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Export Changes Due to the 2011 Great East Japan Earthquake and Tsunami: Expanding the Scale of Shift-share Analysis

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ABSTRACT

Introduction: Disasters can impact national economies in many ways, one of which is through international trade components such as export. with estimated direct damages of over US$211 billion, the Great Eastern Japan earthquake of 2011 has been the costliest disaster in the history of Japan. Although this disaster occurred in an area with lower share in the national and global economy, many Japanese and non-Japanese firms outside the affected area were affected by the ripple effects of this disaster. This study aimed to investigate the extent to which changes in post disaster exports of Japan can be attributed to this disaster.

Methods: A modified version of shift-share method was employed to examine the impacts of the disaster on Japan's export. Considering the regional economic analysis, shift-share analysis is often used to compare regional economic changes with regard to national changes. It decomposes the regional economy changes into universal, industry mix, and competitive advantage components. In this study, an up-scaled shift share analysis was conducted that examined the changes of Japan export versus the world. Two datasets were used in this study. The first dataset included Japan's exports and the other contained the world's exports. . The World Trade Organization (WTO)'s online database constituted the main data source.

Results: According to the shift-share analysis, Japan experienced some increase in export during the study years, which was due to the overall universal export increases. In the same period, Japan lost some of its exports due to the industry mix component. The results showed that the 2011 Great East Japan disaster had a substantial impact on Japan's exports through the export reduction caused by the competitive effect.

Conclusions: Large-scale disasters may have a significant impact on the overall national economy and export. The results of this study highlighted that the disaster had a negative competitive advantage for all economic sectors of Japan.

Keywords: 2011 Tohoku Earthquake and Tsunami; Shift-share Analysis; Japan's Export; Supply-chain Disruption; Global Disasters

Introduction

Globalization has increased the importance of international trade in the world's economy. As a result, large disasters, especially in countries with a significant presence in the international trade and global supply chain, can disturb the global economy (1). In other words, "when local disasters occur in globally integrated economies, the impacts ripple through regional and global supply chains causing indirect losses to businesses on the other side of the globe" (2**).** History showed that large-scale disasters

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could even push the world's economy into an irreversible decay or collapse (3). Mega disasters could cause a decrease in production through direct (human capital, buildings, utility networks, and transportation infrastructure such as roads, ports, and rails) and indirect losses (4, 5, 6), which in turn could reduce the export by the impacted country. Depending on the nature of the reduced products (i.e., raw material such as oil, intermediate goods, or final products), disasters can disrupt and impact the international supply chain and markets. With regard to the increasing share of tourism in the global economy, service exports may also be negatively influenced by disasters (7). Moreover, disasters may have an impact on the global economy through expectation modifications. Considering the possible supply chain disruptions and risks involved, innovative companies try to identify disaster hot spots in their supply chains and seek alternative options to reduce their vulnerability (2).

In today's interconnected global economy, indirect impacts of large disaster events may be dispersed among many countries. Depending on the nature of trade, other countries may suffer economic losses due to supply chain disruptions or possibly gain profit from increasing exports to the disrupted country (8).

This paper assessed the extent to which the changes in post-disaster exports of Japan could be attributed to the disaster. The export changes in Japan and the world were examined from 2010 to 2012 using a modified version of shift-share analysis. The remaining parts of this paper are organized as follows: Section two describes the Great East Japan Earthquake and Tsunami case study while section three discusses the original shift-share methodology. Main findings are presented in section four followed by discussions and conclusions in section five and six.

Japan Case Study: March 2011 Great East Japan Earthquake and Tsunami

On March 11, 2011, the strongest earthquake in Japan's recorded history struck 40 miles off the east coast of Japan and led to over 15,000 deaths. The 9.0 magnitude Great East Japan earthquake also damaged four nuclear plants. In particular, the Tokyo Electric Power's Fukushima Daiichi (Fukushima I) nuclear plant on the nation's east coast was decimated. The disaster led to the failure of cooling systems at the Fukushima I nuclear plant and the declaration of Japan's first-ever nuclear emergency. Uncontrolled off-site releases of radioactivity forced the evacuation of over 150,000 residents within 20 km (12 miles) of the nuclear plant; many people are still unable or unwilling to return. The complete cleanup of the nuclear plant is expected to take 40 years and financial compensation to the survivors requires significant resources. In the aftermath of the disaster, the government ordered decommissioning of damaged reactors, a gradual nationwide shut down of nuclear operations and implementation of more rigorous safety standards. Japan's nuclear power capacity was completely shut down in 2013 and reactors started going back online only in August 2015.

