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AN ASSESSMENT OF THE IMPACT OF THE PANDEMIC ON GLOBAL SUPPLY CHAINS AND ITS POTENTIAL OUTCOMES

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Abstract

This study evaluates the potential effects of the COVID-19 pandemic on the world economy from the aspects of global production and supply chains. The pandemic has accelerated geographical diffusion, which, in turn, led to supply and demand shocks, decreased the predictability of risk, and made supply chain disruptions inevitable. Besides, these disruptions spread not only to firms, which operate interdependently along a global supply chain, but also to their industrial linkages and countries, where the related industries are mostly located. This study considers a range of disruptions emerging from the processes of global supply chains, such as production, transportation, and customs clearance; presents varying extents of disruptions in terms of specific articulation types of firms, industries, and countries into global production; and discusses in how possible measures might change the functioning of supply chain to overcome these disruptions.

Keywords: Pandemic, supply chain, and global production

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Introduction

The potential risks of a global pandemic are well recognized since 20 years, given the globalization and the resultant convergence of several production and consumption activities, fostering networking, and close contact among people across countries and continents. The appearance of SARS-CoV in 2002 rang an alarm of the threat to human health as well as the economic dangers of a global pandemic. These risks have increased exponentially, with advancements in transportation and communication technologies that have shortened transportation lead times, increased the amount of freight, and helped in organizing production on a global scale, leading to even greater global networking and close human contact.

The world is reeling under severe health and economic calamity generated by the COVID-19 pandemic, which has led to plant closures as well as increased quarantine measures and disruptions in global supply chains, first in China, and then rapidly across the globe. The Chinese economy, which has become a global production base, bore the initial brunt of the pandemic. Global economic crises soon followed, with a domino effect. Following plant closures, Chinese industrial production decreased 13.5% in the first two months as compared with the same period in 2019 (National Bureau of Statistics of China). Since February 2, 2020, the China Council for the Promotion of International Trade had issued a total of 4,811 factual proofs of *force majeure*[1], involving a contract value of approximately 373.7 billion yuan ($52.83 billion) (Xinhua News Agency, 03.03.2020). Due to global production sharing, this supply shock started a domino effect by disrupting production activities of hundreds of thousands of firms in various countries having suppliers in China. As a result, pandemic-driven economic crises began to severely deepen across the globe.

This study primarily addresses pandemic-induced disruptions of global production chains in the world economy. These disruptions can be considered as one of the main structural factors underlying the global economic crisis. The study examines how the pandemic has affected the operation mechanism of supply chains. Finally, the study suggests and evaluates the possible policy measures to avert a similar shock in the future; and, once implemented, the effect of these measures on the structure and operations of supply chains.

An Overlook of Global Production Chains

In the present day, industrial production activities are undertaken by global production

1 *Force majeure* refers to a clause in contracts that essentially removes liability for both parties when natural and unavoidable catastrophes or man-made events prevent one or both parties from fulfilling their obligations under the contract.

chains, which comprise complex networks. The extent of participation in global production networks differs in terms of industrial and territorial characteristics. These differences are critical when discerning the most vulnerable countries and sectors to pandemic-driven economic shocks. As an indicator of this participation, UNCTAD (2013) uses foreign value-added share of exports, which is expected to increase as participating countries begin to use parts and components of other countries in their production activities. Accordingly, manufacturing industry (as distinct from primary and tertiary industries) has the highest foreign value-added share in exports, with an average of 29.4%. In the manufacturing industry, the sub-sectors with a 30% share or above in 2010 were as follows: "Manufacture of office, accounting and computing machinery," "Manufacture of motor vehicles and other transport equipment," "Manufacture of radio, television and communication equipment," "Manufacture of man-made fibers, plastics and synthetic rubber," and "Manufacture of other electrical machinery and apparatus" (UNCTAD, 2013: 128). Similar to industrial average, country-specific import dependency of exports was realized at an average of 30% in 2017 (UNCTAD, 2018: 22).[2]

Referred to as new international division of labor by Fröbel, Heinrichs, Kreye (1980), the present day economic structure has made all economic agents (humans, firms, states, and countries), goods, and services interdependent. The underlying feature is global supply chains, which are based on specific production methods such as flexible and lean production, and just-in-time stock control. However, beginning with SARS-CoV in 2002 and evolving dramatically with COVID-19, epidemics have clearly displayed the fragile nature of global supply chains. Figure 1 illustrates the interconnected and interdependent nature of countries, industries, and firms in the global economy. Solid lines represent various supply chains that connect firms and industries in different countries. However, the impact of COVID-19 pandemic on the underlying mechanisms of global production and supply chains has severely affected the global supply chain participants, such as firms, countries, and industries.

2 The value of this indicator is expected to be low for large economies with well-developed local value chains. In contrast, the value will most probably be higher for small countries, and especially those of which specialize in the highly segmented industries (UNCTAD, 2013, 130).

