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Geographic Diversification of Supply Chains of Japanese Firms^{*}

Yasuyuki Todo[†] and Hiroyasu Inoue[‡]

Abstract

Geographically expanded supply chains incur a risk of inflows of negative economic shocks from other regions and countries, but this risk can be alleviated by geographically diversifying supply-chain partners more. Although domestic supply chains of Japanese firms started to be diversified recently, firms in domestic supply chains still agglomerate in Tokyo substantially. Moreover, international supply chains of Japanese firms considerably rely on Chinese suppliers and clients. Therefore, more geographic diversification of supply chains of Japanese firms is suggested, including diversifying within Japan, reducing the reliance on China, and strengthening links with developed countries, with the help of the government.

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1. Introduction

In the past few decades, firms in the world expanded supply chains across countries, procuring materials, parts, and components from overseas, in some cases from their own foreign subsidiaries but in others from independent local firms, and exporting products to overseas. The expansion of global supply chains enables firms to minimize the cost of production by sourcing labor- and skill-intensive activities to labor- and skill-abundant countries, respectively (Baldwin 2016).

However, risks of global supply chains have been recognized, because economic shocks originating from a region are observed to propagate to other regions and countries through geographically expanded supply chains. When an economic shock reduces production of a firm, its suppliers are affected because of lack of demand, and its client firms are also affected because of lack of supply of material, parts, or components. The propagation of economic shocks through supply chains was paid particular attention to in 2011 when the Great East Japan earthquake led to stagnation of production in regions that were not directly hit by the earthquake due to supply-chain disruptions. The negative production effect reached foreign countries: some automobile manufacturers in the United States, South Korea, and Thailand paused production because of lack of supply from the disaster-hit areas in Japan (Nikkei Newspaper, May 3, 2011).

Recently, risks of global supply chains are highlighted further, as COVID-19 spread across countries. Notably, at the early stage of the pandemic, the Chinese government "locked down" many cities and regions to prevent its spread, substantially restricting social and economic activities and thus reducing production. Because some locked-down cities, such as Wuhan, the epicenter of the pandemic, are hubs of global supply chains in the electric equipment and automobile industries, client firms in other countries had to shrink their production because of lack of supply of inputs from China. In addition, some other firms shrank production because of lack of demand of Chinese consumers under lockdown (Kubono and Chikaoka 2020).

Another notable risk of global supply chains stems from the US-China economic decoupling. Because the United States prohibits exports of inputs to Huawei, a Chinese giant firm in the information and communication technology (ICT) industry, and other high-technology firms, transactions with Chinese firms may be associated with a risk of losing the US market.

Given these circumstances, this paper provides policy suggestions to create resilient and performance-enhancing supply chains of Japanese firms based on the recent studies on the effect of supply chains and current characteristics of their domestic and international supply chains.

The rest of the paper is organized as follows. Section 2 reviews the literature on the effect of supply chains on resilience and performance of firms and argues the effective structure of supply chains. Section 3 shows changes in the characteristics of domestic and international supply chains of Japanese firms and highlights the current characteristics. Section 4 provides policy and managerial suggestions to supply chains of Japanese firms based on Sections 2 and 3. Section 5 summarizes and concludes the paper.

2. Effects of Supply Chains on Firms' Resilience and Performance

2.1 *Supply chains resilient to natural disasters*

A growing strand of literature investigates whether negative economic shocks due to natural disasters propagate through supply chains. Barrot and Sauvagnat (2016) is a seminal paper in the literature, using firm-level data for

the United States from 1978 to 2013 and testing whether firms that are outside of areas hit by major natural disasters but are suppliers or clients of firms in the disaster areas reduced production. Supply chains examined in their analysis are restricted to those among firms located in the US and do not include those across countries. They confirm downstream propagation from suppliers to their clients, finding that sales growth of firms with any supplier hit by a disaster declines by 2 percentage points. They also find that the propagation effect is larger when suppliers are in industries where the share of differentiated goods defined by Rauch (1999) is large. This result implies that when intermediate products provided by disaster-hit suppliers are specific, their clients find it difficult to substitute for the specific products and hence reduce their production. Further, Barrot and Sauvagnat (2016) find that when a supplier of any customer of a firm is hit by a disaster, the firm reduces its sales growth by four percentage points. This "horizontal" propagation suggests that negative effects can diffuse to firms linked indirectly to disaster-hit firms through supply chains.

Carvalho et al. (2016) apply a similar approach to supply-chain relationships among 649 thousand Japanese firms collected by Tokyo Shoko Research (TSR), utilizing the case of the Great East Japan earthquake in 2011 as a source of negative shocks. They find both downstream and upstream propagation: Firms outside the disaster-hit areas reduced sales growth when they are linked with any supplier or client in the disaster-hit areas. Further, the negative effect of disaster-hit firms is found to reach their indirect suppliers and clients three steps away through supply chains.

These two studies suggest that economic shocks widely propagate through supply chains. To highlight propagation across regions, Inoue and Todo (2019a) apply the TSR data for supply chains among 888 thousand firms in Japan to an agent-based model and simulate propagation of the negative shock due to the Great East Japan earthquake within Japan. The agent-based model assumes that when a firm shrinks its production due to the earthquake, its suppliers shrink production because of shortage of demand. Its client firms should also shrink production because of shortage of supply of intermediate goods, unless they can replace disaster-hit suppliers with other current suppliers in the same industry. In other words, it is assumed that because firms in the same industry produce the same good, suppliers in the same industry are substitutable.

They first estimate the values of the parameters used in the model by fitting the simulated trajectory of aggregate production of Japan after the earthquake to its actual trajectory. They find that although the direct loss in value-added production due to the earthquake was approximately 100 billion yen, or 0.02 percent of GDP, the indirect loss due to propagation through supply chains was 11.4 trillion yen, or 2.32 percent of GDP. Their geographic presentation of the simulation results indicates that firms all over Japan were heavily affected. These results emphasize that a negative economic shock in a particular region propagates across regions, leading to a total effect far more substantial than the direct effect. Therefore, the propagation effect through supply chains should not be undervalued.

