Parts_j$ is 1 if product j is machinery parts and components, and 0 otherwise (machinery final goods). Besides, country/region dummies expressed as $Country_n$ are included for 14 East Asian countries, the US, and EU in order to capture the features of trade relationships with these countries/region at the crises.

3.2.2. Results

Table 4 shows the results and provides several interesting findings. First, machinery parts and components trade are less likely to be discontinued and are likely to recover even if they stop once. The coefficient for parts is negative for the analysis of trade fall and positive for the analysis of trade recovery with statistical significance. It suggests the robust trade relationships for machinery parts and components, compared with machinery final products, which is consistent with the results of decomposition analysis.

Table 4. Logit Estimation of Trade Relationships of Japan's Machinery Exports at the Global Financial Crisis

	Machinery exports		Machinery exports (except HS87)	
	Fall	Recovery	Fall	Recovery
Distance (log)	-0.05	0.10 *	-0.02	0.09
	(-1.55)	(1.84)	(-0.50)	(1.62)
Parts	-0.51 ***	0.28 ***	-0.59 ***	0.33 ***
	(-25.78)	(8.84)	(-27.35)	(9.58)
Korea	-1.37 ***	1.38 ***	-1.52 ***	1.51 ***
	(-13.54)	(8.54)	(-13.79)	(8.66)
China	-1.74 ***	1.20 ***	-1.95 ***	1.43 ***
	(-18.85)	(7.70)	(-19.42)	(8.43)
Taiwan	-1.31 ***	1.05 ***	-1.44 ***	1.13 ***
	(-14.91)	(7.31)	(-15.22)	(7.41)
Hong Kong	-1.35 ***	0.91 ***	-1.39 ***	0.97 ***
	(-16.16)	(6.54)	(-15.85)	(6.69)
Viet Nam	-0.96 ***	1.38 ***	-1.10 ***	1.42 ***
	(-12.11)	(10.92)	(-13.18)	(10.67)
Thailand	-1.53 ***	1.11 ***	-1.67 ***	1.21 ***
	(-19.32)	(8.11)	(-19.82)	(8.30)
Singapore	-1.39 ***	0.68 ***	-1.55 ***	0.77 ***
	(-17.88)	(4.92)	(-18.76)	(5.30)
Malaysia	-0.91 ***	0.92 ***	-1.02 ***	1.00 ***
	(-12.33)	(7.69)	(-13.07)	(7.97)
Brunei	0.88 ***	-0.75 **	1.18 ***	-1.57 ***
	(4.17)	(-2.38)	(4.19)	(-3.03)
Philippines	-0.99 ***	1.03 ***	-1.07 ***	0.99 ***
	(-12.17)	(7.90)	(-12.26)	(7.14)
Indonesia	-0.91 ***	0.86 ***	-1.06 ***	0.92 ***
	(-12.41)	(7.19)	(-13.73)	(7.28)
Cambodia	0.76 ***	0.30	0.57 ***	0.00
	(4.08)	(1.45)	(2.70)	(-0.01)
Laos	0.53 *	-1.05 **	2.29 ***	-1.35 *
	(1.86)	(-1.99)	(3.12)	(-1.84)
Myanmar	0.35 **	0.12	0.54 ***	-0.03
	(2.21)	(0.58)	(2.82)	(-0.10)
US	-1.99 ***	0.37 **	-2.22 ***	0.54 ***
	(-23.37)	(2.18)	(-24.31)	(3.01)
EU	-0.53 ***	0.07 *	-0.63 ***	0.12 ***
	(-22.05)	(1.78)	(-24.4)	(2.83)
Constant	0.93 ***	-2.09 ***	0.82 **	-2.15 ***
	(2.89)	(-4.38)	(2.29)	(-4.09)
Log likelihood	-29744	-11949	-25209	-10302
Number of observations	45979	20507	39546	17930

Source: Authors' calculation.

Notes: Dependent variable for the analysis of trade fall is 1 if trade stops and 0 otherwise. Similarly, dependent variable for the analysis of trade recovery is 1 if trade recovers and 0 otherwise. Product-country pairs used in the analysis of trade fall are those with exports in October 2008 (and/or one-month before and after), and product-country pairs used in the analysis of trade recovery are those for which trade stops in January 2009. Figures in parenthesis are z-statistics. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Second, among East Asian countries, those who are heavily involved in the regional production networks tend to maintain the trade relationships and tend to recover trade even if it stops. The coefficients for dummies of East Asian countries are mostly negative for the analysis of trade fall and positive for the analysis of trade recovery with statistical significance; in particular, the absolute values of coefficients for countries such as China, Thailand, Korea, Taiwan, and Vietnam are large for both analyses, indicating the strong trade relationships in the production networks. On the other hand, the coefficients for countries such as Brunei, Cambodia, Laos, and Myanmar are either statistically insignificant, small in absolute terms, or even opposite. It implies that these countries are not deeply involved in regional production networks in machinery industries. Combined with the fact that the variable for distance is statistically insignificant in most cases, these results suggest whether the country is deeply involved in production networks matters rather than the distance from Japan.

Third, Japan has a strong trade relationship with the US for machinery exports. The US is one of the important markets for Japan to sell machinery final products. Some of machinery final products sold in the US may be produced in Japan or may be assembled in the US using core parts and components exported from Japan, sometimes with assembling in Mexico.[16] Unlike the case of East Asia, where alternative supply sources may be found relatively quickly, it would not be easy to change the route of supply chains in the US-Mexico nexus and find substitutes, as not many neighborhood countries are

[16] Note that Japanese exports to Mexico are typically via Los Angeles and are thus often recorded as Japanese exports to the US in Japanese statistics of exports.

involved in production networks. Therefore, Japanese machinery exports to the US are less likely to be discontinued, considering the importance of production activities and customers in the US.

3.3. Probability of Trade Recovery and its Timing

This subsection analyzes the probability of the recovery of machinery exports, employing one of survival analyses or the Kaplan-Meier Product-Limit method.[17]

3.3.1. Methodology and Data

To examine the probability of the recovery of trade, we estimate Kaplan-Meier failure rates as well as hazard rates for Japanese exports at the product-country level from January 2009 to December 2010; the hazard rate here is the conditional probability of the recovery given that they have been inactive until the previous month.[18] As our interest is to investigate patterns of recovery in the 2008-2009 Global Financial Crisis, we collect only product-country pairs with exports in October (and/or one-month before and after) 2008 and no exports in January 2009, and focus on when exports are restarted; in January 2009, the total value of exports is at the minimum level and the total number of exported products tailed by partner country is at the least level (see Figures 1 and 2).

[17] See Obashi (2009) for survival analysis of the duration of trade relationships for machinery goods and probability of trade recovery from the Asian Crisis.

