



# KNOWLEDGE NOTE 6-3

**CLUSTER 6: The economics of disaster risk,  
risk management, and risk financing**

## Economic Impacts



Prepared by Masafumi Fujita, Research Institute of Economy, Trade and Industry; and Hamaguchi Nobuaki, Kobe University (on global supply chain); Financial Service Agency (on the double debt problem); and Junko Sagara, CTI Engineering; with contributions from Bianca Adam, World Bank.

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### Economic Impacts

**Following the Great East Japan Earthquake (GEJE), the government of Japan responded promptly to stabilize markets and ensure a swift recovery. Economic activity has since started picking up, thanks in part to domestic demand driven by the massive reconstruction effort. Uncertainties remain, however, surrounding the restructuring of power supply and both national and global economic prospects. The year 2011 will be remembered for the severe challenges to the global supply chain posed by the GEJE and the Thai flood. As an important part of the networked production system, developing countries must share responsibility in making the supply chain more resilient under international cooperation.**

#### FINDINGS

Following the GEJE, the government of Japan initially estimated the direct damages between ¥16 trillion and ¥25 trillion (see box 1). The Cabinet Office (CAO) later put estimated damages at ¥16.9 trillion (\$210 billion), or about 4 percent of Japan's gross domestic product (GDP). Before the disasters, approximately two-thirds of nonfinancial assets were held by the private sector. This is in line with the breakdown of the direct damage figures released by the CAO (table 1).

Most of the damages were concentrated in three prefectures of the Tohoku region: Fukushima, Iwate, and Miyagi. The sparsely populated pacific coast of the Tohoku region, where agriculture and fishery are the main activities, accounts for only 2.5 percent of the total Japanese economy in terms of industrial production (figure 1).

Despite the relatively small extent of economic activities in the affected region, the GEJE had severe and widespread economic impacts, partly due to the Accident at Fukushima Daiichi Nuclear Power Station and ensuing energy supply disruptions, and the supply chain disruptions (compounded by widespread flooding in Thailand a few months later).

In the first quarter of 2011, Japan's GDP contracted by 3.5 percent. According to the International Monetary Fund (IMF), GDP contracted by 0.7 percent in all of 2011, and the estimates for 2012 put GDP growth at 2 percent, stimulated by reconstruction work.

### BOX 1: Government of Japan's estimates of the economic effect of the GEJE

The CAO released two different sets of estimated economic damages (damage on capital stocks) of the GEJE (table A).

**Table A. Estimated economic damages of the GEJE by the CAO (¥ trillion)**

	<i>Disaster Reduction Section</i>	<i>Economic and Financial Analysis Section</i>	
		<i>Case 1</i>	<i>Case 2</i>
Buildings and houses	10.4	11	20
Utilities	1.3	1	1
Infrastructure	2.2	2	2
Others		2	2
Agriculture	1.9		
Others	1.1		
Total	16.9		

*Note:* Case 1 uses damage rates twice as high as the Kobe earthquake, while Case 2 employs the even higher damage rates against buildings and houses for the tsunami-affected areas.

The economic impacts are estimated separately for damages (on capital stocks) and losses (on flow). The estimation results for damages in table A are calculated by multiplying the existing predisaster capital stock data (based on the CAO's macroeconomic database), by damage rates twice as high as the ones observed for the Hanshin-Awaji (Kobe) earthquake for Case 1 and by even higher damage rates against buildings and houses for Case 2 to take into account the damages from the tsunami. In this estimation the damaged areas include the prefectures of Iwate, Miyagi, and Fukushima (the above-mentioned damage rates are applied to the tsunami-affected areas in these prefectures, while damage rates equivalent to the Kobe earthquake's are used for the non-tsunami-affected areas) and the surrounding prefectures of Hokkaido, Aomori, Ibaraki, and Chiba, for which damages are calculated by multiplying the capital stock data by damage rates modified based on the seismic intensity of each prefecture (details unknown).

The estimation of the economic impact from the GEJE (not included in table A) covers the same prefectures and is carried out for three fiscal years (table B).

The estimated production losses due to damages (first-order loss) by the GEJE are calculated based on the damages listed in table A using the production function of each sector. The production loss due to supply chain disruption (roughly equivalent to a higher-order loss) is estimated with the calculated production loss (the above first-order loss) and an interregional input-output table (between Tohoku and the rest of Japan). While the production losses due to limited (electric) power supply were considered, they were not estimated due to the uncertainty of effects on production (resiliency, conservation, or use of other adaptive measures). The production gains

BOX 1, continued

**Table B. Estimated economic impact of the GEJE (¥ trillion)**

	FY2011		FY2012	FY2013
	First half	Second half		
Production loss due to damages	-1.25 to -0.5	-1.25 to -0.5	-2.25 to -1.25	-2.25 to -1.25
Production loss due to supply chain disruption	-0.25	—	—	—
Production loss due to limited power supply	—	—	—	—
Production gain from recovery and reconstruction	2 to 3	3 to 5	6 to 9.5	5 to 7.75
Total	0.5 to 2.25	2 to 4.25	3.75 to 8.25	2.75 to 6.5

— Not available.