Inoue and Todo (2019a) further investigate what network structure promotes propagation, finding three factors. First, because the distribution of the number of suppliers and clients of each firm is fat-tailed, following a power law, there are several hub firms that are linked with more than 1,000 firms although its median is only five. In this scale-free network, once a shock reaches a hub firm, it quickly spreads to many firms linked with the hub. The role of scale-free property is confirmed by an experiment in which hypothetical supply chains without a scale-free property result in negligible propagation. Second, as found in Barrot and Sauvagnat (2016), supplier substitutability largely affects propagation. When no supplier substitutability is assumed in their simulations, i.e., each firm is

assumed to produce a specific product, the propagation effect is greater and lasts longer. When complete substitutability is assumed, i.e., all firms produce the same product, the propagation is negligible. Finally, loops in supply chains are found to intensify the propagation. Usually, supply chains are considered to have a tree-like structure, but in practice, there are many loops in a complex manner because supplier firms often purchase final goods, such as machinery, computers, and automobiles, for production. When a shock happens in a loop, it can circulate, be magnified and long lasting. This is confirmed by an experiment in which hypothetical tree-like supply chains do not generate much propagation.

All these three studies above focus on domestic supply chains due to availability of data. Kashiwagi, Todo, and Matous (2018) examine propagation of shocks across countries, using supply-chain data for approximately 9,000 major firms in the world. Using an econometric approach as used in Barrot and Sauvagnat (2016) and Carvalho et al. (2016), they examine whether the shock by Hurricane Sandy that hit the US east coast in 2012 propagated within and beyond the US through supply chains. Although they confirm the findings of Barrot and Sauvagnat (2016) and Carvalho et al. (2016) that the shock propagated upstream and downstream through supply chains within the US, they find no statistically significant evidence of international propagation. That is, firms that were located outside the US and linked with disaster-hit firms in the US did not reduce sales growth after the hurricane. Further, Kashiwagi, Todo, and Matous (2018) find that firms in the US linked with disaster-hit firms did not reduce post-disaster sales growth substantially when they were also linked with non-US firms through global supply chains. In other words, firms directly linked with foreign firms, regardless of whether they are located within or outside the source country of an economic shock, can mitigate propagation of the shock through supply chains. When any of the suppliers or clients of a globalized firm is affected by a shock, it can be replaced with another relatively easily because the globalized firm may be linked with or informed of firms in countries not affected by the shock. This implication is consistent with the finding of Barrot and Sauvagnat (2016) and Inoue and Todo (2019a) that substitutability of suppliers is a key factor to mitigate propagation through supply chains.

So far, we have looked at the literature on propagation of negative economic shocks. However, supply chains can also be a channel of positive economic aspects. Todo, Nakajima, and Matous (2015) examine how supply chains affected the recovery of small and medium enterprises (SMEs) in the areas directly hit by the Great East Japan earthquake, combining the TSR data on supply chains and unique firm-level data for SMEs collected after the earthquake. They find that SMEs resumed production earlier after the earthquake when they are linked with suppliers or clients outside the disaster-hit areas, while links with those in the disaster-hit areas had no such effect on recovery. They further find that SMEs were more likely to receive physical and financial support from other firms if they were linked with more clients outside the disaster-hit areas. These findings suggest that when firms are linked with distant partners, they may be negatively affected by a shock originating from distant regions, but when they are directly affected by a shock, they may receive positive support from the distant partners and hence alleviate the negative effect.

Moreover, Todo, Nakajima, and Matous (2015) reveal that sales growth for the six months after the earthquake was higher for SMEs linked with more firms in the disaster-hit areas, while links with those outside the disaster-hit areas were not effective to sales growth. Because the median number of days without operation after the earthquake is 5, the effect of supply-chain links on resuming operation should be viewed as a short-term effect, while their effect on sales growth for the subsequent six months indicates a medium-term effect. The findings that links with distant partners promote short-term recovery while links with neighboring partners stimulate medium-term sales

growth suggest that diversity of partners is helpful to create resilient supply chains.

2.2 *Supply chains resilient to the spread of COVID-19*

As COVID-19 spread across countries rapidly in the early 2020, many countries, 158 as of April 2020 according to Hale et al. (2020), locked down cities and regions, requiring closing temporarily or working from home for some sectors. These lockdowns apparently reduce production in the locked-down regions but also negatively affected production in others by supply-chain disruptions. The propagation of negative economic shocks due to the lockdowns has also been examined in the recent literature (Bonadio et al. 2020, Guan et al. 2020, McCann and Myers 2020, McKibbin and Fernando 2020).

Guan et al. (2020), for example, utilize international input-output tables at the country-sector level and estimate impacts of lockdowns of heavily infected countries on production in the world economy. According to their estimates, if only China had imposed strict lockdown for two months, other countries would have also been affected through input-output linkages, and hence the world GDP would have declined by 3.5 percent. If Europe and the United States had additionally imposed lockdown, the world GDP would have declined by 13 percent. In this scenario, because of a large decline in production of the German automotive industry, its upstream and downstream industries in other countries, such as the automotive industry in Czech Republic and the consumption-good industry in the US and China, are heavily affected. Although Guan et al. (2020) clearly shows that negative economic shocks due to lockdown propagate through global supply chains across countries, affecting countries without any lockdown, they ignore firm-level supply chains but focus on industry-level input-output linkages. Accordingly, their estimate of the propagation effect may be undervalued, because propagation is intensified by complex network characteristics, such as scale-free properties, supplier substitutability, and loops (Inoue and Todo 2019a, b).

To overcome the disadvantage of Guan et al. (2020), Inoue and Todo (2020) apply the simulation framework of Inoue and Todo (2019a) using supply chains of nearly 1 million Japanese firms to examine propagation of the negative economic effect of a strict lockdown of Tokyo to other regions of Japan not under lockdown. They find that a lockdown of Tokyo for 1 month could reduce the value added production in Tokyo by 9.3 trillion yen directly and further the total GDP of Japan by 18 trillion yen indirectly by propagation through supply chains, leading to a total loss in GDP by 28 percent. This simulation result indicates that when a mega city like Tokyo is locked down, many other regions linked closely with the mega city through supply chains are heavily affected.