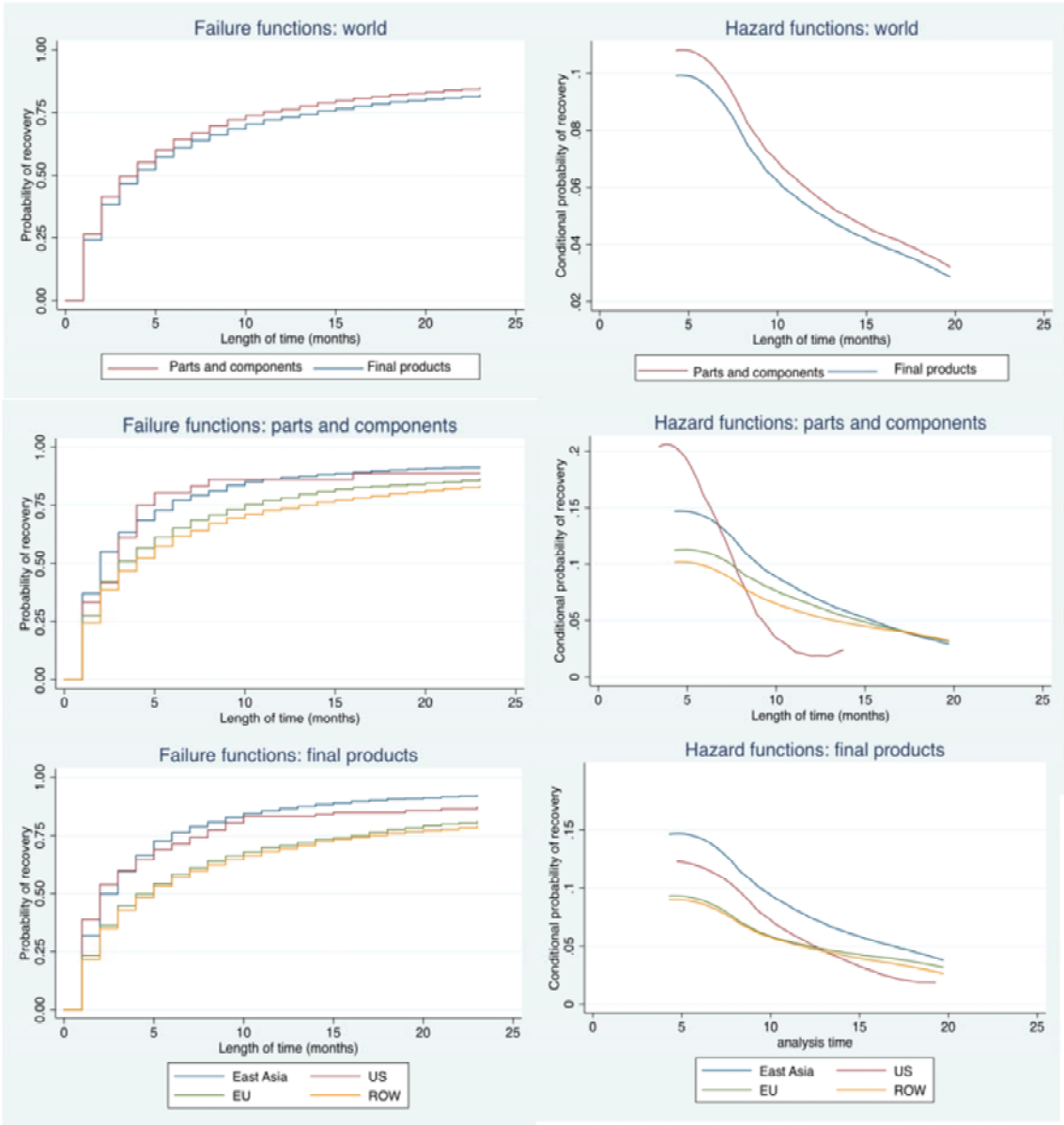
[18] The failure function, $F(t)$, equals $1-S(t)$, where $S(t)$ is the survival function. The survival function of T, the time for failure event, is given by $S(t)=\Pr(T>t)$. $S(t)$ equals one at $t=0$ and decreases towards zero as t increases. The hazard function is given by $h(t)=\Pr(T=t \mid T \geq t)$. The graph of hazard function is based on a (standard) weighted kernel smooth of the estimated hazed contributions.

We estimate Kaplan-Meier failure rates as well as hazard rates for machinery final products and machinery parts and components, to see whether there exist any differences in the probability of recovery between machinery final and intermediate goods. We also estimate failure rates and hazard rates not only for exports to all partner countries but also exports to East Asia, the US, and EU to see whether there exit any differences in the probability among countries/regions. In order to check a statistical significance for the differences in the failure/hazard functions among product groups/regions, we apply the log-rank test.

3.3.2. Results

Figure 5 presents Kaplan-Meier estimates of failure functions and hazard functions. As these figures show, regardless of products/regions, both curves of estimated failure rates and hazard rates are steeper (with the upward and downward trends, respectively) in the earlier period, suggesting the higher probability of restarting exports at the sooner timing.

Figure 5. Kaplan-Meier Estimates of Failure Functions and Hazard Functions for Machinery Exports: Recovery from the Global Financial Crisis



Data: Authors' calculation.
Note: ROW is the rest of the world.

Let us focus on the differences among product/regional groups. First, the probability of recovery is higher for machinery parts and components than machinery final products in general. Both failure rates and hazard rates are higher for machinery parts and components than machinery final products at any point of time. For instance, 55 percent

of machinery parts and components that discontinued exports in January 2009 restart exports within the first four months, and 85 percent restart exports by the end of 2010 (Table 5). On the other hand, 52 percent of machinery final products that discontinued exports in January 2009 restart within the first four months, and 82 percent restart exports by the end of 2010. Combined with the fact that the effect of trade stops (the exit effect) at the crisis is much smaller for machinery parts and components than machinery final products, these findings suggest that trade in machinery parts and components are less likely to be discontinued, and tend to restart sooner even if they stop. In other words, the trade relationships are more robust and stronger for machinery parts and components.

Table 5. Estimated Kaplan-Meier Failure Rates: Recovery from the Global Financial Crisis

		4th month (May 2009)	23rd month (December 2010)
Machiinery parts and components		0.55	0.85
Machinery final products		0.52	0.82
Machiinery parts and components	2nd month (March 2009)	3rd month (April 2009)	23rd month (December 2010)
East Asia	0.55	0.64	0.91
US	0.42	0.61	0.89
EU	0.42	0.51	0.86
ROW	0.39	0.47	0.83
Machinery final products	2nd month (March 2009)	4th month (May 2009)	23rd month (December 2010)
East Asia	0.50	0.66	0.92
US	0.54	0.64	0.87
EU	0.36	0.50	0.81
ROW	0.35	0.48	0.79

Data: Authors' calculation.

Notes: The month with a highlighted rate is the one when the estimated K-M failure rate exceeds 0.5 for the first time. The difference of failure function between machinery final products and machinery parts and components and that among regions are statistically significant at the 1 percent level, using the log-rank test. ROW denotes the rest of the world.