Nuclear Power Plant Closures

Japan's energy policy has been dominated by the Great East Japan earthquake and the Fukushima Daiichi crisis. Prior to the March 2011 triple disasters (earthquake, tsunami, and nuclear crisis), Japan was the world's third-biggest user of atomic energy and generated nearly a third of its electrical power from nuclear reactors. In 2009, Japan pledged to increase nuclear power's share in electricity supply from 30 to 50 percent in part to reduce its greenhouse gas (GHG) emissions by 25 percent from 1990 to 2020 at the 15th Conference of the Parties (COP15)(9).

Nuclear-related accidents and nuclear cover-ups dating back several decades contributed to growth of anti-nuclear protests, pressure to close plants, and an erosion in public trust of the nuclear power industry in Japan. Problems in stabilizing the triple reactor meltdowns at Fukushima Daiichi nuclear plant served as a tipping point in public opposition against nuclear power and greater government scrutiny of Japan's safety culture in the nuclear industry. After the 2011 Fukushima Daiichi nuclear accident, the government of Japan took a number of decisive actions to gradually shut down nuclear

operations in the light of hardening attitudes against nuclear energy. Specifically, on May 6, 2011, Prime Minister Naoto Kan ordered closing of the Hamaoka Nuclear Power Plant due to the known seismic risks. On May 5, 2012 Japan shut down or suspended (for maintenance and/or safety inspections) its last 50 working nuclear reactors (Tomari-3) leaving the nation completely without nuclear-produced electrical power for the first time since 1970 (10). In March 2016, a court in Japan ordered the Takahama Nuclear Power Plant, one of the two nuclear power plants operating in the country, to shut down (after being online for only two months after the atomic power freeze) due to insufficient safety measures (11).

Although nuclear power is viewed by many Japanese leaders as critical to support Japan's economic growth and its lack slows Japan to lower-cost countries, the government of Japan is faced with major public opposition to reactivate the plants. Despite new nuclear safety standards introduced in 2013, Japan's government and its power companies have struggled to restart the nuclear industry since it was completely closed in 2013. Only a handful of Japan's 42 operable nuclear reactors have met the new safety rules and lawsuits have made it difficult to restart them.

Japan is the world's fifth largest electricity user. The idling of Japan's nuclear reactors following the Great East Japan earthquake led to a 30 percent gap in Japan's electricity supply (9), particularly in Western Japan. While conservation measures and additional renewable electricity capacity (since 2012) have helped to reduce this gap, Japan was ranked as the second largest net importer of fossil fuels in the world in 2012, trailing only China. Specifically, from 2010 to 2013 Japan's energy dependence on imports rose to 94 percent (from 80% in 2010) and annual carbon dioxide emissions from power generation increased by 25 percent during the same period (more than 110 million tons) (9).

Since the nuclear shutdown, electricity prices have increased by 16 percent for households and 25 percent for industry, because of increased imports of expensive fossil fuels; liquefied natural gas (LNG), oil, and then coal from 2013. Imports are likely to rise in an unsustainable fashion, although a decline in oil price has recently reduced some costs (9). The Japanese Finance Ministry recently reported that additional fuel imports contributed significantly to a record $109 billion dollar trade deficit in 2014. In order to compensate for the post-Fukushima loss of its nuclear power plants, Japan's utilities have increased use of non-nuclear energy infrastructure, including gas and oil-fired power plants that produce more expensive electricity. With a budget deficit of 7.7 percent of gross domestic product in 2014 (compared with 2.8 percent in the U.S.), Japan continues to be weighed down by post-Fukushima energy bills.

The Global Reach of Japan's Economy

The earthquake and tsunami of March 11, 2011 and the ensuring nuclear meltdown are now examined with a particular focus on how the disaster impacted Japanese exports and the global economy. With estimated direct damages of over US$211 billion, the Great Eastern Japan earthquake of 2011 has been the costliest disaster in the history of Japan. Fisheries and agriculture were the most impacted sectors. Due to initial reports about possible radioactivity in Japan's food exports, many countries including USA, Canada, European Union, New Zealand, Australia, India, and other South East Asian nations increased their surveillance of possible contamination in food imports from Japan (12).

