ASIAN ECONOMIC JOURNAL
Journal of the East Asian Economic Association

How did the Japanese Exports Respond to Two Crises in the International Production Networks? The Global Financial Crisis and the Great East Japan Earthquake*

Mitsuyo Ando and Fukunari Kimura

Received 1 November 2011; accepted 1 May 2012

This paper analyzes the impact of two massive shocks on Japanese exports, the 2008–2009 Global Financial Crisis and the 2011 Great East Japan Earthquake, focusing on the characteristics of domestic/international production networks in machinery industries. Using monthly data for Japanese bilateral exports at the most disaggregated level, the paper decomposes the fall and recovery of Japanese exports into intensive and extensive margins. It also examines the exit and re-entry of exports using logit estimation and survival analysis. The experience after both shocks confirms the stability and robustness of production networks and the enhancing link with East Asia. However, differences between the two shocks seem to generate differential impacts on corporate behavior.

Keywords: fragmentation theory, intensive/extensive margins, supply and demand shocks, exchange rates, survival analysis.

JEL classification codes: F14, F23.

doi: 10.1111/j.1467-8381.2012.02085.x

I. Introduction

Two recent massive shocks seriously affected the Japanese economy: the 2008–2009 Global Financial Crisis (GFC) and the 2011 Great East Japan Earthquake (EJE). International production/distribution networks, which are major sources of international competitiveness for Japan and East Asia, transmitted these negative shocks from the origin to all over the world, and, thus, some people, including researchers and governments, have claimed that the vulnerability of production networks was revealed. However, the present paper shows that international

*Ando (corresponding author), Faculty of Business and Commerce, Keio University, 2-15-45 Mita, Minato-ku, Tokyo 108-8345, Japan. Email: m-ando@fbc.keio.ac.jp. Kimura: Faculty of Economics, Keio University, Japan, 2-15-45 Mita, Minato-ku, Tokyo 108-8345, Japan (and Economic Research Institute for ASEAN and East Asia, Indonesia). Email: fkimura@econ.keio.ac.jp. The authors would like to thank the Editor for insightful comments and suggestions.

production/distribution networks instead demonstrated 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 had a massive impact on 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, demonstrated distinctive stability and resiliency vis-à-vis trade in machinery final products and other products. In contrast, the magnitude and duration of shocks were different; the 2008–2009 GFC had huge and prolonged impacts, while the 2011 EJE had much smaller and more temporary impacts, at least for Japan as a nation. The former was primarily a demand shock due to drastic drops in demand in the US and EU markets, whereas the latter was a supply shock due to the devastation of production plants located in the disaster areas. These differences partially explain such a dissimilar response, with a perception of the crisis as a permanent shock or temporary shock.

The present paper focuses on Japan's machinery industries, with a distinction between machinery intermediate goods and final products and examines how and to what extent the two crises affected Japanese exports, from the viewpoint of domestic and international production networks. More specifically, the paper first describes patterns and trends of Japanese exports to major markets, using monthly country–product data for Japanese exports at the most disaggregated level. Then, the paper decomposes 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), to identify major factors of trade falls and recoveries associated with the crises for machinery parts and components and machinery final products.[2] Moreover, the paper examines the probability of trade falls and recoveries using logit estimation, with a particular interest in the 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 over a longer period.

The rest of the paper is organized as follows. Section II describes patterns of Japanese exports, particularly focusing on machinery exports. Sections III and IV provide analyses of falls and recoveries of machinery trade with the 2008–2009 GFC and the 2011 EJE, respectively. Section V concludes the paper by discussing the similarities and differences in the two massive shocks as well as policy implications.

1 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 (Ando, 2010). Also see Haddad and Shepherd (2011) for interesting series of analyses of trade and economies under the GFC.
2 See Subsection III.1 for the details of extensive and intensive margins.

II. Patterns of Japanese Exports: Descriptive Analysis

Figure 1 presents movements in Japanese real exports in US dollars for all products, machinery parts and components, and machinery final goods (total and only automobiles) from January 2007 to October 2011.[3] The figure clearly shows the existence of significant negative impacts of the 2008–2009 GFC 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 gradual growth until the EJE occurs in March 2011.[4]

However, we observe a permanent change in extensive margins of machinery exports. The number of exported product–country pairs in the case of all products exported to the world significantly dropped in the 2008–2009 GFC, with the bottom reached in January 2009 (Figure 2).[5] Although the number of exported products had a tendency to increase from January 2009, it did not return to 2007 or 2008 levels. Figure 2 also presents the number of product–country pairs for exports to East Asian countries only;[6] it shows a significant drop in the number of exported products for East Asia as well, although the decline is not so serious as the case of exports to all countries in the world. This reflects 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 GFC as a trigger.

The effects of the EJE 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

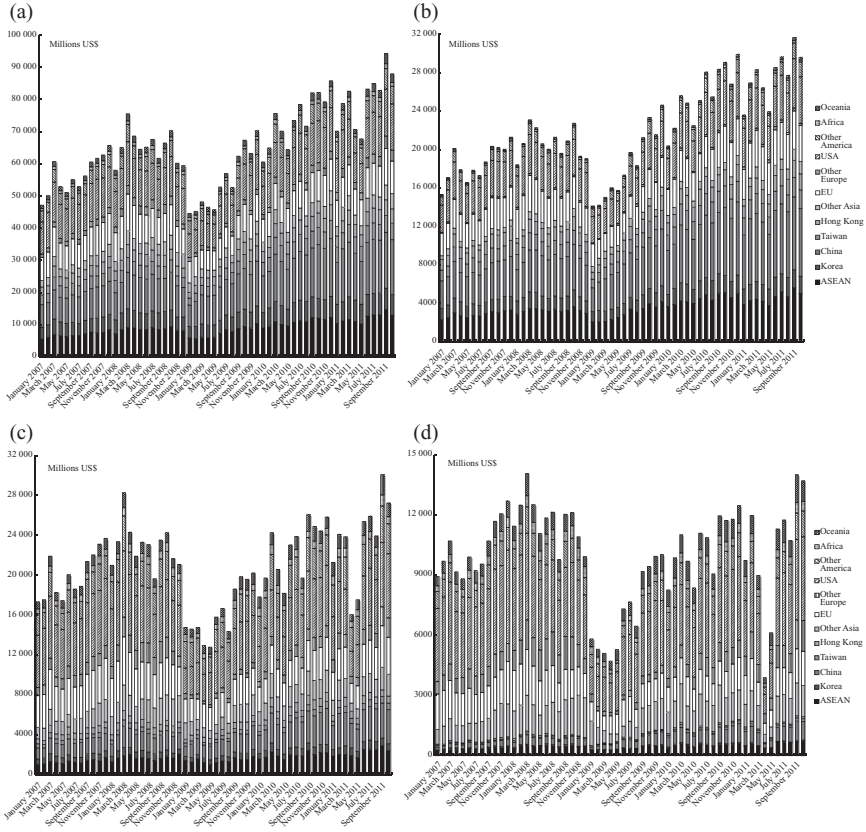
3 Machinery goods are composed of general machinery, electric machinery, transport equipment, and precision machinery (Harmonized System (HS) 84-92) in this paper. The definition of machinery parts and components is based on Ando and Kimura (2005), which is adjusted to the 2007 version of HS classification: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

4 As the yen has tended to appreciate since the GFC, the corresponding figure for exports in yen demonstrates a slightly different picture (see Ando and Kimura, 2012).