Second, the probability of recovery is higher for East Asia than the US, EU, and the rest of the world (ROW) in general. At any point of time, the failure rate for all products is slightly higher in East Asia, though the rates are higher for the US than East Asia at some times in the earlier period for machinery final/intermediate goods.[19] Moreover, the portion of trade relationships that are recovered by the end of 2010 is higher for East Asia than other regions; the failure rates in December 2010 for East Asia, the US, EU, and ROW are 91 (92) percent, 89 (87) percent, 86 (81) percent, and 83 (79) percent for machinery parts and components (machinery final products), respectively. It suggests that trade relationships with East Asia, particularly trade relationships for machinery goods with East Asia, are robust, which significantly contributes to the recovery of trade. Considering the fact that the trade relationships are robust, which is suggested by the low exit effect in the export decline in the crisis in the previous subsection, these results imply that the existence of dense production/distribution networks in East Asia do help trade in the 2008-2009 Global Financial Crisis.

Third, the probability of recovery at some times in the earlier period for the US is high for machinery goods, particularly machinery parts and components. For machinery intermediate goods, the hazard rate is beyond 20 percent in around the fifth month, which is much higher than the rate for other regions including East Asia, and is rapidly decreasing; the hazard rate lowered to the level below the one for East Asia in the eighth month. These may indicate the importance of production activities in the local market

[19] The results for all products are not included in the paper due to the limitation of the space. They are available upon request.

and customers in the US, which is consistent with the finding from logit estimation in the previous subsection.

4. Analysis of the Effects of the 2011 East Japan Earthquake

This section examines the effects of the 2011 East Japan Earthquake on Japanese machinery exports from March 2011 to October 2011, which is the latest month in terms of the availability of data at the end of November 2011. We conduct detailed analyses parallel to those in Section 3.

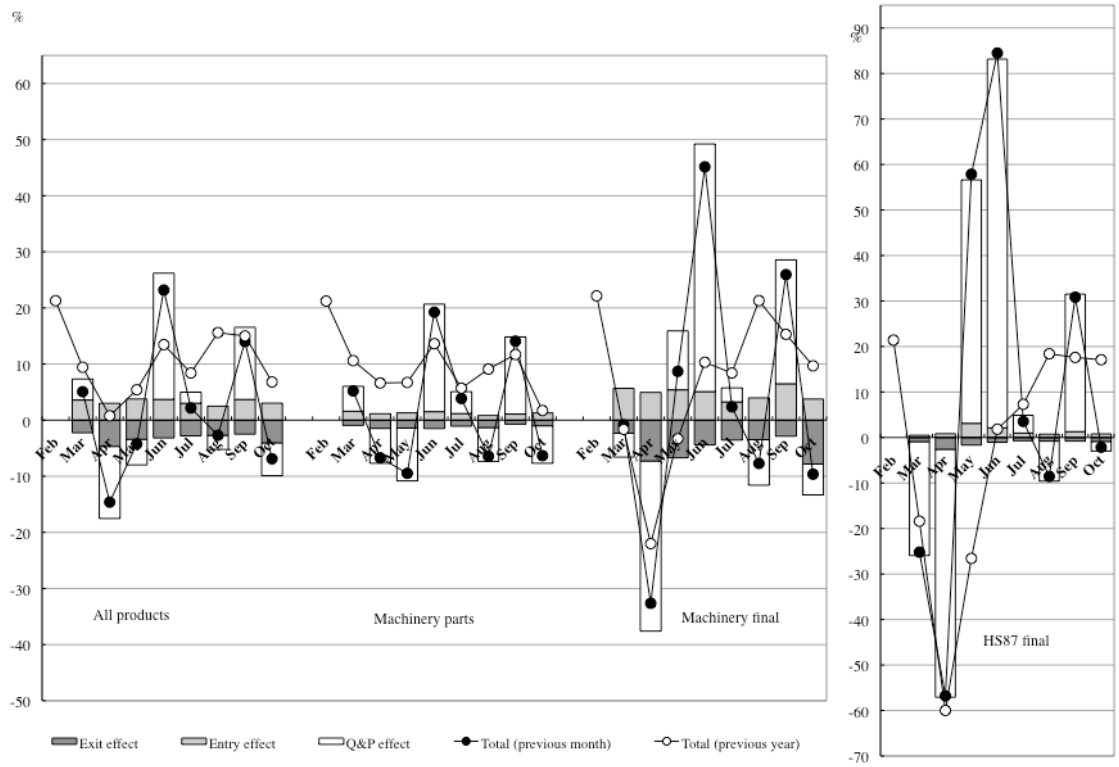
4.1. Decomposition of Trade Changes

To understand patterns of export changes since March when the earthquake occurs, we apply the decomposition approach used in subsection 3.1. Unlike the analysis for the 2008-2009 Global Financial Crisis, however, we investigate patterns of monthly changes or changes from previous month to capture features of trade movements within several months. As monthly changes tend to be more influenced by the seasonality, we consider changes from the corresponding month of the previous year (changes from previous year) as well.

Figure 6 and Table 6 represent monthly changes in total exports from March to October 2011 and the decomposition for all products, machinery parts and components, and machinery final products. The results for automobiles only (HS87 final goods) are

also displayed since the 2011 East Japan Earthquake has significant negative impacts on automobiles as Figure 1 clearly demonstrates. Figures 7 to 9 show corresponding figures for the decomposition of monthly changes in exports to East Asia, US, and EU, respectively.

Figure 6. Decomposition of Export Changes in the 2011 Earthquake Disaster (US$)



Data: See Table 6.

Note: Q&P effect is the sum of quantity effect, price effect, and unidentified effect.

Table 6. Export Changes in the 2011 Earthquake Disaster: Decomposition of Real Changes in Exports (US$)

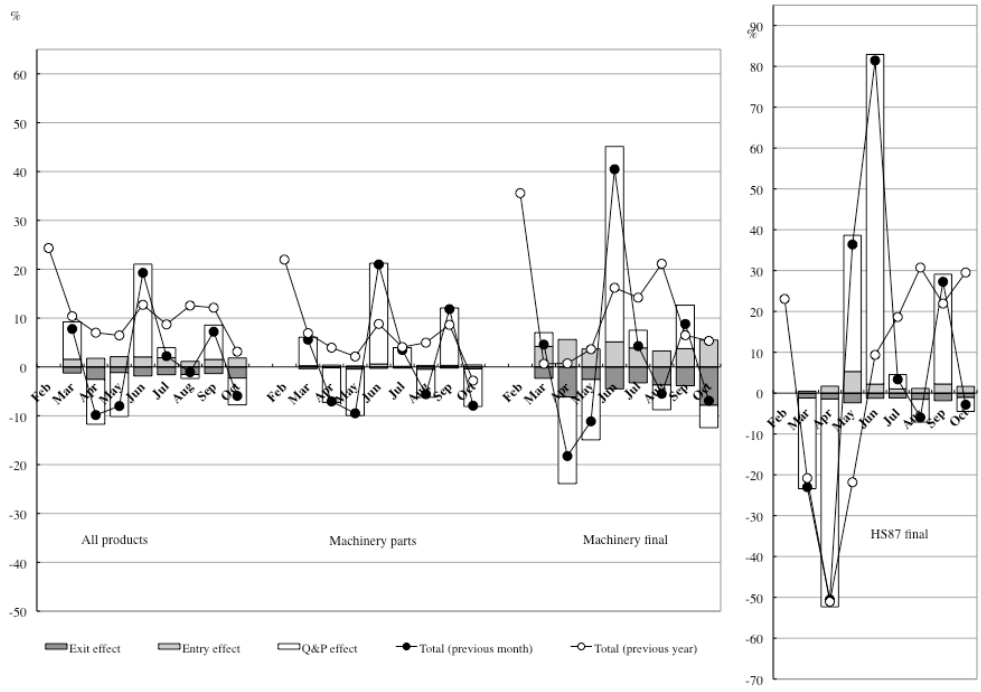
(%)