Inoue, Murase, and Todo (2020) further investigate what network characteristics of a region can mitigate propagation of the effect of lockdowns of other regions. For this purpose, they assume that after all prefectures in Japan are locked down, only one prefecture lifts its lockdown and examine how the economic recovery of the prefecture is affected by its network characteristics. They find that the economic recovery of a prefecture is larger when more firms are linked within the prefecture and form loops in the prefecture, or when fewer firms are linked with those in other prefectures. These findings suggest that when a prefecture is more isolated from others in supply chains, it can mitigate propagation of negative shocks. Moreover, prefectures in which firms are located in more upstream positions can recover less. This implies that because more upstream firms, i.e., suppliers of simpler parts, are more likely to be smaller and linked with fewer firms, they cannot mitigate the negative effect of locked-down clients. When locked-down suppliers of firms in a prefecture are less likely to be replaced with those in the prefecture, its recovery is smaller. These findings confirm the importance of supplier substitutability in mitigating propagation of negative economic shocks through supply chains.

2.3 Are geographically expanded supply chains vulnerable to economic shocks?

The literature in the previous subsections shows that geographically expanded supply chains are most likely to increase the risk of inflows of economic shocks originating from other regions and countries. However, it also suggests that such risk can be alleviated by more geographic diversification of supply-chain partners, because supplier substitutability is the key to supply-chain resilience. Suppose, for example, that firms are linked with suppliers and clients in various different regions and countries. Then, when some of their suppliers and clients are negatively affected by a region- or country-specific shock, they may be able to replace the affected partners with others in unaffected regions or countries.

Even in the case of a world-wide shock, such as the Global Financial Crisis and the spread of COVID-19, the timing of the realization of its negative effect in each country may differ. For example, COVID-19 first spread in China in January and February, 2020 but has been controlled since March, while its spread has become substantial in other countries since March or April. Accordingly, imports from China to Japan, including those of materials, parts, and components in various industries, drastically declined in February, 2020, by 47 percent compared with those in February, 2019, because at that time many major industrial cities in China were locked down and largely shrank production. In the same month, imports from the US and ASEAN did not decline much because of less infection in these countries. Later, when China successfully controlled COVID-19 although other countries became seriously infected, imports from China recovered while imports from other countries declined (Figure 1). Therefore, by diversifying trade partners, firms could alleviate mitigate supply-chain disruptions in the world-wide pandemic.

Figure 1: Percentage change in of imports from selected countries and regions to Japan
(compared with those in the same month in the previous year)



Source: Ministry of Finance of Japan, Trade Statistics of Japan.

2.4 Effects of Supply Chains on Firm Performance

Firms are apparently concerned about their performance, in addition to their resilience. Therefore, it is important to know the structure of supply chains that can enhance firm performance. In this regard, there are two classes of thoughts. First, Coleman (1988) and Putnam (1993) argue that in a network where individuals trust each other, or in a society with thick social capital, knowledge and information are actively exchanged, resulting in higher social and economic development. Trust can be promoted in a dense network where most individuals (or firms) within a

group are connected with each other. Centola (2010) confirms that human behaviors diffuse among individuals more quickly in a dense network than in a small-world network where most individuals are indirectly connected in a small number of steps.

A good example of dense supply chains is *keiretsu*, meaning "group" in Japanese, or supplier-client relationships typically observed in Japan. In *keiretsu* relationships, suppliers and clients form an exclusive group, and suppliers mostly sell their material, parts, and components to particular clients in the same *keiretsu* for a long time (Dyer and Nobeoka 2000). For example, the share of sales of Denso and Aisin, two major long-time direct suppliers of Toyota, to Toyota in their total sales exceeds 50 percent. In *keiretsu*, clients often pay higher prices than in the market so that suppliers are incentivized to provide high-quality inputs and not to sell them to others. This long-term and strong tie enables clients and suppliers to work closely together for development of new firm- or product-specific inputs. Accordingly, *keiretsu* relationships provide a win-win situation to both clients and suppliers and was a major driver of high economic growth of Japanese firms in the 1980s (Aoki 1988).

However, some others argue that relationships of individuals and organizations with "outsiders" that are socially or geographically far from their own groups improve their performance through inflows of new knowledge and information from the outsiders. For example, Granovetter (1973), one of the most cited papers in social science, find that job seekers obtain most valuable information through "weak ties," ties with people who are not very familiar. Burt (1992) also argues that persons who bridge different groups play a significant role in information dissemination. Based on this argument, Burt (2004) empirically shows that persons bridging different groups tend to perform better than others confined within a group. Using the TSR data for supply chains in Japan, Todo, Matous, and Inoue (2016) show that sales growth of and the number of patents granted to firms linked with distant suppliers or clients is higher than others, possibly because of inter-regional knowledge diffusion. They also find that when a firm belongs to a dense sub-network, its performance is lower than otherwise. Although not focusing on supply chains but on research collaboration networks of firms, Iino et al. (2021) reveal that a firm's collaboration with foreign partners substantially improve the quality of its innovation measured by patent citations, although the density of its collaboration network is negatively correlated with the quality.

The contrasting results on the structure of performance-enhancing networks in the literature suggest that dense links or external links with outsiders perform better, depending on the situation. Todo, Nakajima, and Matous (2015) mentioned in Section 2.1 show that after the Great East Japan earthquake, supply-chain ties with distant partners had a short-run effect on resuming operation while dense ties within the earthquake-hit areas had a medium-run effect on sales growth. Phelps (2010) and Rost (2011) find complementarity between dense and external links in their analysis on the effect of firms' research alliance on innovation. Therefore, the literature suggests that while geographically diverse supply-chain partners most likely magnify firm performance because of their knowledge, a dense network in a region or group may also play an important role by fostering trust in the network.

3. Changes in Characteristics of Supply Chains of Japanese Firms

The previous section highlighted the importance of diversity of supply-chain partners in promoting performance and resilience of firms. Let us now evaluate domestic and international supply chains of Japan from this perspective.