5 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.

6 East Asia in this paper includes the following 14 countries/economies: ASEA 10, China, Korea, Hong Kong and Taiwan.

Figure 1 Japanese real exports by region: (a) all products, (b) machinery parts and components, (c) machinery final goods and (d) HS87 final goods only



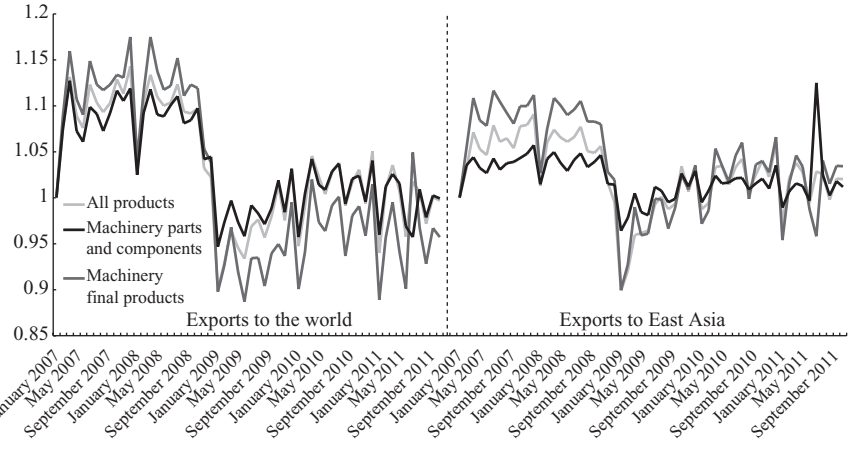
Source: Authors' preparation, using data available from the websites of the Ministry of Finance and the Bank of Japan.

year. Exports in May are greater than those in the previous year. Interestingly, exports rapidly increase in June, achieving positive growth in terms of both changes from the previous month and the previous year; exports in June 2011 are more than 10 percent greater than exports in June 2010. Compared with the 2008–2009 GFC, the degree of the fall in overall trade is much smaller, its recovery is more rapid, and no distinctive change in extensive margins of exports is observed.[7,8]

7 For Japanese exports in agriculture and food industries, not only the earthquake itself but also the tsunami caused by the earthquake resulting in the Fukushima nuclear disaster has had significant negative impacts. Many importing countries introduced additional safety inspections and trade restrictions for imports of agriculture and food products produced in Japan. As a result, the number of agriculture and food industry exports significantly dropped in April–June 2011 to some countries, such as China, Korea, the EU and the Middle East.

8 The index of industrial production for Japan also suggests that the direct impacts of the GFC were more serious than those of the EJE. Although the impacts of the EJE were, indeed, more serious if

Figure 2 Number of exported products (tallied by partner country), indexed to January 2007 = 1



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

At the sectoral level, for machinery final products, major markets include developed countries, such as the USA and the European Union (EU).[9] Since the GFC, the value of exports to the USA and the EU has not returned to the level in 2007 (Table 1). However, East Asia is growing in terms of the value of exports as well as the share in the regional share in exports to the world (total exports); in 2010, the value of exports was 1.6 times as high as that in 2007, and the share in total exports increased from 22 percent in 2007 to 30 percent in 2010. For automobiles (final products), both of the 2007 export value and share had doubled by 2010. With the GFC as a trigger, East Asia is gaining importance as a market for machinery final products, although the USA and the EU remain as significant markets.

Exports in machinery final products suffered severe negative impacts from the GFC, reaching a bottom in April/May 2010, which is later than the average. Furthermore, the 2011 EJE seriously affected 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 a level much lower than the previous year. In particular, the impacts on exports in automobiles are the most serious; exports in April, at the bottom, are even lower than exports at the bottom during the

focused only on the disaster areas, the magnitude of the direct impacts of the GFC were greater for the country as a whole, at least from the perspective of production and exports.

9 In this paper, the EU refers to the EU27.

Table 1 By-region value and share of Japan's real exports

	Value of exports, indexed to 2007 = 1				*Share in total exports (%)*			
Destination	*2007*	*2008*	*2009*	*2010*	*2007*	*2008*	*2009*	*2010*
(a) All products								
East Asia	1.00	1.18	1.09	1.53	47	48	53	54
USA	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
(b) Machinery parts and components								
East Asia	1.00	1.13	1.06	1.54	56	56	59	62
USA	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
(c) Machinery final products								
East Asia	1.00	1.19	1.02	1.55	22	23	28	30
USA	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
(d) HS87 final goods only								
East Asia	1.00	1.38	1.20	2.00	7	8	12	14
USA	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

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

2008–2009 GFC. Exports in machinery final products, including automobiles, however, rapidly recover from May, and even exceed the level of the previous year in June. Permanent changes in the export pattern do not seem to be observed here.

East Asia occupies approximately 60 percent of machinery parts and components exports to the world. East Asia's share increased slightly after the GFC, and the value in 2010 was as large as 1.5 times that in 2007. East Asia is the most important destination for Japanese exports of machinery parts and components because Japanese firms are major players in production/distribution networks in the region. Although exports dropped significantly during the GFC, they had recovered by October 2009, with a drastic recovery of exports to East Asia. They continued to grow from 2009, partially reflecting an increase in prices in US dollars due to the appreciation of the yen. After the 2011 EJE, exports declined in April and May, but exports in US dollars were still greater than the previous year. Moreover, in June, as is the case for other products, exports increased. As a result, in June, exports had returned to the level of the previous year, in terms of both US dollars and yen, although exports in yen were lower than the level of the previous

year in April and May. Note that the number of product–country pairs for exports to the world sharply rose in July for machinery parts and components, whereas the number drastically increased in June for all products and machinery final products (Figure 2). Interestingly, the number of product–country pairs for machinery parts and components exported to East Asia only increased sharply in June, rather than July, as is the general case, which suggests the importance of maintaining supply chains in regional production networks.

III. 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. For the analysis of the decomposition approach and the logit estimation, the paper sets the period of trade fall as from October 2008 to January 2009 and the period of trade recovery as from January to October 2009.

III.1 Decomposition of trade changes

Methodology and data

The decomposition approach used in the paper is proposed by Haddad et al. (2010).[10] The first step of their approach is to identify the category of a product exported to a given partner country: 'continuing', 'entry' or 'exit'. If a product is exported to a given 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 extensive and intensive 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:

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

10 Their approach is inspired by the earlier work by Bernard et al. (2009), who analyze the 1997 Asian crisis using trade data for US firms.