	Total (v.s. previous year)	Total (v.s. previous month)			
		Quantity effect	Price effect	Entry effect	Exit effect
All products					
March	9.4	5.1	2.1	1.7	3.6	-2.2
April	0.8	-14.6	-7.8	-5.0	3.0	-4.7
May	5.4	-4.2	-22.9	18.4	3.8	-3.4
June	13.5	23.2	19.4	3.1	3.7	-3.2
July	8.4	2.2	3.6	-1.7	3.0	-2.8
August	15.6	-2.7	-5.8	3.3	2.5	-2.7
September	15.0	14.0	24.9	-12.0	3.7	-2.5
October	6.8	-6.9	-36.9	31.0	3.0	-4.1
Machinery parts and components						
March	10.6	5.2	2.9	1.5	1.6	-0.9
April	6.6	-6.7	-8.6	2.4	1.1	-1.5
May	6.7	-9.5	-12.7	3.3	1.3	-1.4
June	13.5	19.2	19.6	-0.4	1.5	-1.5
July	5.7	3.9	3.4	0.6	1.2	-1.1
August	9.1	-6.4	-9.9	3.9	0.8	-1.4
September	11.7	14.1	12.4	1.4	1.1	-0.7
October	1.7	-6.3	-6.9	0.2	1.3	-1.0
Machinery final goods						
March	-1.7	-0.8	-4.9	0.6	5.7	-2.3
April	-22.0	-32.6	-27.0	-3.3	4.9	-7.3
May	-3.3	8.7	-2.0	12.5	5.4	-6.7
June	10.0	45.1	41.6	2.5	5.1	-4.4
July	8.4	2.4	-0.4	2.9	3.3	-3.6
August	21.3	-7.7	-12.3	4.2	4.0	-3.5
September	15.3	25.9	29.8	-7.7	6.5	-2.9
October	9.7	-9.6	-6.8	1.3	3.8	-7.8
HS87 final goods only						
March	-18.4	-25.2	-25.0	0.6	0.5	-1.0
April	-60.0	-56.8	-54.4	-0.5	0.8	-2.6
May	-26.6	57.9	53.5	2.9	3.1	-1.7
June	1.8	84.5	81.0	2.2	2.1	-1.1
July	7.3	3.5	2.6	1.3	1.0	-0.7
August	18.4	-8.6	-11.0	2.2	0.7	-0.8
September	17.6	30.8	28.1	2.1	1.3	-0.8
October	17.1	-2.1	-0.6	-1.5	0.8	-0.9

Data: Authors' calculation, using data available from the websites of the Ministry of Finance and the Bank of Japan.

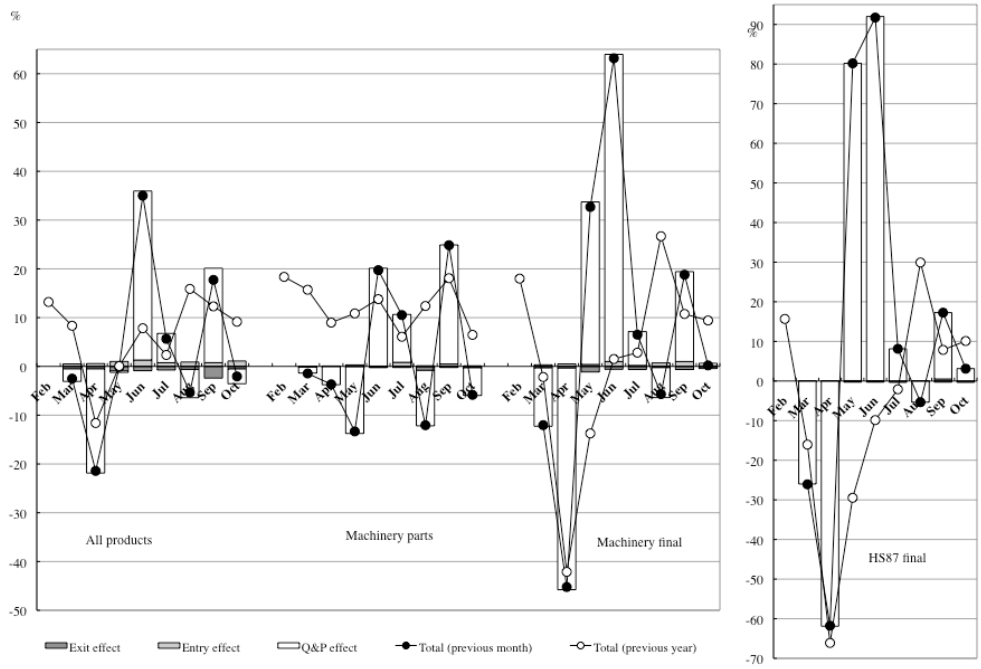
Note: The category of "unidentied" is omitted since the values for this category is zero or pretty close to zero. Export changes are calculated, using data at the country-product level. Changes in exchange rates (JPYen/US$) in March, April, May, and June, for instance, are 0.0%, 0.7%, -1.7%, and -0.7% when compared with previous month and -11.0%, -10.8%, -10.7%, and -9.1% when compared with previous year.

