

Impacts of COVID-19 on Global Supply Chains: Facts and Perspectives

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Abstract—The COVID-19 pandemic has caused considerable damage to various industries worldwide. Availability and supply of a wide range of raw materials, intermediate goods, and finished products have been seriously disrupted. Global supply chains (GSCs), which had shown a high level of robustness and resiliency against several disruptions in recent decades, are genuinely compromised. Using a critical reading and a causal analysis of facts and figures, this article aims to investigate the COVID-19 impacts on the effectiveness and responsiveness of GSCs and to propose a set of managerial insights to mitigate their risks and enhance their resilience in various industrial sectors. The study showed that the COVID-19 pandemic has resulted in unprecedented disruptions to the mechanics of most GSCs such as pharmaceuticals, food, electronics, automotive industry, etc. Unlike previous major disruptions, COVID-19 has adversely affected GSCs throughout all their stages with major turbulences in manufacturing, processing, transport, and logistics, as well as significant shifts in demand. The analysis pinpointed that enhancing the supply chain resilience is the main key driver to reducing vulnerability in disruptive times. Furthermore, the analysis indicated that the post-COVID-19 GSCs will tend to be shorter through revamped strategies focusing more and more on relocations and back-shoring.

Key words: COVID-19, disruption, managerial insights, resilience, supply chain management

1. INTRODUCTION

SINCE the COVID-19 outbreak was first announced, more than 210 countries and territories have reported more than one case. By the early August of 2020, there have been more than 20 million confirmed cases of COVID-19, including more than 700 thousands deaths reported to the World Health Organization (WHO) [1]. The situation would have been much worse if the pandemic was completely unmitigated [2]. The world is experiencing the worst recession since the Second World War, and the global economy is predicted to contract by 3% in 2020 [3]. Consequently, the World Trade Organization predicts that global trade volume will decline from 13% to 32% [4]. The estimated global trade

volumes of the major economic regions are shown in Figure 1, where “O-2020” and “P-2020” represent the optimistic and pessimistic scenarios for the year. The threats of the expanding COVID-19 outbreak have aroused worldwide concern for the damage to and the recovery of global supply chains (GSCs).

To avoid large-scale infections, a range of precautionary measures to curb the spread of COVID-19 was adopted by governments, including travel restrictions, temporary shutdowns of factories and outlets, and mandatory confinement of all inhabitants. These restrictions led to shortages in labor, active ingredients, and raw materials. Moreover, this situation was aggravated by tightening controls on logistical systems.

Consequently, GSCs face delays and inventory shortages. The impacts of COVID-19 have been far-reaching, and, according to some analysts, they will not disappear before the end of 2022 [5]. This prompts firms to improve their preparation for a quick recovery and mitigation of unanticipated disruptions in the future. This article aims to investigate and analyze the impacts of the COVID-19 pandemic on GSCs and to provide insights and recommendations to develop resilience by enhancing visibility and responsiveness.

2. IMPACTS OF COVID-19 ON GSCs

The COVID-19 pandemic is not the first disaster that abruptly damaged GSCs. Several other natural catastrophes, such as the 2011 mega-earthquake in Japan, the 2003 SARS outbreak in China, and the 2004 tsunami in Indonesia [6], [7], have led to shortages of parts and products. It is worth noting that the production is recovered from these disasters in a matter of weeks. However, as shown in Figure 2, based on the scope and magnitude, the impacts of COVID-19 are different from those of all previous events.

Most of the events, such as earthquakes, tsunamis, nuclear or radiation accidents, and wars, are usually limited to specific geographic areas over relatively short periods. However, within four months of its first outbreak, the COVID-19 virus had spread throughout the planet, sending billions of people into lockdown and total confinement, and contributing to the partial or total shutdown of major economic sectors. Also, there is a complete inability to predict when this pandemic will be contained; any single infected area in the globe is undoubtedly a high-risk area for a new outbreak.

In contrast to other natural or man-made disasters or infectious pandemics, COVID-19 not only disrupted the local supply chains, but it profoundly affected GSCs at all stages, from the supply sources to the final customers. COVID-19 has shown that businesses are interconnected through complex networks of GSCs in which the actors at the upstream of a supply chain are seriously affected by the almost "erratic" behavior of downstream actors, essentially large companies, who experience disruptions and very sharp variations in demand [8]. This well-known

bullwhip effect is devastating for upstream actors, mainly small and medium-sized enterprises.