Intensive margins are composed of effects due to changes in quantity and price: changes in export values for country–product pairs that are classified into 'continuing' due to changes in quantity (quantity effect) and changes in price (price effect). Extensive margins consist 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 product–country pairs that are classified into 'exit' and an increase in export values due to new exports in t for product–country pairs that are classified into 'entry'. By rewriting Equation (2), the percentage change in the total value of exports can be expressed as the sum of the quantity effect, the price effect, the entry effect and the exit effect:

$$\frac{dv_t}{v_{t-1}} = \frac{\sum_{c=1}^{C} \frac{p_t^c + p_{t-1}^c}{2} \Delta q_t^c}{v_{t-1}} + \frac{\sum_{c=1}^{C} \Delta p_t^c \frac{q_t^c + q_{t-1}^c}{2}}{v_{t-1}} + \frac{\sum_{n=1}^{N} p_t^n q_t^n}{v_{t-1}} - \frac{\sum_{x=1}^{X} p_{t-1}^x q_{t-1}^x}{v_{t-1}} \quad (3)$$
$$(I = C + N + X),$$

where c are products that are traded in both t–1 and t (in the category 'continuing'), n are products that are traded only in t (in the category 'entry'), x are products that are traded only in t–1 (in the category 'exit'), C expresses the total number of products in the category 'continuing', N is the total number of products in the category 'entry', and X is the total number of products in the category 'exit'.[11]

In order to apply this method to decompose changes in values of Japanese exports, the paper uses monthly data for Japanese bilateral exports at the most disaggregated level or the Harmonized System (HS) 9-digit level.[12] The monthly data for Japanese bilateral exports by products and destination countries in yen are available from the Trade Statistics of Japan, the Ministry of Finance, Japan.[13] To convert exports in yen in nominal terms into exports in US dollars in real terms, we use the export price index, available from the Bank of Japan,[14] and exchange rates that are the monthly average of public rates announced by Japan Customs, available from the Ministry of Finance, Japan.[15]

Results

Table 2 and Figure 3 show changes in total exports during the periods of trade fall and trade recovery. Figure 3 also shows the decomposition for machinery

11 Haddad et al. (2010) provide a detailed explanation of how to obtain Equation (3) by rewriting Equation (2).

12 Prices for some products in the category 'continuing' are missing due to a lack of quantity data. Changes in exports due to these product–country pairs are treated as the 'unidentified effect' so as not to underestimate intensive margins.

13 See: http://www.customs.go.jp/toukei/info/index.htm.

14 See: http://www.boj.or.jp/statistics/pi/index.htm/.

15 See: http://www.customs.go.jp/tetsuzuki/kawase/index.htm.

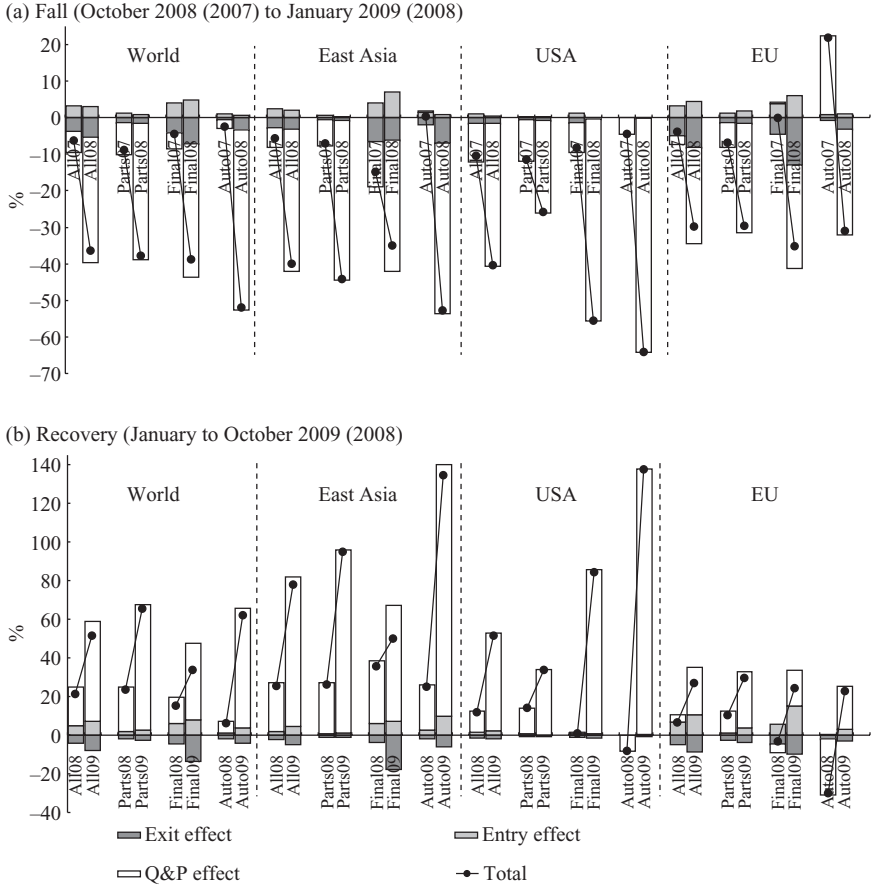
Table 2 Decomposition of real changes in exports (US$) under the Global Financial Crisis: All products %

	Total	*Quantity effect*	*Price effect*	*Entry effect*	*Exit effect*	*Total*	*Quantity effect*	*Price effect*	*Entry effect*	*Exit effect*
(a) Fall	October 2008–January 2009					October 2007–January 2008				
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
USA	−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
(b) Recovery	January 2009–October 2009					January 2008–October 2008				
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
USA	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

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

Note: The category of 'unidentified' is omitted because the values for this category are 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 (yen/US$) are −12.7% in October 2008–January 2009 and −4.6% in October 2007–January 2008, and −0.7% in January 2009–October 2009 and −6.2% in January 2008–October 2008.

Figure 3 Decomposition of real changes in exports under the Global Financial Crisis (US$) (a) Fall (October 2008 (2007) to January 2009 (2008) (b) Recovery (January to October 2009 (2008)



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

intermediate goods, machinery final products, and automobiles only in addition to all products, as well as the results in the same period the previous year to observe seasonal fluctuations.

The results provide five notable findings. First, exports declined from October 2008 to January 2009 by almost 40 percent. Even in typical years, Japanese exports tend to fall from October to January; for instance, exports declined in the same period of the previous year by 5 to 10 percent. Such a 40 percent drop, however, can be attributed to far more than 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). The 2008–2009 GFC did have significant negative impacts on Japanese exports.

Second, the exit effect is much smaller in absolute terms for machinery parts and components than for other products including machinery final products: the exit effect is only –1.6 percent for the world, and is even smaller for East Asia, at –0.7 percent. Moreover, the exit effect for machinery parts and components is almost at the same level as in the same period the previous year. Although large intensive margins induce a significant decline in exports, particularly for East Asia, the small exit effect suggests the robustness of trade relationships for machinery parts and components, with the dense production/distribution networks in the region.

Third, the major factors contributing to the decrease in exports in machinery final goods are different for the USA and the EU. Almost all the decline in exports to the USA (–56 percent) can be explained by the serious negative quantity effect (–69 percent). The corresponding figures are more serious for automobiles only: –64 percent (total changes) and –73 percent (the quantity effect). In other words, the quantity effect is a major factor contributing to the decline of machinery final goods exported to the USA. In contrast, the quantity effect (–38 percent) is less serious and the exit effect (–13 percent) is more serious for their exports to the EU than to other regions. Moreover, the exit effect, in absolute terms, is much larger than in the same period the previous year. These results imply that the exit effect is a relatively major factor contributing to the decline in machinery final goods exported to the EU.