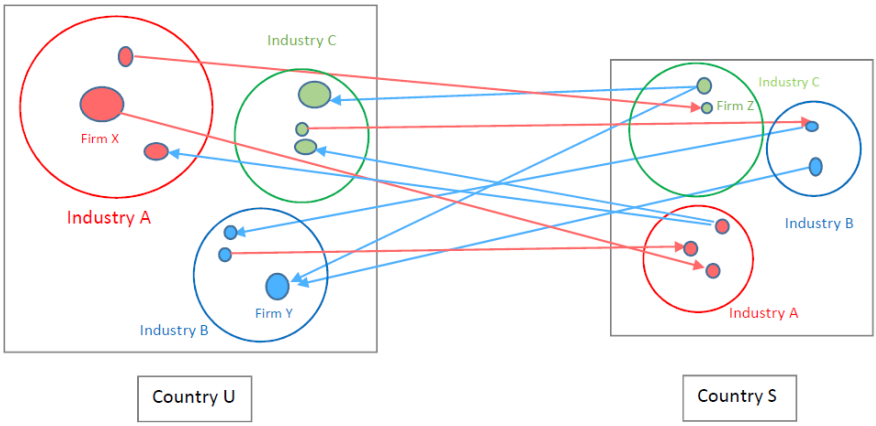

Figure 1. Interconnections and Interdependencies in Global Production Sharing

To understand the fragile nature of supply chains and the impact of pandemic on firms, countries, and industries, the rise of global supply chains and their operation mechanisms must be understood. The driving forces of global supply chains are the developments in transportation and communication technologies. Such technological developments lead to reduced transportation and communication costs and closing distances between countries. For instance, transportation costs, which had accounted for 8% of the average total import costs, decreased to 3% in 2002 (Dicken, 2015: 85). As air transportation became popular, international corporations could well coordinate their worldwide operations in different regions. Under these circumstances, the world economy witnessed increasing tendencies for the global organization of production. Therefore, outsourcing activities of international corporations have progressed rapidly. In short, for majority of the industries, a final product, which had been priorly produced at one production plant, was fragmented into different venues by increased specialization and standardized production stages shifted to low-wage countries, and specifically to China.

A typical example of interconnectedness through global production sharing might be the smart phone production chain. The production cost of an iPhone 3G, introduced in 2009 by Apple, was approximately $179. While 69% of these costs covered parts and components, 27% was due to other material costs and 4% was related to assembly. The US market value of the phone was $500. Hence, $321 of the value in addition to the production costs is Apple's profit margin. The smart phone was assembled by Foxconn, a Chinese company. Among major parts and components suppliers of Apple, Toshiba (Japan) supplied flash memory, display module, and touch screen; Samsung (South Korea) supplied application processor,

and SDRAM-Mobile DDR; Infineon (Germany) supplied baseband, camera module, transceiver–receiver functions; Broadcom (USA) supplied wireless connection infrastructure; Numonyx (USA) supplied Memory MCP; with other parts supplied by Murata (Japan), Dialog Semiconductor (Germany), and Cirrius Logic (USA). On shipping to China, all of these parts and components were assembled and readied for reshipment to United States and other international markets at a cost of $6.5 (Xing & Detert, 2010). Several international corporations, similar to Apple, capture a significant part of the value-added, created along a production chain in return for their operations such as R&D, design, distribution, and marketing. Indeed, this production structure allows for intensifying the market power for international corporations; this power is crucial for restructuring supply chains after the pandemic.

In this process, international firms might either own their suppliers through foreign direct investment or form subcontracting relations through various nonequity modes, such as contract manufacturing and services outsourcing, licensing, franchising, and management contracts (UNCTAD, 2011: 132; Weiss, 2002: 147). Several operational risks emerge with the process of externalization of a production stage to a subcontractor without direct control of international firms. Stock management and supply risks, legal and contractual risks, institutional risks, and financial risks play a crucial role in the decision of externalization. Thus, international firms aim to reduce transaction costs through supply chain management methods, which in part emerge as a result of externalized production activities. Advancement in information technologies enables application of full automation technology in stock management and control and savings on transaction costs (Kaplinsky, 1998: 24). However, until recently, large companies preferred to shift these costs and possible information technology solutions to key suppliers. Such an organization structure is related to the power of the leader firms. Using this power, the leader firms direct the entire supply chain through contractual obligations and decide on the prospective production and organization processes to shift suppliers (Henderson, Dicken, Hess, Coe, and Wai-Chung Yeung, 2002).