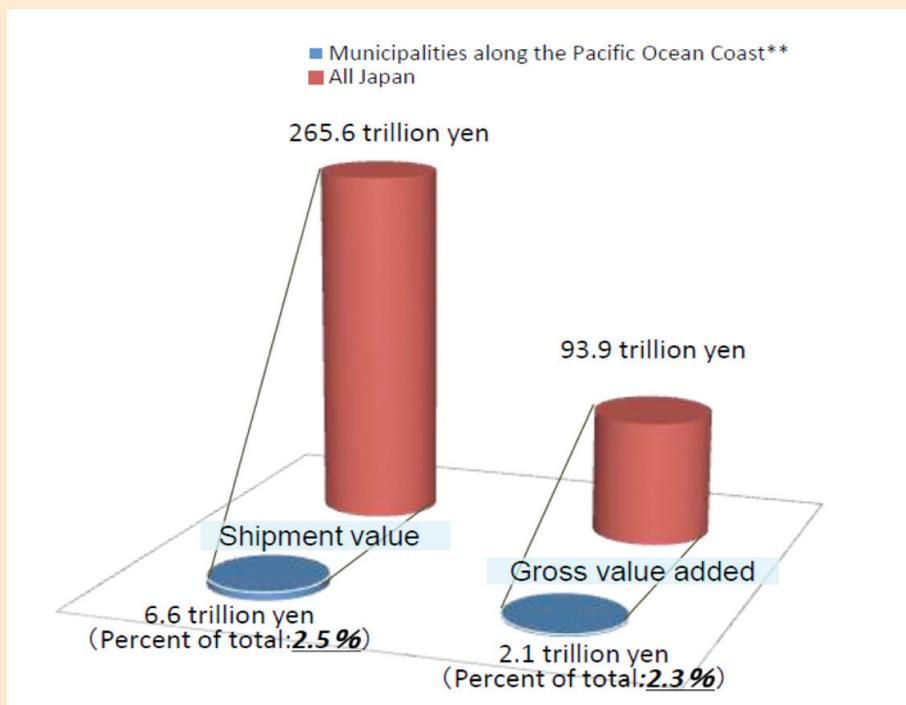
from recovery and reconstruction activities are derived by distributing the amount of estimated damages in table A over three years (meaning it is assumed that all the damaged capital stocks will be restored).

**TABLE 1: Direct economic impact of the GEJE**

Categories	Damage (¥ trillion)	Percentage of total damage
Buildings (housing, offices, plants, machinery, and so on)	10.4	62
Lifeline utilities (electricity, gas, water, communication, and so on)	1.3	8
Social infrastructure (waterways, roads, harbors, drainage, airports, and so on)	2.2	13
Others (including agriculture and fisheries, and so on)	3.0	17
Total	16.9	

Source: CAO.

FIGURE 1: **The extent of economic activity in the municipalities along the Pacific Ocean coast**



Source: Ministry of Economy, Trade and Industry.

There are approximately 80,000 businesses in the tsunami-affected areas, 740,000 businesses in the earthquake-affected areas, 8,000 businesses in the evacuation zones of the Fukushima nuclear accident, and 1.45 million businesses in the prefectures covered by the Tokyo Electric Power Company (TEPCO).

### IMPACTS ON AGRICULTURE, FORESTRY, AND FISHERIES

The amount of damage to agriculture, forests, and fisheries by the GEJE was estimated as ¥2.34 trillion (table 2).

Around 24,000 hectares of agricultural land (approximately 80 percent of paddy fields and 20 percent of farmland) were flooded by the tsunami. Over 95 percent of the damaged agricultural land is located in the three prefectures most severely affected: Iwate, Miyagi, and Fukushima.

TABLE 2: **Damage caused by the GEJE**

<i>Sector</i>		<i>Direct damage</i>	<i>Monetary damage (¥100 million)</i>
Fisheries	Fish vessels	25,014	1,701
	Fishery harbor facilities	319 harbors	8,230
	Aquaculture facilities	—	738
	Aquaculture products	—	575
	Common use facilities	1,725 facilities	1,249
Subtotal, fisheries			12,493
Agricultural land, facilities	Damaged agricultural land	17,456 areas	4,012
	Damaged agricultural facilities	21,866 points	4,290
Subtotal, agricultural land, and facilities			8,302
Agricultural crops and so on	Agricultural crops and livestock, and so on	—	140
	Agricultural livestock production facilities, and so on (mainly country elevators, agricultural warehouses, PVC greenhouses, livestock barns, compost depots, and so on)	—	487
Subtotal, agricultural crops and so on			626
Forestry	Desolation of forest land	429 points	238
	Damage of facilities for maintaining forest	255 points	1,167
	Damage of forest road	2,632 points	42
	Damage of forests	(1,065 ha)	10
	Processing and marketing facilities and so on	112 points	508
	Cultivating facilities for forest products	473 points	25
Subtotal, forestry			1,989
TOTAL			23,410

Source: Ministry of Agriculture, Forestry, and Fisheries, (November 25, 2011), [http://www.maff.go.jp/e/quake/press\\_111125-2.html](http://www.maff.go.jp/e/quake/press_111125-2.html).