Fourth, the price effects are positive in the period of trade fall. The US dollar-based price effect is 13.6 percent for machinery final products exported to the USA and 9.5 percent for those exported to the EU. The corresponding figures for machinery parts and components are 16.3 and 40.3 percent, respectively.[16] Because the shock was initiated by a demand decline in the US and the EU markets, a negative price effect might be expected in general. Several factors, however, can explain the positive price effect. During the sample period, the 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 the yen was largely passed through to the price in the USA. Another factor would be the shift in the composition of export goods toward highly valued products.[17]

Fifth, the trade recovery shows a symmetric picture to the trade fall. The features for the trade fall, which are discussed above, can be reversely applied to

16 Due to the space limitations, detailed figures for the decomposition by products are excluded in Table 2. See Ando and Kimura (2012) for the details, including figures for the price effects and the movement of yen exchange rates.

17 Amiti and Weinstein (2011) suggest that the health of financial institutions is an important determinant of firm-level exports during crises. Ahn et al. (2011) propose a hypothesis that the increase in import prices in the USA could be explained by the malfunctioning of trade finance. However, it does not seem to explain the case of Japanese exports because no major malfunctioning in trade finance occurred in Japan.

the recovery of trade. For machinery parts and components exported to East Asia, the extensive margin is quite small, and a large positive quantity effect is observed. Regarding major factors contributing to a rise in exports in machinery final goods, the positive quantity effect is large for the USA, while the entry effect is relatively large for the 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 effects; the price effect is positive as expected for automobiles and also in most cases for the USA.

III.2 Probability of trade fall and recovery

This subsection investigates the probability of the fall and recovery of machinery exports under the 2008–2009 GFC, using logit estimation, and formalizes the features of machinery exports in responding to the crisis.

Methodology

For the analysis of trade fall, product–country pairs at the HS 9-digit level with exports in October 2008 (and/or 1 month before and after) are used to examine whether their exports existed in January 2009 or not. For the analysis of trade recovery, in contrast, product–country pairs at the HS 9-digit level with exports in October 2008 (and/or 1 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 a 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 the natural logarithm. $Parts_j$ is 1 if product j is machinery parts and components, and 0 otherwise (machinery final goods). Country/region dummies expressed as $Country_n$ are included for 14 East Asian countries, the USA and the EU to capture the features of trade relationships with these countries/regions under the crisis.

Results

Table 3 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 trade ceases for a period. The coefficient for parts is negative for the analysis of trade fall and positive for the analysis of trade recovery, with

Table 3 Logit estimation for Japan's machinery exports under the Global Financial Crisis

	(a) Fall		*(b) Recovery*	
Distance (log)	−0.05	(−1.6)	0.10	(1.8)*
Parts	−0.51	(−25.8)***	0.28	(8.8)***
Korea	−1.37	(−13.5)***	1.38	(8.5)***
China	−1.74	(−18.9)***	1.20	(7.7)***
Taiwan	−1.31	(−14.9)***	1.05	(7.3)***
Hong Kong	−1.35	(−16)***	0.91	(6.5)***
Vietnam	−0.96	(−12.12)***	1.38	(10.9)***
Thailand	−1.53	(−19.3)***	1.11	(8.1)***
Singapore	−1.39	(−17.9)***	0.68	(4.9)***
Malaysia	−0.91	(−12.3)***	0.92	(7.7)***
Brunei	0.88	(4.2)***	−0.75	(−2.4)**
Philippines	−0.99	(−12.2)***	1.03	(7.9)***
Indonesia	−0.91	(−12.4)***	0.86	(7.2)***
Cambodia	0.76	(4.08)***	0.30	(1.5)
Laos	0.53	(1.9)*	−1.05	(−2.0)**
Myanmar	0.35	(2.2)**	0.12	(0.6)
USA	−1.99	(−23.4)***	0.37	(2.2)**
EU	−0.53	(−22.1)***	0.07	(1.8)*
Constant	0.93	(2.9)***	−2.09	(−4.384)***
Log-likelihood	−29 744		−11 949	
Number of observations	45 979		20 507	

Source: Authors' calculation.

Note: The dependent variable for the analysis of trade fall is 1 if trade stops and 0 otherwise. Similarly, the dependent variable for the analysis of trade recovery is 1 if trade recovers and 0 otherwise. Figures in parentheses are *Z*-statistics. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

statistical significance. This suggests a robust trade relationship for machinery parts and components compared with machinery final products, which is consistent with the results of the decomposition analysis.

Second, among East Asian countries, those that are heavily involved in the regional production networks tend to maintain trade relationships and are likely to recover trade even if they cease trade for a period. 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. In contrast, the coefficients for countries such as Brunei, Cambodia, Laos and Myanmar are either statistically insignificant, small in absolute terms, or even opposite. This 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 that 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 USA for machinery exports. The USA is an important market for Japan; some machinery final products sold there are produced in Japan, whereas others are assembled in the USA or Mexico using core parts and components exported from Japan.[18] 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 for the US–Mexico nexus and find substitutes, as not many neighboring countries are involved in production networks. Therefore, Japanese machinery exports to the USA are less likely to be discontinued, considering the importance of supply production to the customers in the USA.

III.3 Probability of trade recovery and its timing

Using survival analyses and the Kaplan–Meier product-limit method, this subsection analyzes the probability of the recovery of machinery exports.[19]

Methodology and data

This subsection estimates 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 trade relationships have been inactive before the previous month.[20] To investigate patterns of recovery after the 2008–2009 GFC, we collect only product–country pairs with exports in October 2008 (and/or 1-month before and after) and no exports in January 2009, and focus on when their exports recommenced.

The Kaplan–Meier failure rates and hazard rates are estimated separately for machinery final products and machinery parts and components to determine whether there exist any differences in the probability of recovery between these products. In addition, those rates are estimated not only for exports to all partner countries but also exports to East Asia, the USA and the EU to see whether any differences in the probability among countries/regions exist. The log-rank test is applied to check statistical significance for the differences in the failure/hazard functions among product groups/regions.

