

Ye, Linghe; Abe, Masato

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The impacts of natural disasters on global supply chains

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Asia-Pacific Research and Training Network on Trade

The impacts of natural disasters on global supply chains

By Linghe Ye and Masato Abe

ARTNeT Working Paper Series No. 115/June 2012

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*Linghe Ye is a consultant and Masato Abe is an Economic Affairs Officer in the Private Sector and Development Section of the Trade and Investment Division of the United Nations Economic and Social Commission for Asia and the Pacific in Bangkok. The technical support of the ARTNeT Secretariat is gratefully acknowledged. Diana Dai edited the manuscript and the copy-editing was by Ellie Meleisea. The views expressed herein are those of the authors and do not necessarily reflect the views of the United Nations. It is acknowledged that Marc Proksch, Pisit Puapan, Heini Amanda Salonen, Shaina Hasan and Yoko Ono provided very useful inputs and comments to this paper. Any remaining errors are the responsibility of the authors, who can be contacted at tel: +6692881483, fax: +6622881027 email: abem@un.org.

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Acronyms

APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
HDD	Hard Disk Drive
ICT	Information and Communication Technology
JCCB	Japan Chamber of Commerce Bangkok
JETRO	Japan External Trade Organization
M&A	Mergers and Acquisitions
MNC	Multinational Corporation
ODI	Overseas Development Institute
OECD	Organisation for Economic Co-operation and Development
R & D	Research and Development
SMEs	Small and Medium-sized Enterprises
THB	Thai Baht
TISN	Trusted Information Sharing Network
TNC	Transnational Corporation
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
USD	United States Dollars

1. Introduction

Globalization has transformed business environments worldwide, including in the Asia-Pacific region. The fast expansion of global supply chains (typically comprised of firms, suppliers, distribution links and labour), which are cross-border business and production networks, allows firms to allocate scarce resources more efficiently than ever before. The advancement of information and communication technology (ICT), the development of international logistics systems and the reduction of trade barriers have all facilitated the integration of economies through the web of global supply chains. Recent disasters in Japan and Thailand demonstrate, however, that the development of global supply chains have also changed the risk profile of business and could potentially increase economic vulnerability in Asia and the Pacific through higher direct and indirect disaster risks.

This paper explores how global supply chains expand the risks of natural disasters and how natural disasters affect supply chain operations in the Asia-Pacific context. The paper will first discuss the emergence and development of global supply chains in the Asia-Pacific region and will then examine how these new developments globalize disaster risks and bring extra vulnerability to businesses, particularly to their production networks. Following this, the paper will describe the impact of natural disasters on the global supply chains, on the basis of two natural disasters that occurred in 2011 in the region: the Great East Japan earthquake and the South-East Asian floods (focusing on the flood of Thailand). Finally, policy options are proposed to enhance disaster resilience for business in the context of globalization.

2. Development of global supply chains

Driven by trade and investment liberalization and continued cost reduction pressures from customers, businesses have been extending worldwide to make the most of each location's comparative advantage. Many industries have adopted highly integrated global supply chains in which products are supplied, manufactured and distributed across national boundaries through offshore activities and outsourcing strategies. At the same time, economies of scale have driven the consolidation and agglomeration of firms in the supply chains, which have also promoted logistic consolidation. As a result, supply chains are becoming more complex with wider geographical coverage, which has increased the invisibility of the supply chains.

Offshore activities refer to activities that utilize facilities located in a country other than where the enterprise is based (incorporated) and can include production, service and sourcing (Vitasek, 2006). The motivation for offshore activities has primarily been cost, including lower labour, setup and ongoing costs, higher cost efficiency with larger production scale, and possibly lower financial costs such as borrowing costs and tax rates. An example of offshore activities is the overseas production network of Toyota. As shown in Figure 1, Toyota conducts its business in 26 countries and regions, with 50 overseas manufacturing operations. As of 2011, Toyota's vehicles from these production bases were supplied to more than 170 countries and regions (Toyota, 2012).

Figure 1. Overseas production network of Toyota



Source: Toyota, 2012

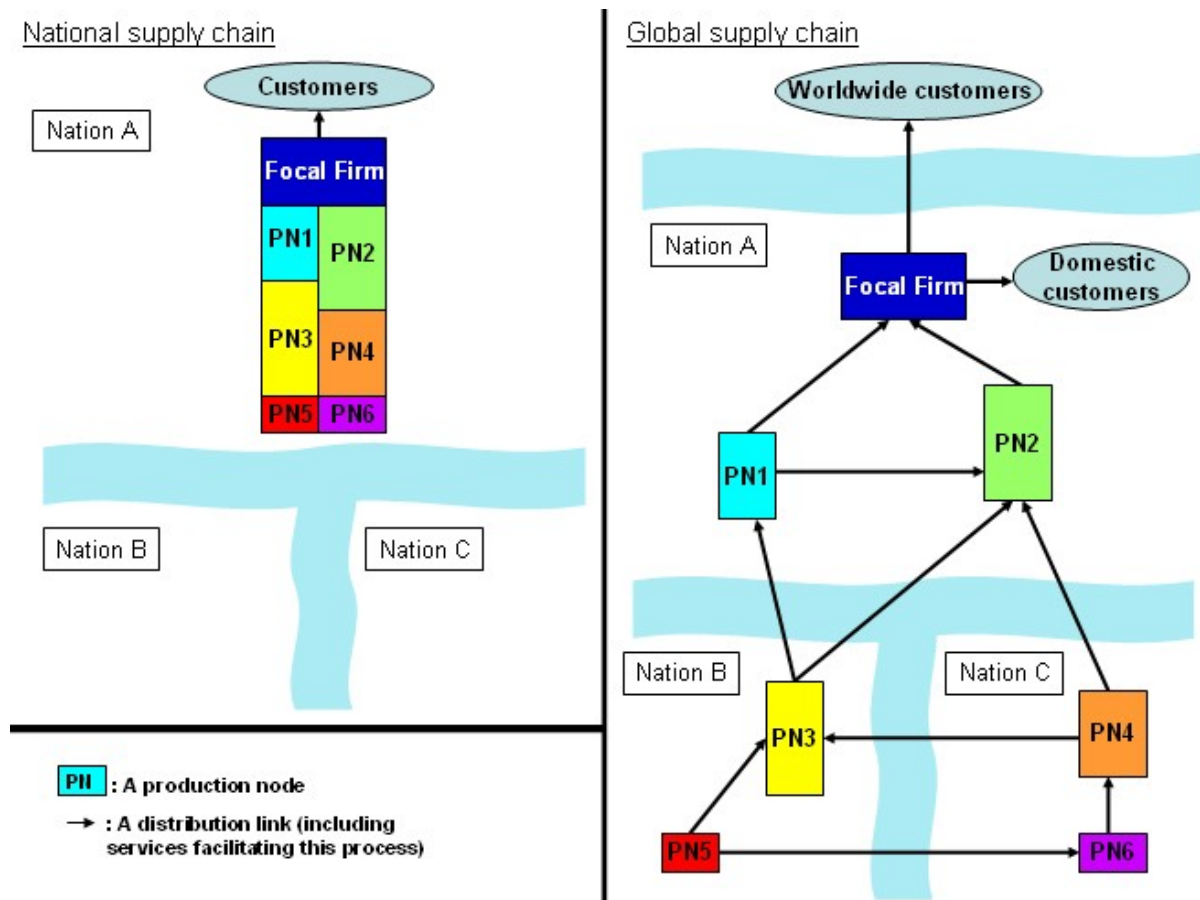
Outsourcing represents one of the greatest changes to global business practices. Today, firms do not just procure materials and parts from overseas suppliers, but also outsource various functions such as product design and logistics services (e.g. turnkey products¹ and third-party warehousing) that were conventionally provided in-house. The logic behind this trend is that outsourcing can enable firms to focus on their core value added activities, where they have a distinct advantage. Overall efficiency increases because each firm in the supply chain can maximise its competitive advantage through strategically focused resource allocation (Christopher, 2011). Consequently, the supply chain becomes a web involving multi-tier suppliers and service providers. Focal firms² are at the centre of an international production network (global supply chain), linked with several interrelated but independent entities.