It is estimated that the area of agricultural land that will be restored and cultivated again by 2012 could be less than 50 percent in Iwate and Miyagi prefectures, and only up to 20 percent in Fukushima Prefecture as a result of the nuclear accident.

Many plywood-processing factories in Iwate and Miyagi, where about one-third of plywood products are produced, were damaged.

The Fukushima nuclear accident further impacted the agriculture, forestry, and fisheries sectors. Based on the provisional regulation on radiation instated on March 17, 2011, shipping of food products containing radioactive iodine above a certain threshold has been restricted. In addition to the national regulation, some prefectures and local associations set additional restrictions on the shipping of food products.

The accident also affected trade flows of food products with other countries. Import controls for Japanese food products were intensified in 43 countries, and Japanese exports have declined.

## **IMPACTS ON THE TOURISM INDUSTRY**

The GEJE have severely affected the tourism industry in Japan, but, according to a report by the World Travel and Tourism Council (WTCC), recovery has been more rapid than previously expected for both domestic and international tourism.

Foreign visitor arrivals in the month immediately following the GEJE were 62 percent lower than the previous year. But recovery was swift and, by the fall of 2011, arrivals were only 15 percent down compared to the previous year. Inbound international travel was more severely affected compared to outbound international travel and domestic travel (figure 2). This trend reflects fears generated by the nuclear power plant accident and loss of competitiveness as a result of the appreciation of the yen in the months following the disaster.

The WTCC estimates that the negative impact of the GEJE on the tourism industry amounts to approximately ¥0.7 trillion.

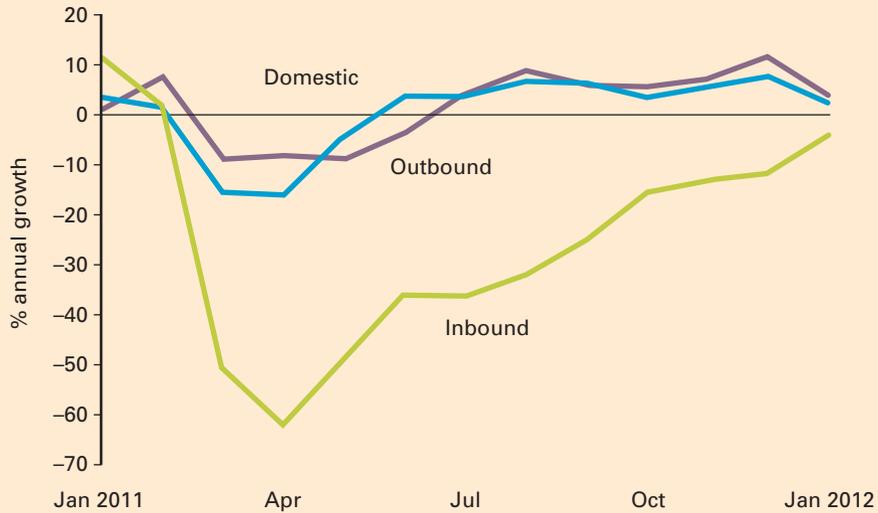
## **IMPACTS ON FINANCIAL AND CURRENCY MARKETS**

Financial and currency markets stabilized quickly after the earthquake. Equity markets fell by over 15 percent in the first weeks after the earthquake, but recouped roughly one-third of their losses by mid-June 2011.

Figure 3 shows the Nikkei Index from January 2011 to June 2012. The Nikkei Index is a stock market index for the Tokyo Stock Exchange (TSE). It is a price-weighted average (the unit is yen), which indexes 225 companies in the TSE (components are reviewed once a year).

The figure clearly shows the fall after March 11 and the recovery till summer 2011. High volatility followed, but those values cannot be strictly connected to the recovery process, as the international financial crisis impacted the TSE.

FIGURE 2: Japanese tourism demand, 2011–12



Source: WTCC 2012.

FIGURE 3: Nikkei Index, January 2011–Jun 2012



Source: Nikkei 2012.

**BOX 2: Measures to address the double-debt problem for small and medium enterprises; agriculture, forestry, and fishery businesses; and residential mortgages**

**Individual debtor guidelines for out-of-court workouts**

Guidelines for individuals on out-of-court debt restructuring: Individual Debtor Guidelines for Out-of-Court Workouts were released on July 15, 2011, and took effect on August 22, 2011.

The Guidelines aimed at individual debtors who are unable, or deemed certain to soon become unable, to repay their existing loans—in other words, those who would in principle qualify to initiate bankruptcy or civil rehabilitation procedures. The creditors subject to the Guidelines consist primarily of private sector banks, cooperative financial institutions, government-affiliated financial institutions, money lenders, and leasing companies.

As of March 30, 2012, the accumulated total number of cases consulted was 1,850, of which 538 cases were in the process of restructuring loans. This system is the first of its kind in Japan and is unprecedented even in the world.

**Clearer application of financial inspection manuals**

In the case of a company resuming or continuing its operations while repairing damage sustained from the earthquake and tsunami, there is a risk that its capital has been impaired due to the impact of the disaster. Capital augmentation is therefore urgently needed.