Results

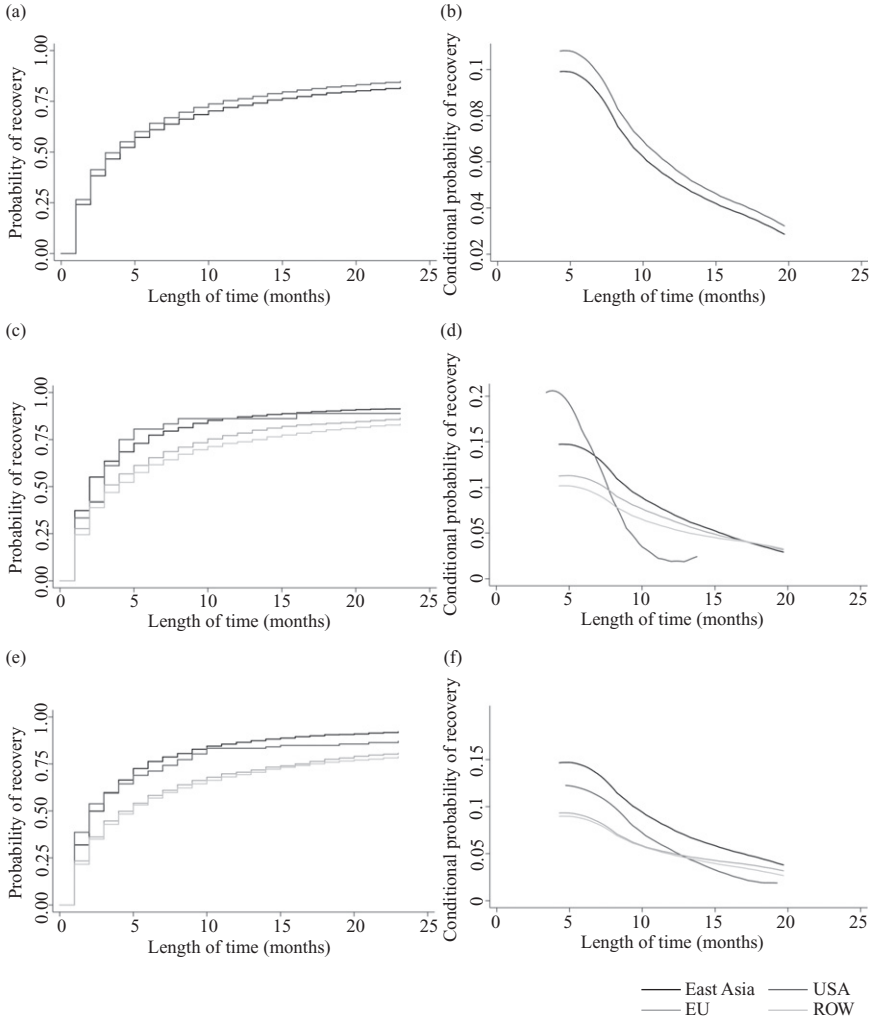
Figure 4 presents Kaplan–Meier estimates of failure functions and hazard functions. Regardless of products/regions, both curves of estimated failure rates and

18 Note that Japanese exports to Mexico are typically via Los Angeles and are, therefore, often recorded as Japanese exports to the USA in Japanese statistics of exports.

19 See Obashi (2011) for survival analysis of the duration of trade relationships for machinery goods and the probability of trade recovery from the Asian crisis.

20 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 hazard function graph is based on a (standard) weighted kernel smooth of the estimated hazard contributions.

Figure 4 Kaplan–Meier estimates of failure functions and hazard functions for machinery exports, recovery from the Global Financial Crisis: (a) failure functions, world, (b) hazard functions, world, (c) failure functions, parts and components, (d) hazard functions, parts and components, (e) failure functions, final products and (f) hazard functions, final products



Source: Author's calculation.

hazard rates are steeper (with the upward and downward trends, respectively) in the earlier period, suggesting the higher probability of recommencing export activity sooner.

The figure also indicates three interesting differences among product/regional groups. First, the probability of recovery is higher for machinery parts and

Table 4 Estimated Kaplan–Meier failure rates: Recovery from the Global Financial Crisis

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

Source: Authors' calculation.

Note: [a]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. EU, European Union; ROW, rest of the world.

components than for machinery final products in general. Both failure rates and hazard rates are higher for machinery parts and components than for machinery final products at any point in time. For instance, 55 percent of machinery parts and component exporters that discontinue trade in January 2009 recommence exporting within the first 4 months, and 85 percent restart exporting by the end of 2010 (Table 4). In contrast, 52 percent of machinery final product exporters that discontinue trade in January 2009 restart within the first 4 months, and 82 percent recommence exporting 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 is less likely to be discontinued, and tends to restart sooner even if trade ceases for a period. In other words, the trade relationships are more robust and stronger for machinery parts and components.

Second, the probability of recovery is higher for East Asia than for the USA, the EU and the rest of the world (ROW) in general. At any point in time, the failure rate for all products is slightly higher in East Asia, although the rates are higher for the USA than for East Asia at certain points in the earlier period for machinery

final/intermediate goods.[21] Moreover, the portion of trade relationships that have recovered by the end of 2010 is higher for East Asia than other regions; the failure rates in December 2010 for East Asia, the USA, the EU and the ROW are 91 (92), 89 (87), 86 (81) and 83 (79) percent for machinery parts and components (machinery final products), respectively. This 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 during the 2008–2009 GFC.

Third, the probability of recovery at certain times in the earlier period for the USA 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, but rapidly decreases. As a result, the hazard rate falls to a level below that for East Asia by the eighth month. This might indicate the importance of production activities in the local market and customers in the USA, which is consistent with the finding from logit estimation in the previous subsection.

IV. Analysis of the Effects of the 2011 Great East Japan Earthquake

This section examines the effects of the 2011 EJE on Japanese machinery exports from March 2011 to October 2011, using the same methodologies as in Section III.

IV.1 Decomposition of trade changes

To understand patterns of export changes after March when the earthquake occurred, this subsection follows the decomposition approach used in Subsection III.1. Unlike the analysis for the 2008–2009 GFC, however, this subsection investigates patterns of monthly changes or changes from previous months to capture features of trade movements over several months. As monthly changes tend to be significantly influenced by seasonality, changes from the corresponding month of the previous year (changes from previous year) are also considered.

Table 5 and Figure 5 present monthly changes in total exports to the world from March to October 2011. Figures 6–8 show corresponding figures for monthly changes in exports to East Asia, the USA and the EU, respectively.

The results provide several important insights. First, the exit effect is much smaller for machinery parts and components than for other products, including machinery final products: the exit effect is only around –1.5 percent in a month.

21 The results for all products are not included in the paper due to space limitations. They are available upon request.

Table 5 Decomposition of real changes in exports (US$) under the Great East Japan Earthquake: All products exported to the World %

	Total (versus previous year)	*Total (versus previous month)*				
			Quantity effect	*Price effect*	*Entry effect*	*Exit effect*
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

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

Note: The category of 'unidentified' is omitted becausae 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.

Moreover, the exit effect for machinery parts and components is more or less equal to the low level of of the same month of the previous year, 2010. Although their exports 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 exceeded those in June 2010 by 14 percent.[22] Furthermore, the exit effect is even smaller for East Asia (i.e. less than –0.5 percent in a month, compared with other regions).[23] These findings suggest that the robustness of trade relationships for machinery parts and components, and that firms prioritized maintaining international production networks, even after the 2011 EJE, just as is the case for the 2008–2009 GFC.

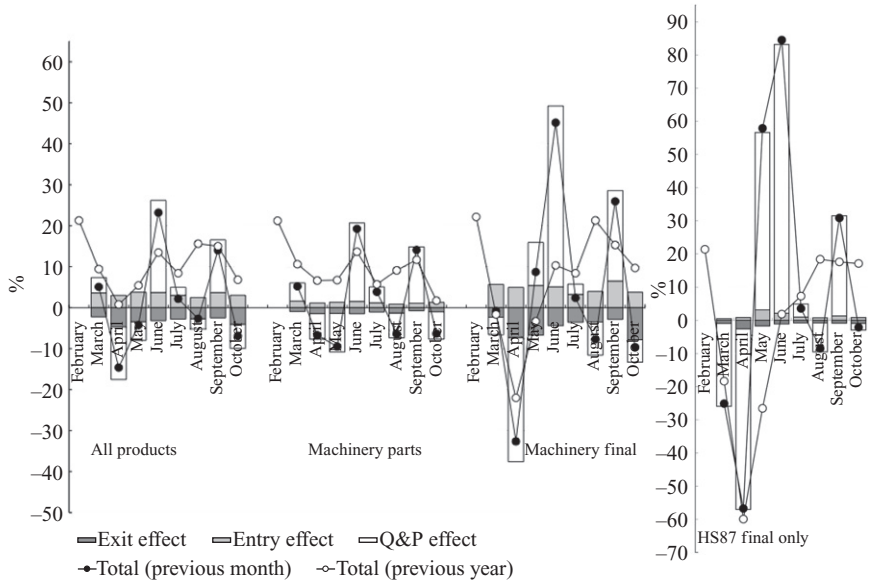
Second, exports in machinery final goods substantially declined in April 2011, mainly due to the significant negative quantity effect as well as the exit effect that is much larger than the effect in March 2011 and the effect in April 2010. In addition, the price effect is positive and higher than 10 percent in May 2011.[24] Although the yen appreciated by 0.7 percent in May, that exchange rate appreciation cannot explain the high degree of the positive price effect. Rather, the positive price effect partially implies an upward pressure on prices due to a reduction in the supply of exported products; some of the critical SME were

22 Exports in yen also returned to the level of the previous year in June.

23 The exit effect for the USA is also small. Note that the figure for the USA is based on trade data only for the USA so it is less likely to be influenced by other countries.