As a result of outsourcing, to take advantage of the lower costs in each location as well as to penetrate untouched foreign markets, supply chains have been extended from one side of the globe to the other (Christopher, 2011). As described in fragmentation theory, a whole production process is now split into separate nodes in different locations (Jones and Kierzkowski, 1990). These production nodes are connected by distribution links, which refer to activities coordinating the operation between these nodes such as administration, transportation, warehousing and financing among participating firms (Jones and Kierzkowski, 1990). The final products are produced across the borders and then sold beyond the borders to consumers worldwide. Unlike a local (national) supply chain, a global supply chain involves transporting large amounts of supplies across long distances, which increases the frequency of using multi-modal distribution facilities. Figure 2 illustrates national and cross-border supply chains.

¹ A turnkey product or service is one that is installed fully complete and ready for a user to operate. The term implies that the user just has to turn a key and start using the product or service (TechTarget, 2002).

² A focal firm is the initiator of an international business transaction, which conceives designs and produces goods or services (Cavusgil, Knight and Riesenberger, 2008).

Figure 2. Comparison of national and global supply chains



Another prevailing trend is supplier consolidation, which refers to the reduction by firms of their total number of suppliers while increasing business with individual suppliers (EIU, 2005). In some cases this corporate strategy has been extended to “single sourcing” whereby one supplier would supply one business input (e.g. a part, component or module). With this strategy, focal firms aim to build strong partnerships with their suppliers and achieve price advantages from the economies of scale and bargaining power while utilizing suppliers’ expertise in research and development (R&D), design, production and distribution. It also lowers transaction costs, with fewer orders to be managed by the focal firms. An example of supplier consolidation can be seen in the automobile industry, in which the number of automotive parts suppliers dropped from over 30,000 in 1998 to around 4,500 in 2008 (KPMG, 2009). Mergers and acquisitions (M&A) among major suppliers have facilitated supplier consolidation.

A similar trend is production agglomeration, which refers to the geographical concentration of production facilities and activities (cf. Healey and Ilbery, 1990). Firms in the same industry tend to locate themselves very close to one another, leading to geographical concentration of the industry. The producers of substitutable products locate in close proximity to each other so as to reduce production costs. Production agglomeration is also driven by economies of scale. Agglomeration in a particular location is also generally related to accessibility to natural resources (such as petroleum or sunny weather) or other resources (such as low cost labour) or because of favourable business

conditions in that location. This process also enhances cooperation between firms (e.g. development of industrial clusters and estates). Supplier consolidation and production agglomeration have also increased the importance of certain production bases in the supply chain, which provide necessary supplies and business and logistics related services. In order to be close to transportation and logistics facilities and to lower transport costs, production centres are often established and developed in coastal areas and river basins with high population concentrations (Clay and Benson, 2005). The benefits derived from production agglomeration include knowledge spill-over, labour market pooling, input sharing and lower product shipping costs (Rosenthal and Strange, 2001).

Another trend is logistics consolidation, which refers to the combination of two or more shipments in order to realize lower transportation costs. For example, inputs and components from a number of suppliers for one production site can be combined into a single delivery rather than each supplier delivering small quantities separately. This enables the suppliers to share the costs of transportation, warehousing and administration. This trend has been accompanied by the emergence of third-party distribution and logistics firms, including various turnkey service providers specializing in providing an in-bound consolidation service (Christopher, 2011). The expansion of the global supply chains combined with logistics consolidation has also increased the dependence of distribution links on selected international distribution facilities including transport infrastructure, logistics systems and communication infrastructure.

While streamlining production networks, supplier consolidation and production agglomeration have increased the importance of certain suppliers and locations by concentrating physical assets and production facilities, the structure of the supply chains is becoming more complex, with more individual production nodes and distribution links involved across borders. Consequently, it has become more difficult for focal firms to identify the risks in the supply chain.

3. Supply chain disruptions and increasing risks

A supply chain disruption is defined as a major breakdown in a production node or a distribution link that is part of a supply chain. Natural disasters are one cause of disruptions to supply chains. They usually result in widespread damage to several firms and facilities at the same time. This has a severe impact on an industry and significant time is often required for recovery from natural disasters.

With the globalization of supply chains, the exposure of firms to risks of disasters has been expanded across national borders as a natural disaster in one geographical location can also affect firms in other locations. Furthermore, with offshore and outsourcing activities, the level of interdependence among firms has increased, which has increased vulnerability because disruption of even one part of the global supply chain can result in operational failure of the other parts. Though the focal firm may be able to recognize some disaster-prone nodes or links within the supply chain, fragmented production has reduced the degree of control and monitoring of the focal firm over production nodes and distribution links (Kimura and Ando, 2005).

At the same time, with supplier consolidation and production agglomeration and consequent high density of production assets and economic activities in certain locations,

the risks have been centralized in those locations. When disasters affect areas where production facilities are concentrated (particularly those located in areas vulnerable to storms and flooding, such as coastal areas or areas close to rivers), supply chains are disrupted, which results in significant structural losses to the whole production network and even to related industries. During the disaster and recovery period, other firms in the supply chain may encounter difficulties in finding proper substitute suppliers or customers elsewhere, making the impact of the disaster last longer. Furthermore, dependence on international distribution facilities has increased vulnerability to disaster as damage to these facilities can easily lead to supply chain disruption.

Some widely adopted supply chain management strategies also increase the risks of problems in situations of natural disasters. Examples include the “just-in-time” practice and lean supply chain management, which require more frequent deliveries of supplies, minimizing the non-value-added time and inventory. These efficiency maximization models in business increase the level of interdependence between firms and correspondingly raise the chances of a supply chain disruption. Also, the compression of non-value-added time in inventory transfer and storage may remove the essential risk buffer between the production nodes and deepen the negative impact when natural hazards occur in the global supply chain. For example, when a disaster hits a supplier or a distribution link and disrupts the supply chain, the focal firm that adopts “just-in-time” practices will suddenly encounter production suspension due to supply shortages and the negative effect will transmit quickly to the downstream supply chain.

In addition to the loss due to direct damage and recovery cost, natural disasters may cause cash flow problems among participating firms if the partners in the supply chain cannot settle their payables in time, and thus pose threats to the financial situation of a firm. Negative financial outlooks may raise the concerns of financial institutions and pose obstacles for firms in obtaining external financial resources during the recovery phase. If the firm is publicly traded, a supply chain disruption may negatively impact their reputation and cause underperformance in the market (Hendricks and Singhal, 2005).

Financial institutions can also be affected by disruptions to the supply chain caused by natural disasters. In addition to losses in the insurance industry, financial difficulties of client firms caused by disasters and the subsequent supply chain disruptions may create unexpected problems in the repayment of loans and in turn undermine the stability of financial institutions.

An increasing number of small and medium-sized enterprises (SMEs) are involved in global supply chains. SMEs are generally suppliers of labour-intensive parts and components or providers of other basic services, usually on a subcontracting basis (Abe, 2012). Larger partners in the global supply chain often take advantage of the greater flexibility of SMEs and their adaptability to local economic conditions and capacity to serve orders for smaller quantities, but SMEs have been identified as a highly disaster-vulnerable group in the supply chain. The small market share and weak bargaining power of individual SMEs places them in a disadvantaged position in negotiations with supply chain partners to obtain resources and support to deal with the impact of disasters. Lack of output diversification also limits the ability of SMEs to cope with supply and demand shocks and market volatility generated by disasters. Studies have revealed that few SMEs are adequately prepared for natural hazards.³ SMEs have

³ cf. Alesch *et al.* 2001; Wedawatta, Ingirige and Amaratunga, 2010

been identified as the top sector of underinsurance, and they usually do not conduct risk assessments or implement business continuity plans (CERNO, 2010; CII, 2009). This lack of preparation consequently increases the difficulty of recovery from disasters and the subsequent supply chain disruptions (Wedawatta et al., 2010).