3. MAJOR GSC DISRUPTIONS

The pipelines of GSCs, from raw materials supply to delivery of products, are heavily affected by the COVID-19 pandemic, and the disruptions are observed during all phases of the GSCs, as shown in Figure 3.

The disruptions in GSCs happened in all sectors. In a general sense, products can be grouped into two categories: functional products and innovative products. Functional products experience stable supply and demand in normal times. However, some products, like masks, have turned from functional products to innovative products, due to the volatile demand and the supply. Quick response to customers and high profits become important features of GSCs during the pandemic. On the one hand, it is essential to address the COVID-19-related disruptions in the GSCs of all the product groups. On the other hand, due to the limited space, only the GSCs of the products, which are manufactured and consumed

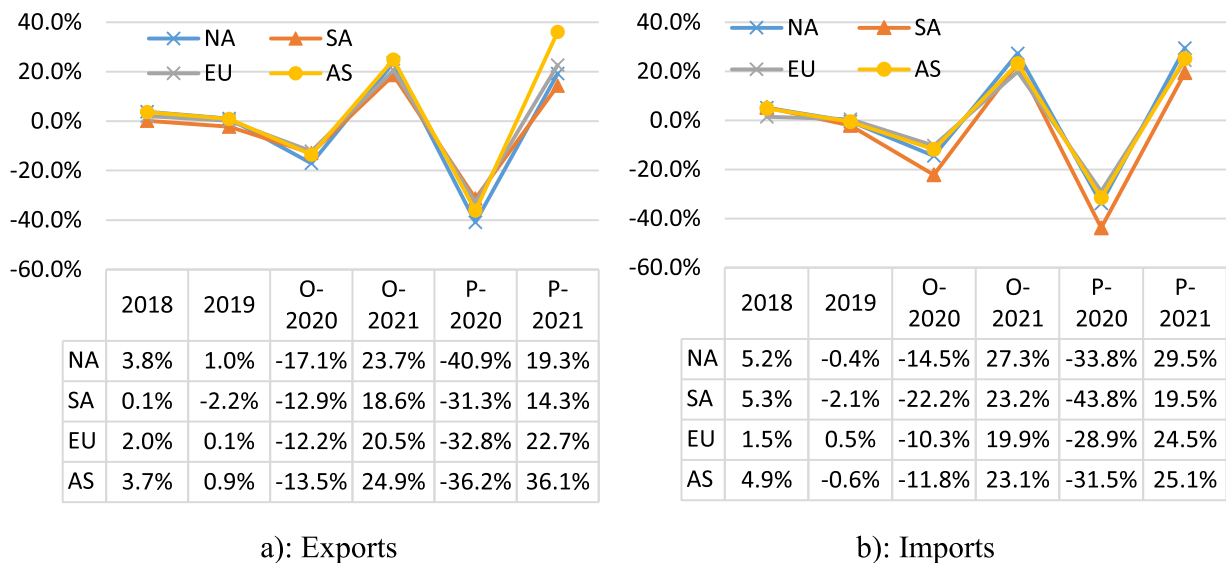


Figure 1. Global trade volume in 2020 and 2021 (data collected from Jackson, *et al.* [4]). (NA: North America; SA: South and Central America; EU: Europe; AS: Asia). (a) Exports. (b) Imports.

globally and make the greatest contribution to the world economy, are selected for further analysis, as shown in Figure 3.

Due to the lockdown in many cities, the constrained availability of human resources, raw materials, and consumables resulted in shutdown or capability suspension in almost all sectors. However, on the customer side, demands relevant to the prevention of COVID-19 were rising. Demand for items like masks was high, whereas demand for electronics was falling. The international logistics for maritime, air, and terrestrial routes experienced delays, postponements, cancellations, and obstructions due to

large-scale travel restrictions and the closing of borders.

3.1. Disrupted Commodities and Supply Chain

1) *High-Tech Products:* The high-tech industry covering products such as smartphones, virtual reality headsets, and other tech accessories, had their supply chains tangled by shortages of various parts. For instance, Apple had to postpone deliveries of its new products to the market due to the shutdown of Foxconn plants in China [9]. Samsung and LG suspended production in their factories in South Korea and India. A further revealing

example is Tesla Motors, which closed its factories in Shanghai, California, and New York. In the aeronautic sector, Airbus, Boeing, and Lockheed halted production activities at some of their plants in Europe and the US [10].