Figure 7. Decomposition of Export Changes in the 2011 Earthquake Disaster (US$): East Asia



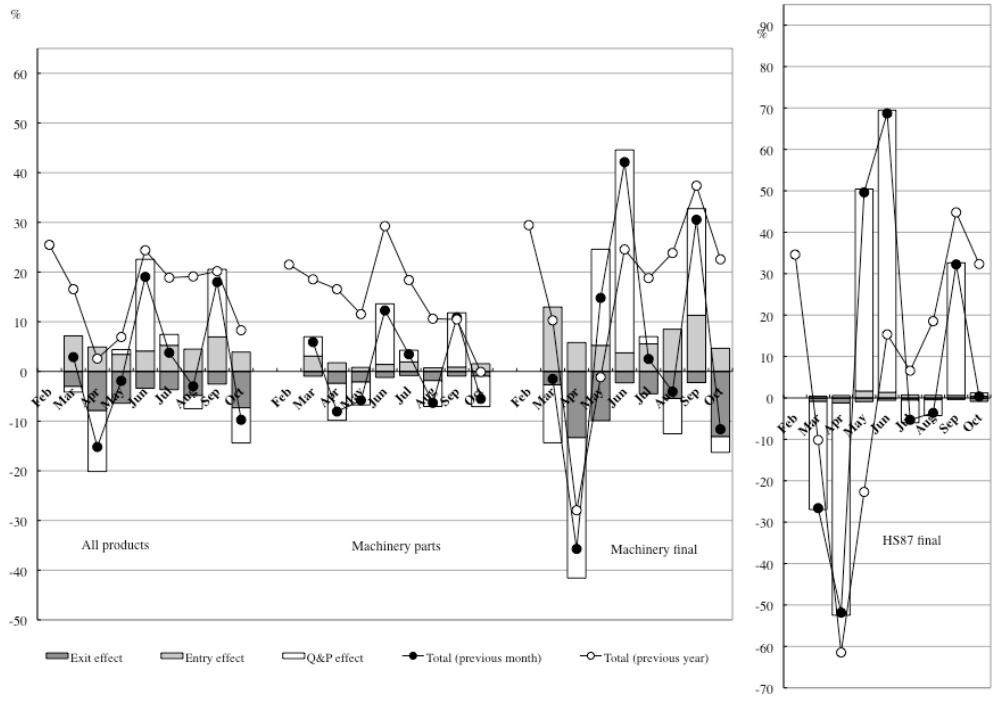
Note: Q&P effect is the sum of quantity effect, price effect, and unidentified effect.

Figure 8. Decomposition of Export Changes in the 2011 Earthquake Disaster (US$): US



Note: Q&P effect is the sum of quantity effect, price effect, and unidentified effect.

Figure 9. Decomposition of Export Changes in the 2011 Earthquake Disaster (US$): EU



Note: Q&P effect is the sum of quantity effect, price effect, and unidentified effect.

The results provide several important insights. First, the exit effect for machinery parts and components is much smaller than other products including machinery final products: the exit effect is only around -1.5 percent in a month (Figure 7). Moreover, the exit effect for machinery parts and components is more or less at the same low levels of the exit effect in corresponding months in 2010. Although exports in machinery parts and components decreased in April and May 2011, they significantly expanded in June 2011, reflecting a large and positive quantity effect. As a result, exports in June 2011 reached the higher level than those in June 2010 by 14 percent.[20] Furthermore, the exit effect is

[20] Exports in JP Yen also returned to the level of the previous year in June.

even smaller for East Asia, i.e., less than -0.5 percent in a month (Figure 8).[21] These findings suggest that the robustness of trade relationships for machinery parts and components, and that firms place priorities to keep international production networks even in the 2011 East Japan Earthquake, just as is the case of the 2008-2009 Global Financial Crisis.

Second, machinery final goods experienced a significant decline in exports in April 2011, mainly due to a significant degree of the negative quantity effect as well as the exit effect that is much larger than the effect in March 2011 and the effect in April 2010. In addition, the price effect is positive and higher than 10 percent in May 2011. Although Japanese Yen was appreciated by 0.7 percent in May, such a high degree of the positive price effect cannot be explained by the change in exchange rates; rather the positive price effect partially implies an upward pressure on prices due to a reduction in the supply of exported products. All of these figures indicate the negative supply shock; some of the critical SMEs are located in the disaster areas, and exports are negatively affected through production chains.

Third, exports in machinery final products achieve a dramatic recovery in May and June. Their exports recovered the level of the previous year in June; exports in June 2011 are higher than those in June 2010 by more than 10 percent.[22] The outstanding recovery, in particular, can be observed for automobiles (final goods only). Exports in automobiles drastically declined in April by around 60 percent for the previous month or the same

[21] The exit effect for the US is also small. Note that the figure for the US is based on trade data only for the US so that it is less likely to be influenced by other countries.
[22] Exports in JP Yen almost reached the level of the previous year in June.

month of the previous year, mostly due to the negative quantity effect. In the case of US and EU, in particular, the drop is even larger in April; exports declined by close to 70 percent in US and over 60 percent for EU, compared with the same month of the previous year (Figures 8 and 9). As a result, total exports of machinery final products in April 2011 are even below the minimum level of exports under the 2008-2009 Global Financial Crisis. Exports, however, already returned to the level of the previous year in June mostly.[23]

Behind such a dramatic recovery for automobiles, private companies did not wait for the government's support and made great "private" efforts to restore the supply chains. One symbolic episode is the case of Japan Renesas.[24] This company was producing several key electronic parts and components called micro-processing units (MPU), memory control units (MCU), and application specific standard products (ASSP) for automobiles and various ICT products. Its factories including Naka Factory in Ibaraki Prefecture were severely hit and damaged by the East Japan Earthquake. In order to resume the supply chains, Japan Automobile Manufacturers Association (JAMA) and others gathered workers from a number of companies and sent them to Naka Factory to help restore the operation; the number of such helpers exceeded 2,500 a day at maximum.

4.2. Probability of Trade Fall and Recovery

Parallel to the analysis of trade fall and recovery in subsection 3.2, this subsection

[23] Exports of automobiles to the US finally returned to the level of the previous year in August 2011.
[24] Drawn from Nihon Keizai Shinbun, April 28, 2011.

investigates probability of fall and recovery of machinery exports at the 2011 East Japan Earthquake.

Based on the trade movement for all products shown in Figure 1, we basically regard the period of trade fall as the one from March to May 2011 and the period of trade recovery as the one from May to July 2011. For the analysis of trade fall, those product-country pairs at the HS 9-digit level with exports in March 2011 (and/or one-month before and after) are employed to examine whether their exports exist in May 2011 or not. For the analysis of trade recovery, on the other hand, those product-country pairs at the HS 9-digit level with exports in March 2011 (and/or one-month before and after) and no exports in May 2011 are used to investigate whether their exports recover in July 2011. Using the same equation in Section 3, we conduct logit estimation analysis for export fall and recovery defined above at the 2011 East Japan Earthquake.

Table 7 shows the results and provides almost the same findings as the case of the Global Financial Crisis, even though the period of fall and recovery is much shorter for the 2011 East Japan Earthquake. First, machinery parts and components trade are less likely to be discontinued and are likely to recover even if they stop. The coefficient for parts is negative for the analysis of trade fall and positive for the analysis of trade recovery with statistical significance.