4. Case studies: Japan earthquake and Thailand floods

The natural disasters that hit Japan and Thailand in 2011 were among most devastating in the Asia-Pacific region in recent history. In March 2011, a massive earthquake (known now as the Great East Japan earthquake) hit the northeast part of Japan and was followed by devastating tsunami. Then, in late 2011, floods in Thailand caused huge damage to the country. Given the important positions of Japan and Thailand in the global supply chains for many economic sectors, the two disasters caused large disruptions both domestically and worldwide, thus highlighting the interconnected nature of world markets and economies.

The two cases highlight the different types of impacts of natural disasters on the global supply chain. Japan not only acts as a major supplier in many industries (e.g. automotive parts, chemicals, electronic parts and steel) but also as a producer of end products to the mass market. As a result, the Great East Japan earthquake impacted both upstream suppliers in developing countries and end customers in developed countries, as both demand signal and supply flows were severely disrupted. In comparison, Thailand is a major supplier in the global supply chain, particularly in the auto and electronic sectors. Therefore, downstream partners in the supply chain were adversely affected by the disaster as they were unable to source parts and components from Thailand during the flood.

4.1 The Great East Japan earthquake

In March 2011, an earthquake struck Japan triggering a devastating tsunami, which led to the meltdown of nuclear reactors in Fukushima. The disaster caused a record 210 billion United States Dollars (USD) in economic damage, representing 3.8 per cent of Japan's Gross Domestic Product (GDP).⁴ Production sites in affected coastal areas experienced one and half times as much damage as inland areas (Okada, 2011). The combination of the earthquake and tsunami damage and the meltdown of the Fukushima nuclear reactors affected broad areas and caused severe damage in various sectors, especially in the manufacturing and chemical industries. As a result of this disaster, individual firms suffered huge direct losses, and the disaster could have a long-term impact on the ability of firms to produce and deliver their products or services.

⁴ EM-DAT, the international disaster database, Available from <http://www.emdat.be/> (Accessed 30 March 2012)

Box 1. Earthquake damage of Renesas Electronics Corporation

Renesas Electronics Corporation is a Japanese semiconductor manufacturer and the world's largest manufacturer of microcontrollers. The corporation's Naka Factory and other manufacturing facilities were severely damaged by the earthquake. In addition to the cost for restoring damaged properties, Renesas had to dispose of damaged stock and other fixed assets as well as compensate the loss of leasing contracts. Renesas also needed to cover fixed expenses in spite of production stoppage. Although the company carried insurance, it recovered less than one quarter of the total loss on the disaster as the insurance only covered part of the disaster risks. Table 1 presents the corporate losses to Renesas caused by the earthquake.

Table 1. Losses for earthquake damages in 2011, Renesas Electronic Corp

Items	Amount (USD millions)
Repairs to property, plant and equipment (expenses for restoring to the original condition)	535.8
Loss on disposal of stock	90.7
Loss on disposal of fixed assets	77.1
Fixed expenses during suspension of operations (loss for inability to operate)	73.3
Loss on cancellation of lease contracts and others	37.3
Total loss on the disaster	814.2
Insurance payments received	(198.9)
Net loss on the disaster	615.3

Note: Calculated based on 1USD = 80.5 Japanese Yen

Source: Renesas Annual Report 2011

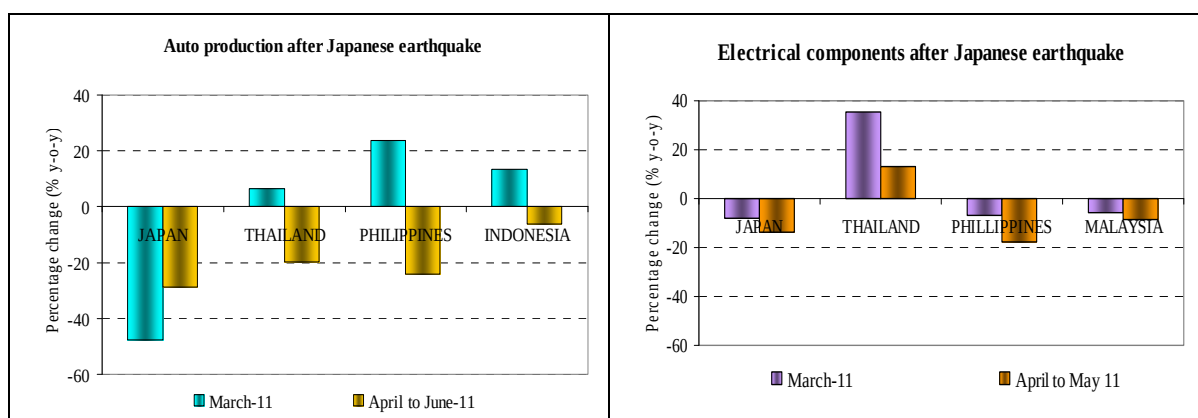
Some firms, although they were not hit directly by the earthquake and tsunami, experienced the disaster impact indirectly due to damaged infrastructure in the country. The power supply in the northern part of Japan was severely disrupted due to the failure of the Fukushima nuclear power plant. As a result, the production of many industrial plants stagnated (Davis, 2011). Furthermore, many roads and railways were destroyed and almost all major sea ports in the affected areas were closed (Wassener and Nicholson, 2011). This rendered the mobility of final products, components and raw materials very difficult, thus causing various supply chain disruptions.

The catastrophe also generated several impacts on human capital and the labour market. In the directly-affected region, the number of applications for unemployment insurance rose sharply in the first few months (Berkmen et al., 2011). The disaster also had a nationwide impact on the labour market due to increased bankruptcies and loss of employment. In addition, the disaster forced a reallocation of human capital to different geographical locations and industrial sectors (Kirchberger, 2011). As a consequence, gaps between labour demand and supply in terms of quantity and skills further raised unemployment.

In response to the disaster, the Government of Japan implemented a number of employment promoting programmes, such as “Hello-works” and the “Japan as One” work project, to facilitate job creation and job matching (Rokumoto, 2012; Japan Ministry of Health, Labour and Welfare, 2012). Therefore, affected firms, especially those in the manufacturing sector, rapidly regained their levels of employment, as they were working to recover their production to the level prior to the earthquake and tsunami (Thompson, 2012). In March 2012, employment in the finance, insurance, real estate, mining, construction and services sectors exceeded the level of March 2011 (Thompson, 2012).

As the economy of Japan is highly integrated into the world economy, the direct and indirect supply disruptions caused by the disaster were experienced globally. Following the Great East Japan earthquake, Japanese automobile production and electrical component production declined by 47.7 per cent and 8.25 per cent, respectively.⁵ As Figure 3 illustrates, the ill effects of the Japanese catastrophe spilled over to other countries in the region. This was most clearly evident in the cases of Thailand (-19.7 per cent), the Philippines (-24 per cent), Indonesia (-6.1 per cent) for automobile production, and the Philippines (-17.5 per cent) and Malaysia (-8.4 per cent) for electrical component production. Disruptive impacts from the Great East Japan earthquake had a longer impact on the automotive sector (about three months) than on the electrical sector (about two months).