3.1 Domestic supply chains in Japan

Although *keiretsu* relationships can enhance firm performance, as explained in Section 2.4, they may not be resilient

to economic shocks because of difficult substitution of suppliers and clients. When suppliers or clients are damaged by an economic shock, their partners cannot replace them with others because inputs produced by *keiretsu* suppliers are often specific to their clients thanks to their collaboration to innovate new inputs. This risk was highlighted after the Great East Japan earthquake when many Japanese firms outside the earthquake-hit areas were forced to stop production because of supply-chain disruptions. Accordingly, Japanese firms, particularly those in the automobile industry, started to diversify their supply-chain partners for resilience after the earthquake (Shiromizu 2015). Standardization or modularization of parts across car types that had been implemented to minimize production costs for several decades by European automobile manufacturers (Takeishi and Fujimoto 2003) also motivated Japanese manufactures to follow. For example, in March 2013, Toyota announced to increase the share of standardized parts to 20-30 percent in 2015 and to 70-80 percent eventually (Nikkei Newspaper, March 28, 2013). Honda also promoted standardization of parts and started to procure parts from the world market, rather than from exclusive *keiretsu* partners (Nikkei Newspaper, February 4, 2013).

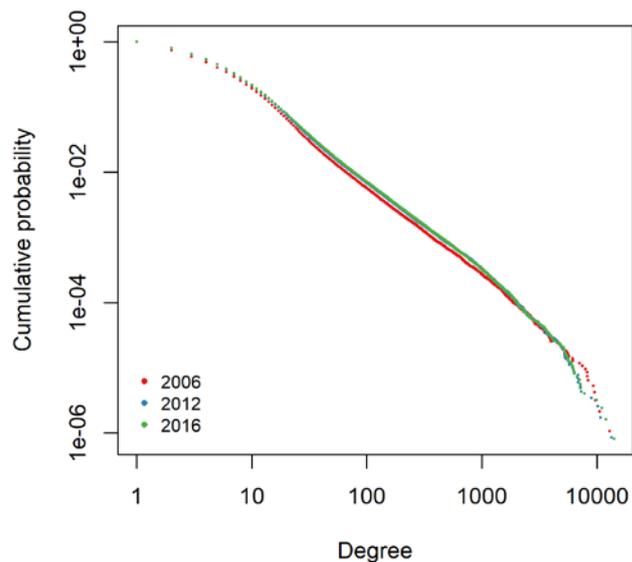
To confirm this trend, we use the TSR data and examine changes in the distributions of the degree, the constraint measure of Burt (1992, 2004), and the local clustering coefficient. The degree is defined as the number of supply-chain partners, roughly indicating the degree of diversity of partners. Burt's constraint measure for node i is defined as follows:

$$C(i) = \sum_{j \in V_i, j \neq i} \left(p_{ij} + \sum_{q \in V_i, q \neq i, j} p_{iq} p_{qj} \right)^2 .$$

where V_i is the set of nodes directly connected with node i , and the number of such nodes is represented by N_i . The weight of the link between nodes i and j is denoted by p_{ij} , usually simplified as $1/N_i$ assuming the same weight for all links. If the second term in the parenthesis of the definition is ignored, this measure is the same as the Herfindahl-Hirschman index, defined by the sum of the squared share, that indicates the degree of agglomeration or the inverse degree of diversification. The second term indicates that this measure incorporates diversity of indirect partners. As the direct partners of node i are connected with more partners, the second term becomes smaller. Therefore, this measure is smaller when node i are connected with more partners and when i 's partners are connected with more partners. The local clustering coefficient is an index to measure the density of each node's ego-network. It is defined as the ratio of the number of pairs of nodes that are connected with node i and are also connected with each other to the number of all possible pairs of firms that are connected with node i . For example, if firm i is linked with three firms, among which only two are linked, then i 's local clustering coefficient is $1/3$.

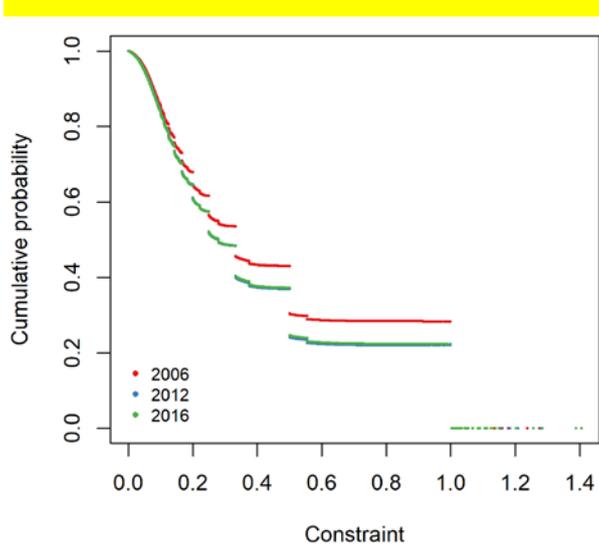
We find that while the distributions of the degree and the cluster coefficient were relatively stable in the period from 2006, five years before the Great East Japan earthquake, to 2012 and to 2016 (Figures 2 and 4), the distribution of Burt's constraint measure changed substantially from 2006 to 2012 (Figure 3). Note that because the distribution for observations in 2012 is almost identical to that for 2016 in these figures, the distribution for 2012 is not clearly visible. Burt's constraint measure is smaller on average in 2012 and 2016 than in 2006, implying that supply-chain partners are more diversified over time, particularly after the Great East Japan earthquake in 2011. The clustering coefficient becomes larger over time, suggesting that supply-chain partners become more densely connected, but its change is not large, relative to the change in Burt's constraint measure.