2) *Automotive Parts:* Most of the main automobile manufacturers are experiencing production shutdowns in some of their plants in China and other countries. The global output for the automotive industry is expected to drop by 13% [11]. Volkswagen shut down its automotive plants in China due to travel restrictions and lack of parts. General Motors restarted its Chinese plants but at a very low-production rate for basically the same reasons. Hyundai shut down its assembly plants in South Korea, mainly due to shortages of parts from China [12]. Nissan factories in Asia, Africa, and the Middle East halted their production [13].

3) *Medicines and Medical Devices:* Chinese manufacturers are estimated to account for 40% of all active pharmaceutical ingredients (API) used worldwide [14]. India is the third-largest medicine exporting country in the world and, therefore, plays a central role as a supplier of needed COVID-19 medications. However, as more than 70% of India's bulk drug production relies on Chinese sources [15], Indian pharmaceutical companies are facing severe shortages of materials because of the suspended production of their suppliers in China.

In addition to medications, we are witnessing a shortage of personal protective equipment (PPE). The current global shortage of PPE, particularly of medical masks, respirators, protective gear, footwear, gowns, and goggles is severely affecting the containment of the virus. This is because front-line healthcare workers are at a high risk of being

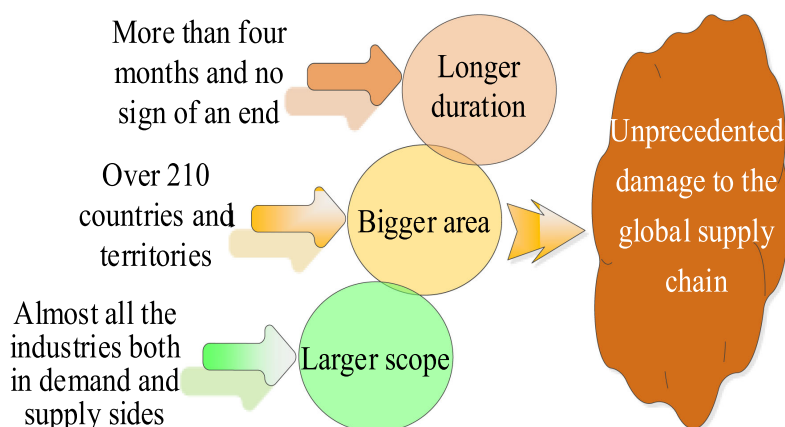


Figure 2. Features of the damage of the COVID-19 pandemic o GSCs (data from Ali and Alharbi [2]).

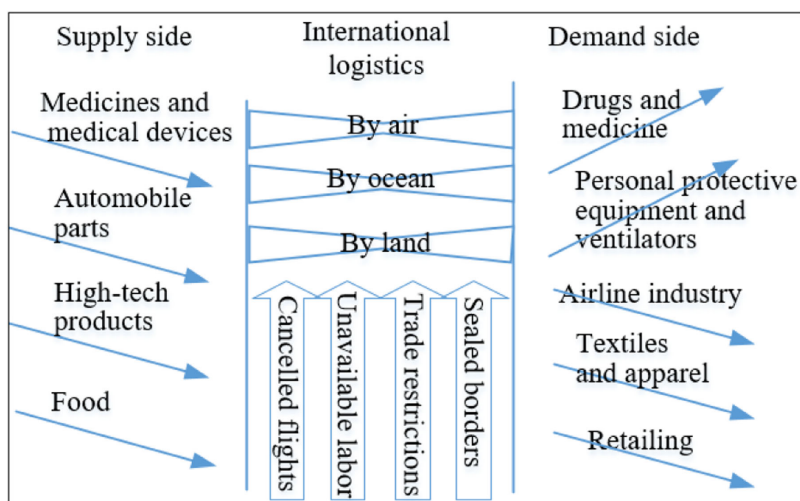


Figure 3. GSCs disrupted by the COVID-19 pandemic.

infected, and hundreds of medical and paramedical staff died in Spain, Italy, and the US. Moreover, global demand is not only driven by COVID-19 cases but also by misinformation, fake news, panic buying, and product stockpiling, which will undoubtedly further aggravate global shortages.

As the Chinese suppliers are almost the only vendors of PPE to domestic and international markets, their production capacities are insufficient and, therefore, they prioritize local demand. In this context, governments and various organizations are asking different manufacturers to step in to compensate for the current shortages. Consequently, some major companies such as Tesla Motors, Peugeot, and a consortium of other manufacturers are producing ventilators, and they are joining forces with PPE suppliers by adapting their processes to produce some of the needed products.