Figure 3. Disaster impact spill-over from the Great East Japan earthquake



Source: CEIC Data Company Ltd (Accessed 30 March 2012)

The disruptions caused by the disaster in Japan strongly impacted some supply chains, particularly those that rely on few sources or a single source for a certain inputs. For example, Ethox Chemicals, an American chemical multinational, relies on a key material supplied by only three companies in the world, one of which is located in Japan. After the disaster in Japan, Ethox suffered supply shortages as the other two suppliers (in Europe and Malaysia) were not able to make up for the supply stoppage in Japan. Another example is in the automobile industry. With the damage to Renesas Electronic Corp, the largest manufacturer of custom-made microchips in the world, the entire automotive industry in Japan and the other parts of the world experienced severe production suspension, because the user-specific chips were difficult to re-source and the tight "just-in-time" management in the industry resulted in extremely low inventory, usually for up to only six hours (Endo, 2011)

⁵ CEIC. Available from <http://ceicdata.com/> (Accessed 30 March 2012)

Supply chain disruptions and corresponding production stagnation in several industries, particularly export-oriented industries, highlighted the risks of losing global market share. For example, in the steel industry, Posco, the world's third-largest steelmaker by output, based in the Republic of Korea, gained a share in the market for materials for shipbuilders in the region, replacing Japanese steelmakers (Narayanan, 2011) The supply chain disruptions in the automobile industry in Japan caused by the earthquake resulted in a severe shortage of small and mid-sized cars in the world market as well as reduced automobile production in the United States of America and Europe, which depend on Japanese suppliers of parts (Snyder, 2011) As a result, less affected automakers gained shares in the global market, at least temporarily (Toyota, 2012; General Motors, 2012) Data indicate that Toyota was overtaken by General Motors as the world's biggest carmaker by volume in 2011.

4.2 The 2011 floods of Thailand

In the second half of 2011, severe floods inflicted heavy damage in a number of South-East Asian countries and the Sindh region of Pakistan. Thailand experienced particularly severe flooding between June and December 2011, causing over USD 40 billion in damages and losses and hampering the country's manufacturing capacity. The flooding in Thailand was attributed to various factors, including a combination of poor urban planning, deforestation, lack of floodwater management systems and failure of previous master plans on flood mitigation.

One of the major negative impacts of the floods in Thailand was in the context of the global supply chains. As a consequence of globalization, Thailand's economy has been integrated into global supply chains and now has an important position in them, as indicated by significant inflows of foreign direct investment (FDI), high intensity of export activities and extensive activity by multinational corporations (MNCs) (Chongvilaivan, 2012)

Driven by pressures to reduce costs, firms and suppliers in Thailand tend to cluster in a small number of industrial locations (Ibid). Partially due to inadequate urban planning, seven industrial estates in the provinces of Ayutthaya and Pathum Thani had been built on low-lying land. During the flooding these industrial estates were severely inundated, resulting in large manufacturing production losses, averaging 29.4 per cent, between October 2011 and January 2012.⁶ In addition to the direct losses due to physical asset damage, many firms suffered from supply chain disruptions. These disruptions also impacted firms whose physical assets were unaffected. For example, Nissan and Toyota's plants in Thailand were not physically damaged by the floods, but both companies had to suspend production due to difficulties in obtaining parts from suppliers that had been directly impacted by the floods. (Nissan, 2011; Toyota, 2011) In the case of Toyota, the indirect effects of the halt in manufacturing spread to other production sites around the world. Production lines in Malaysia, Viet Nam, Pakistan, the Philippines, the United States and Canada had to be adjusted in order to make up for the lost outputs in Thailand. (Toyota, 2011)

According to a survey of Japanese enterprises regarding the impact of the floods in Thailand, including enterprises in both manufacturing and non-manufacturing sectors, 78

⁶ Available from <http://ceicdata.com/> (Accessed 30 March 2012)

per cent of all respondents were directly or indirectly affected (see Table 2). Among the affected enterprises, the automotive sector, trading sector, electronics sector and steel and metal sector accounted for 17 per cent, 16 per cent, 11 per cent and 9 per cent, respectively. (JCCB, 2012) Those directly affected, particularly manufacturers, located in the inundated industrial estates outnumbered those outside the estates. Indirect damage included supply disruptions. (JETRO, 2012) The majority of the enterprises were covered by disaster insurance for damaged assets and reduced incomes,⁷ but 12 per cent of the respondents carried no insurance. Disruption of production and corresponding financial losses of enterprises led directly to a decrease in employment in the affected zones. The survey results indicate that 21 per cent of the directly affected firms plan to “conduct layoffs” or “solicit voluntary retirement” (JCCB, 2012) To cope with the supply chain disruptions, over 60 per cent of directly affected manufacturers, particularly those in the electronics sector, temporarily relocated their production to other Asian countries, including to other member countries of the Association of Southeast Asian Nations (ASEAN), Japan and China, with some considering permanent relocation (Ibid).

Table 2. The impact of the Thai 2011 Floods on Japanese enterprises

Sector	Type of industry	Number of enterprises with direct damage, such as damage of buildings and equipment (%)	Number of enterprises with direct damage - in the inundated industrial estates (%)	Number of enterprises with direct damage - outside the inundated industrial estates (%)	Number of enterprises with indirect losses - due to supply chain disruption (%)	Not affected (%)	Number of respondent companies
Manufacturing	Food processing	4 (29)	2 (14)	2 (14)	11 (79)	3 (21)	14
	Textiles	3 (33)	1 (11)	2 (22)	5 (56)	2 (22)	9
	Chemicals	1 (4)	1 (4)	0 (0)	19 (79)	4 (17)	24
	Steel and other metal	2 (7)	1 (3)	1 (3)	24 (83)	3 (10)	29
	General machinery	5 (42)	5 (42)	0 (0)	8 (67)	4 (33)	12
	Electronics	20 (56)	18 (50)	3 (8)	31 (86)	2 (6)	36
	Automotives	7 (13)	6 (11)	1 (2)	47 (84)	8 (14)	56
	Others	9 (24)	7 (18)	2 (5)	26 (68)	7 (18)	38
	Manufacturing Total	51 (23)	41 (19)	11 (5)	171 (78)	33 (15)	218
Non-manufacturing	Trading companies	5 (11)	4 (9)	1 (2)	45 (100)	9 (20)	45
	Retail	3 (27)	3 (27)	2 (18)	8 (73)	3 (27)	11
	Finance	2 (13)	0 (0)	2 (13)	10 (63)	5 (31)	16
	Construction and civil engineering	5 (29)	3 (18)	3 (18)	8 (47)	9 (53)	17
	Transportation and communication	2 (9)	0 (0)	2 (9)	18 (78)	5 (22)	23
	Others	1 (4)	0 (0)	1 (4)	15 (63)	12 (50)	24
	Non-manufacturing Total	18 (13)	10 (7)	11 (8)	104 (76)	43 (32)	136
Total		69 (19)	51 (14)	22 (6)	275 (78)	76 (21)	354

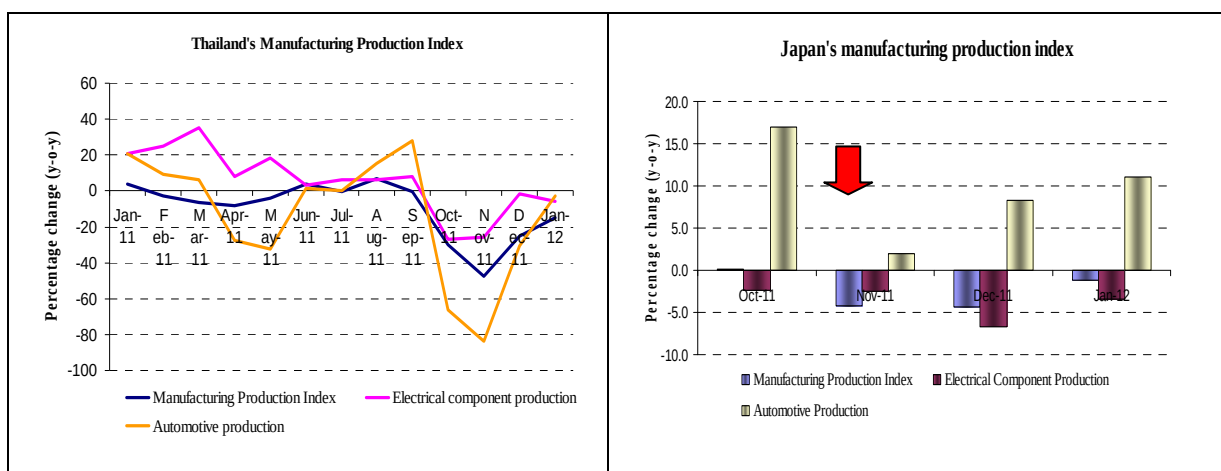
Note: The survey resulted in multiple answers. The unit is the number of enterprises. The parentheses indicate the percentage of respondent companies.