24 See footnote 16.

Figure 5 Decomposition of real changes in exports under the Great East Japan Earthquake (US$): World



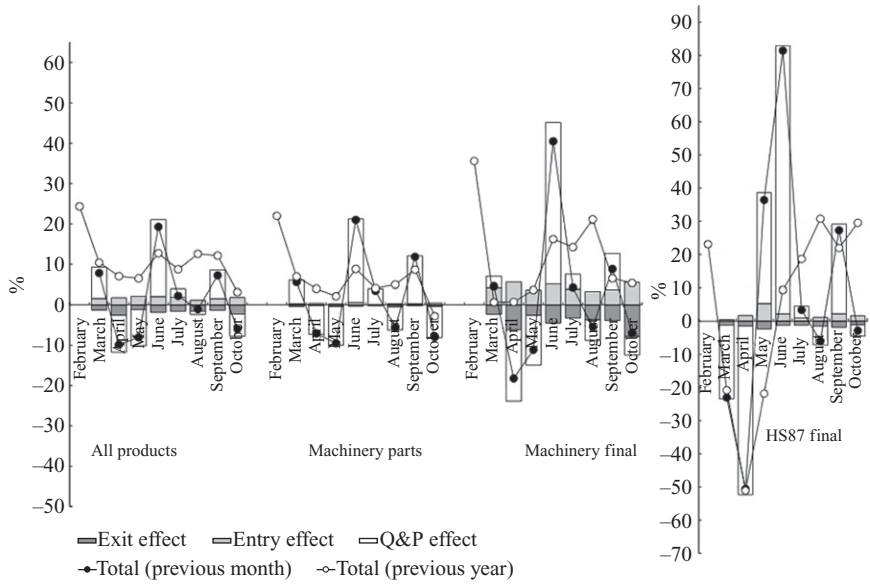
Source: Authors' calculation, using data available from the websites of the Ministry of Finance and the Bank of Japan.
Note: Q & P effect is the sum of quantity effect, price effect, and unidentified effect.

located in the disaster areas, and exports were negatively affected through production chains. All of these figures reflect the negative supply shock.

Third, exports in machinery final products achieve a dramatic recovery in May and June. Their exports recovered to the level of the previous June; exports in June 2011 are more than 10 percent higher than those in June 2010.[25] The outstanding recovery, in particular, can be observed for automobiles. Exports in automobiles drastically declined in April, by around 60 percent from the previous month or the same month of the previous year, mostly due to the negative quantity effect. For the USA and the EU, in particular, the drop is even larger in April; exports declined by close to 70 percent for the USA and over 60 percent for the EU, compared with the same month of the previous year. As a result, in April 2011, total exports of machinery final products are below the minimum level of exports during the 2008–2009 GFC. Exports, however, mostly return to the level of the previous June.[26]

25 Exports in yen almost reached the level of the previous year in June.
26 Exports of automobiles to the USA finally returned to the level of the previous year in August 2011.

Figure 6 Decomposition of real changes in exports under the Great East Japan Earthquake (US$): East Asia



Source: Authors' calculation, using data available from the websites of the Ministry of Finance and the Bank of Japan.
Note: Q & P effect is the sum of quantity effect, price effect, and unidentified effect.

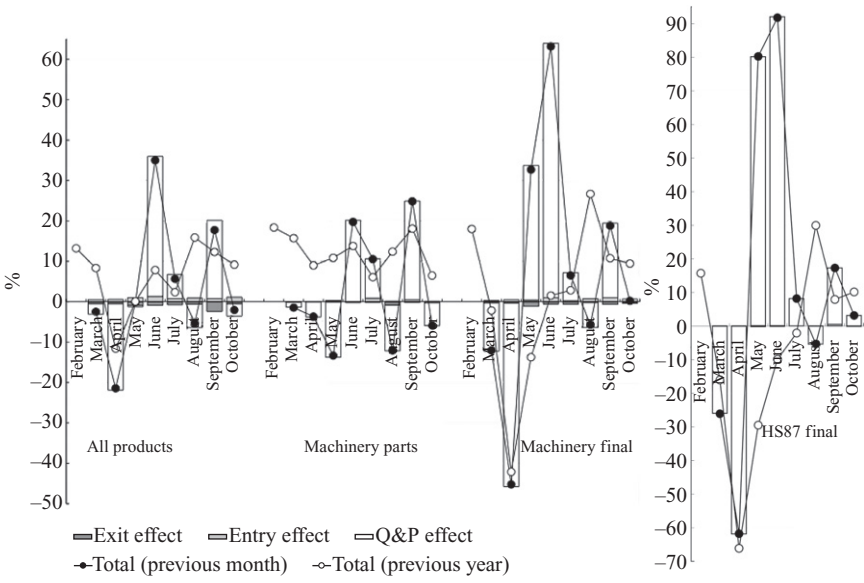
Behind such a dramatic recovery for automobiles were great 'private' efforts to restore the supply chains by private companies that were not willing to wait for the government's support. One symbolic episode is the case of Japan Renesas.[27] This company was producing several key electronic parts and components for automobiles (micro-processing units, memory control units and application specific standard products) and various information and communications technology products. The 2011 EJE severely hit and damaged its factories, including Naka Factory in Ibaraki Prefecture. To resume the operation of supply chains, Japan Automobile Manufacturers Association 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 2500 a day.

IV.2 Probability of trade fall and recovery

Similar to the analysis in Subsection III.2, this subsection investigates the probability of the fall and recovery of machinery exports under the 2011 EJE.