The Financial Services Agency introduced measures to apply its financial inspection manuals in a clearer manner, aiming to promote more active use of capital-eligible debt and thereby enable undercapitalized companies to improve their balance sheets and management.

These measures are expected to yield a number of positive effects. For example, even if a company's capital has been impaired due to the impact of the disaster, the company is able to exchange its existing loans for new ones that satisfy the requirements for capital-eligible debt (that is, a debt-debt swap). As a result, its balance sheet will become healthier, which will in turn lead to greater chances of obtaining new loans from financial institutions.

**Measures for financial institutions**

Some financial institutions located in the disaster-stricken area sustained significant damage; some institutions operational bases were almost entirely destroyed by the disaster. It is imperative to maintain and strengthen the financial functions of banks

## BOX 2, continued

and other institutions to revitalize the regional economy. To that end, special provisions concerning the disaster have been added to the Act on Special Measures for Strengthening Financial Functions. First, special provisions for disaster-affected financial institutions in need of the government's capital injection to strengthen its financial functions have been added. For instance, when such a financial institution draws up a management enhancement plan, its top executives are not held responsible or required to set profitability and efficiency targets, on the grounds that the impact of the earthquake and tsunami is beyond their control. Furthermore, the costs the financial institution bears for receiving capital injection are substantially lower than the costs needed under normal conditions. In addition, a much longer period is allowed for securing the repayment funds. In return for receiving this capital injection under very favorable conditions, the financial institution is expected to play its financial intermediary functions in an even more active way. Second, special provisions have been incorporated for *shinkin* banks, credit cooperatives, and other cooperative financial institutions to further ease the requirements for capital injection. Under the amended law, the government and the central organization of a financial institution jointly inject capital, and the financial institution is required to conclude a management guidance agreement with the central organization. In the event that the injected capital is highly unlikely to be repaid by the set date, said capital will be liquidated and the financial institution's business restructured. The Deposit Insurance Corporation's funds are used as the source of capital injection. The amendments also include a five-year extension to the end of March 2017 of the time limit for applications for the government's capital injection.

As of March 30, 2012, the government has decided to inject capital (¥191.0 billion in total) into 10 financial institutions—three banks, four *shinkin* banks, and three credit cooperatives—operating in the disaster-stricken areas in accordance with the Act on Special Measures for Strengthening Financial Functions.

In the immediate aftermath of the earthquake, the yen appreciated sharply because of speculation around sizeable repatriation flows by insurance companies, corporations, and households. The value of the yen touched a record ¥76.25 per dollar on March 17, before retreating to the 80-yen level. After concerted intervention in coordination with the G-7, the yen/dollar rate has traded in a band of 80 to 84. Approximately a quarter of developing East Asia's long-term debt is denominated in yen. For China, 8 percent of its external government debt is in yen. The figure for Thailand is about 60 percent, for Vietnam about 35 percent, for the Philippines about 32 percent, and for Indonesia about 30 percent. A 1 percent appreciation in the value of the yen translates into a \$250 million increase in annual debt servicing on yen-denominated securities by East Asia's developing countries.

After the disaster, the Bank of Japan injected liquidity to ensure that there would be no shortage of cash or funds to lend and no spikes in Japan's interest rates. Massive liquidity injections flattened the Japan Government Bond yield curve, with the 10-year rate moving in a narrow range between 1.1 and 1.2 percent.

One of the critical challenges for the Japanese economy remains overcoming deflation to return to a sustainable growth path with price stability. The Bank of Japan and the government are working together to prevent the economy from falling into a vicious cycle between yen appreciation and deflation.

### **IMPACTS ON ENERGY SUPPLY**

The damage resulting from the earthquake and tsunami is being compounded by the resulting shortages in energy supply. Energy supply disruptions have caused rolling blackouts that have disrupted Japan's production capacity in its industrial heartland in the Kanto region, which accounts for about 40 percent of national GDP.

The Fukushima nuclear accident has pushed the government to explore alternative energy sources. Ministry of Economy, Trade and Industry (METI) established the Fundamental Issues Subcommittee under the Advisory Committee for Natural Resources and Energy to advise a new long-term energy plan. In the interim report, the committee emphasized the need to reform the demand structure, including energy conservation measures and controls on peak-time electricity demand.

In the short term, the shift toward other energy sources will boost imports from oil- and petroleum-exporting countries in the East Asia region, in particular Indonesia, Malaysia, and Australia.

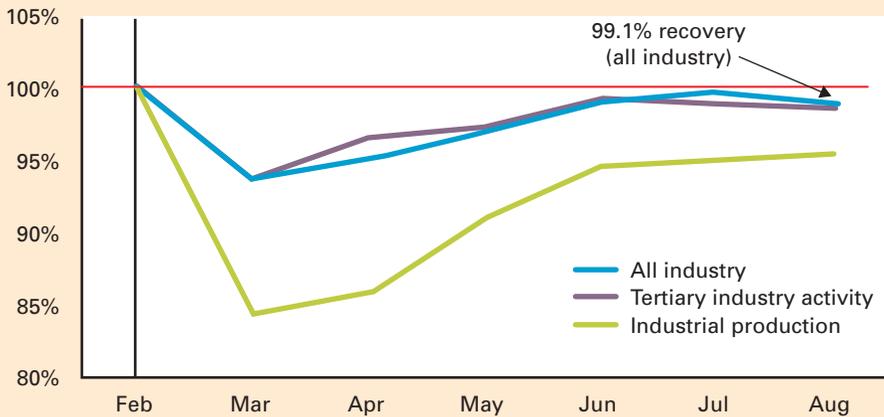
### **IMPACTS ON INDUSTRIAL PRODUCTION**

The main economic activities in the affected region are agriculture (mainly rice paddy fields) and fisheries, but manufacturing accounts for about a quarter of production in the region, and plants in the most severely damaged areas supply parts and products used in manufacturing elsewhere in Japan and Asia.