Source: JCCB (2012).

⁷ Corporate disaster insurances typically cover damaged assets, damaged products in transit, third-party's damage and lost income (JCCB, 2012)

The floods in Thailand caused significant spill-over impacts on other countries through the global supply chains. For instance, given the close economic linkages between Thailand and Japan, Thailand's supply chain disruption and production losses affected Japan, where the manufacturing production index fell by 2.4 per cent.⁸ This fall was led by the reduction in electrical component production which contracted by 3.7 per cent between October 2011 and January 2012 (see Figure 4). As Thailand is the world's second largest producer of hard disk drives (HDDs), the lower HDD production capacity caused by the flood in Thailand resulted in an increase of the HDD price in the world market (see Box 2).

Figure 4. Disaster impact of the Southeast Asian floods on Japan's manufacturing sector



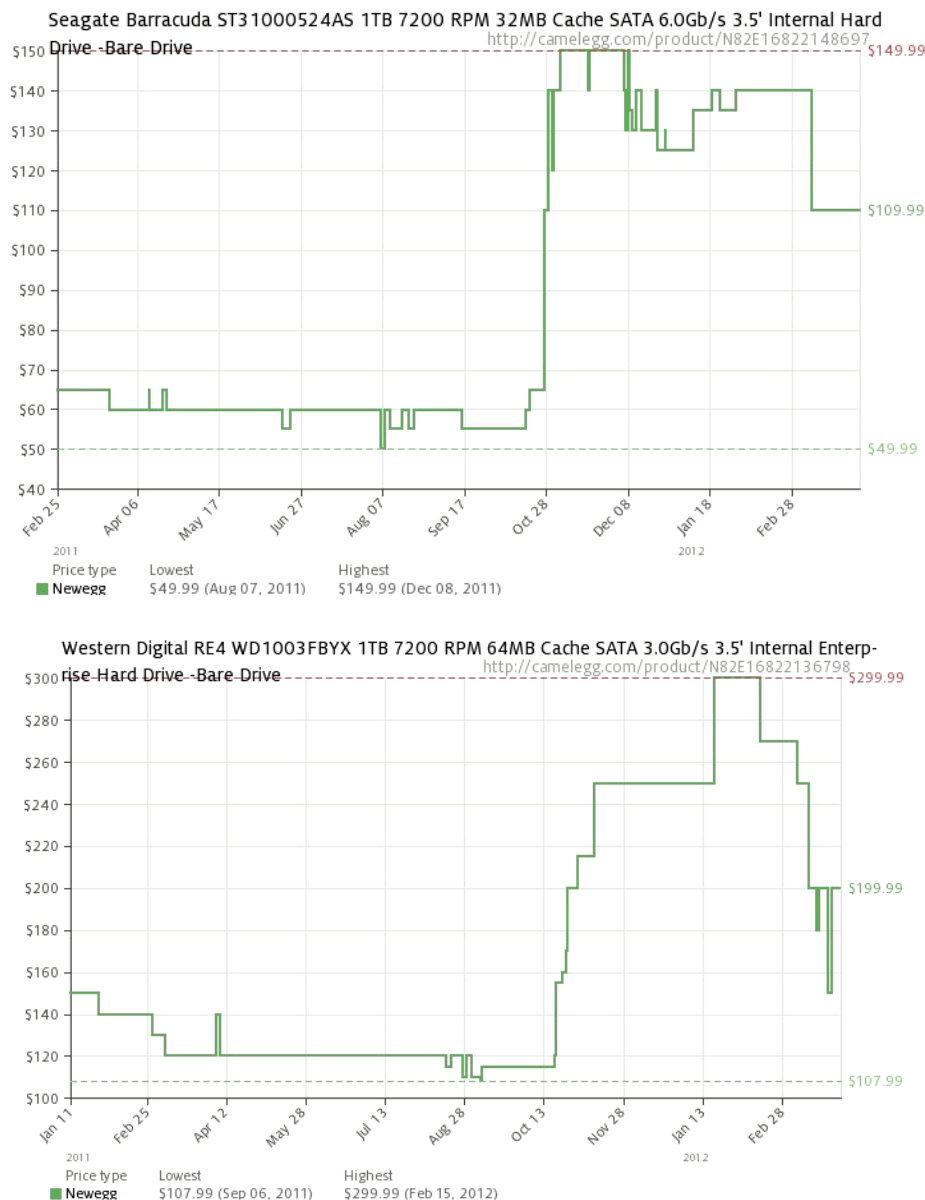
Source: CEIC

Box 2: The impact of the flooding in Thailand on the price of hard disk drives

Thailand is the world's second largest producer of hard disk drives after China and is a major supplier of HDD parts. Some of the leading HDD producers operate in Thailand, including Western Digital, Seagate, Toshiba and Hitachi, and many of these producers were affected by the floods. As a result of the Thailand Floods in 2011, the global HDD industry suffered its worst downturn in three years and the world price of HDDs increased dramatically.

According to the price history records of Newegg Inc., a major online retailer of computer hardware and software in North America, the prices of HDDs made by Seagate and Western Digital tripled during the flood period. In addition to the direct stoppage of HDD production in factories impacted by the flooding in Thailand, the HDD price hike was also caused by defensive purchases by consumers and inventory hoarding by resellers and wholesalers, who anticipated the upward trend of the price of HDDs.

⁸ Available from <http://ceicdata.com/> (Accessed 30 March 2012)

Figure 5. The price history of two HDD products

Source: Camelegg.com & newegg.com - Price Tracker

The floods also had a heavy impact on SMEs, which participate in the global supply chains as suppliers to large enterprises and transnational corporations (TNCs). At the end of 2010, the total number of SMEs in Thailand was 2,913,167, which accounted for 99.6 per cent of all enterprises (Thailand, Office of Small and Medium-Sized Enterprises Promotion, 2011). SMEs were responsible for 77.9 per cent of all employment in 2010 (Ibid). During the 2011 flood, approximately 550,000 small businesses experienced direct and indirect damage, estimated at 71.1 billion Thai Baht (THB) per month, with 2.32 million jobs lost, at least temporarily (Thai Business Council, 2011).

The severe impact of the flood on global supply chains and the inefficient government management of flood recovery have raised investors' concerns about the

long-term viability of Thailand as an investment destination. According to a survey of 50 multinational firms directly affected by the floods, 38 per cent of the firms reported that they would “scale back” in the future. (JETRO, 2012) These firms are concerned about increases in production costs due to higher insurance premiums, as well as the expense of building their own flood defences. (Sathirathai, 2012) Even though Thailand serves as an important link in the global supply chains of several industries, more attention should be paid to mitigating the risks of possible future flooding and improving water resource management if the country is to remain a significant investment destination.

5. Policy options to enhance disaster resilience

In light of the interdependency of businesses as a result of the development of global supply chains, even relatively small supply disruptions caused by a natural disaster can ultimately have consequences for all participating firms in a supply chain. To address the risks and build resilience to disasters, efforts from all individual entities and cooperation between the private and public sectors are essential.

Enterprises

The firms involved in global supply chains must adopt risk reduction strategies to increase resilience. Two key strategies are described below:

(i) Find a balance between efficiency and risk

The tradeoffs between supply chain efficiency and disaster risk preparation should be carefully considered. Finding a proper balance between efficiency and risk is a key factor in supply chain management for enhancing disaster resilience. While sourcing from only one supplier can reduce production costs, it can also make producers vulnerable to disasters. Although having multiple suppliers in different locations may raise transaction costs, it reduces the risk of disruption by securing supply substitutes. To achieve a proper balance between efficiency and risk, firms should take risk into account and conduct a prudent cost-benefit analysis and implement measures to enhance disaster resilience. Such measures may include: 1) raising production flexibility to cater to the volatile nature of the market, 2) selecting suppliers on the basis of risk criteria rather than on pure cost minimization (Christopher, 2011), 3) shortening the supply chain and increasing supply chain visibility, 4) diversifying risks by using different distribution channels and suppliers, 5) enhancing relationships with other supply chain partners (Catto-Smith, 2012).