For instance, since the beginning of 1990s, big automotive companies began to shift not only production of particular parts and components, but also product design, stock control, and management responsibilities of diverse modular systems such as braking system, electronic components, seating system, and cooling system to their first-tier suppliers (Veloso & Kumar, 2002: 15). In the global automotive production, big producers seek only a specific product, or system, from their suppliers. In turn, the subcontractor/country and the conditions under which their first-tier supplier procures parts and components of that product or system

became irrelevant. In this process, first-tier suppliers began to form their own production networks and decide on the quality and costs. Referred to as mega-suppliers, these first-tier supplier firms began to control majority of the supply chain with forward and backward linkages. Operating as a global production base for international automotive firms such as Mitsubishi, Honda, and BMW, Thailand automotive industry is home to at least 200 companies, 4% of which includes foreign affiliates of big companies. With regard to backward linkages of these firms, the number of intra-firm suppliers exporting to Thailand grew to 6000, which originated from a total of 61 countries. In terms of forward linkages, there are about 850 potential intra-firm client links that import automotive products from Thailand; and all these clients are spread across 57 countries in the world (UNCTAD, 2013: 139). The number of nonequity subcontractor firms reveals the expanse of these supply networks.

According to supply chain specialist Michael Essig, German automobile producer Volkswagen has 5000 first-tier suppliers, and each supplier has nearly 250 sub suppliers, which constitutes a total of 1,250,000 (Braw, 2020). In such a production structure, it is very likely, for an international firm, to have an informal subsupplier, resident in China.

It is difficult to follow the entire global footprint of a supply chain in not only the automotive and electronics industries but also other manufacturing industries such as clothing and toys. For instance, in the toy industry, various raw materials such as plastics, wooden, and metal parts are assembled manually with electronic components. Therefore, it is accepted as a general strategy to shift the assembly stage to low-wage countries. China hosts more than 8000 toy suppliers; and 70% of the toy products in the United States are imported from China (Wong, Stentoft, and Johansen, 2005: 369). Currently, about 20% of global trade in intermediate products originates in China (up from 4% in 2002) (UNCTAD, 2020). These developments reveal China's position in the pandemic-driven shock, as well as its role in global production sharing. Indeed, pandemic-induced disruptions to China's integral involvement in global supply chains have sent shock waves across manufacturing centers all over the world.

Overall, international corporations, with their global organization strategies, have created complex and untraceable production networks, which further led to a vulnerable supply mechanism to production disruptions arising from external factors. Hence, simply put, the ongoing COVID-19 pandemic has compelled all firms to reevaluate their supply chain strategies.

The Impact of Pandemic on Global Supply Chains and Possible Outcomes

Progress in transportation technologies led to the organization of production on a global scale. However, it also accelerated spread of the pandemic. Therefore, a contagious disease can be transmitted to nonendemic areas and easily turn into a pandemic. The role of transportation in facilitating the pandemic is apparent through examples of the numerous cases of malaria, recorded near major metropolitan airports of United Kingdom and the United States or typhoid fever cases in the United States, 70% of which were infections with overseas travel history (Brower & Chalk, 2003: 15–16). Similarly, the dramatic rise of recorded cases of COVID-19 in Italy was not only a result of delayed precautions, but also the country's position in terms of global tourism. The first case in Italy was seen on January 31, 2020, which was only a month later than the officially informed case by China to the World Health Organization. The speed of pandemic's global propagation is one of its novel features that distinguish it from other unexpected supply chain risks, such as natural or man-made catastrophes (Ivanov, 2020: 9). Accordingly, this feature reduces the predictability of risk, making it difficult for firms to implement the right strategies to avert supply chain disruptions.

Following the outbreak of COVID-19, one of the primary measures to slow down its propagation was suspension of all transportation activities between countries. In turn, the impact on global supply chains was termination of all business meetings, trainings, and visits by majority of the firms indefinitely. Although these delays are likely compensated by the apparatus of communications technology, it will not be possible, at least in the short run, to avert disruptions majorly in the production and assembly of raw materials, intermediate goods, parts and components in quarantined areas as well as in all other stages of supply chains related to carriage capacity and lead time, customs clearance time, and velocity of processing activities. All these disruptions accurately describe the meaning of the pandemic-driven supply-side shock.

In China, COVID-19 prevention measures taken alongside the Chinese New Year have led to plant closures first in the provincial capital, Wuhan, and then in the other cities of Hubei province. Based on the data of a supply chain risk monitoring company, Resilinc, Figure 2 shows the industrial dispersion of activities in the quarantined areas of China, South Korea, and Italy for the world's largest 1000 companies or their suppliers. Accordingly, the total number of the subsuppliers in the quarantined areas of China is 10,447 and 30% (3238 units) of these subsuppliers operate in high-tech, semiconductor, and consumer electronics and 26% (2730 units) of them operate in automotive and heavy machinery industries. The subcontractors in Italy and South Korea add up to 12,097.