Figure 2: Changes in the degree distribution over time



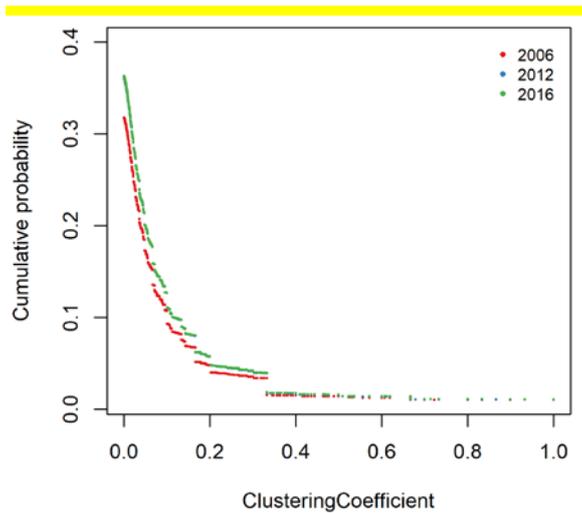
Source: Tokyo Shoko Research.

Figure 3: Changes in the distribution of Burt's constraint measure over time



Source: Tokyo Shoko Research.

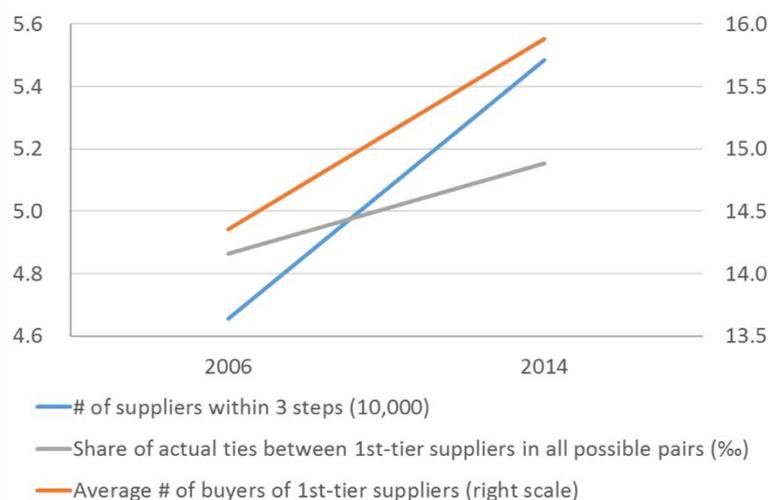
Figure 4: Changes in the distribution of the local cluster coefficient over time



Source: Tokyo Shoko Research.

Figure 5 shows changes in selected supply-chain characteristics of top five automotive firms in Japan from 2006 to 2014. The number of the top five auto makers' suppliers within three steps (i.e., their direct suppliers, suppliers of their suppliers and suppliers of suppliers of their suppliers) increased, indicating that they diversify their suppliers. Also, the average number of client firms of the top five makers' direct suppliers also increased, implying that suppliers are also diversifying their partners. Applying a stochastic actor-based model that can analyze factors of network dynamics (Snijders, Van de Bunt, and Steglich 2010) to the top 100 automotive firms in Japan, Matous and Todo (2017) find that dense connections among three firms (i.e., all of the three are linked with each other) in 2006 tend not to be kept in 2011 (although bilateral connections tend to be kept). This evidence suggests that the *keiretsu* relationships that are characterized as dense connections among *keiretsu* firms started to be dissolved. This tendency that firms have started to be linked with diverse partners, rather than exclusively with *keiretsu* partners, is favorable to the improvement of resilience of domestic supply chains of Japanese firms.

Figure 5: Changes in supply-chain characteristics of the top 100 automotive firms



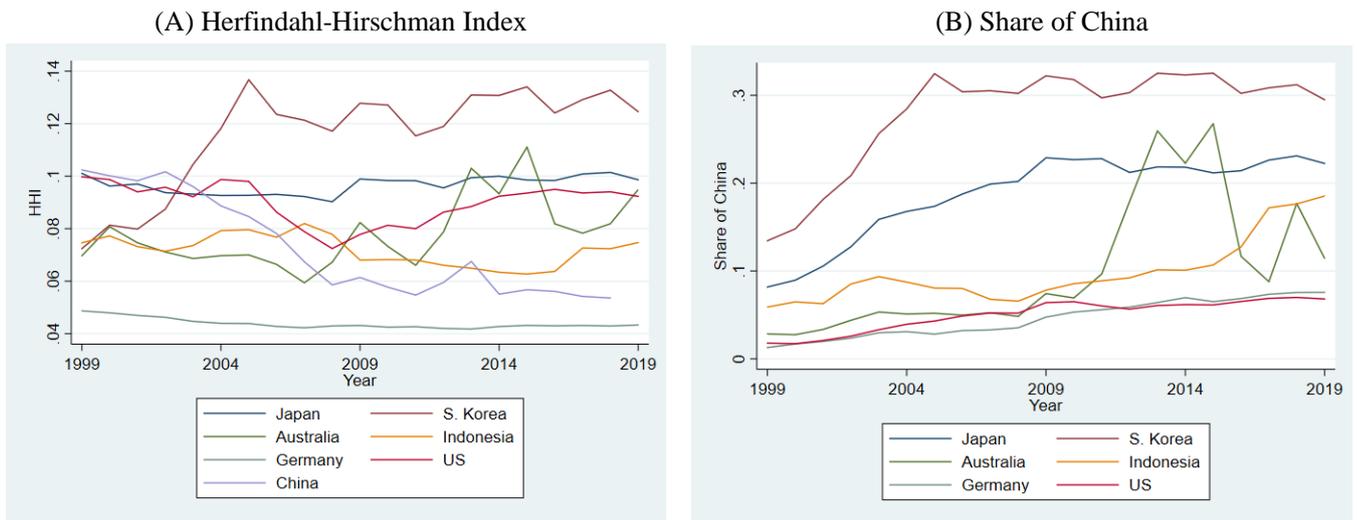
Source: Tokyo Shoko Research.