27 This is drawn from Nihon Keizai Shinbun, 28 April 2011.

Figure 7 Decomposition of real changes in exports under the Great East Japan Earthquake (US$): USA

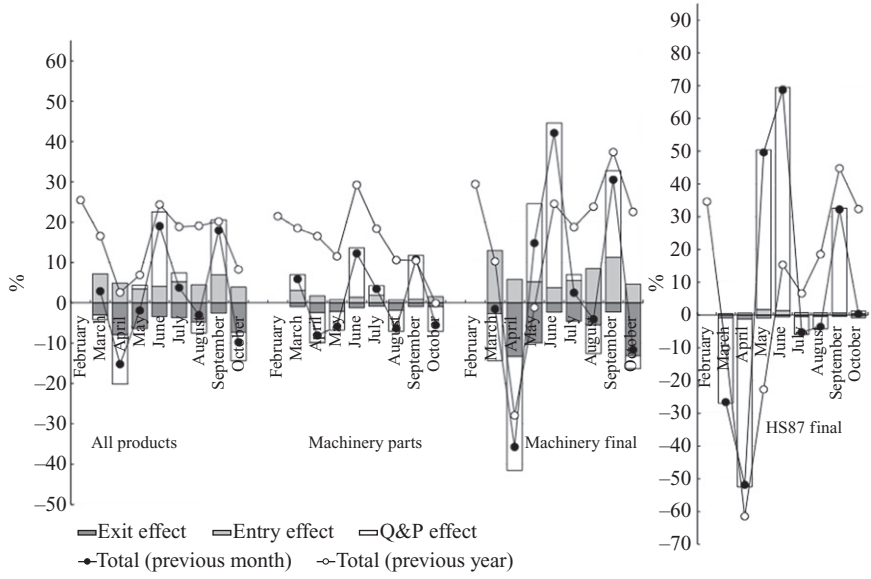


Source: Authors' calculation, using data available from the websites of the Ministry of Finance and the Bank of Japan.
Note: Q & P effect is the sum of quantity effect, price effect, and unidentified effect.

Based on trade patterns for all products shown in Figure 1, the paper basically regards the period from March to May 2011 as that of trade fall and the period from May to July 2011 as that of trade recovery. For the analysis of trade fall, those product–country pairs at the HS 9-digit level with exports in March 2011 (and/or 1-month before and after) are used to examine whether exports exist or not in May 2011. For the analysis of trade recovery, in contrast, those product–country pairs at the HS 9-digit level with exports in March 2011 (and/or 1-month before and after) and no exports in May 2011 are used to investigate whether exports recover in July 2011. Using the same equation as in Section III, logit estimation analysis for export fall and recovery is conducted for the 2011 EJE.

Table 6 shows the results and provides almost the same findings as the case of the GFC, even though the period of trade fall and recovery is much shorter for the 2011 EJE. First, trade in machinery parts and components is less likely to be discontinued and is likely to recover even if trade ceases for a period. The coefficient for parts is negative for the analysis of trade fall and positive for the analysis of trade recovery, with statistical significance.

Figure 8 Decomposition of real changes in exports under the Great East Japan Earthquake (US$): EU



Source: Authors' calculation, using data available from the websites of the Ministry of Finance and the Bank of Japan.
Note: Q & P effect is the sum of quantity effect, price effect, and unidentified effect.

Second, among East Asian countries, those who are heavily involved in the regional production networks tend to maintain trade relationships, and to recover trade relationships even if trade ceases for a period. 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 larger than the values of coefficients for the USA.

Third, Japan has a strong trade relationship with the USA for machinery exports. The USA is an important export market for Japan for machinery final products as well as machinery parts and components, as is Mexico.

Fourth, the distance matters in the probability of trade fall and recovery after the EJE, unlike the case of the GFC. The coefficient for distance is negative (positive) and statistically significant for the analysis of trade fall (recovery). This suggests that exports to countries that are located closer to Japan are less likely to be discontinued and are likely to recover even if they cease for a period, and, thus, their trade relationships with Japan are more robust, compared to those countries located a greater distance from Japan.

Table 6 Logit estimation of Japan's machinery exports after the Great East Japan Earthquake

	(a) Fall		*(b) Recovery*	
Distance (log)	–0.14	(–3.9)***	0.11	(2.0)**
Parts	–0.47	(–22)***	0.06	(1.8)*
Korea	–1.88	(–16.7)***	0.96	(5.0)***
China	–2.11	(–20.4)***	0.89	(4.8)***
Taiwan	–1.69	(–17.3)***	0.95	(5.6)***
Hong Kong	–1.58	(–17.1)***	0.74	(4.6)***
Vietnam	–1.30	(–15.0)***	0.87	(5.9)***
Thailand	–1.76	(–19.8)***	0.79	(4.9)***
Singapore	–1.39	(–16.8)***	0.77	(5.3)***
Malaysia	–1.18	(–14.4)***	0.77	(5.5)***
Brunei	1.02	(4.1)***	–0.38	(–1.2)
Philippines	–1.18	(–13.4)***	0.33	(2.1)**
Indonesia	–1.15	(–14.3)***	0.83	(6.0)***
Cambodia	0.43	(2.8)***	0.12	(0.6)
Laos	0.67	(2.2)*	–1.79	(–2.5)**
Myanmar	0.06	(0.4)	–0.03	(–0.1)
USA	–1.78	(–20.6)***	0.52	(3.2)***
EU	–0.50	(–19.4)***	0.14	(3.2)***
Constant	1.53	(4.5)***	–2.06	(–3.4)***
Log-likelihood	–26 132		–9749	
Number of observations	41 827		16221	

Source: Authors' calculation.

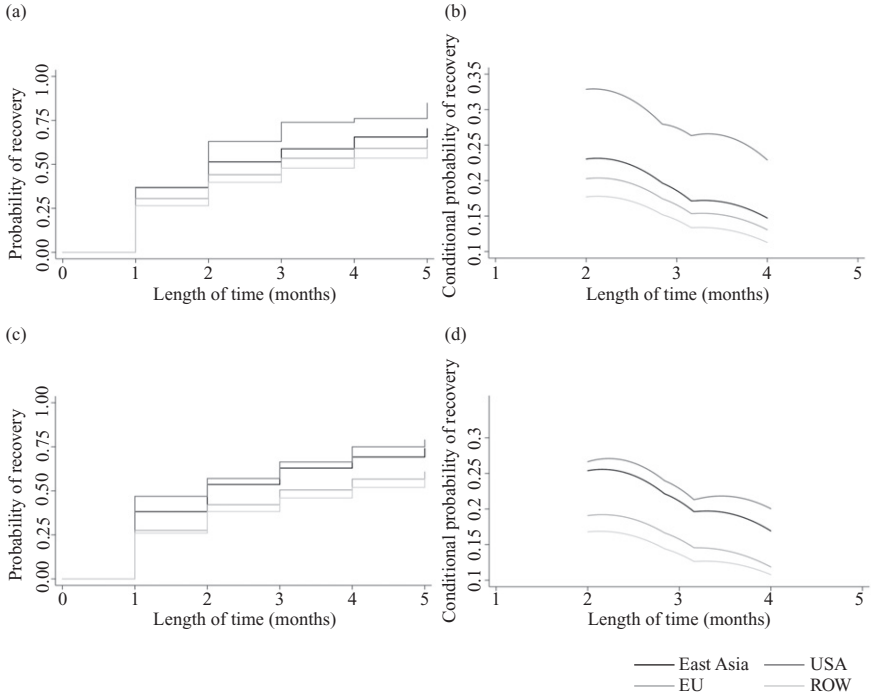
Notes: The dependent variables for the analysis of trade fall is 1 if trade stops and 0 otherwise. Similarly, the dependent variable for the analysis of trade recovery is 1 if trade recovers and 0 otherwise. Figures in parenthesis are *Z*-statistics. ***, ** and * denote significance at the 1, 5 and 10% levels, respectively.