(ii) Invest in long-term continuity

Firms need to be aware that institutional capacities in disaster resilience and business continuity are strong determinates of long-term competitiveness. Even though natural disasters have a low frequency, the expansion in global supply chains has greatly increased the possibility of production disruption from such disasters. As demonstrated by the earthquake in Japan and the floods in Thailand, the consequences of natural disasters may hamper a firm by inhibiting normal production activities, bringing financial losses and a smaller market share in the long run. To reinforce their long-term competitiveness, firms need to invest more in the long-term continuity of the supply

chain and implement risk management measures. A comprehensive assessment of a firm's vulnerability to disasters and the potential impact of a disaster on the supply chains that the firm is involved in can facilitate the establishment of risk transfer, contingency financing and mitigation strategies. With the increasing complexity of supply chains, it is also important to focus on the management of critical sub-tier risks and share information with supply chain partners to enhance network visibility.

Governments

Governments at all levels play a fundamental role in coordinating and mainstreaming risk reduction strategies to achieve long-term disaster resilience of the supply chains. Many researchers on disaster risk reduction have argued that *ex-ante* public responses (i.e. policy instruments to enhance disaster resilience before natural disasters happen) are likely to be more effective than *ex-post* ones (i.e. policies promoting recovery after disasters).⁹ *Ex-ante* measures are more effective because they can contribute to welfare gain through increasing net savings and promoting better mitigation, while the *ex-post* measures may result in welfare loss due to unprepared consumption fluctuations and may trigger moral hazard problems (Phaup and Kirschner, 2010). Moreover, constraints against recovery such as problems with financial resources and information flows may rise exponentially during a crisis (Blomquist et al, 2002).

Governments have a responsibility to develop and disseminate information about risk and risk reduction measures to raise awareness within global supply chains and assist individual entities to prepare for potential natural hazards. More importantly, governments have a responsibility to incorporate disaster risk reduction criteria into development planning to mitigate the negative impact of disasters in the long run. For example, disaster vulnerability in the global supply chain can be reduced through setting stricter building codes and providing more reliable public infrastructure. Disaster exposure in the global supply chain can be also lowered through diversified economic structures, meticulous selection of production sites, rational urban planning and diversified energy sources. Additionally, governments should provide adequate protection to disadvantaged groups, such as SMEs and the poor, by facilitating the implementation of disaster risk reduction measures, such as helping with preparedness and promoting disaster insurance coverage (Baez, de la Fuente and Santos, 2010). These *ex-ante* policies can reduce disaster losses and post-disaster spending and can control the spread of indirect impacts in the supply chain by maintaining normal production and distribution operations.

Post-disaster recovery is another important issue for governments as the speed of the recovery process is the key to mitigating negative consequences on global supply chains. The quick recovery of local production assets and distribution links can address disruptions and reduce the spread of disruptions throughout the global supply chains (World Economic Forum, 2008). Government policies for post-disaster recovery should concentrate on several key aspects, including providing financial resources, promoting employment and facilitating business rehabilitation and maintenance. Financial incentives can be adopted for multiple purposes and provide the core resources for recovery. Many policy instruments are available in the event of natural disasters, including direct cash transfers, additional credit lines, soft loans, credit guarantee

⁹ cf. Blomquist et al., 2002; Phaup and Kirschner, 2010

schemes, micro-finance and social fund programmes (Skoufias, 2003). In terms of assistance in employment, financial instruments such as wage subsidies could be adopted to stimulate job supply. Skills development programmes and information services can be useful in narrowing the gap between affected workers and market demand and have a long-term positive impact on the labour market. The facilitation of business rehabilitation and maintenance needs to be flexible and fulfil the specific demand from business sectors. For example, following the 2011 flood in South-East Asia, the Government of Thailand provided assistance in draining water and replacing damaged assets, compiling damage information for insurance compensation claims and accelerating the preparation of export-import documentation (Thailand Ministry of Foreign Affairs, 2011). All these measures were tailored in accordance with the needs of businesses to maximise the utility of government efforts.

Disaster risks are increasingly being taken into consideration when making investment decisions and specific measures for disaster risk reduction should be adopted to increase attractiveness as an investment destination. One of the core tasks for governments in this regard is to ensure the safety of the production nodes and distribution links where foreign investments are involved. This can be achieved by strict location selection for industrial estates, comprehensive planning of industrial clusters and enhancing the standard of public infrastructure. During the recovery process after a disaster, governments should provide timely and effective measures tailored to investors' specific needs to prevent further losses of these investments and, more importantly, their confidence. An apt example of this was the response of the Government of Thailand following the floods in 2011, where the government implemented simplified visa procedures for foreign experts, mechanics and other technical personnel. This met the needs of investors and facilitated the recovery process (Thailand Ministry of Foreign Affairs, 2011).

Public-private partnerships

Increasing evidence indicates that collaboration between the public and private sectors can improve the ability of a society to prepare for, respond to and recover from disasters. In building disaster resilience, the private sector has proven it plays a fundamental role in providing resources, expertise and essential services (APEC, 2010). The collective efforts of both the public and private sectors can identify interdependencies and enable the utilization of each other's resources in advance for the purpose of disaster risk reduction.

One of the areas with huge potential for public-private partnership is insurance. As an important component of a risk management strategy, insurance not only provides compensation for disaster damage, but also encourages disaster preparedness when the product is designed with an appropriate premium structure. Insurance markets are limited in their ability to inter-temporally diversify catastrophic risk, however, mainly due to the potentially huge and systematic losses of natural disasters (Lewis and Murdock, 1996). Insurance companies may also be reluctant to provide specific services such as micro-insurance for small enterprises due to their higher risk and management costs. Therefore, on the supply side, governments could explore cooperation with private insurance providers to develop disaster risk transfer and insurance schemes by sharing disaster risks and facilitating underwriting or compensation processes. Cooperation can occur in developing social and publicly funded insurance schemes for target groups (e.g.

SME suppliers), including innovative micro-insurance services and products. On the demand side, compulsory requirements may be implemented to encourage the private sector to conduct disaster risk transfer.

The public and private sectors can also jointly collect information on disaster risks and risk reduction measures and share information and experiences by forming relevant databases. For example, in 2003, the Australian Government established the Trusted Information Sharing Network (TISN) for critical infrastructure resilience. By involving owners and operators of critical infrastructure, government agency representatives and peak national bodies, the TISN aims to raise awareness of risks to critical infrastructure, share information and techniques required to assess and mitigate risks and build resilience capacity within organizations (APEC, 2010).

Other examples of disaster risk reduction efforts in which the private and public sectors have worked cooperatively include implementing building codes, retrofitting vulnerable production assets and issuing extreme-weather warnings.¹⁰ Another example is dialogue between governments and the private sector, such as dialogue that has taken place through the chamber of commerce in Viet Nam on flood mitigation activities. The private sector was involved in the needs assessment of the local communities and the local government facilitated the participation of businesses in flood risk reduction actions, including initiatives to provide public recognition of this role.

6. Conclusion

In the era of globalization, firms in many industries are seeking to globalize their supply chains to take full advantage of world resources and minimize production costs while penetrating untouched foreign markets. In this context, supply chains are being extended worldwide through outsourcing and offshore activities. The number of production nodes and distribution links are continuously increasing and fragmenting, while firms in the supply chain are becoming more interdependent. At the same time, supply chains are becoming more streamlined through supplier consolidation and production agglomeration to achieve economies of scale.