Damage to Japan's industrial facilities caused a sharp drop in production following the GEJE, but swift reconstruction has minimized the long-term impact on production.

Japan's METI reported that, as of August 2011, restoration works had been completed for 93 percent of the 91 production bases directly affecting Japan's major manufacturing industries, including machinery, automotive, and consumer electronics. The automotive industry recorded the greatest fall in production, but recovered rapidly as facilities reopened and vital transport networks were repaired. Industrial production rebounded from April onwards with a growth of 6.2 percent in May and 3.8 percent in June. But this is still not sufficient to fully offset the initial 15 percent fall experienced in March. Production in June remained lower than in 2010 and was 5 percent lower than in February, on a seasonally adjusted basis. Most affected industries have now reached almost predisaster levels of production (figure 4).

FIGURE 4: Indices of all industry activity (seasonally adjusted)



Source: METI 2012.

## DOUBLE DEBT

The “double debt problem” generally refers to the financial difficulties facing individuals and business owners stricken by the GEJE who need to borrow to rebuild their destroyed houses and offices. But as they have existing loans on such premises, borrowing additional money results in two debts on the same property. The Japanese government as a whole worked on policy responses and formulated the Policy for the Double Debt Problem, which was released on June 17, 2011 (as explained in box 2).

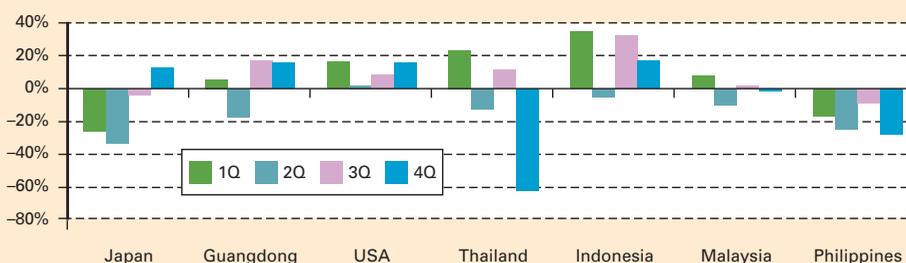
## GLOBAL SUPPLY CHAINS

### IT'S A SMALL (NETWORKED) WORLD AFTER ALL

With the rapid progress of information and transport technology together with the promotion of free trade, humans have developed an extensive network of production, trade, and investment throughout the world. Moreover, we have intensive agglomeration of production and consumption in major cities throughout the world, which are mutually connected through a dense supply chain network. Today's global production system is a complex, networked system that has operated efficiently under normal conditions. Nevertheless, recent megadisasters in Japan and Thailand have revealed the networked world's vulnerability to major disasters.

The magnitude of the Japanese economic impact is partially attributable to supply chain network disruptions. The disaster-affected area serves as a major source of supply chain flow of goods (from procurement of parts to the delivery of finished products) for Japan's

FIGURE 5: **Impact of GEJE and Thai flood on the global automobile industry**



manufacturing industry. Failures of parts and materials deliveries from this area have forced many manufacturers nationwide to suspend their operations. The automobile industry, the electronic equipment industry, and the metal industry were affected most severely because they particularly depended on key parts and basic materials produced in the disaster-affected area. Figure 5 shows that Japanese automobile production in the first and second quarter of 2011 were, respectively, 25 percent and 33.8 percent less than those in the same period the prior year.

Eastern Asia today, often called the World Factory, is based on a supply chain network centering around dozens of major cities and industrial agglomerations. Consequently, the impact of the GEJE and tsunami disaster could not remain limited to Japan. Figure 5 shows that automobile output in China’s Guangdong Province and Thailand declined, respectively, by 17.3 percent and 11.5 percent in the second quarter. Other Asian countries such as Indonesia, Malaysia, and the Philippines were also affected. The impact extended beyond Asia. In the United States, where automakers, including those of Japanese origin, depend on the supply of some crucial parts from Japan, production growth plunged from 15.6 percent in the first quarter to 2.3 percent in the second. These results reaffirm that disruption in a specific region affects the world through the supply chain network.

In the fourth quarter of 2011, when Japanese manufacturing industries had almost recovered from the impact of the disaster, the Eastern Asian supply chain was challenged again by the great flood in Thailand, the worst in 50 years. Automobile output in Thailand dropped by 61.5 percent in the fourth quarter compared to the same period of the prior year. Affected by the shortage of parts supplies from Thailand, Japanese automobile production was limited to a 4.5 percent year-on-year growth in November after recording 20.3 percent growth in October, although the impact was short-lived, and growth returned to 13.4 percent in December. Being the local hub of the automobile supply chain in the Association of Southeast Asian Nations (ASEAN), the Thai effect was felt more severely in Malaysia and the Philippines, while the impact on Indonesia was sharp and short (year-on-year growth rates dropped to 0.7 percent in November but showed greater than 20 percent growth in October and December).