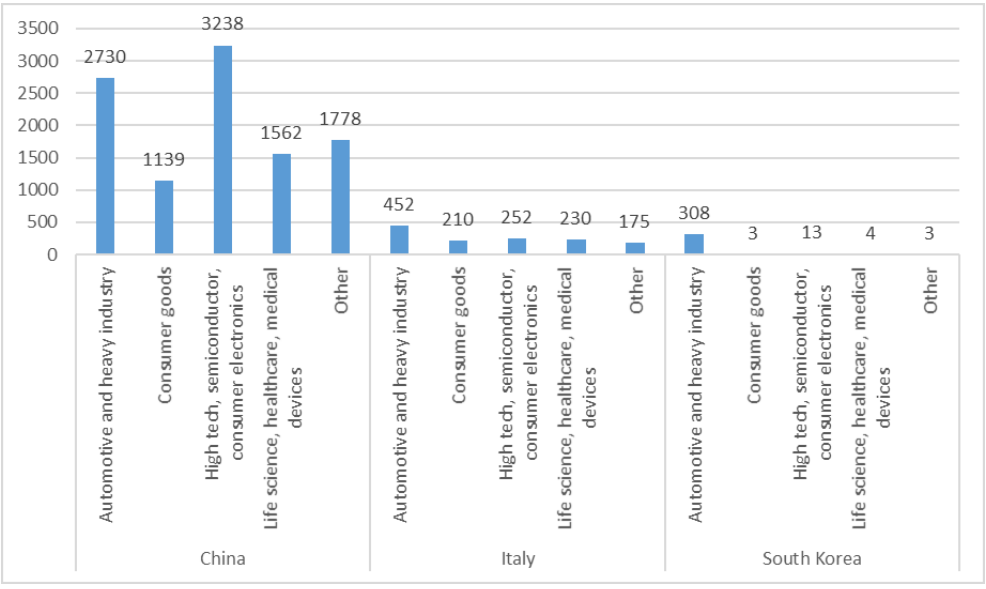

Figure 2. Industrial Dispersion of Subsuppliers in Quarantined Areas
Note: Adapted from Resilinc, as cited by Linton & Vakil, 2020.

This unexpected disruption has stunned international firms, especially those that had shifted their production activities to regions in quarantined areas. Figure 3 shows countries related to business activities in these areas. It appears that more than half of these activities are related to the United States, France, Germany, Spain, and UK, which are the countries of settlement for majority of the international firms.

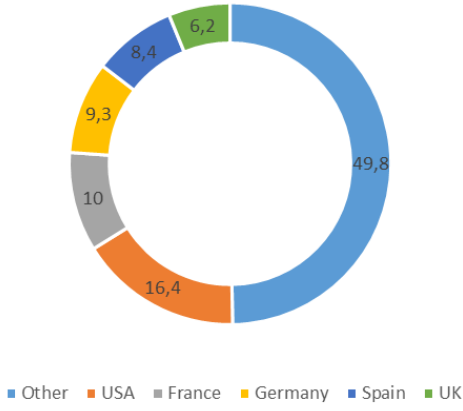

Figure 3. Distribution of Businesses in The Most Affected Regions in terms of Their Country of Settlement of The Global Headquarters
Note: Dun & Bradstreet, 2020: 7

A direct consequence of disruptions in supply chains has been reductions in exports. The World Trade Organization reports that the drop in world trade due to pandemic-driven decline of international economic activities will be between 13% and 32% in 2020. It is further expected that trade will decline further in sectors with complex value chains, particularly, electronics and automotive products (WTO, 2020). Figure 4 illustrates the top 10 products exported across the world from the most affected locations as a percentage of total export value. These products comprise 60% of total exports value. Apparently, the trade in *electrical machinery, equipment, and parts* has the major share, which is expected because of the intensive parts and components trade in the electronics supply chain.

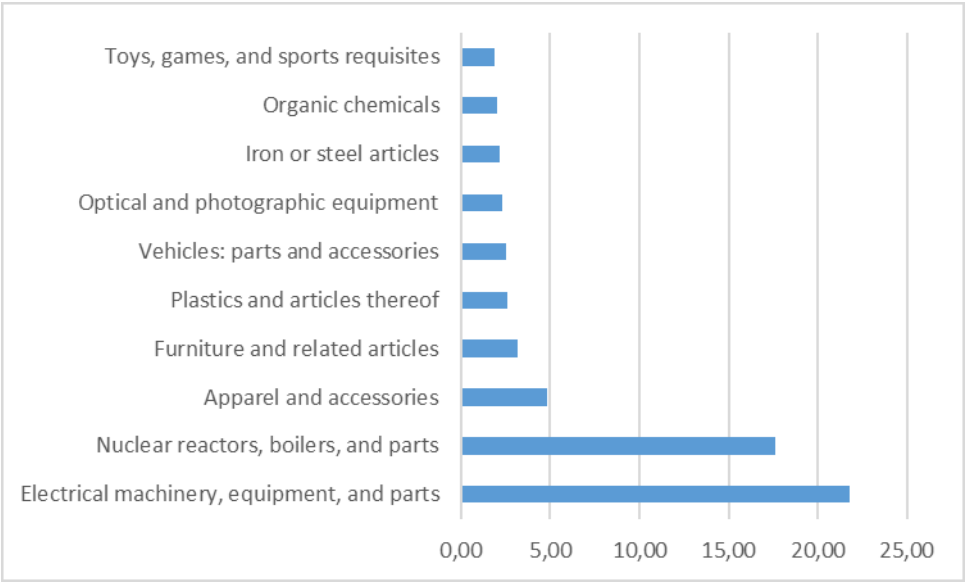

Figure 4. Top 10 Exports to The World from The Most Affected Locations
Note: Dun & Bradstreet, 2020: 8.