Global supply chains are vulnerable to the effects of natural disasters because the consolidation of production bases, supplier networks and distribution channels concentrates risks in certain locations and decreases the possible substitutes in the market. Furthermore, the heavy reliance on specific transport facilities for cross-border production increases supply disruptions in times of infrastructural failure. In addition, supply chain strategies that increase business efficiency may actually deepen the negative impact of natural disasters. For SMEs involved in global supply chains, natural disasters pose particularly serious risks.

As the two case studies, the Japan earthquake and Thailand floods, showed, natural disasters can cause huge domestic losses by damaging production assets and public infrastructure, inhibiting the development of SMEs and creating high levels of unemployment. Additionally, disasters can weaken firms' financial situation through increasing unexpected spending and obstructing external financing. In addition to direct losses from the natural disasters, firms may be affected indirectly due to supply disruptions,

¹⁰ cf., Mason, 2006; Jones Kershaw, 2005

even when the disasters occur in other countries or regions. The indirect impacts can spill over to the whole world through the global supply chains, which may result in production losses and price fluctuations in many industries. Furthermore, the damage caused by natural disasters in some countries, especially in developing countries, may hamper their global competitiveness and cause concern among foreign investors.

Enterprises must think beyond themselves if they are to reduce their vulnerability to supply chain disruption. The trade-offs between efficiency and risk in supply chain management should be carefully balanced and more effort should be given to building disaster resilience to ensure long-term competitiveness. Governments play a fundamental role in building supply chain resilience. As the *ex-ante* policies are likely to be more effective, governments should be aware that disaster risk reduction is essential to lowering potential disaster impacts and should incorporate into long-term development plans actions that foster more disaster-resilient supply chains. At the same time, measures should be taken to increase the speed and effectiveness of disaster recovery in order to prevent the spread of the impact of the disaster through the global supply chains. Specific measures could include providing financial support, protecting and promoting employment and facilitating business rehabilitation and maintenance. Corresponding measures should also be adopted to maintain the confidence of investors in global supply chains and therefore ensure the long-term competitiveness of the country. Effective management of the risks also requires collaboration between the public and private sectors. Public-private partnership in managing risks arising from natural disasters should be explored in areas such as insurance, strengthening physical assets, issuing extreme-weather warnings and sharing information on disaster risks and risk reduction strategies. Successful implementation of public-private partnerships in managing risks arising from natural disasters is crucial for the security and well-being of global supply chains and national economies in the future.

References

- Abe, Masato (2012). "Global Supply Chains - A Big Opening for Asia's Small Firms. Article for Fung Global Institute". Fung Global Institute. Available from <http://www.fungglobalinstitute.org/publications/articles/global-supply-chains---a-big-opening-for-asias-small-firms-251.html>
- Alesch, Daniel. J., James. N. Holly, Elliott Mittler and Robert Nagy. (2001). *Organizations at Risk: What happens when small businesses and not-for-profits encounter natural disasters*. Small Organizations Natural Hazards Project, University of Wisconsin-Green Bay. Fairfax: Public Entity Risk Institute.
- Asia-Pacific Economic Cooperation (2010). "Public-Private Partnerships and Disaster Resilience", Report from the APEC Workshop on Public Private Partnerships and Disaster Resilience Bangkok 24-29 August, 2010. Singapore: APEC. Available from http://www.csr-asia.com/report/APECFinalOutcomesReport_201103.pdf
- Baez, Javier, Alejandro de la Fuente and Indhira Santos (2010). "Do Natural Disasters Affect Human Capital? An Assessment Based on Existing Empirical Evidence". *Discussion Paper*. No. 5164. Bonn: The Institute for the Study of Labor (IZA). Available from <http://ftp.iza.org/dp5164.pdf>
- Berkmen, Pelin, W. Raphael Lam, Chad Steinberg and Kiichi Tokuoka (2011). "Japan: Selected Issues", IMF Country Report No. 11/182, Washington D.C.: International Monetary Fund. Available from <http://www.imf.org/external/pubs/ft/scr/2011/cr11182.pdf>
- Blomquist, John, Marijn Verhoeven, Juan Pablo Cordoba, César Bouillon and Patricia Moser (2002). "Social safety nets in response to crisis: lessons and guidelines from Asia and Latin America". In *Towards Asia's Sustainable Development: The Role of Social Protection*. Paris: OECD.
- Canis, Bill (2011). *The Motor Vehicle Supply Chain: Effects of the Japanese Earthquake and Tsunami*. Washington D.C.: Congressional Research Service. Available from <http://www.oesa.org/Doc-Vault/Industry-Information-Analysis/Japan-Earthquake-Information/CRS-The-Motor-Vehicle-Supply-Chain-Effects-of-the-Japanese-Earthquake-and-Tsunami-May-23.pdf>
- Catto-Smith (2012). "Rethinking Security: Supply Chain in Crisis". *Bangkok Post*. 4 April 2012.
- Cavusgil, Knight and Riesenberger (2008). *International Business: Strategy, Management, and the New Realities*. Upper Saddle River: Pearson/Prentice Hall
- CEIC (2012a). *Global database Thailand*. Available from <http://www.ceicdata.com/>
- CEIC (2012b). *Japan Manufacturing Production Index*. Available from <http://www.ceicdata.com/>
- Cerno (2010). "World-wide Exposure: The Top Areas of Underinsurance". White Paper. Cerno Ltd. Available from <http://www.cerno.co/TheTopAreasofUnderinsurance.pdf>

- Chartered Insurance Institute (2009). "Small and medium enterprises" in *Coping with climate change risks and opportunities for insurers*. The Chartered Insurance Institute (CII). Available from: <http://www.cii.co.uk/ciiimages/public/climatechange/ClimateChangereportChp8.pdf>
- Chongvilaivan, Aekapol (2012). "Thailand's 2011 flooding: Its impact on direct exports, and disruption of global supply chains". *ARTNeT Working Paper No. 113*, May, Bangkok: UNESCAP. Available from www.artnetontrade.org
- Christopher, Martin (2011). *Logistics and Supply Chain Management*, 4th Edition. Harlow: Pearson Education Limited.
- Clay, Edward and Charlotte Benson (2005). "After Shocks: Natural Disaster Risk and Economic Development Policy", Overseas Development Institute Briefing Paper, London: ODI. Available from <http://www.odi.org.uk/resources/docs/2596.pdf>
- Davis, Nigel (2011). "Japan earthquake's impact on supply chains". *ICIS News*. 21 March 2011. Available from <http://www.icis.com/Articles/2011/03/21/9445788/insight-japan-earthquakes-impact-on-supply-chains.html>
- Economist Intelligence Unit (2005). *The new face of purchasing*. An Economist Intelligence Unit White Paper sponsored by SAP. *The Economist*. Available from: http://www.bostonstrategy.com/images/Jacoby-New_Face_of_Purchasing.pdf
- Endo, Koji (2011). "Viewpoint: How Japan's car industry almost shut down". Advanced Research Japan. *British Broadcasting Corporation*. 18 May 2011. Available from: <http://www.bbc.co.uk/news/business-13421065>
- General Motors (2012) *Vision in Motion - General Motors 2011 Annual Report*. Available from http://www.gm.com/content/dam/gmcom/COMPANY/Investors/Stockholder_Information/PDFs/2011_GM_Annual_Report.pdf
- Healey, Michael and Brian W. Ilbery (1990). *Location and Change: Perspectives on Economic Geography*, Oxford, New York: Oxford University Press.
- Hendricks, Kevin B. and Vinod R. Singhal (2005). "An Empirical Analysis of the Effect of Supply Chain Disruptions on Long-Run Stock Price Performance and Equity Risk of the Firm", *Production and Operations Management*, vol. 14, Issue 1 (March 2005), pp. 35–52. Available from <http://onlinelibrary.wiley.com/doi/10.1111/j.1937-5956.2005.tb00008.x/abstract>
- Japanese Chamber of Commerce Bangkok (2012). *Thai Koku Nikkei Kigyō Keiki Doukou Chousa: 2011 Shimoki*, JCCB, 29 February 2012.
- Japan External Trade Organization (2012). "Survey of business sentiment on Japanese corporations in Thailand for the 2nd half of 2011", JETRO. Available from http://www.jetro.go.jp/thailand/e_survey/pdf/jccaut11eng.pdf