Thailand is also known as the global center of hard disk drive production—accounting for almost 20 percent of world exports, on par with China. According to a market survey conducted by Kakaku.com, compared to the beginning of October 2011 retail prices of

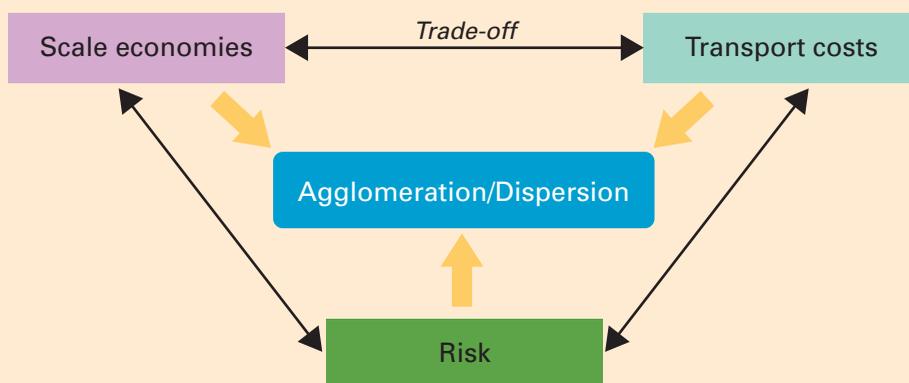
popular-type hard disk drives (1 terabyte capacity and 7,200 rpm spin speed) in the Japanese market shot up 150 percent–200 percent by mid-November before settling down, but remained about two times as high as the preflood level at the beginning of February 2012.

### DISASTER STRIKES WHEN YOU LEAST EXPECT IT

Recent experiences remind us of the vulnerability of supply chain networks, which contain some critical nodes wherein production of particular parts and components is concentrated among a few suppliers. Importantly, such concentrations do not result from planning failures. Rather, they are self-organized through market interactions. Because of scale economies, production concentration is preferred by both suppliers and customers. Although a trade-off relation exists between scale economies and transport costs to deliver products to distant customers, lower transport costs make the concentration of production more profitable, as shown in figure 6. Consequently, globalization (decline of broadly defined international transport/transaction costs) tends to enhance the formation of agglomeration within a global supply chain. Because of self-organization, it is not feasible to eliminate potential risks by agglomeration in highly complex supply chains. To complicate matters further, when a disruption occurs, it is impossible to find replacements from other suppliers, at least in the short run, because of a high degree of customization. An example from the 2011 disaster was the Renesas Electronics Corporation’s Naka plant, located in Ibaraki Prefecture. It produces a micro control unit (MCU) for high-quality motor vehicles that makes extensive use of electronic control technology. Over the years, Renesas has become a supplier of customized MCUs for major automobile companies throughout the world.

We might find other cases of dispersion forces if concentration increases the potential risk of disruption for the entire supply chain. Dispersions in this case might involve: building sufficient safety stocks (dispersion of products), use of multiple suppliers, and duplication of production facilities. These actions, which are components of so-called business conti-

FIGURE 6: **Trilateral trade-offs in global resilience**



nuity plans (BCPs), are aimed at increasing redundancy and resiliency. They garner great attention in the supply chain management literature.

But individual firms are rarely capable of taking sufficient actions to mitigate the potential loss from supply chain disruptions because they are generally reluctant to assume the loss of efficiency derived through scale economies. High impact/low probability events, such as huge earthquakes and tsunamis, make our predictions more diverse and imprecise. Generally, although people's awareness of risk is tuned to a high level soon after experiencing an important natural disaster, heterogeneity in beliefs will increase with the passage of time. Moreover, uncertainty will be high in the decision-making process because the valuation of risks is difficult. In such a case, the market equilibrium can only reflect the opinion of the more optimistic firms, which avoids the costs of risk management. Agency problems might also be an issue. A risk-conscious buyer might wish to enforce a BCP on its supplier in the business contract, but the supplier's implementation could be partial if monitoring costs are high.

Actually, the 2011 disaster was not the first supply chain crisis in eastern Asia, even in recent times. A strong earthquake in Taiwan in March 2000 shut down large liquid crystal display factories agglomerated around the Hsinchu Science Park. The outbreak of the SARS epidemic in southern China in 2002–03 sent ripples through the global supply chain. Japan itself also suffered disruptions after the Great Hanshin-Awaji Earthquake of 1995 and the Chuetsu Offshore Earthquake of 2007. Those disasters and their effects notwithstanding, critical nodes still widely persist.

### **BETTER TO BE BRISK AND SLAPDASH THAN SLOW AND ELABORATE**

Prompt measures to remove bottlenecks are undoubtedly necessary to avoid prolonged dysfunction of supply chain networks. Agglomeration has a lock-in effect: that is, firms take actions reflexively to restore the agglomeration after it is damaged by temporary shocks. Collaboration among firms and/or government support stimulation of such efforts hasten rehabilitation.