Although China relaxed its quarantine measures by the end of March and restarted production in factories, the rapid spread of the pandemic toward Europe and America disrupted production and trade in these regions and largely blunted the positive effect of Chinese recovery. Big automotive producers, such as Volkswagen, Toyota, BMW, Fiat Chrysler, Peugeot, and Renault, decided to close their production plants based in various locations in Europe (Riley, 2020). Their decisions were based on disruptions in European economy, which is exposed to protective measures against the spread of pandemic, and disruptions in supply and delivery of critical raw materials, parts, and components from China. The latter is also referred to as the *ripple effect* in the literature on supply chain. Ivanov (2020: 2) argued that the simultaneous incidence of pandemic propagation and ripple

effect is a major pandemic-specific risk in the supply chains. The pandemic has caused significant contraction in global production and trade with its simultaneous disruption effects in supply, demand, and logistics.

The pandemic has disrupted production in other regions and affected global demand in two ways. First, in classical terms, demand for final goods fluctuates as a result of the precautionary consumption choices of economic agents and rise in unemployment. Demand for some products has increased, while decreased for others. Second and more importantly, the emergence of supply chains has created various demands at each stage of the production process. Thus, a disruption in developed countries led to increasing fluctuations in the orders at each stage, as one goes upstream along a global production chain, where the orders for upstream companies comes from the companies in the immediate downstream supply chain. This is known as the *bullwhip effect,* which is one of the main reasons of increased stock, distribution, and management costs in supply chain (Metters, 1997). When a pandemic leads to a short-term product shortage, retailers might place excess orders to their wholesalers. Increased wholesaler demand is directly reflected to manufacturers and from manufacturer to suppliers in order to stock up that product.

Demand uncertainties and fluctuations in supply chains can differ depending on the characteristics of the final product. Demand uncertainties are likely to be low in *functional products*, such as basic food products, which have long life cycles, low product variety, low inventory costs, low profit margins, and stable demand structure. In contrast, demand uncertainties are likely to be higher in *innovative products*, such as fashion apparel, high-segment computers, and high-tech products, while they have short life cycles, high product variety, high inventory costs, and variable demand structure (Lee, 2002: 106). The pandemic has increased such demand-side differences in supply chains.

A consumer survey conducted in Spain, Italy, UK, and the United States from March 21 to 23, 2020, on the changing demand structure in retail industry after the pandemic has found that for the next two weeks, there will be increased demand for grocery among the customers to satisfy their needs of basic food products, while they will decrease their demand for more discretionary supply chains, such as restaurants, shoes, apparel, jewelry, accessories, household appliances, and furniture. In this situation, it is likely that the mitigation strategies will differ substantially by business line in retail industry. For instance, under the conditions of increased demand, basic food supplier groceries will try to meet the challenges by focusing on the basic capabilities. Thus, it is important to reallocate workforce, capital, and all other resources to the supply of the most essential products, simplify supply process by reducing

variety and increasing quantity, and thereby improve on-shelf availability, whereas delivery speed and variety are examples of qualifications that grocery retailers compromise on. In contrast, leading apparel retailers with declining demand for their products are worst affected by the ongoing pandemic. Hence, they have decided to cancel orders from their suppliers and reduce future orders in terms of variety and quantity to overcome their cash flow problem in the short run. These decisions, in turn, have led to several Asian suppliers to shut down their operations because of inadequate demand for their products (Aryapadi et al., 2020).

In Table 1, supply chains are classified according to their day-to-day (or operational) uncertainties. In addition to demand-side uncertainties, summarized earlier, supply-side uncertainties are likely to be low in *stable supply processes* with simple, manageable, and highly automated manufacturing structure, mature production technology, and strong supply base with long-term supply contracts. In contrast, an *evolving supply process* has potentially higher supply-side uncertainties with its complex, variable, and currently evolving manufacturing structure, unreliable supplier base, and variable lead times and yields (Lee, 2002, 107).

Table 1. Supply-side and demand-side uncertainties in supply chains

		Demand-side Uncertainties	
		Functional Products	*Innovative Products*
Supply-side Uncertainties	*Stable Supply Processes*	Grocery, basic apparel, food, oil and gas, automobile	Fashion apparel, computers, music, consumer electronics
	Evolving Supply Processes	Hydro-electric power, some food produce (such as fishing)	Telecom, high-end computers, semiconductor, digital games

Note: Lee, 2002: 108.