Table 7. Logit Estimation of Trade Relationship of Japan's Machinery Exports at the East Japan Earthquake

	Machinery exports		Machinery exports (except HS87)	
	Fall	Recovery	Fall	Recovery
Distance (log)	-0.14 ***	0.11 **	-0.08 **	0.13 **
	(-3.87)	(1.98)	(-2.05)	(2.13)
Parts	-0.47 ***	0.06 *	-0.53 ***	0.13 ***
	(-22.3)	(1.79)	(-23.30)	(3.45)
Korea	-1.88 ***	0.96 ***	-1.91 ***	1.05 ***
	(-16.69)	(5.01)	(-15.75)	(5.16)
China	-2.11 ***	0.89 ***	-2.18 ***	0.98 ***
	(-20.4)	(4.81)	(-19.73)	(5.01)
Taiwan	-1.69 ***	0.95 ***	-1.76 ***	1.18 ***
	(-17.32)	(5.63)	(-16.83)	(6.64)
Hong Kong	-1.58 ***	0.74 ***	-1.63 ***	0.89 ***
	(-17.12)	(4.56)	(-16.75)	(5.26)
Viet Nam	-1.30 ***	0.87 ***	-1.37 ***	1.04 ***
	(-15.00)	(5.85)	(-15.10)	(6.74)
Thailand	-1.76 ***	0.79 ***	-1.90 ***	0.81 ***
	(-19.8)	(4.91)	(-19.93)	(4.64)
Singapore	-1.39 ***	0.77 ***	-1.48 ***	0.84 ***
	(-16.82)	(5.29)	(-17.12)	(5.54)
Malaysia	-1.18 ***	0.77 ***	-1.21 ***	0.83 ***
	(-14.38)	(5.46)	(-14.21)	(5.70)
Brunei	1.02 ***	-0.38	2.07 ***	-0.49
	(4.05)	(-1.16)	(4.76)	(-1.24)
Philippines	-1.18 ***	0.33 **	-1.18 ***	0.47 **
	(-13.38)	(2.10)	(-12.69)	(2.92)
Indonesia	-1.15 ***	0.83 ***	-1.24 ***	0.99 ***
	(-14.31)	(5.96)	(-14.66)	(6.89)
Cambodia	0.43 ***	0.12	0.53 ***	0.23
	(2.75)	(0.55)	(2.90)	(0.98)
Laos	0.67 *	-1.79 **	1.28 ***	-2.11 **
	(2.24)	(-2.46)	(2.83)	(-2.06)
Myanmar	0.06	-0.03	0.25	-0.05
	(0.39)	(-0.12)	(1.47)	(-0.21)
US	-1.78 ***	0.52 ***	-1.94 ***	0.58 ***
	(-20.61)	(3.22)	(-21.43)	(3.39)
EU	-0.50 ***	0.14 ***	-0.57 ***	0.19 ***
	(-19.43)	(3.23)	(-20.66)	(4.16)
Constant	1.53 ***	-2.06 ***	1.14 ***	-2.35 ***
	(4.48)	(-3.89)	(3.01)	(-4.04)
Log likelihood	-26132	-9749	-22388	-8507
Number of observations	41827	16221	36156	14317

Source: Authors' calculation.

Notes: Dependent variables for the analysis of trade fall is 1 if trade stops and 0 otherwise. Similarly, dependent variable for the analysis of trade recovery is 1 if trade recovers and 0 otherwise. Product-country pairs used in the analysis of trade fall are those with exports in May 2011 (and/or one-month before and after), and product-country pairs used in the analysis of trade recovery are those for which trade stops in May 2011. Figures in parenthesis are z-statistics. *** indicates that the results are statistically significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Second, among East Asian countries, those who are heavily involved in the regional production networks tend to maintain the trade relationships, and tend to recover trade even if it stops. The coefficients for dummies of East Asian countries are mostly negative for the analysis of trade fall and positive for the analysis of trade recovery with statistical significance; in particular, the absolute values of coefficients for countries such as China, Korea, Thailand, Taiwan, and Vietnam are large for both analyses, and are even much larger than the value of coefficient for the U.S.

Third, Japan has a strong trade relationship with US for machinery exports. The US is one of the important markets for Japan to sell machinery final products as well as machinery parts and components, together with Mexico.

Fourth, the distance matters in the probability of trade fall and recovery at the East Japan Earthquake, unlike the case of the Global Financial Crisis. The coefficient for distance is negative for the analysis of trade fall and positive for the analysis of trade recovery with statistical significance. It suggests that exports to countries located closer to Japan are less likely to be discontinued and are likely to recover even if they stop, and thus their trade relationships with Japan are more robust, compared with exports to countries located in a longer distance from Japan.

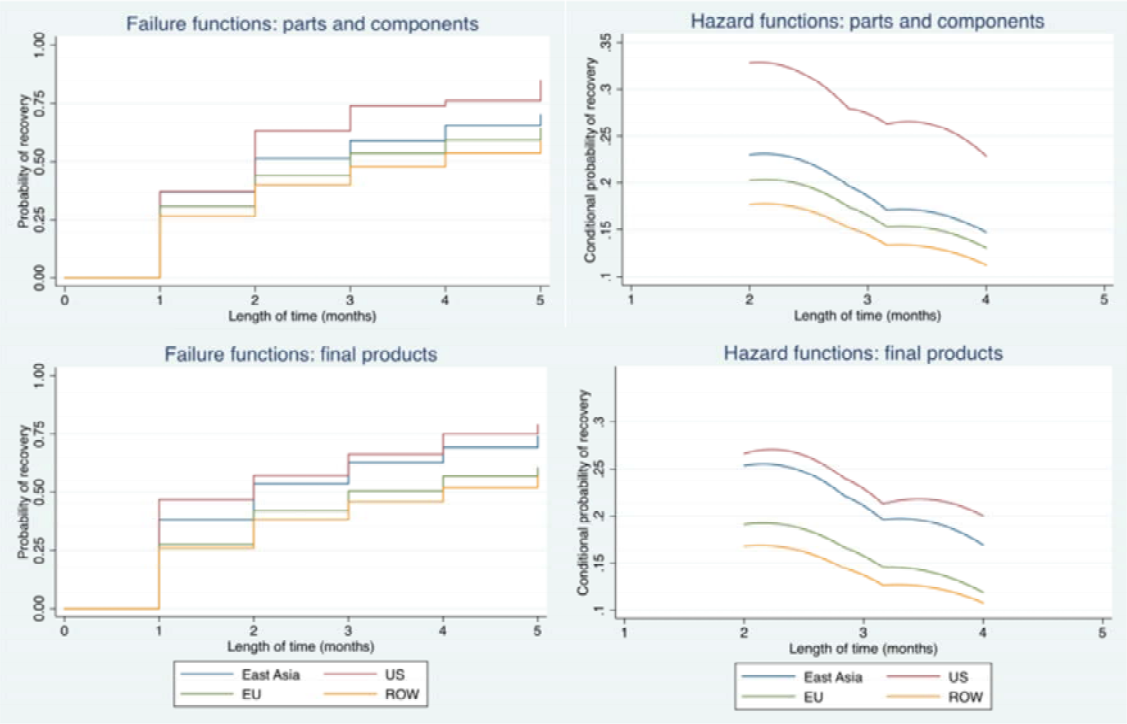
4.3. Probability of Trade Recovery and its Timing

Similar to the analysis in Subsection 3.3, to examine the probability of the recovery of trade, we estimate Kaplan-Meier failure rates as well as hazard rates for Japanese machinery exports at the product-country level from May 2011, when the exports are the

smallest since the earthquake occurs, to October 2011, when the latest data is available. As our interest is to investigate the pattern of the recovery of exports in the 2011 East Japan Earthquake, we collect only product-country pairs with exports in March (and/or one-month before and after) 2011 and no exports in May 2011 and focus on when exports are restarted. In order to check a statistical significance for the differences in the failure/hazard functions among product groups/regions, we apply the log-rank test.