3.2 International supply chains of Japanese firms

Next, let us look at changes in international supply chains of Japanese firms, paying special attention to their geographic diversification. For this purpose, because comprehensive firm-level data for global supply chains are not available, we will rely on aggregate trade data at the country-pair level taken from UN Comtrade. Because we are interested in supply-chain relationships between countries, we focus on trade in intermediate goods defined as commodity codes 22 (industrial suppliers n.e.s., processed), 42 (parts and accessories of capital goods [except transport equipment]), and 53 (parts and accessories of transport equipment) of the Broad Economic Categories (BEC). To highlight the degree of diversity of partners of intermediate-good trade, we compute the Herfindahl-Hirschman Index (HHI) of bilateral exports and imports for Japan and selected countries for comparison, such as Australia, China, Germany, Indonesia, and the US. The HHI for exports from country i is defined as $HHI_i = \sum_j (\text{share of exports to } j)^2$ and thus presents the degree of concentration of export destinations. The HHI takes a value between zero and one, and a higher value indicates a higher degree of concentration. The HHI for imports to each country is defined in the same way. Besides the HHI, we also show the share of China in total exports and imports, because China has emerged as a major hub of global supply chains since its participation in the World Trade Organization (WTO) in 2000.

The left and right panels of Figure 6 illustrate changes in the HHI and the share of China, respectively, for exports from the seven countries from 1999 to 2019. Figures every five years are shown for the earlier period, whereas those in each year are shown for the recent six years. The HHI for exports from Japan was relatively stable the period, while the share of China increased substantially particularly in the 2000s, from eight percent in 1999 to 23 percent in 2009. The rise of China corresponds to the decline in the share of the US from 26 percent in 1999 to 13 percent in 2009 (Figure 7). The share of ASEAN has been quite stable, being 14.5 percent in 1999, 13.2 percent in 2009, and 14.1 percent in 2019. In other words, the dominance of the US was replaced by China, but the degree of diversification of clients of Japanese intermediate goods did not change much. Other countries also increased their reliance on China, although their HHIs did not change considerably. The HHI and the share of China is larger for Japan than others, except for South Korea that relies extensively on China. It should be emphasized that the HHI of China has declined drastically during the period, suggesting that China itself has diversified its supply-chain partners while other countries strengthened their reliance on China.

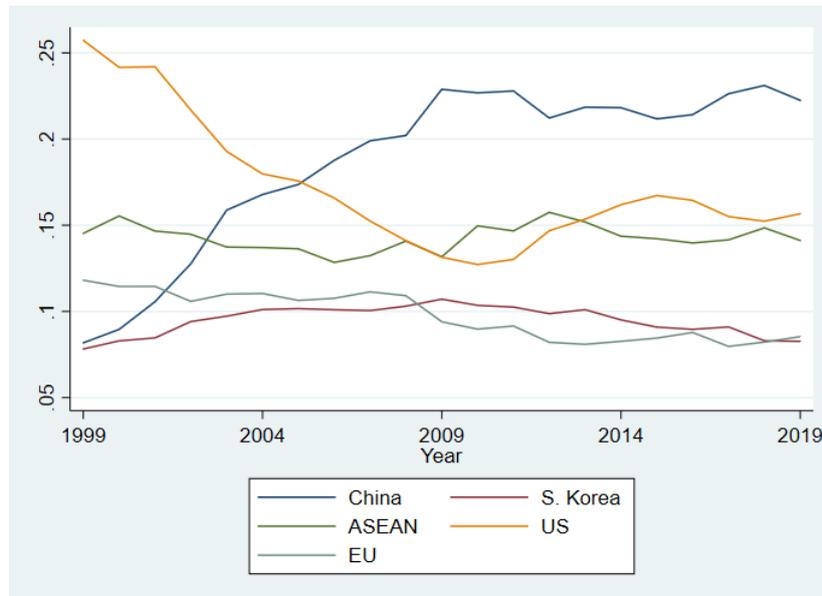
Figure 6: Herfindahl-Hirschman Index and the Share of China in Intermediate-Good Exports from Selected Countries



Source: UN Comtrade.

Note: Intermediate goods are defined as commodity codes 22, 42, and 53 of the Broad Economic Categories.

Figure 7: Shares of China, ASEAN, the US, and the EU in Intermediate-Good Exports from Japan

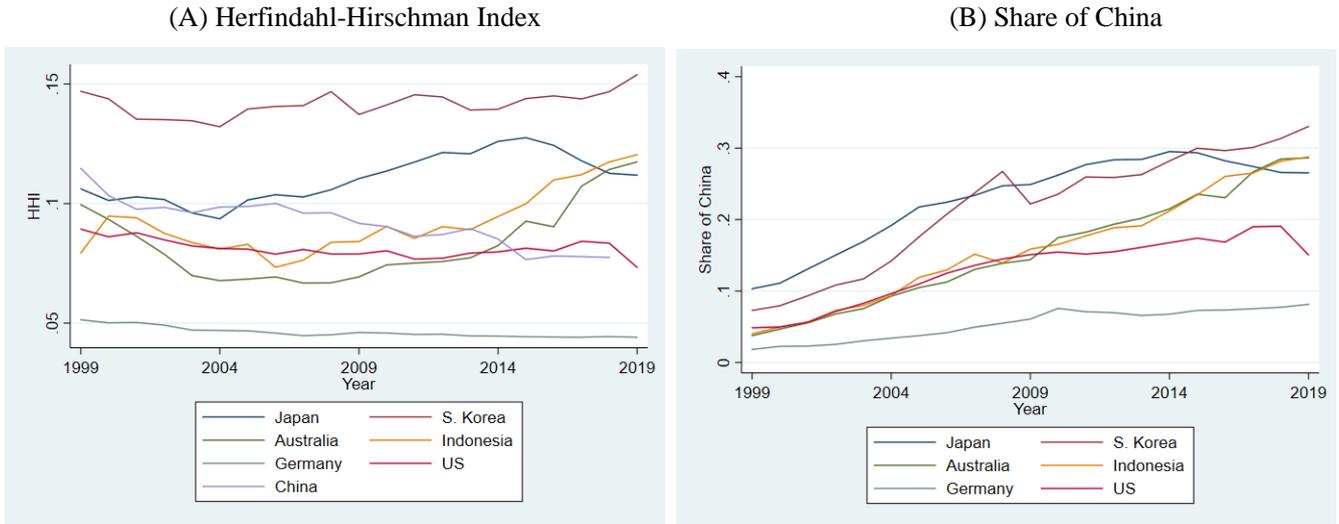


Source: UN Comtrade.