The pandemic has led simultaneous disruptions in both supply and demand. The impact of the pandemic on supply chains that are operating in different industries is related to how these industries are vulnerable and responsive to uncertainties in supply and demand in normal times. Therefore, the impact of a pandemic is likely to be low in industries such as grocery, food, and basic clothing, which have a stable supply process of functional products. Nonetheless, such an inference does not necessarily indicate that evolving industrial production structures of innovative products with higher uncertainties would be highly affected by the pandemic. Instead, it is likely that supply chains, which deal continuously with supply and demand uncertainties, might be resilient. However, such labels will become more complicated when one considers those items mostly produced in quarantined areas and

the interdependency and interconnectedness of firms participating in production processes of these items. For instance, the automotive industry has been affected severely by the pandemic because of the global spread of its operations, although it has commonly been accepted as a less-fragile industry to operational uncertainties. Furthermore, long-term supplier contracts, which normally provide assurance for continuity of supply chain in the automotive industry, could hinder implementation of flexible methods during the pandemic (Fernandes, Chaudhuri, and Shukla, 2020). In contrast, majority of the produced items in quarantined areas are innovative products, which have uncertain supply and demand conditions (Table 1). For international firms in the United States and Europe, majority of their second- and third-tier subcontractors supply innovative parts and components, such as resistors, capacitors, connectors, and integrated circuits to original equipment manufacturers in various industries such as high-tech, consumer electronics, medical devices, and automotive (Resilinc, as cited by Linton & Vakil, 2020). Nevertheless, this is an advantage to safeguard the supply chain, considering the recent developments in high-tech semiconductor chip production. For instance, in response to the diverse and changing demand structure, several Asian semiconductor producers began to produce chips, for which some functionalities can be specified by Internet-Reconfigurable-Logic (IRL) even after they have been delivered to customers. Similarly, these semiconductor chip producers can organize their subsuppliers and assembly partners for all their supply chain activities, such as design, test results, production, and shipment schedules using various software programs (Lee, 2002: 118). In this respect, it is possible to enhance supply resilience against pandemics using innovations, such as smart manufacturing technologies, Industry 4.0, internet of things, and radio-frequency identification sensor technologies (Sarkis, Cohen, Dewick, Schröder, 2020). First-mover firms will be those who will deal intensively with supply and demand uncertainties in their day-to-day activities and try to find solutions.

Recent developments in production, consumption, and trade patterns have further affected the transportation sector, which is a significant instrument in global supply chains. Although freight transport (as distinct from passenger transport) is exempted from the limitations brought about by the pandemic, demand has declined in maritime transportation (which accounts for 80% of goods traded in the world) mainly due to the interruptions in Chinese production. These suspensions have resulted in a numerous blank sailings and reduced the number of container shipping fleet, which, in turn, has increased the number of idle containers at the port and has led to extra costs such as demurrage charge, detention, and chassis fees for nonvessel operating common carriers in intercontinental container shipment (Jensen, 2020).

China has the largest number of container usage with its massive trade capacity. However, the problem of unshipped and idle containers at Chinese ports caused container shortages at major ports in other countries. In particular, lack of reefer container is a serious problem, especially for countries exporting fresh fruits and vegetables (Bolloré-Logistics, 2020; Agility, 2020).

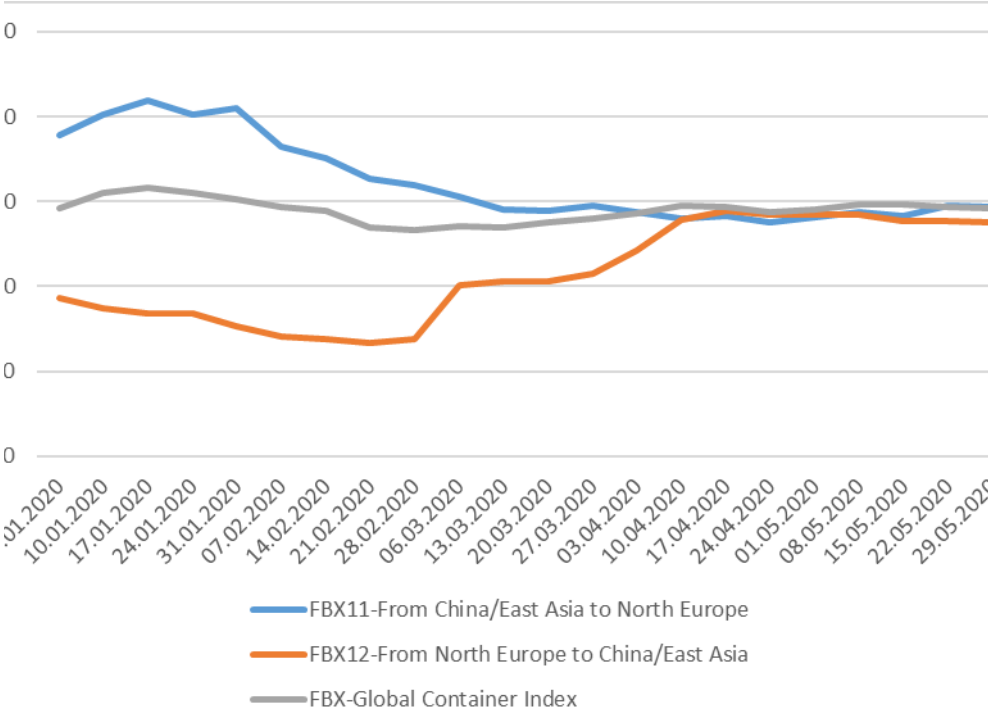

Figure 5. Container Freight Indexes of Specific Routes
Note: The Freightos Baltic Global Container Index (FBX), as retrieved from https://fbx.freightos.com/freight-index/FBX.