Although this disaster occurred in an area with a lower share in the national and global economy by volumes and values (7 to 8 percent of GDP), many Japanese and non-Japanese firms outside the affected area were impacted by the ripple effects from the disaster. a halt in industrial production by companies in the disaster zone led to chaos in supply chains throughout Japan and around the world (13). For example, supply shocks disrupted the key production plants located in the affected disaster region such as Sony, NEC, Toyota, Fujitsu, and Renesas Electronics Corporation, which suffered from an estimated loss of US$615 million. In particular, Renesas, the world's largest custom manufacturer of microchips for the automobile industry controlled about 40 percent of the world's

share of microcontrollers used for automobiles (14). Other products impacted by supply chain disruptions on a massive scale included rubber for tires, paint pigments, condenser electrolytes for silicon semiconductor wafers, and thyroid hormone preparation (13).

It has been estimated that about "90 percent of the output loss in Japan due to the earthquake resulted from indirect effects through the disruption of supply chains rather than the direct effects of damage caused by the disaster" (15). Major auto manufacturing companies including Toyota and Honda stopped or reduced their production in industrial plants due to disruptions in the supply of parts and components originating in the disaster impacted area (16). Toyota lost US$1.2 billion in product revenue owing to shortage of parts that caused cascading supply chain impacts around the world, including 150,000 fewer Toyota automobiles manufactured in the US. Toyota also experienced production stoppages at five plants in the United Kingdom and reductions in manufacturing around the world, including a 70 percent decline in India and 50 percent decrease in China (Asano 2012). According to Ye and Abe (17), automobile and electrical component production in Japan declined by 48 percent and 8 percent, respectively following the disaster and this did not stop in Japan's borders. Automobile production also fell in by 20 percent in Thailand by 18 percent in the Philippines and by 6 percent in Indonesia. Similarly, electrical component production fell in Philippines (by 18 percent) and in Malaysia (by 8 percent). Hence, the economic impacts of the disaster extended far beyond the damaged region, including significant losses in gross domestic product (GDP), in manufacturing (due to supply-chain disruptions), in retail trade, and tourism (due to consumption decreases and radiation fears) (18). Hence, although the disaster impacted largely a vast rural area, the overall economic impacts of the disaster extended far beyond the damaged region and resulted in more severe disaster losses than the 1995 Great Hanshin (Kobe) earthquake (19).

A large body of economic scholarship focuses on the impacts of large disasters on international economy. A number of studies examined the March 11, 2011 earthquake and tsunami. For example, MacKenzie et al. (8) used multiregional input-output model to examine the impacts of this disaster on not only the domestic Japanese economy, but also the international economy. It was shown that the supply chain disruptions and the unavailability of Japanese products decreased both domestic and international production. China was mostly affected through these linkages and slowdowns in European and North American manufacturing were observed as early as Spring 2011. Finally, Belke (20) examined the short-term shock of this disaster on international financial markets. The studies also mentioned several confounding international economic issues that may contributed to the production and export declines.

Materials and Methods

Shift-share analysis is normally used to analyze the differences between regional and national/global growth rates. Macroeconomic variables such as export, employment, and production can be used in the analysis. Shift-share analysis was initially used in regional studies (21, 22, 23). Different versions of shift-share models have been proposed and used by researchers. Esteban-Marquillas (24) applied a shift-share model that uses homothetic sectorial employment by region. It allows for the identification of additional allocation effects. Arcelus (25) adopted a model that includes a specific regional effect and a sectorial regional effect, reflecting the amount of growth derived from the regional industry mix. McDonough and Sihag (26) proposed a different shift-share version by including multiple bases or relative weights for variables used in computations.

Shift-share has been used in the international trade studies (27, 28, 29, 30). Chiang (30) attested that shift-share analysis provided reasonable results in todays globalized economy. Shift-share method allows incorporation of international trade into the regional or national economy and provides valuable economic insights into trade and fiscal policies (31).

The shift-share was also used in disaster studies (32). Chang (33) applied shift share method after

Kobe earthquake in Japan to understand the role of transportation systems in disaster recovery and the long-term economic effects of earthquakes. She concluded that the city of Kobe lost its competitiveness after the earthquake. Bricongne et al. (34) examined the impacts of the recent global economic crisis (2008–2009) on the French firms using shift-share method. They found that most of the reduction in trade was attributed to the unprecedented demand shock and product characteristics. This crisis impacted smaller exporters more than larger ones as they were forced to reduce the range of destinations served or cease their exports. Mehregan et al. (35) applied shift-share method to assess the potential long-term impacts of earthquake disaster on employment using the December 2003 Bam earthquake in Iran.