Note: Intermediate goods are defined as commodity codes 22, 42, and 53 of the Broad Economic Categories.

The HHI and share of China for intermediate imports to Japan and selected countries are shown in Figure 8. The HHI for Japan increased from 2004 to 2015 but then decreased more recently. This corresponds to the rise of the share of China until the first half of 2010s and its slight decline in the late 2010s. These changes suggest that Japanese firms have recently diversified suppliers of intermediate goods by reducing their reliance on China. In Figure 9 showing the share of selected countries and regions in Japan's imports of intermediate goods suggests that the recent decline in China's share was compensated by a slight increase in EU's share. Japan's decline in the HHI and share of China contrasts with the continuous increase in the two variables for other Asian countries, such as South Korea, Indonesia, and Australia. However, the HHI of Japanese intermediate imports is still far greater than that for the US, Germany, and China, indicating a large degree of geographic concentration of suppliers of Japanese firms.

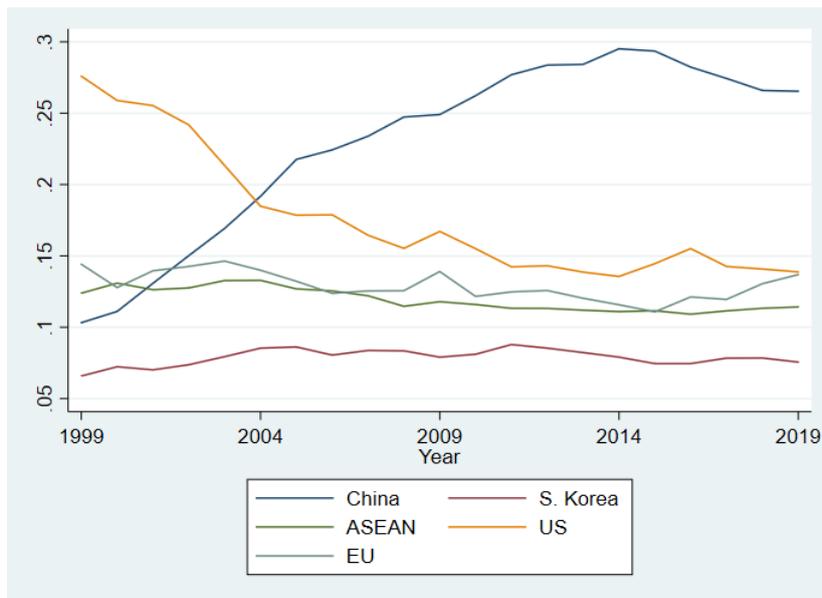
Figure 8: Herfindahl-Hirschman Index and the Share of China in Intermediate-Good Imports to Selected Countries



Source: UN Comtrade.

Note: Intermediate goods are defined as commodity codes 22, 42, and 53 of the Broad Economic Categories.

Figure 9: Shares of China, ASEAN, the US, and the EU in Intermediate-Good Imports to Japan



Source: UN Comtrade.

Note: Intermediate goods are defined as commodity codes 22, 42, and 53 of the Broad Economic Categories.

4. Policy and Managerial Suggestions

In Section 2, we argue that diversity, particularly geographic diversity, of supply-chain partners plays a significant role in promoting resilience to propagation of economic shocks by increasing supplier substitutability and in improving performance by increasing access to new knowledge and information. Section 3 demonstrates that while domestic supply chains within Japan have become more diversified as firms realize risks of *keiretsu*-type dense supply chains, the degree of the geographic concentration of Japanese firms' foreign suppliers increased from 2004 to 2015 as Japan relied more on Chinese suppliers. Combining the implications from empirical analysis and the

recent changes in the characteristics of domestic and international supply chains of Japanese firms, we provide policy and managerial suggestions as follows.

First, the recent diversification of domestic supply chains driven by standardization of parts is favorable to strengthen the resilience of Japanese firms to region-specific economic shocks within Japan, for example, those originating from natural disasters and lockdowns in particular regions. However, *keiretsu*-type supply chains should not be eliminated completely, as they play significant roles in performance and resilience. *Keiretsu* relationships contribute to improve firm performance by providing high-quality specific inputs. Also, in the wake of economic shocks that cause supply-chain disruptions, long-term strong relationships among *keiretsu* partners provide incentives to support each other, resulting in resilience. Therefore, it is suggested that firms keep or create *keiretsu* relationships for knowledge-intensive key inputs (including services) while expanding supply chains geographically for more general products and services that can be standardized.

Second, one concern about the current situation of the Japanese domestic supply chains is too much concentration in Tokyo. Gross regional product of Tokyo in 2016 was 1.04 trillion yen or 19 percent of gross domestic product (GDP) of Japan. Including its surrounding prefectures, Saitama, Chiba, and Kanagawa, production of the greater Tokyo is 1/3 of Japan's GDP (Cabinet Office of Japan 2020). However, the greater Tokyo has large risks of great natural disasters, such as the possible Great Tokyo earthquake, Nankai Trough earthquake, and eruption of Mt. Fuji closely located to Tokyo. Also, the risk of a lockdown of Tokyo to prevent the spread of infectious diseases is high, because its dense population enlarges the risk of infection. In fact, the state of emergency to prevent the spread of COVID-19 was first declared in Tokyo and its surrounding prefectures as well as some other major industrial areas in April and May, 2020. The analysis of Inoue and Todo (2020) shows that if Tokyo were locked down, the negative economic shock would propagate to other regions, leading to a substantial reduction in production in other regions without any lockdown. Inoue, Murase, and Todo (2020) additionally find that if a prefecture lifts a lockdown, its economic recovery is limited unless Tokyo also lifts its lockdown because of a large propagation effect of Tokyo's lockdown through supply chains. Because other regions of Japan rely too much on Tokyo in terms of supply chains, expanding the risk of Tokyo to that of entire Japan, geographic diversification of supply chains within Japan is necessary.