IV.3 Probability of trade recovery and its timing

Based on the methodology explained in Subsection III.3, in this subsection we estimate Kaplan–Meier failure rates and hazard rates for Japanese machinery exports at the product–country level from May 2011, when the exports are the smallest due to the earthquake, to October 2011. To investigate patterns of the recovery from the 2011 EJE, we collect only product–country pairs with exports in March (and/or 1-month before and after) 2011 and no exports in May 2011, and focus on when their exports recommence. Again, the log-rank test is used to check a statistical significance for the differences in the failure/hazard functions among product groups/regions.

Figure 9 presents Kaplan–Meier estimates of failure functions and hazard functions with a distinction among regions: East Asia, the USA, the EU and the ROW. The figure demonstrates 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

Figure 9 Kaplan–Meier estimates of failure functions and hazard functions for machinery exports, recovery from the Great East Japan Earthquake: (a) failure functions, parts and components (b) hazard functions, parts and components, (c) failure functions, final products and (d) hazard functions, final products



Source: Author's calculation.

the higher probability of restarting exporting sooner. The probability of trade recovery within the first 2 months, in particular, is extremely high. For instance, in the case of exports to East Asia, more than half of machinery goods exporters that discontinue trade in May 2011 restart exporting within the first 2 months, and three-quarters of machinery final product exporters (70 percent of machinery parts and components) restart exporting by October 2011 (Table 7).

Second, the probability of recovery is higher for machinery parts and components than for machinery final products in the USA and the EU, whereas the probability is higher for machinery final products than for 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 in the survival analysis for machinery parts and components. This generates more rapid recovery for machinery final products than for machinery parts and components in the case

Table 7 Estimated Kaplan–Meier failure rates: Recovery from the Great East Japan Earthquake

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

Source: Authors' calculation.
Notes: [a]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% level, using the log-rank test. ROW denotes the rest of the world.

of East Asia. In contrast, the economies in the USA and the EU are not so strong, 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 USA and East Asia than for the EU and the ROW, for both machinery final products or intermediate goods. In particular, the probability is much higher for the USA 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 USA and East Asia and the coefficients for dummies of these countries in the logit estimation in absolute values are large, this suggests that the USA and East Asia have more robust trade relationships through production networks and highlights the importance of production activities in the local market and customers.

V. Conclusion: Similarities and Differences for Two Massive Shocks

This paper conducted a multi-angled analysis of trade movements in Japan in response to the 2008–2009 GFC and the 2011 EJE and made a comparison of export changes with the two massive shocks. Due to the nature and characteristics of the two crises, the adjustments made by private firms involved in production networks had similarities and differences.

The Japanese economy seriously suffered from both crises and large adjustments were required in international production networks. However, the shock from the GFC was obviously larger and more prolonged than the shock from the EJE. The former was primarily a negative demand shock, while the latter was a

negative supply shock. In the case of the GFC, 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 EJE, although some uncertain elements existed, such as nuclear issues, firms could judge, to some extent, the overall seriousness of negative shocks from the beginning. Worldwide drops in demand as a result of the GFC were obviously beyond the control of individual firms.

Based on the nature and characteristics of the two crises, Japanese exports revealed similar and dissimilar responses to the two crises. The most important similarity was the stability and robustness of production networks in machinery industries. Shocks seriously damaged production networks and the negative impacts were transmitted through production networks. Strong forces, however, worked to maintain production networks, and quick adjustments for recovery were implemented. As a result, exports of machinery parts and components remained stable and robust. The 2011 Thailand floods also had negative impacts on the production networks and Japanese firms as well because many Japanese firms have operations in Thailand and play important roles in supply chains in the country. Those firms that seriously suffered from this crisis are making great efforts to restore operations as quickly as possible, rather than exiting from Thailand, because they are heavily involved in the production networks.

The extended fragmentation theory states that the fragmentation of production takes advantage of the reduction in production costs within production blocks, while the fragmentation should pay for the network set-up/adjustment cost and the service link cost.[28] 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 reduce these costs by maintaining transaction channels for parts and components. Thus, exports in machinery parts and components tend to be sustained, and are likely to recover rapidly even if they discontinue for a period. Although the data are not readily available, a similar argument should be applied to adjustments for 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.

A notable dissimilarity is whether firms use a shock as a trigger for a structural reform or not. The GFC 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 is another example of permanent changes. In contrast, in response to the EJE, the adjustment of production was more abrupt, but corporate activities bounced back pretty quickly.

The policy implications drawn from these two crises are profound, particularly from the viewpoint of the Japanese Government. The Japanese Government should attempt to prevent firms from utilizing crises as a trigger for removing

28 See Ando et al. (2009) for the two-dimensional fragmentation and their costs in terms of fixed costs, services link costs and production cost per se.

production blocks from Japan. Indeed, in the case of the EJE, there still remains the risk of 'hollowing-out (kudo-ka)' due to continuing shortage of electricity supply accompanied by unwise electricity saving policies and secular yen appreciation. The real end of the current crisis should be realized by removing various concerns in the business environment. At least before the GFC, Japanese firms that expanded operations in East Asia successfully generated employment and economic activity in Japan by sophisticating the division of labor in production networks. Effective utilization of the mechanics of production networks is the key to revitalizing the Japanese economy.

References

Ando, M., 2010, Machinery trade in East Asia and the global financial crisis. *Korea and the World Economy*, **11**, pp. 361–94.

Ando, M. and F. Kimura, 2005, The formation of international production and distribution networks in East Asia. In: *International Trade (NBER–East Asia Seminar on Economics, Volume 14* (eds Ito T. and Rose A.), pp. 177–213. University of Chicago Press, Chicago.

Ando, M., S. W. Arndt and F. Kimura, 2009, Production networks in East Asia: Strategic behavior by Japanese and U.S. firms. *Keio Business Review*, **45-2**, pp. 24–54.

Ando, M. and F. Kimura, 2012, How did the Japanese exports respond to two crises in the international production network? The global financial crisis and the East Japan earthquake. Economic Research Institute for ASEAN and East Asia Discussion Paper No. 2012-01. Economic Research Institute for ASEAN and East Asia, Indonesia.

Ahn, J., M. Amiti and D. E. Weinstein, 2011, Trade finance and the great trade collapse. *American Economic Review*, **101**, pp. 298–302.

Amiti, M. and D. E. Weinstein, 2011, Trade finance and the great trade collapse. *Quarterly Journal of Economics*, **126**, pp. 1841–77.

Bernard, A. B., J. Bradford Jensen, S. J. Redding and P. K. Schott, 2009, Trade, product turnover and quality: The margins of US trade. *American Economic Review: Papers & Proceedings* **99**, pp. 487–93.

Haddad, M., A. Harrison and C. Hausman, 2010, Decomposing the Great Trade Collapse: Products, prices, and quantities in the 2008–2009 crisis. National Bureau of Economic Research Working Paper Series No. 16253. National Bureau of Economic Research, Cambridge, MA.

Haddad, M. and B. Shepherd, eds, 2011, *Managing Openness: Trade and Outward-Oriented Growth After the Crisis*. World Bank, Washington, DC.

Obashi, A., 2011, Resiliency of production networks in Asia: Evidence from the Asian crisis. In: (eds Evenett S. J., Mikic M. and Ratnayake R.), pp. 29–52. *Trade-led Growth: A Sound Strategy for the Asian Region*. United Nations Publication, Bangkok.