Figure 5 demonstrates ocean container transport spot freight rates for the trade-lanes in opposite directions. In other words, it shows a full round-trip of a vessel from China/East Asia to North Europe (head-haul), and then from North Europe back to China/East Asia (back-haul).[3] These freight rates indicate the median all-in price for a 40-foot dry container, including tariffs and related surcharges. Accordingly, in the first week of 2020, prices were $1888 and $928 for head-haul and back-haul indexes, respectively. The underlying reason for this price discrepancy is the mismatch of trading volume between head-haul and back-haul. Because of China's massive trade volume, the head-haul demand is higher than back-haul

3 In a trade route, the direction, which has the highest container volume is often called "head-haul," whereas the return trip is often referred to as "back-haul."

demand, which leads to higher prices for head-haul route. Nevertheless, in the following weeks, the head-haul price (FBX11) has declined severely to $1453 on March 13, whereas the back-haul price (FBX12) began to rise after the first week of March. The former is an indicator of the dwindling demand on the head-haul trades and idle vessel capacity from China to other destinations as a result of quarantine measures and factory closings in China. The latter, on the other hand, is due to the container shortages out of China. Transport time for a container from Chinese ports to Europe is approximately 30–33 days. Hence, the last delivery reached European ports at the end of February, as the last vessel left Chinese ports just before quarantine measures prior to Chinese New Year, which began on January 25, 2020. In a month, excess supply of containers in China created an excess demand in Europe and back-haul prices began to rise gradually. In sum, Figure 5 illustrates a convergence of head-haul and back-haul prices as a result of the changing container market dynamics after the pandemic.

Despite these disruptions such as price fluctuations and capacity cuts, ocean freight shipping has continued to operate. By using survey data from International Association of Ports and Harbors, Notteboom and Pallis (2020) confirmed that the decline in demand for passenger vessels has been more dramatic than for container and other cargo vessels. As much as 66% of the port authorities indicated that passenger vessel calls have declined by more than 50%. In contrast, the demand for container and other cargo vessels is stable at more than 50% of the ports, while it declined between 5% and 25% at 35% of the ports.

Similarly, in the air transportation, global international passenger capacity decreased by 10% in comparison to the originally planned seat capacity in February 2020. In the following months, it has been recorded as 48% in March and with an unprecedented peak (94%) in April. In contrast, air cargo has decreased by 19% in March 2020 in comparison to the same month of the previous year. This is mainly because of 31% decrease in passenger aircraft belly capacity, while cargo freighters have recorded a 9% increase. In sum, it has not been possible to prevent a 22% drop on air cargo revenues (ICAO, 2020).

With regard to customs clearance, countries differ in their quarantine measures, subsequent to the pandemic. In Europe, personnel limitation has been enforced by UK, Italy, and Switzerland. Working time has been restricted in France and Belgium. In Norway, Denmark, and Finland, “back office staff” has started to work from home (KGH, 2020). All these developments have led to a rise in average time to clear exports through customs and in storage costs of exports at the port. For the case of road transport, *waiting time* for border crossing increased, although some facilitations have been made (Sixfold, 2020).

Consequently, disruptions have led to severe decline in global production and trade, primarily in production and in all other activities, such as transportation, customs clearance, and personnel capacity along global supply chains. With regard to demand uncertainties and fluctuations for not only final goods but also intermediate goods along a chain, it appears impossible for economic growth to reach positive values in 2020. According to the interim economic assessment report of OECD, economic growth rates are expected to decline 1.5% in a scenario of pandemic propagation toward regions out of Asia-Pacific (OECD, 2020: 7–8). IMF has even more pessimistic expectations on the economic fallout and projects, such that global economy will contract sharply by 3% in 2020, much worse than during the 2008–2009 financial crisis (IMF, 2020: 1).