Shift-Share Analysis

Shift-share analysis is traditionally used for comparing regional changes (e.g. Tohoku region's exports) with national changes (e.g. Japan's total exports). With roots in regional economic analysis, shift-share analysis has expanded to international trade studies and to examine trade issues at a global scale. In this manuscript we presented a new methodology that compared changes in the national economy of Japan with global changes. While disaster impacts in developed countries are often concentrated regionally after the 2011 Great East Japan Earthquake and nuclear meltdown, Japan stopped the operations of all nuclear power plants. As previously discussed in Section 2, this negatively impacted all Japanese producers throughout the country since they faced the threat of blackouts, power reductions, and more expensive energy.

In traditional shift-share analysis, a particular region is compared to a benchmark (usually a larger entity such as a nation) in order to extract how the smaller region is different from the larger benchmark, namely the average of a larger entity. In this paper, the benchmark is set to the total of global exports and Japan's exports are compared with the average tendency of the world exports. Then, the change in Japan's exports is decomposed into a universal component (i.e. as the total of world exports grows/declines, a part of Japan's export grows/declines accordingly), the industry mix (on average over the world, some industries grows/declines faster than others and Japan's same industries are likely to grow/decline accordingly), and the competitive component (the residual of Japan's export changes), which is defined as follows:

1) Competitive component = Japan's total export changes – universal component – industry mix component

Accordingly, in the shift-share analysis, the competitive component is the residual, which includes anything other than the average changes with the benchmark and industry specific changes. Accordingly, it can encompass many things, such as changes from the currency exchange rate change (Japanese Yen to foreign currency), from the domestic interest rate change to other domestic macroeconomic changes in Japan and also from the changes in other countries' demand to Japan (export demand from other countries). In the case of Japan, we argue that a significant portion of the competitive component can be attributed to the disaster impact.

Shift-share method has evolved and its different formulations have been proposed (36). In this paper, we apply Lonsdale and Archer's version of the method (37), taking into consideration the international trade. In this formulation, we suppose that changes in export, T_{ij}, for industry *i* in country *j* (Japan in this study) during the study period (2010 to 2012) can be divided into universal component (N_{ij}), industry mix component (M_{ij}), and competitive component (C_{ij}):

2) $T_{ij}=N_{ij}+M_{ij}+C_{ij}$

The N_{ij} (universal component for a section) states that the expected change for that sector in Japan is the same as the total export change in the entire sectors in the country.

Where, e_{ij} the base-year (2010) is export in sector *i* in country *j*, and r_{tn} is the growth rate between the base year and the end-of-period year (2012).

3) $N_{ij}= e_{ij}*r_{tn}$

The industry mix component (M_{ij}) measures the changes that can be attributed to the global performance of a sector. The industry mix component is the expected export change if a sector has changed at the same rate as that sector internationally, minus the universal or global component. The industry mix component is calculated as:

4) $M_{ij} = e_{ij} * (r_{in} - r_{tn})$

Where, r_{in} is the growth rate for sector *i* for world as a whole. The industry mix component accounts for intersectional variation in export growth.

The competitive component, C_{ij}, displays export changes due to an industry growing at a distinct rate in Japan, relative to that section internationally. Competitive components for different sectors show the economic activities, for which Japan had a competitive advantage during the study period (2010 to 2012). The competitive component is calculated as:

5) $C_{ij} = e_{ij} * (r_{ij} - r_{in})$

Where, r_{in} represents the rate of change for sector *i* in region *j* (Japan) during the study period.

Data

Two datasets were used in this study. The first includes Japan's exports and the other contains the world's exports. The World Trade Organization (38)'s online database constitutes the main data source. Since the study focus was on examining the growth of various sectors of Japan, the data collected on total exports were categorized into seventeen sectors as shown in **Table 1**.

Table 1. Export sectors used in the study

1	Agricultural products,	10	Office equipment
2	Food	11	Electronic data processing and equipment
3	Fuels and mining products	12	Telecommunications equipment
4	Fuels	13	Integrated circuits and electronic components
5	Manufactures	14	Transport equipment
6	Iron and steel	15	Automotive products
7	Chemicals	16	Textiles
8	Pharmaceuticals	17	Clothing.
9	Machinery and transport equipment		

Results

An overview of Japan's Export Changes

Japan's export growth was negative from 2012 to 2014, although global export growth was positive. Moreover, Japan export's growth was positive in 2011, but it was lower than the world's export growth (**Figure 1**).