4) *Food Supply Chain:*

Food GSCs, from seeds to dry products such as rice and wheat, as well as fresh food, such as meat, vegetables, and fruits, are mainly affected by two aspects: farming and transportation. Almost all the stages of food production, such as seeding, picking, and delivery, are labor-intensive. India, the world's biggest rice exporter, suspended its exports due to labor shortages and logistics disruptions. The world's third-largest rice exporter, Vietnam, plans to reduce its quotas by 40% compared with the corresponding period last year [16]. Lack of truckers, canceled flights, time-consuming inspections, and quarantine in customs, have hampered the delivery of fresh food [17].

Therefore, if this situation is not contained, soon, it may result in a global famine [18]. The massive disruptions to food supplies caused by COVID-19 are expected to double the number of people suffering from

chronic hunger. The Global Report on Food Crises estimates that 135 million people were food insecure in 2019. In 2020, this number could double to 265 million people.

3.2. Disrupted International Logistics

1) *Shortages in the Labor Force:*

The logistics sector is suffering from a lack of workers throughout all the stages of the supply chain, as both white- and blue-collar labors were not available due to quarantine restrictions or infections. Furthermore, vital roles in the supply chain were unable to perform their duties due to quarantine, travel restrictions, and the temporary shutdown of some plants. For instance, some experts and technicians from China were unable to travel to the camera assembly line in India [19]. Similarly, technicians from South Korea were unable to travel to the Samsung plant in Vietnam [20].

2) *Shutdown of Commercial Aviation:*

The shutdown of commercial aviation severely limited air cargo capacities making it harder to move vital supplies such as medical equipment to fight the outbreak around the world. It is estimated that more than \$6.2 trillion worth of goods are transported by air every year and that air cargo represents more than 35% of the value of the world trade [21], [22]. However, around 50%–60% of all airfreights are transported in the belly of passenger planes. According to the US Department Of Transportation Security Administration, passenger flights fell by about 95% compared to a year ago [23].

3) *Sealed Borders and Trade Restrictions:*

Another obstacle facing global logistics are the stringent export and import restrictions and the sealing of borders. Logistics between countries

are experiencing significant disruptions. Moreover, the export restrictions imposed by some countries, such as India, France, Germany, and the US on some medicines and medical equipment, are delaying transactions and even barring some products from leaving and entering different countries.

The shortage of truck drivers to pick up containers and the stringent inspection and quarantine in customs has delayed the delivery of maritime freight, which represents 90% of global trade volume [24]. The declining global container trade has translated into falling demand for container shipping services. Over 30% of container capacity has been removed from the market due to blank sailings, and a 45% rate of blank sailings was announced for the transpacific trade [25]. Blank sailings is one of the major ways adopted by the ocean carriers to sustain a stable ocean freight rate.

3.3. Distorted Demand

1) *Drugs and Medicine:*

The demand for drugs such as chloroquine and hydroxychloroquine, used by some countries to treat COVID-19 infections, has accelerated [26]. The soaring demand for common drugs such as cough and cold medications, pain relief, and children's medicines is mainly caused by panic buying and worries about shortages. The higher-than-normal demand has disrupted the medicine supply system, which has led some governments to ration the number of items purchased by a customer.

2) *PPE and Ventilators:*

As a response to the COVID-19 pandemic, there is a soaring demand for PPE, such as surgical masks, gloves, and surgical coveralls. Almost all the countries are experiencing severe shortages of these consumables. The WHO estimated

that 89 million medical masks are required each month, along with 76 million examination gloves and 1.6 million medical goggles [27]. The dramatic rise in the demand for PPE has led to production backlogs of 4–6 months in fulfilling orders [28]. In 2019, the global demand for new ventilators was 77 000. [29]. In 2020, however, the number is estimated to be over 250 000 [30].

3) *Airline Industry:*

Government-mandated border closings and travel restrictions led to massive disruptions in the demand for air travel. The International Civil Aviation Organization claims that the number of seats offered by airlines will reduce by 57%–64% during 2020 [31]. The majority of carriers face the prospect of running out of cash because of the sudden halt in international flights. Qatar Airways is one of few airlines continuing to ensure scheduled commercial passenger services. However, it is estimated that it will run out of cash soon [32]. The destinations of Fly Emirates have been reduced from more than 150 to two, namely London and Frankfurt [33]. US airlines are seeking \$50 billion in government aid to get through the crisis, while, in Australia, Qantas is cutting all international flights [34].