Auto production in Japan recovered nearly to a normal level in August, five months after the shock. We might consider that the rapid recovery showed the high resilience of supply chain networks in the Japanese automobile industry. This was in part due to emergency relief measures taken by the private sector such as sending technical personnel from all rival customer firms collaborating to help rehabilitate damaged suppliers' factories. The rapid revival of transportation networks (highways, railways, airports, and seaports) was also of fundamental importance.

After the Thai flood, the government implemented some measures to support firms striving for continuing production. These measures included: permission for temporary production relocation and outsourcing and the exemption of import tariffs on locally unavailable parts, components, and industrial equipment. Additional corporate tax exemption was also given to flood-hit companies. For the automobile industry, imports of assembled cars were allowed free of tax. Entry of foreign experts to engage in rehabilitation of factories was made flexible.

These measures were complemented by international cooperation. The Japanese government issued temporary work visas for six months to Thai workers employed by flood-hit factories of Japanese affiliates. By the end of 2011 about 3,700 workers had participated in the program. This program benefited Japanese firms who needed quick startup of back-up production in Japan to mitigate the disruption of the supply chain; it benefited Thai workers who might have lost jobs otherwise. The Bank of Thailand and the Bank of Japan launched a cooperative effort to provide Thai baht loans to flood-hit Japanese affiliates backed by Japanese government bonds.

## **PROVIDING IS PREVENTING: FINDING OPPORTUNITY IN CRISIS**

There is no time to lose in emergencies. At the same time, it is necessary to consider whether returning to the predisaster situation is truly desirable if potential risks latent in agglomerations become glaringly apparent. We now confront the urgent task of promoting global disaster risk management of highly networked supply chains while our memory of 2011 is still fresh.

### **INDIVIDUAL FIRM/INDUSTRY LEVEL**

The main issue will be to enhance the resiliency of the supply chain while maintaining its efficiency. To minimize supply disruption, each company can seek the best mix of the following strategies at the individual firm level:

- Elaborate a workable BCP that includes remote backup production provisions. Although this does not mean actual dispersion of production under normal conditions, repeated simulation training is necessary.
- Procure key parts and materials from multiple sources routinely, sharing the costs of dispersion between buyers and suppliers.
- Divide production and locate productive facilities in different locations, whether interregionally or internationally, even under normal conditions. Innovative production technology must be promoted by which higher-scale economies are obtainable with smaller production volumes.
- Coordinate standardization and sharing of parts and materials among companies. Avoiding excessive company-specific customization, such coordination provides sufficient lot size to suppliers by which dividing production facilities becomes economically viable.

These strategies have already been put into practice to some degree. Regarding strategy (1), when the earthquake halted desktop computer production at the Fukushima plant of Fujitsu, the company was able to restart production 12 days later at a factory 740 kilometers away in Shimane Prefecture in western Japan, which usually produced notebook computers, as had been simulated many times. This operation enabled Fujitsu to minimize the disruption period. Regarding strategy (2), Nissan has pursued a strategy of standardizing and sharing parts and materials aggressively through its experience of partnership with Renault. In fact, Nissan was able to recover production from the impact of the Thai flood quickly because it

was able to switch to other suppliers of its global procurement network. For strategy (3), high global market-share companies have recognized the importance of risk-averse dispersion to maintain their market positions. One such company, Nidec-Shimpo Corp., which supplies small motors used in various machine products, boasts an 80 percent share of the global hard disk drive motor market (according to the company's Web site). When its three plants in Thailand were damaged by the flood, Nidec reacted quickly by increasing production capacity in China by 50 percent and that in the Philippines by 60 percent to compensate for the loss of operations in Thailand. This action avoided the collapse of hard disk drive production. The company announced that the proportion of the production in Thailand would be reduced from its original 60 percent even after the rehabilitation of the factories, thereby reducing the risk of concentration. As an example of strategy (4), companies are usually reluctant because they are concerned that the use of standardized parts would require compromises in product quality, leading to the loss of competitiveness. After the GEJE, however, METI took initiatives to coordinate parts sharing in the Japanese automobile industry, and it is expected that more concrete measures will be taken as well.

#### LOCAL AND NATIONAL GOVERNMENT LEVEL

As might be expected, local and national governments have roles in areas where private initiatives cannot suffice. Typically, public policies are expected to enhance the resilience of infrastructure of all kinds supporting industrial production and the daily life of people. For example, in Japan, earthquake-resistance standards for public facilities and infrastructure were revised based on analyses of the damage that occurred. Still, the 2011 disaster left us lessons of not mythologizing safety: provisions in land-use planning are necessary where there is a tsunami risk because tide walls can never be sufficiently high. Moreover, society must take a hard look at the benefits and shortcomings of dependence on nuclear power generation. Strengthening local infrastructure for prevention of urban flooding in developing countries should be greatly emphasized. On this aspect, international cooperation is necessary, for example, the Japan International Cooperation Agency (JICA) will aid the Thai government in presenting a new master plan for flood mitigation in the Chao Phraya Delta.