In 2010, the Manufacturing sector was the leading export sector in Japan and the world (**Table 2 and Figure 2**): more than 36 percent of Japan's export was in this sector. The second largest sector was machinery and transport equipment sector (with 24.6 percent of the total export). Clothing had the lowest percentage of the total export (0.02 percent). Globally, manufacturing was the top sector (with 31.1 percent of the global export) followed by the machinery and transport equipment sector (with 15.8 percent of global export). This shows the similarities between Japan and the world's export structures in 2010.

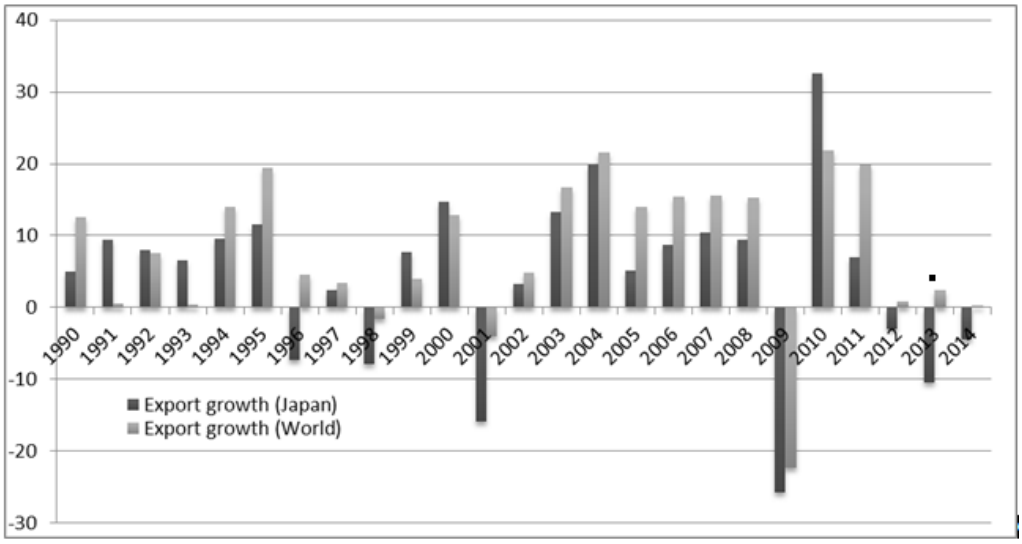

Figure 1. Export growth from 1970 to 2014 Japan and world

Source: World Trade Organization (38), Time Series on international, trade Statistics Database, Total merchandise trade.1970-2014

Table 2. Distribution of exports among economic sectors in 2010

	Japan		*World*	
Indicator	***Value* ($ mllion)**	***percent***	***Value* ($ million)**	***Percent***
Agricultural products	10166	0.55	1365093	4.25
Food	4755	0.25	1124829	3.5
Fuels and mining products	32853	1.76	3026779	9.5
Fuels	13048	0.7	2349953	7.3
Manufactures	680218	36.5	9995410	31.07
Iron and steel	41974	2.25	424353	1.32
Chemicals	78419	4.21	1709907	5.3
Pharmaceuticals	4324	0.23	463309	1.44
Machinery and transport equipment	458036	24.58	5096325	15.84
Office equipment	92610	4.97	1613508	5.01
Electronic data processing and equipment	20727	1.11	545841	1.7
Telecommunications equipment	24454	1.31	583280	1.8
Integrated circuits and electronic components	47430	2.55	484387	1.5
Transport equipment	197369	10.6	1688292	5.25
Automotive products	149528	8.02	1092938	3.34
Textiles	7086	0.38	252458	0.78
Clothing	531	0.03	353415	1.1
Total	1863528	100	32170077	100

Source: World Trade Organization (38)

Table 3 shows the export data in 2012 for both Japan and the world. The data highlight the significant changes that occurred in the export structure of Japan after the disaster. First, the share of the Manufacturing sector increased to 36.8 percent of exports. Second, the share of the manufacturing and mining sector increased from 24.6 to 24.7 percent in total export in 2012. Third, no important changes occurred in the export share of the clothing sector. It is clear that little changes happened in the export structure at the global level. The manufacturing sector had the largest share, followed by the machinery and transport equipment sector. However, by 2012, some changes took place in the overall share of the main economic sectors in global exports (similar to the

situation for Japan's exports). While the overall pattern did not change compared to 2010, the share of the manufacturing sector declined in favor of other sectors, particularly the machinery and transport equipment sectors.