4) *Textiles and Apparel:*

The textiles and apparel industry is a labor-intensive and highly globalized sector with long lead times. Quarantine measures, closure of retail stores, and loss of income, as well as fear of spending money in a time of recession, have suppressed consumer demand for textiles and apparel. In the European Union, the textile and apparel sector is forecasted to face a potential 50% drop in sales for 2020 [35]. McKinsey & Company predicts that the revenues for the apparel and footwear sectors will be 27%–30% less in 2020 [36]. According to a survey by the Responsible Business Alliance, 50% of the factories and their supplier

factories are not functioning at full capacity, and 15% of all factories are operating below 50% production [37]. Crushed consumer demand is one reason. The shortages of raw materials and inputs and the lack of workers also contribute to the substantial drops expected in the textile and apparel sector.

5) *Retailing Activities:*

With COVID-19 dominating the headlines, panic behavior prompted people to do forward buying for basic products such as toilet paper and nonperishables (dry goods). A survey by Search Engine Journal reveals that sales of basic consumer goods increased by up to 53% in the early stage of the outbreak in the US [38]. However, in China, due to a sharp downturn in consumer confidence, average sales declined by 29% in categories such as homeware and furniture, as well as apparel and electronics [39]. Similarly, in the US, retail sales plunged by 8.7% [40].

4. ANALYSIS OF INDUSTRY DISRUPTIONS AND MITIGATION PLANS

4.1. Hidden Disruption in GSC Layers

A GSC is a multitier system with numerous invisible lower-tier suppliers who are critically important to the overall supply system. For instance, an automobile firm has more than 900 tier-1 suppliers, each having an average of over 500 tier-2 suppliers [41]. According to the literature, only very few firms managed to keep track of their suppliers at the tier-2 or more levels. These extended networks reduce the GSCs' visibility and favor slow responses to unexpected damage [42].

Disruption to a key player in the supply chain can cause damaging consequences for the whole GSC. A good illustration is the suppliers based in Wuhan. According to an investigation by Dun & Bradstreet, at

least five million companies around the world have one or more tier-2 suppliers in the Wuhan region [43]. Furthermore, these are often nonsubstitutable suppliers for whom it is virtually impossible to find appropriate alternatives elsewhere, especially during such a crisis.

4.2. Mitigation Plans Under Tight Time Constraints

The timing of the first case and the lockdown of a city in a country, or of the whole country, are signs of an impending GSC disruption risk for firms. Decision-makers must show vigilance and sensitivity to the milestones of the COVID-19 outbreak at global and local levels. Therefore, the timing of the first case and the first lockdown in a country are of great importance for firms, because they determine the time left for the firms to prepare to cope with more stringent restrictions.

The first lockdown, which can be enforced in a city or a state or the whole country, is a warning of future disruptions in the country. Whether a full lockdown, as in Wuhan, or a partial lockdown, as in South Korea [44], is adopted, the flow of the logistics and travel of the workers is under unpredictable constraints. The absolute response time (ART) is defined as the time between the appearance of the first coronavirus case and the mandatory restrictions imposed by governments. These observed response times are highlighted in Figure 4.

The shortest ART, 23 days, was observed in Wuhan. The longest ART of 62 days was observed in the US, followed a 54 day ART in Germany. It means that the GSCs affected by the restrictions in Wuhan had very little time to avoid disruptions. However, this is not the case in the US and Germany as the decision-makers could mitigate these risks and take appropriate actions to minimize their losses. Similarly, organizations in the US had as many as 62 days in terms

of ART to contact their suppliers and assess the risks due to COVID-19.

Another key indicator is the relative response time (RRT), which represents the time span between the imposed restrictions in Wuhan and in a given city or country. This can give firms more time to prepare mitigation plans. The biggest RRTs were observed in the US and the UK, as shown in Figure 4. Because COVID-19 is a new strain of coronavirus and its impacts are difficult to predict, an extension of the ART or the RRT requires firms to stay in close communication not only with national authorities but also with other international institutes and informed experts and to collect information about the ongoing pandemic, like the infection rates and the mitigations are adopted by governments in different countries. For instance, the

lockdown implemented in Wuhan to control COVID-19 could be implemented in any other city affected by COVID-19.

A rolling assessment of the impacts of COVID-19 on firms and their suppliers contributes to the complete preparation required in the event of a lockdown. However, unfortunately, recent reports on closed plants revealed that most companies failed to act promptly to improve the resilience of their supply chains.