In broader perspectives, national spatial planning must be readdressed to decentralize the over concentrated economic-political functions in capital cities (for example, Tokyo, Bangkok, Manila, and Jakarta), and to develop a more resilient nationwide system of regions.

There is a need for accelerating the integration of the private sector into existing platforms and activities. One effective example of partnership and cooperation among national and local governments, volunteers, and the private sector is the Global Compact Network Japan (GCNJ). GCNJ joins the top corporate management of leading Japanese companies in a platform for linking corporate social responsibilities with business activities. GCNJ was established in 2003 and currently has a membership of more than 160 leading companies. GCNJ has been providing a platform for the private sector to address issues such as climate change and water, and create an enabling environment for PPP. After the GEJE, GCNJ organized a collective action program in which companies provided voluntary-based assistance to several disaster-affected cities in Miyagi Prefecture by utilizing and combining the resources and strengths of each company.

## INTERNATIONAL COOPERATION

As we noted above, firms' risk aversion functions to some degree as a dispersive force, but this necessarily involves additional transport costs. Because dispersion will be international, we must recognize transport costs in a broad sense including import tariffs and nontariff barriers, customs clearance procedures, communications costs, and even exchange rates. Countries must join forces to mitigate widely various costs related to cross-border transactions. Such cooperation will increase connectivity to the global supply chain and thus the chance of attracting investment.

The 2011 earthquake and tsunami disaster came as a further blow to the Japanese manufacturing sector, which had already been threatened by high factor costs and a strong yen. But when firms were inclined to transfer more production overseas, the Thai flood occurred, compelling firms to revise their risk assessments of excessive concentration of operations overseas. Given the existence of critical parts and material suppliers within Japan, Japanese firms will find it attractive to determine an appropriate mix of production in Japan and overseas. That will seem preferable to accelerating the hollowing out of the business environment for the improvement of taxation and expansion of free trade agreement networks.

Recently, the Thai government is proposing to Japanese local governments and industrial groups that small and medium-size firms in local industrial clusters invest as a group and establish **sister clusters** in Thailand. Sister clusters can operate with vertically linked specialization at normal times, thereby realizing cost reduction, while they can mutually back up production in cases of large natural disasters. Firms can thereby enjoy the same collective efficiency overseas through familiar face-to-face contacts as they do in Japan. This will promote locational diversification of small firms, for which related costs are unaffordable.

## LESSONS

Measuring the full extent of the GEJE's economic impacts will take time. All industrial sectors as well as services suffered significant direct and indirect impacts. A lot will depend on how the government will address the energy supply issues.

The Bank of Japan's swift intervention to ensure immediate liquidity was instrumental in mitigating impacts related to yen appreciation and access to financing.

The government played an important role in alleviating the impacts on households and businesses thanks to the subsequent approvals of supplementary budgets and regulations such as the Policy for the Double Debt Problem (KN 6-4).

Unplanned concentration in supply chains is self-organized because of agglomeration economies. The network of agglomerations is efficient in normal times, but the global production system is thereby vulnerable to natural disasters.

When agglomeration is locked in, firms promptly react to restore the original structure against the damage of disaster. Cooperation among firms and supporting policies can accelerate the process.

Although quick restoration is necessary to avoid exacerbation of a crisis through prolonged dysfunction of supply chains, structural changes must be provided to enhance the resiliency of a supply chain, without mythologizing the safety of the status quo.

Resilience of supply chains demands a certain degree of geographical dispersion. To mitigate the loss of efficiency by dispersion, the previously described individual firm strategies (1)–(4), government policies, and international cooperation are in order.

## RECOMMENDATIONS FOR DEVELOPING COUNTRIES

In today's networked world, most countries are involved in the global supply chain, of which developing countries are an important part. A major disaster occurring in one country can have a global impact. Consequently, it is expected that developing countries will share the burden of strengthening the global resilience of supply chains.

Vulnerability is particularly high in many developing countries because political and economic activities are excessively concentrated in capital cities. An urgent need exists for bold measures aimed at decentralization and establishing backup systems for emergencies. Furthermore, recent rapid urbanization during economic growth has led to the destruction of natural systems of disaster prevention such as the water retention capacity of forests, thereby increasing risks of flooding. Moreover, urban sprawl is occurring in marginal areas where the infrastructure is unprepared for severe natural events.

A pressing need exists to remedy such weaknesses under international cooperation. Coordination among neighboring countries is also necessary in such areas as cross-border transportation systems and water resource management. Policy makers should assess natural disaster risks in a new light—as a mainstream issue that must be addressed by a country to play a major role in global production networks.

It is important that the impacts of a large-scale disaster such as the GEJE are not assessed and addressed in isolation but also by taking into account potential region- and worldwide impacts. Many countries in developing East Asia have strong ties with Japan and would be affected by an appreciation of the yen. In the immediate aftermath of the earthquake, when the yen appreciated sharply because of speculation about sizeable repatriation flows by insurance companies, corporations, and households, the Japanese authorities and the G-7 undertook a concerted effort to stabilize the course of the yen to avoid repercussions for the rest of the world, and East Asia specifically. Coordination among countries is fundamental in mitigating potential impacts of large-scale disasters.

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