Figure 10 presents Kaplan-Meier estimates of failure functions and hazard functions with a distinction among regions: East Asia, the US, EU, and ROW. They demonstrate several findings. First, regardless of products/regions, both curves of estimated failure rates and hazard rates are steeper (with the upward and downward trends, respectively) in the earlier period, suggesting the higher probability of restarting exports at the sooner timing. The probability of trade recovery within the first two months, in particular, is extremely high; for instance, in the case of exports to East Asia, more than half of machinery goods that discontinued exports in May 2011 restart exports within the first two months, and three-forth for machinery final products (70 percent for machinery parts and components) restart exports by October 2011 (Table 8).

Figure 10. Kaplan-Meier Estimates of Failure Functions and Hazard Functions for Machinery Exports: Recovery from the East Japan Earthquake



Data: Authors' calculation.

Table 8. Estimated Kaplan-Meier Failure Rates: Recovery from the East Japan Earthquake

	2nd month (July 2011)	3rd month (August 2011)	5th month (October 2011)
Machinery parts and components			
East Asia	0.51	0.59	0.70
US	0.63	0.74	0.85
EU	0.44	0.53	0.64
ROW	0.40	0.48	0.59
Machinery final products			
East Asia	0.54	0.63	0.74
US	0.57	0.66	0.79
EU	0.42	0.51	0.61
ROW	0.38	0.46	0.57

Data: Authors' calculation.
Notes: See table 5.

Second, the probability of recovery is higher for machinery parts and components than machinery final products in the US and EU, while the probability is higher for machinery final products than machinery parts and components in East Asia. In East Asia, demand for final products is strong reflecting good economic conditions, and the exit effect is small for machinery parts and components resulting in a small number of samples for machinery parts and components in this survival analysis. These generate more rapid recovery for machinery final products than machinery parts and components in the case of East Asia. On the other hand, the economies in the US and EU are not so good, and the recovery of the supply of core parts and components is prioritized in these regions.

Third, the probability of recovery is higher for the US and East Asia than EU and ROW, regardless of whether machinery final products or intermediate goods. In particular, the probability is much higher for the US and East Asia in the case of machinery final products. Combined with the facts that the exit effect for machinery parts and components is quite small for the US and East Asia, and that the coefficients for dummies of these countries in logit estimation in absolute values are large, it suggests that US and East Asia have more robust trade relationships through production networks and the importance of production activities in the local market and customers.

5. Conclusion: Similarities and Differences in Two Massive Shocks

This paper conduct a multi-angled analysis of trade movements in Japan in response to the 2008-2009 Global Financial Crisis and the 2011 East Japan Earthquake and make a comparison in export changes in facing the two massive shocks. Due to the nature and characteristics of the two crises, we find similarities and differences in the adjustments made by private firms in production networks.

The Japanese economy seriously suffered from both crises and required large adjustments in international production networks. However, the shock form the Global Financial Crisis was obviously larger and more prolonged than the shock from the East Japan Earthquake. The former was primarily a negative demand shock while the latter was a negative supply shock. In the case of the Global Financial Crisis, it was very difficult for firms to assess the magnitude and duration of negative shocks at the beginning of the crisis. In the case of the East Japan Earthquake, though some uncertain elements such as nuclear issues existed, firms could judge to some extent the overall seriousness of negative shocks from the beginning. Worldwide drops of demand in the Global Financial Crisis were obviously beyond the control by individual firms.

Based on such nature and characteristics of the two crises, Japanese exports revealed similar and dissimilar responses to the two crises. As for similarities, we must point out the stability and robustness of production networks in machinery industries. It is true that shocks seriously damaged production networks and its negative impacts were transmitted through production networks. Strong forces, however, worked to keep production

networks, and quick adjustments for recovery were implemented. As a result, exports of machinery parts and components were kept stable and robust.

Why do exports of machinery parts and components tend to be sustained? The extended fragmentation theory states that the fragmentation of production takes advantage of the reduction in production cost within production blocks while it should pay for the network set-up/adjustment cost and the service link cost.[25] The latter two costs are particularly high for transactions of parts and components compared with transactions of final products. In order to respond to massive shocks, firms try to save these costs by keeping transaction channels for parts and components. Although the data are not readily available, a similar argument should be applied to adjustments across intra-firm and inter-firm (arm's length) transactions; costs for adjustments for intra-firm transactions must be lower than those for inter-firm transactions.[26]

As for dissimilarities, we should point out a notable difference in whether firms use a shock as a trigger for a structural reform. In the Global Financial Crisis, the shock was massive and prolonged and thus was used as a trigger for permanent changes such as the permanent shrinkage of the basis of Japanese exports. The increasing importance of trade with other East Asian countries was another example of permanent changes. On the other hand, in response to the East Japan Earthquake, the adjustment of production was more abrupt, but corporate activities were coming back to the original pretty quickly.

[25] See Ando, Arndt, and Kimura (2009) for the two-dimensional fragmentation and their costs in terms of fixed costs, services link costs, and production cost per se.

[26] Ando and Iriyama (2009) employ micro data of Japanese manufacturing firms and find that export/import responsiveness to exchange rate fluctuation is higher in intra-firm transactions than inter-firm transactions. In the context of responses to macro shocks, the same logic would be applied.

Policy implications drawn from these two crises are profound. Particularly from the viewpoint of the Japanese Government, it should try to contain a crisis in a manageable level and prevent firms from utilizing the crisis as a trigger for removing production blocks from Japan. Indeed, in the case of the East Japan Earthquake, there still remains the risk of "hollowing-out (kudo-ka)" due to continuing shortage of electricity supply accompanied by unwise electricity saving policy and secular JP Yen appreciation. The real wrap-up of the current crisis should be realized by removing various concerns in the business environment. At least before the Global Financial Crisis, Japanese firms that expanded operations in East Asia successfully generated employment and economic activities in Japan by sophisticating the division of labor in production networks (Ando and Kimura (2011)). Effective utilization of the mechanics of production networks is the key for revitalizing the Japanese economy.