Third, Section 3.2 clearly indicates that Japanese firms rely too much on Chinese suppliers and clients, although the reliance has declined most recently. A simple suggestion from this fact is to reduce reliance on China more to alleviate the risk of inflows of economic shocks originating from China, as Japan experienced in February, 2020 when COVID-19 rapidly spread in China. This suggestion can be justified more because exporting inputs to Chinese firms incurs risks of being punished by the US government and losing the US market, as in the scandal of Toshiba that exported machinery controlled by Coordinating Committee for Multilateral Export Controls (COCOM) to the Soviet Union, due to the intensified US-China decoupling.

The Japanese government recently intends to reduce the supply-chain reliance on China, subsidizing to firms that relocate their plants to ASEAN countries and Japan (METI 2020a, b). However, relocating plants in China back to Japan, or reshoring, may not be appropriate, because doing so would increase geographic concentration of supply-chain partners of Japanese firms in Japan, rather than promote diversification. If relocating back to Japan, firms are suggested to relocate their plants not to greater Tokyo or regions close to the headquarters, but to distant regions to alleviate risks from concentration and to enjoy new knowledge and information from outsiders.

Alternatively, firms are more encouraged to relocate their establishments in China to other foreign countries,

including the US, Europe, Australia, and Taiwan. Figures 4 and 5 demonstrate that the share of the US declined significantly over the two decades and that the share of European Union countries has been quite low although their share in intermediate imports to Japan slightly increased in the past four years. Therefore, there should be a large room to create supply-chain links with developed countries by either locating Japanese firms' subsidiaries there or simply transacting with local firms there.

There are three advantages of strengthening supply-chain ties with in developed countries. First, because of the rise of robotics and automation in production (Baldwin 2019), the share of labor costs has been decreasing in many developed countries (Piketty and Zucman 2014). Notably, the labor share in the US declined from the range of 60-63 percent in the 1990s to approximately 52 percent in the late 2010s (Leduc and Liu 2019). Therefore, costs of production or marketing activities by Japanese firms' subsidiaries are relatively low, compared with before.

Second, setting up an establishment for production, marketing, or innovation in some emerging countries, such as China, Vietnam, and Russia, incurs risks of data security, because data should be stored in a server in these countries and may be required to submit to their governments (Cory, Atkinson, and Castro 2019). By contrast, some free trade agreements, such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), the Japan-EU Economic Partnership Agreement, and Japan-US Digital Trade Agreement prohibit such requirements for data. Therefore, setting up establishments in the member countries of these FTAs, namely the US, EU countries, and Australia, is not associated with the risk of data security.

Finally, as stressed in Section 2.4, links with distant partners facilitate inflows of new knowledge and information and thus improve firm performance. For this purpose, links with firms in developed countries with new advanced knowledge that is not available in Japan should be more beneficial to Japanese firms. Moreover, if Japanese firms can engage in research collaboration with technologically advanced firms in developed countries, the benefits should be larger (Iino et al. 2021). These multi-layered international firm networks, i.e., supply chains, shareholding relationships, and research collaboration, can even generate trust among partners and be long-lasting, just like *keiretsu* networks that are also often multi-layered (Section 2.4). Accordingly, the multi-layered networks result in even higher firm performance because of more active exchanges of ideas among trustworthy firms and in higher resilience in the wake of economic shocks because of their long-term nature.

Although the argument above suggests diversification of supply-chain links, it is costly for many firms to actually implement this strategy. Cost of diversification of supply-chain partners includes the cost of gathering information for possible partners. However, if a firm pays the cost and gathers information, the information may spill over to other firms through various channels and be used by firms. In this situation where information spillovers cause externality, rational firms hesitate to pay the cost of information gathering and wait for spillovers from others. Accordingly, supply-chain diversification is not at the optimal level in the market economy, and hence, government interventions are necessary. One possible measure of such interventions is to provide subsidies for relocating production plants, as the Japanese government is currently doing (METI 2020a, b). However, one problem of this policy is its high cost. The Japanese government will spend 243.5 billion yen for the relocation programs in a year (METI 2020c). Other less costly measures include to collect information by public institutions and to provide subsidies for participation of Japanese firms in international trade fairs, both of which are evidenced to be effective. For example, Kim et al. (2018) find that informational seminars to SMEs in Vietnam for export promotion is effective to capable firms, using randomized experiments. Inui, Matsuura, and Pocet (2008) reveal that the presence of the country office of the Japan External Trade Organization (JETRO), a public agency for export promotion,

attracts foreign direct investment inflows from Japan. Makioka (2020) shows that when Japanese firms are supported by JETRO and participate in international trade fairs, they are 10 percent more likely to engage in exporting activities than others. These policy measures whose effectiveness are supported by empirical evidence should be fully utilized to achieve more geographic diversification of supply-chain partners of Japanese firms for their higher resilience and performance.

5. Summary and conclusions

This paper argues the structure of supply chains effective to firms' resilience and performance based on implications from the literature, investigate the current characteristics of domestic and international supply chains of Japanese firms, and provide policy and managerial suggestions. Although geographically expanded supply chains incur a risk of inflows of negative economic shocks originating from other regions and countries, this risk can be alleviated by geographically diversifying supply-chain partners more, including creating links with foreign partners. By so doing, firms can enlarge the possibility of supplier substitution in the wake of region- or country-specific shocks. Furthermore, links with diverse partners, particularly with foreign partners, can enhance firm performance by receiving new knowledge and information through such links. Therefore, geographically diverse supply chains, including internationalized supply chains, can improve both resilience and performance. Although domestic supply chains of Japanese firms started to be diversified after the Great East Japan earthquake to deal with risks of propagation of shocks, firms in domestic supply chains still agglomerate in Tokyo and its surrounding regions to a great extent. Moreover, international supply chains of Japanese firms considerably rely on Chinese suppliers and clients. Therefore, more geographic diversification of supply chains of Japanese firms is suggested, including diversifying within Japan, reducing the reliance on China, and strengthening links with developed countries. Expanding supply chains geographically is costly and associated with externality, government interventions, notably provision of information and support to participation in international trade fairs, should be built up more.

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