4.3. Delayed Responses to GSCS Quick Recoveries Over the last three decades, manufacturing companies have been striving for efficiencies by engaging in lean production, mainly using techniques such as just-in-time. However, as in past, major disruptions, such as tsunamis and earthquakes, these

lean and efficient supply chains have revealed the limits of their lack of flexibility and responsiveness.

This is exactly what is happening today when the most urgent objective for the firms is to recover their plant capacities quickly as well as those of their upstream and downstream supply chain partners.

As the COVID-19 pandemic continues, the focal company of a supply chain needs the support of its supply chain partners, especially small- and medium-sized suppliers. The focal company needs to manufacture or purchase PPE and help supply chain partners to implement protective measures, thereby ensuring the continuity of parts and components production. This strategy is pursued by some firms to protect their employees,

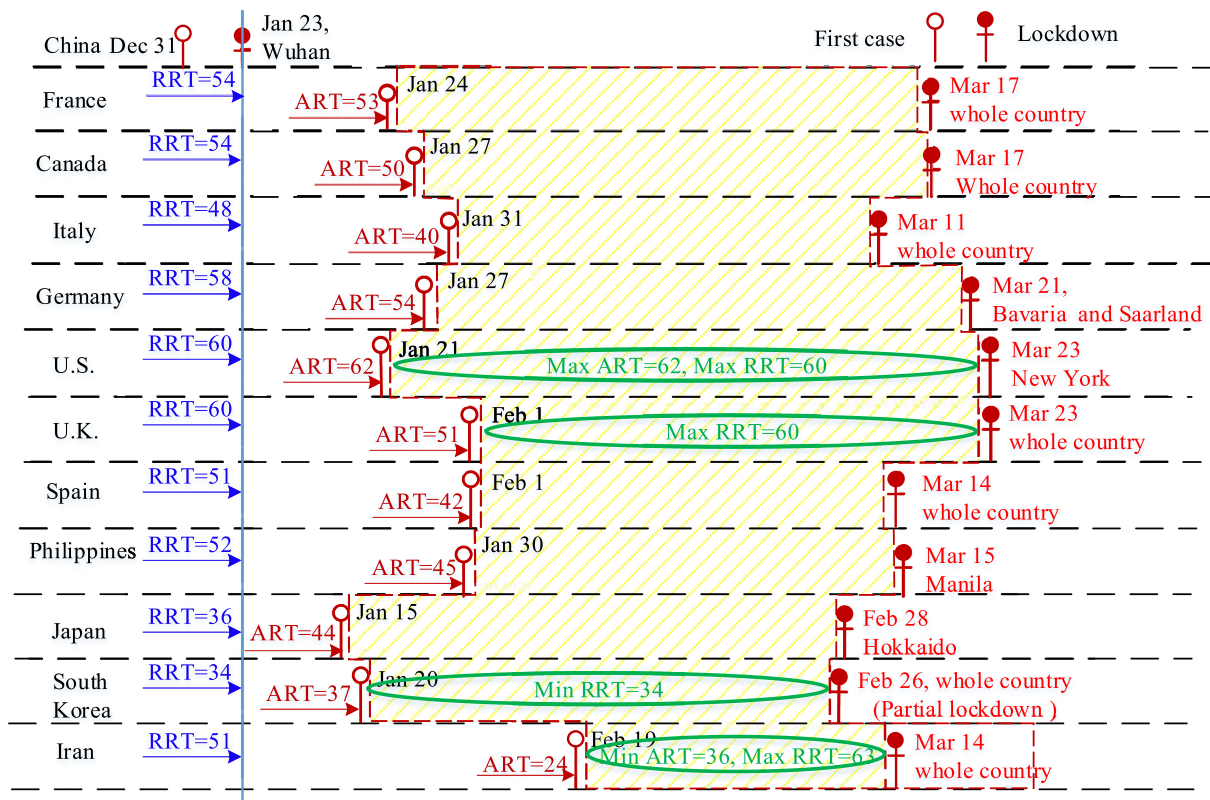


Figure 4. Absolute and relative response time windows (days) for the GSC in different countries (ART: absolute response time ; RRT: relative response time). (The timings of the first case are from Massonnaud *et al.* [45], Jung *et al.* [46, 47], and Janani *et al.* [48]. The reference of the timings of the lockdown are as follows: Wuhan [49], France [50], Canada [51], Italy [52], Bavaria and Saarland [53], New York [54], U.K. [55], Spain [56], Manila [57], Hokkaido [58], South Korea [44], and Iran [59]).

suppliers, and customers from the effects of the shortage of protective products. For instance, the motor manufacturer Tesla decided to manufacture ventilators. The Kering Group in France, known for luxury brands, such as Gucci, decided to manufacture face masks. However, the decision was made almost 60 days after the restrictions were imposed in France.