Table 3. Export distribution among economic sectors in 2012

Indicator	*Japan*		*World*	
	Value ($ million*)*	*Percent*	*Value (*$ million*)*	*Percent*
Agricultural products	10859	0.56	1652780	4.34
Food	4557	0.24	1372648	3.6
Fuels and mining products	35332	1.83	4133088	10.9
Fuels	13420	0.7	3371583	8.89
Manufacturing	709557	36.8	11479344	30.15
Iron and steel	43784	2.27	485006	1.27
Chemicals	78954	4.09	1959738	5.15
Pharmaceuticals	4012	0.21	510675	1.34
Machinery and transport equipment	476028	24.69	5756241	15.1
Office equipment	82485	4.28	1681872	4.4
Electronic data processing and equipment	18464	0.96	554938	1.45
Telecommunications equipment	22183	1.15	640741	1.68
Integrated circuits and electronic components	41839	2.17	486194	1.28
Transport equipment	212472	11.02	1969879	5.17
Automotive products	165888	8.6	1300908	3.42
Textiles	7819	0.4	284158	0.75
Clothing	557	0.03	422573	1.11
Total	1928210	100	38062366	100

Source: World Trade Organization (27)

Table 4 shows the changes in Japan's exports during the study period (2010 to 2012). During this period, Japan's total exports increased by 0.68 percent. Automotive products experienced the greatest rate of change with 2.1 percent growth. During the same period, the total global export growth was 3.42 percent. The integrated circuits and electronic components sector in Japan had the lowest growth rate with -2.48 percent growth.

Some of these reductions in exports may have been attributed to the human and physical impacts of the March 2011 earthquake and tsunami disaster **(**39). The shift-share analysis was carried out to provide some insights into the possible origins and sources of these changes**.**

Shift-Share Findings

Shift-share results provide some further insights into Japan's export and their potential underlying causes including the potential impact of earthquake and tsunami. Since the shift-share results are sensitive to the used industrial composition, this study applied a broader decomposition level that included 17 sectors. The results of the shift-share analysis are presented in **Table 5**. The total exports in all economic sectors increased by 64,682. According to the shift-share analysis, 341,324 additional amounts in Japan were created because of the overall universal increases. This is Japan's share of the universal export growth. In the same period, Japan lost 73037 amount of export due to the industry mix component. The majority of export changes in Japan occurred because of the universal component.

Table 4. changes in export among economic sectors between 2010 and 2012

Indicator	*Japan*		*World*	
	Value ($ million*)*	*Percent*	*Value (*$ million*)*	*Percent*
Agricultural products	693	1.33	287687	3.90
Food	-198	-0.85	247819	4.06
Fuels and mining products	2479	1.46	1106309	6.43
Fuels	372	0.56	1021630	7.49
Manufactures	29339	0.85	1483934	2.81
Iron and steel	1810	0.85	60653	2.71
Chemicals	535	0.14	249831	2.76
Pharmaceuticals	-312	-1.49	47366	1.96
Machinery and transport equipment	17992	0.77	659916	2.46
Office equipment	-10125	-2.29	68364	0.83
Electronic data processing and equipment	-2263	-2.28	9097	0.33
Telecommunications equipment	-2271	-1.90	57461	1.90
Integrated circuits and electronic components	-5591	-2.48	1807	0.07
Transport equipment	15103	1.49	281587	3.13
Automotive products	16360	2.1	207970	3.54
Textiles	733	1.99	31700	2.39
Clothing	26	0.96	69158	3.64
Total	64682	0.68	5892289	3.42

Source: World Trade Organization (38)