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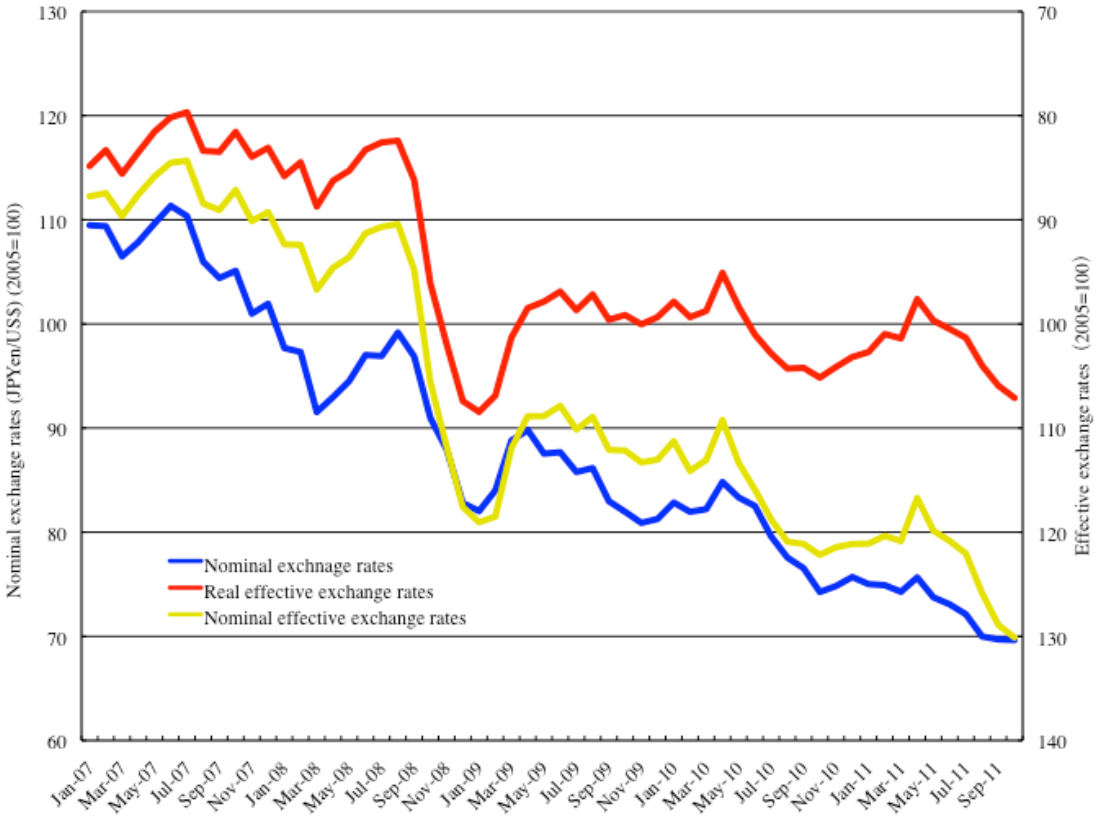
Table A.1. The Definition of Machinery Parts and Components

8406, 8407, 8408, 8409, 8410, 8411, 8412, 8413, 8414, 8416, 8417, 8431, 8448, 8466, 8473, 8480, 8481, 8482, 8483, 8484, 8486, 8487, 8503, 8505, 8507, 8511. 8512, 8522, 8529, 8531, 8532, 8533, 8534, 8535, 8536, 8537, 8538, 8539, 8540, 8541, 8542, 8544, 8545, 8546, 8547, 8548, 8607, 8706, 8707, 8708, 8714, 8803, 8805, 9001, 9002, 9003, 9013, 9014, 9033, 9104, 9110, 9111, 9112, 9113, 9114, 9209, 840140, 840290, 840390, 840490, 841520, 841590, 841891, 841899, 841990, 842091, 842099, 842123, 842129, 842131, 842191, 842199, 842290, 842390, 842490, 843290, 843390, 843490, 843590, 843691, 843699, 843790, 843890, 843991, 843999, 844090, 844190, 844240, 844250, 844391, 844399, 845090, 845190, 845240, 845290, 845390, 845490, 845590, 846791, 846792, 846799, 846890, 847490, 847590, 847690, 847790, 847890, 847990, 850490, 850690, 850870, 850990, 851090, 851390, 851490, 851590. 851690. 851770, 851840, 851850, 851890, 852352, 853090, 854390, 870990, 871690, 900590, 900691, 900699, 900791, 900792, 900890, 901090, 901190, 901290, 901590. 901790, 902490, 902590, 902690, 902790, 902890, 902990, 903090, 903190, 903290

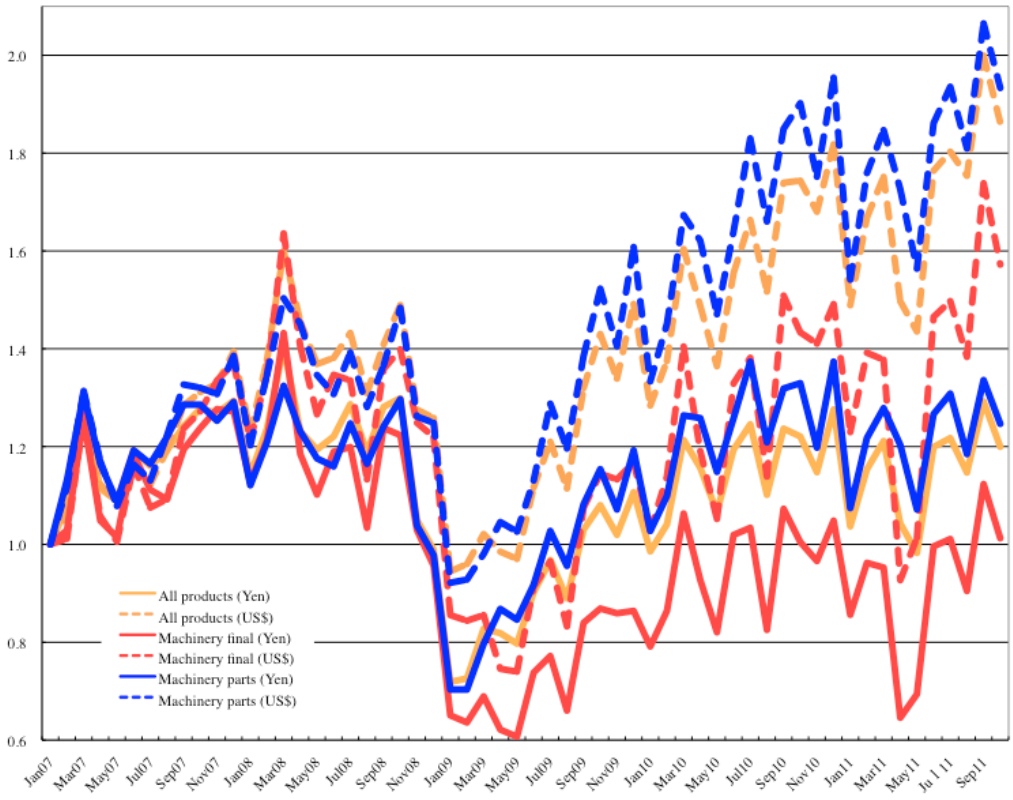
Source: Ando and Kimura (2005) (adjusted to the HS2007 classification).

Figure A.1. Nominal Exchange Rates and Nominal and Real Effective Exchange Rates f JP Yen



Data: Authors' calculation, based on data available from the Bank of Japan's website.

Figure A.2. The Value of Exports in Japanese Yen and US Dollar, Indexed to January 2007=1



Data: Authors' calculation.

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