It is clear that the rate of contraction will differ between countries and industries and even between firms that are interconnected along a global supply chain. For small countries, especially those of which specialize in highly segmented industries, the rate of contraction can be expected to be high because of their high external dependency and domino effects created by the supply chain. For industries intensively engaged in import-processing trade, the adverse effects of pandemic will in all probability are higher than in primary sectors. For firms, as discussed earlier, it is likely that the most vulnerable rings in the global supply chain are small and medium-sized firms, which are operating at the lower segments of a supply chain and located in developing countries, and particularly in quarantine regions such as in Hubei, China. For majority of the industries, subsupplier firms undertake plant-level production in a supply chain, and it becomes impossible to directly continue their operations compared with more virtual operations. However, by contractual obligations, subsuppliers are accountable to leader firms operating in the upper-end segment of a supply chain. Subsequent to the COVID-19 pandemic, it is still ambiguous whether those subsupplier firms, which cannot fulfill their obligations, would face any sanctions or whether the disruptions owing to the pandemic can be accepted as a *force majeure*, or whether declaration of *force majeure* might be obligatory for both the parties in terms of international trade law. When one considers the power relations between firms in a supply chain, it would be much too optimistic to expect a solution in favor of small firms.

In the long-term, it is likely for international firms to restructure their worldwide operations for the sake of their supply chains. One significant idea is the relocation of production activities to places that are closer to the final demand. In such a case, firms have to sacrifice cost advantages specific to certain locations, such as China. However, this might not be a viable alternative for international firms, at least in the short run. Moreover, China

has shown significant progress in terms of technological infrastructure, skilled labor force, scale and scope economies, and transport infrastructure over the past 20 years. With these developments, China provides international firms a host of valuable resource opportunities, besides being a low-wage and raw-material-abundant country. Therefore, it appears quite unlikely that China will be left out of global supply chains to a significant degree, even if international firms diversify their supplier base and move some of their processes to other countries.

Several think-tanks and research companies have recently begun to offer solutions about risk mitigation and supply chain resilience to leader firms. The most prominent suggestions are *supply chain mapping* and *diversification of supply base* (Dun & Bradstreet, 2020: 9; McKinsey & Company, 2020: 80; Resilinc, as cited by Linton & Vakil, 2020). *Supply chain mapping* identifies not only first-tier suppliers, but also second- and third-tier suppliers and maps the locations of their manufacturing, warehousing, and raw material procurement sites. Thus, it aims at conducting *risk assessment process* by considering the effects of a production disruption arising from a subsupplier on backward and forward links along a supply chain. On the other hand, it aims at *diversifying supply base* to provide more flexible supply chain links and dispersion of manufacturing, warehousing, and distribution sites.

International firms will be faced with extra costs because of either *supply chain mapping* or *alternative supplier searching*. Under these circumstances, leader firms, which tend to externalize their operational transaction costs, will likely attempt to transfer their pandemic-driven risk management costs to their first-tier suppliers. Nonetheless, an agile supply chain will possibly result in more vulnerable subsuppliers to unpredictable developments. In sum, the effects of the costs and burdens of pandemic-driven resilience strategies on firms will differ with regard to their position and power in a supply chain.

Concluding Remarks

This study discusses the impact of COVID-19 pandemic on the underlying mechanisms of global production and supply chains, possible mitigation strategies, and the main effects of these strategies, in turn, on firms, countries, and industries, which participate in global production along a supply chain. The most distinctive feature of the recent pandemic (besides other supply chain risks) is the speed of its contagion (Ivanov, 2020: 9). Hence, it has led to various spill-over effects from production facilities to demand-side activities and logistics and created simultaneous disruptions in all stages of supply chains. Although there have been very few and preliminary assessments about the impact of pandemic on global production

and trade as of the time of writing, it is expected that the fallout in the global economy will be between 1.5% and 3.0% in 2020 (OECD, 2020: 7–8; IMF, 2020: 1). It is clear that the rate of contraction will differ between countries and industries and even between firms that are interconnected along a global supply chain. The magnitude of the contraction will possibly be higher for small countries, those of which are specialized at import-processing trade, and have higher share of participation in global production chains relative to their economies. With regard to industries, those of which have widespread and complex supply chains such as electronics and automotive, have been largely affected by the pandemic. Nevertheless, these short-term effects can be mitigated in the long run with the help of the production technologies, such as smart manufacturing, Industry 4.0, internet of things, and radio-frequency identification. In terms of negotiating the adverse effects of the pandemic, successful supply chains will be those that deal intensively with supply and demand uncertainties in their day-to-day activities and try to retool their operations.

Recent developments in production, consumption, and trade patterns have further affected the transportation sector, which is a significant instrument in global supply chains. For example, container shipping is faced with serious fluctuations in shipping costs because of disequilibrium in container market in different regions. All these developments have increased the significance of risk assessment management for supply chains.

Therefore, supply chain mapping and creation of a flexible supply base are the most significant precautionary measures suggested by risk monitoring companies to leader firms. With these measures, there is a larger probability that small subsuppliers would become more vulnerable to unpredictable shocks. Finally, China does not appear to be in danger of losing its position in global supply chains, certainly not in the short run and most likely not in the long run either, although the pandemic-driven crisis has resulted in controversial ideas about relocation of global production, given that China provides international firms a host of valuable resource opportunities, in addition to being a low-wage and raw-material-abundant country, as explained earlier.

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