Table 5. shift-share results for Japan in 2010-2012

Indicator	Index changes	universal component	industry mix component	Competitive component
Agricultural products	693	1862	280	-1449
Food	-198	871	177	-1246
Fuels and mining products	2479	6017	5991	-9529
Fuels	372	2390	3283	-5301
Manufactures	29339	124589	-23603	-71647
Iron and steel	1810	7688	-1689	-4189
Chemicals	535	14364	-2906	-10923
Pharmaceuticals	-312	792	-350	-754
Machinery and transport equipment	17992	83894	-24584	-41318
Office equipment	-10125	16962	-13038	-14049
Electronic data processing and equipment	-2263	3796	-3451	-2608
Telecommunications equipment	-2271	4479	-2070	-4680
Integrated circuits and electronic components	-5591	8687	-8510	-5768
Transport equipment	15103	36150	-3231	-17816
Automotive products	16360	27388	1065	-12093
Textiles	733	1298	-408	-157
Clothing	26	97	7	-78
Total	64682	341324	-73037	-203605

Source: Author's calculation

Table 5 represents the overall shift-share results for economic sectors. The findings reveal that the share of universal growth was positive for all economic sectors in Japan during the study period. The industry mix growth was negative for the manufacturing, iron and steel, chemicals, pharmaceuticals, machinery and transport equipment, office and telecom equipment, electronic data, processing and office equipment, telecommunications equipment, integrated circuits and electronic components, and textiles sectors. Furthermore, it was positive for agricultural products, food, fuels and mining products, fuels, automotive products, and clothing sectors. The

competitive growth component was negative in all sectors.

By comparing the share of universal growth in **Table 5** (column 3) with the actual export growth (column 2), it is shown that all sectors experienced a rate lower than the actual growth. For example, while it was expected that the total export in the agricultural products' sector increase by about 1862 export's amount in this period, it increased only by 693. The food, pharmaceuticals, office and telecom equipment, electronic data processing and equipment, telecommunications equipment and integrated circuits, and electronic components sectors had negative growth.

The universal growth component revealed that the actual export growth of Japan in the study period was lower than the expected or the universal level. If Japan's export growth rate corresponded to the universal growth rate, it would have grown by 341324; however, the actual growth was 64682.

As noted above, the industry mix indicated how a region performed. With respect to the industrial mix effect, important and positive effects of the agricultural products, food, fuels and mining products, fuels, automotive products, and clothing sectors were revealed. On the other hand, other sectors contributed negatively to export growth. The overall industry mix growth is negative for the Japan's entire economy, which shows that Japan's exports declined.

The competitive component, which captures the growth due to the competitiveness of Japan (in contrast to its industry) shows similar results (Figure 2). Japan's exports decreased by 203,605 because of the competitive component. The competitive growth component of the shift-share analysis shows that all sectors exhibited a negative value during the study period. The earthquake and tsunami may have played a major role in these changes. Studies suggest that industries in other countries may have benefited from the Japanese earthquake and tsunami. For example, the U.S. automotive industry benefited as they increased production to meet demand in their home countries (8).