In most cases, the production of the protective products was only part of the mitigation plans in the early stages of the pandemic and would not be a long-term business strategy. However, BYD is an exception; the world's largest electric bus manufacturer has become the largest face mask manufacturer in a short time [60].

From a supply chain perspective, these products provided to partners will prevent the spread of the COVID-19, preserve the human resource capacities, and maintain sufficient capacity for a quick response and recovery as needed by the market demand. As claimed by Prof. Y. Sheffi, a quick recovery represents the ability

to be better positioned than competitors to deal with, and even to gain advantage from disruptions [61]. In short, companies must adopt proactive initiatives and strategies to achieve flexibility, responsiveness, and visibility.

5. BUILDING VISIBILITY AND RESPONSIVENESS IN GSCS

Visibility and the effective response to disruptions are among the most discussed supply chain resilience metrics [62], [63]. In this section, two groups of recommendations to mitigate the impacts of the COVID-19 are provided to enhance visibility and responsiveness to disruptions in GSCs, as shown in Figure 5.

5.1. Visibility Enhancements in the Event of Disruptions

Achieving visibility is not only crucial to gain efficiency and agility during normal production but also vital to the understanding of disruptions within GSCs. The recommendations are provided to develop visibility within

GSCs, as shown in quadrant I in Figure 5.

To mitigate short-term losses, first, the firms are recommended to identify the crisis by examining all the tier-1 and lower-tier key suppliers in areas affected by lockdowns. A supply chain disruption in one segment frequently has a ripple effect, and it impacts the entire chain [64], [65]. Knowing the suppliers who are most exposed and vulnerable to the current situation can significantly reduce the response time needed to activate mitigation measures. Second, collaborative demand forecasting with customers should be performed immediately. It is essential to examine the volatile customer demand carefully, such as a sharp rebound or a decrease due to a lack of confidence [11]. Then, there should be a review of the firm's product portfolio and customer base to set priorities in the event of capacity reduction. Third, firms should communicate with all stakeholders, including customers and suppliers, and provide the necessary support, from legal assistance to financial assistance, for the recovery of the

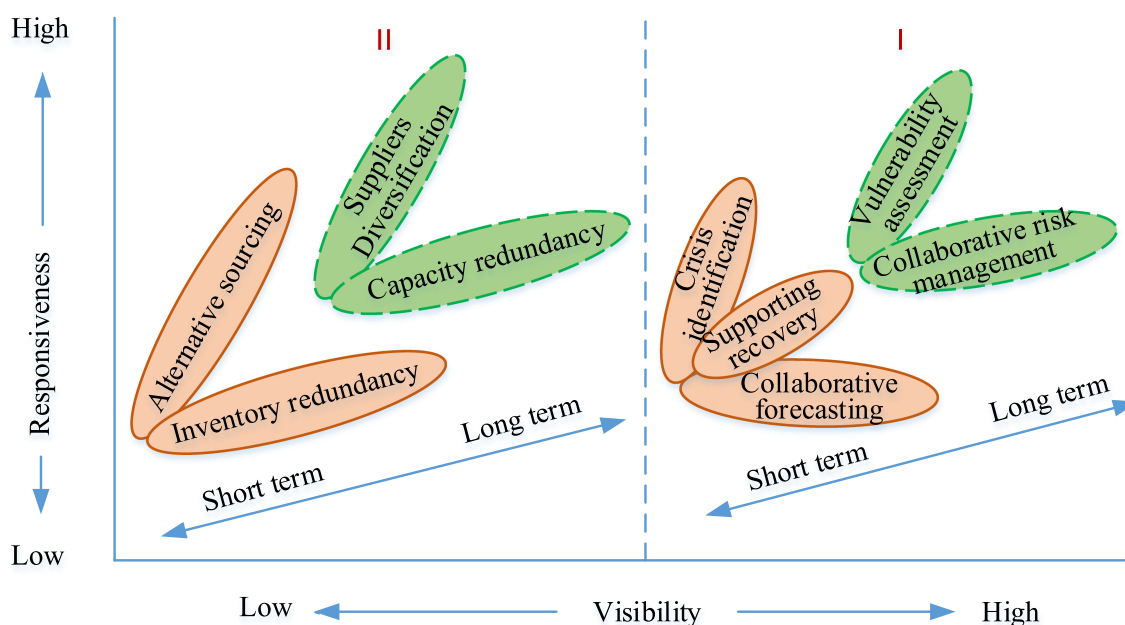


Figure 5. Recommendations for enhancing the visibility and responsiveness to mitigate disruption.

business. Given the potential capacity loss, the supply chain production plans should be renewed and reasonable inventory levels should be determined with the key suppliers.