- Japan, Ministry of Health, Labour and Welfare (2012). “‘Japan As One’ Work Project: Outline of the Measures Taken in the 3rd Stage of the Project, as decided by the Conference on the Promotion of Employment Support and Job Creation for Disaster Victims.” Press Release, 25 October 2011. Available from: <http://www.mhlw.go.jp/english/topics/2011eq/dl/emp04.pdf>
- Jones Kershaw, Patricia (2005). *Creating a Disaster Resilient America: Grand Challenges in Science and Technology: Summary of a Workshop*, Washington, DC: The National Academies Press. Available from <http://www.nap.edu/openbook.php?isbn=0309096634>
- Jones, Ronald W. and Henryk Kierzkowski (1990). “The Role of Services in Production and International Trade: A Theoretical Framework”. *RCER Working Papers Series*, University of Rochester – Center for Economic Research. Available from http://www.econ.rochester.edu/people/jones/Role_of_Services.pdf
- Kimura, Fukunari and Mitsuyo Ando (2005). “Two-dimensional Fragmentation in East Asia: Conceptual Framework and Empirics”. *International Review of Economics and Finance*, vol. 14, No. 3, pp. 317–348. Available from <http://www2.e.u-tokyo.ac.jp/~seido/output/Ishikawa/046.pdf>
- Kirchberger, Martina (2011). “Natural disasters and labor markets”. Conference Paper for Spring Meeting of Young Economists 2011. Hamburg. Available from http://www.smye2011.org/fileadmin/fe_user/mkirchberger/con_paper156.pdf
- KPMG International (2009). *Global M&A: Outlook for Automotive*. Available from <http://www.kpmg.com/Ca/fr/IssuesAndInsights/ArticlesPublications/Documents/global%20ma%20-%20automotive.pdf>
- Lewis, Christopher M. and Kevin C. Murdock (1996). “Contracts in Discretionary Reinsurance Markets for Natural Disasters”. *The Journal of Risk and Insurance*, vol. 63, No. 4, (December 1996), pp. 567-597.
- Mason, Byron, ed. (2006). “Community Disaster Resilience: A Summary of the March 20, 2006 Workshop of the Disasters Roundtable”, Washington, DC: The National Academies Press. Available from http://www.nap.edu/catalog.php?record_id=11769
- Narayanan, Badri (2011). “Impact of the Japan Earthquake on the Steel Industry”, Beroe-inc. Available from: http://www.beroe-inc.com/Insights/WhitePapers/White%20Paper%20on%20Impact%20of%20the%20Japan%20Earthquake%20on%20the%20Steel%20Industry_March%202011.pdf
- Nissan (2011). “Report on the Impact of Flooding in Thailand on Nissan Operations (Report #3)”, 4 November 2011. Available from http://www.nissan-global.com/EN/NEWS/2011/_STORY/111104-01-e.html
- Okada, Satoru (2011). *Hisai Chusyou Kigyou no Fukkyuu: Fukkou Shiensaku*, <http://www.ndl.go.jp/jp/data/publication/issue/pdf/0723.pdf>

- Pelling, Mark, Alpaslan Özerdem and Sultan Barakat (2002). “The macro-economic impact of disasters”, *Progress in Development Studies* vol. 2, No. 4, pp. 283–305. Available from: http://www.relooney.info/SI_Pakistan-Floods/0-Economic-Impact_1.pdf
- Phaup, Marvin and Charlotte Kirschner (2010). “Budgeting for Disasters: Focusing on the Good Times”. *OECD Journal on Budgeting*, Volume 2010/1.
- Reneas (2011). *Reneas Annual Report 2011*. Available from: http://www.reneas.com/media/ir/library/pdf/annual/2011_annual_all.pdf
- Rokumoto, Kayo (2012). *Japan: Employment Situation One Year after the Earthquake*. The National Association of State Workforce Agencies. Available from: http://www.naswa.org/assets/utilities/serve.cfm?gid=c571bba5-9e5e-46f9-a340-9db5c4fbdd08&save=1&dsp_meta=0
- Rosenthal, Stuart S. and William C. Strange (2001). “The Determinants of Agglomeration”, *Journal of Urban Economics*, vol. 50, No. 2, pp. 191-229.
- Sathirathai, Santitarn (2012). *Thailand’s post-flood recovery: Turning the tide*. Credit Swiss Economic Research, 13 February 2012. Available from https://doc.research-andanalytics.csfb.com/docView?language=ENG&format=PDF&document_id=804818550&source_id=em&serialid=%2FuPFdB3n5KRuP7HWRGJetxYWtNJETP4p9yMKQXENObY%3D
- Skoufias, Emmanuel (2003). “Economic Crises and Natural Disasters Coping Strategies and Policy Implications”, *World Development*, vol. 31, No. 7, pp. 1087–1102. Available from: <http://info.worldbank.org/etools/docs/library/78330/3rd%20Workshop/Srmafrica/paristwo/pdf/readings/weather.pdf>
- Snyder, Jesse (2011). “Automakers slash N.A. output schedules”, *Automotive News*. 25 April 2011. Available from: <http://www.autonews.com/apps/pbcs.dll/article?AID=/20110425/OEM01/304259999/1424&template=printart>
- TechTarget (2002). Definition: turnkey. Available from: <http://searchmobilecomputing.techtarget.com/definition/turnkey>
- Thai Business Council (2011). “Floods affect international rice supplies”. Available from <http://www.tbcaae.com/news4.html>
- Thailand, Office of Small and Medium-Sized Enterprises Promotion (OSMEP) (2011). *The White Paper on Small and Medium Enterprises Of Thailand in 2010 and Trends 2011*. Available from <http://eng.sme.go.th/SiteCollectionDocuments/White%20Paper%20on%20SMEs/White%20Paper%20on%20SMEs%202010%20and%20Trends%202011/Executive-Summary-Eng.pdf>
- Thailand Ministry of Foreign Affairs (2011). *Summary of the Government’s Relief and Recovery Plan and Package* (as of 25 October 2011). Available from <http://www.mfa.go.th/web/3082.php/148.php?id=41250>

- Thompson, Mary Anne (2012). "Employment Outlook: Japan", *Going Global*. Available from <http://www.goinglobal.com/articles/1017/>
- Toyota (2012). *Annual Report 2011*. Available from http://www.toyota-global.com/investors/ir_library/annual/pdf/2011/highlights
- Toyota (2011). "Toyota Vehicle Production Adjustments Due to Floods in Thailand", 4 November 2011. Available from <http://www2.toyota.co.jp/en/news/11/11/1104.html>
- Vitasek, Kate (2006). "Supply Chain and Logistics Terms and Glossary", *Supply Chain Visions*. Available from <http://www.logisticsservicelocator.com/resources/glossary03.pdf>
- Wassener, Bettina and Chris V. Nicholson (2011). "In Quake's Aftermath, Japanese Companies Try to Take Stock". *New York Times*, 11 March 2011. Available from http://www.nytimes.com/2011/03/12/business/global/12yen.html?_r=1&partner=rss&emc=rss
- Wedawatta, Gayan, Bingunath Ingirige and Dilanthi Amaratunga (2010). "Building up resilience of construction sector SMEs and their supply chains to extreme weather events", *International Journal of Strategic Property Management*, vol. 14, Issue 4. Available from <http://usir.salford.ac.uk/9767/1/734.pdf>
- World Economic Forum (2008). *Global Risks 2008 A Global Risk Network Report*. Cologny/Geneva: World Economic Forum. Available from <https://members.weforum.org/pdf/globalrisk/report2008.pdf>

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Fax.: +66 2 2881027
E-mail: artnetontrade@un.org
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