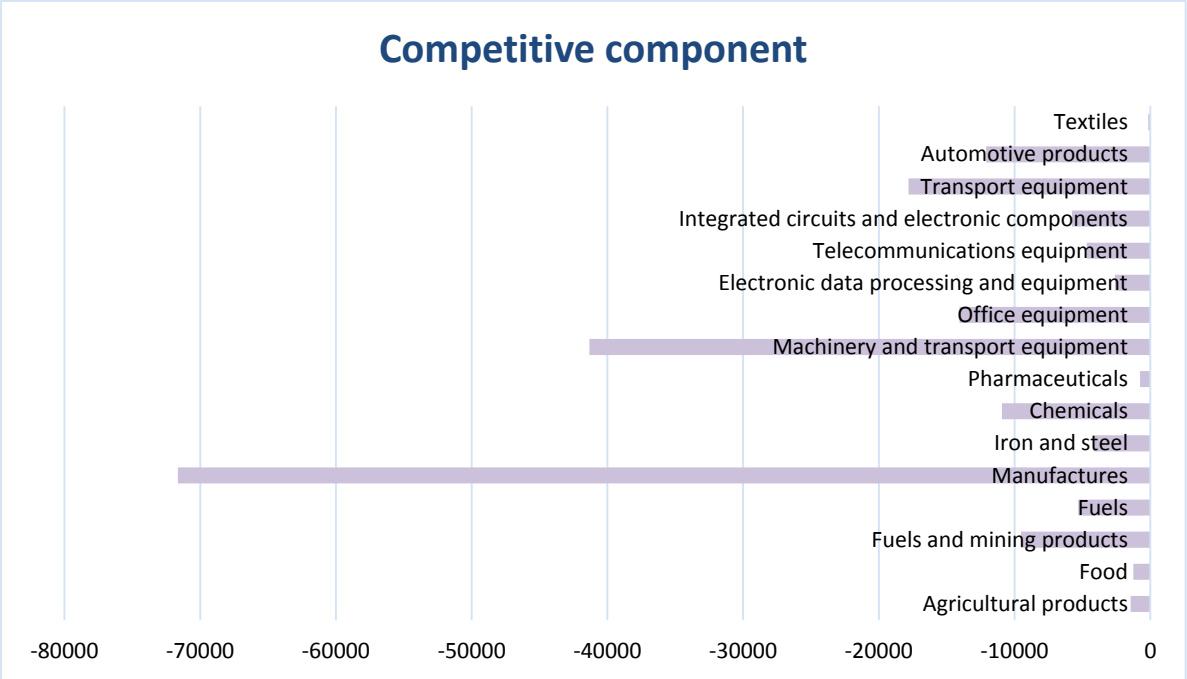

Figure 2. Japan's export changes (2010-2012) due to competitiveness

Discussion

Large-scale disasters may have a significant impact on the overall national economy and a nation's export rates. Although these impacts can be short term, they may be significant over the medium to long-term, particularly considering the competitive world economy. An examination of the export changes after the 2011 Great Eastern earthquake and tsunami in Japan using a modified shift-share analysis shows, Japan did not experience significant shifts in its export structure following the earthquake and tsunami. No evidence of a decrease in exports during the study period was found; rather, Japan had some export growth. However, the growth rates varied among the economic sectors. While agricultural, mining, fuels, manufacturing, iron and steel, chemicals, machinery and transport equipment, transport equipment, automotive products, textiles, and clothing sectors exhibited positive rates of growth, the food, pharmaceuticals, office and telecom equipment, electronic data processing and equipment, and telecommunications equipment sectors observed negative growth, which is different from the global export trends. The automotive products sector had the highest rate of growth. Japan had more than 2.09 percent rise in exports in this sector, although this was lower than the global growth (3.54 percent).

Parts of the export growth are related to the global growth of export. The universal component in all sectors was positive and a significant share of export growth was due to the universal growth. The industry mix component revealed that the value of exports of key sectors exhibited a decline (including Manufactures, Iron and steel, Chemicals, Pharmaceuticals, Machinery and Transport Equipment, Office and Telecommunications, Electronic data processing and equipment, Telecommunications equipment, Integrated circuits and electronic components, Transport equipment and Textiles) during the study period. However, other sectors (Agricultural products, Food, Fuels and mining, products, Fuels, Automotive products and Clothing) showed an increase. It is proposed that the 2011 Great Eastern earthquake and tsunami reconstruction probably played a major role in these changes. For example, post-Fukushima, the Japanese government introduced the legislation to shut down nuclear plants in earthquake-prone areas and prohibited the exportation of nuclear fuel and equipment to other countries.

Conclusion

The regional competitive component shows that the export changes are attributable to an industry growing at a distinct rate in the study area relative to that industry universally. This component reveals that Japan exhibited a negative regional competitive advantage in all sectors. Accordingly, the results suggested a loss of competitiveness across a wide swath of Japanese economy. Future research can be expanded upon our examination of disaster impacts on exports by isolating the disaster effect from all the other macroeconomic influences (such as national policy changes, currency exchange rate changes, interest rate changes, changes in economic conditions of those trade counterparts, and so on). This will allow even more meaningful insights into the impact of disaster given the large scale of shift-share analysis (Japan and the world) and the fact that some impacts are more local/regional in short term. Japan is a relatively stable economy and many macroeconomic variables remained constant. For example, the interest rate declined from 3.84 to 2.36 over the study period. Although some of the changes in Japanese exports may have been due to other factors (currency exchange rate changes, etc.) than earthquake, it is also possible that these factors were influenced by the disaster. Considering the short period of our study (2010-2012) and the lag that exists for economic factors to manifest themselves, the significant effects of these factors are impossible in our study period. Even if one argues that these factors could have impacted Japan's export, it is possible that these factors were themselves impacted by the disaster.

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Conflicts of interest

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Authors' contributions

AA drafting the paper, final read and review of the paper and submission, corresponding author. NM and YH data preparation, analysis and final review. JKL introduction and background sections and overall review and editing.

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