The next two recommendations are the enablers of long-term competitiveness. The first one is the requirement to understand the critical vulnerabilities of a GSC and to monitor potential disruptive risks in real-time. Supply chain vulnerability often occurs across five dimensions: planning and supplier network, transportation and logistics, financial resiliency, product complexity, and organizational maturity [66]. The leading firms also should be sensitive to big events, such as virus outbreaks, local wars, political conflicts, and natural disasters, as these affect the multilayered networks of suppliers down to the final customers. Information technology and digital solutions, such as 5G technology, big data analytics, and cloud computing, can assist firms in developing visibility through the multilayered processes and help recognize disruptions in the early stages of this complex supply system.

The second recommendation is to work with internal stakeholders as well as with strategic and critical suppliers to establish congruent risk management approaches to mitigate material and manufacturing capacity shortages.

5.2. Responsiveness Enhancements in the Event of Disruptions

During disruptive times, responsiveness capability is a key driver allowing firms to make quick and cost-effective responses to deal with disruptions. However, most of the activities for capabilities development involve operational processes that are more complicated; therefore, there is an opportunity for visibility reduction, as shown in quadrant II in Figure 5.

In the short term, alternative sourcing and inventory redundancy enable quick recovery within the GSCs [67]. On the one hand, the existing inventory policy should be reexamined by balancing the predicted demand and current capacity of suppliers. Therefore, the considerable safety stock is significant. Furthermore, it is essential to ensure that all inventory is outside the high-risk areas or logistic hubs. On the other hand, it is also important to propose and verify the alternative materials and to source local substitutes [68]. Alternative materials offer firms more sourcing options, and local suppliers may promise high availability of materials. The alternative materials development and its inventory establishment should take tier-2 or tier-3 suppliers into account.

In long-term planning, supplier diversification, and capacity redundancy reduce the risk of disruptions when supply chains experience restricted activities due to a catastrophic event [68], [69]. A preferred strategy is to cooperate with suppliers in different geographic locations. Secondary sources provide backup capacity for supply, production, and distribution outages. Capacity redundancy is one of the most popular mitigation strategies used to improve flexibility [7]. Capacity redundancy means that the firms in the GSC maintain flexible resources, such as technicians, machines, and trucks, which can be rearranged according to new requirements and can strengthen production capacity when operations are restricted. New emerging vendors of medical devices are developing their capacity redundancy in the fight against COVID-19.

The impacts of COVID-19 on the demand for various products are mixed. Therefore, the strategies of corresponding GSCs should be positioned carefully. Both the visibility and the responsive enhancement activities would increase costs for

GSCs and weaken the competitiveness of their products in the global market. Therefore, decision-makers should not only consider the tradeoffs between GSC risk mitigation and efficiency, but also pay attention to the differential impacts of those measures on both the functional product and the innovative product. This is because the customer is more sensitive to the cost of the functional product.

Given the low value and easy access to functional products, inventory redundancy establishment is an effective way to increase the resilience of the efficiency GSCs. Furthermore, the urgent task for these firms is to survive the pandemic, rather than to spend additional money to develop a new supply chain. High value and short expiration dates are important features of innovative products. In the case of products, like medical masks, necessary in the current emergency, capacity redundancy in GSCs is relevant. This is because a high inventory level would increase the operational costs and raise the risk of expiration loss.

Efficient GSCs dealing with functional products need to privilege global rather than local sourcing to ensure cost benefits and prevent shortages. Responsive GSCs dealing with innovative products find that local sourcing plays a critical role in preventing shortages. In particular, for GSCs providing emergency products in a crisis, strategic relations development with both the global suppliers and local suppliers are equally important. Global sourcing ensures the efficiency of the supply system, while local sourcing guarantees a quick response to a pandemic.

6. CONCLUSIONS

It is impossible to anticipate the manifestation of global crises such

as the COVID-19 outbreak. However, firms can derive mitigation plans for the potential impacts by developing robust and resilient supply chain processes and readiness plans. The effectiveness of emergency preparedness and responses is highly dependent on a deep and comprehensive understanding of the impact of COVID-19 on GSCs.

This article discusses the impact of three unique features of the impact of COVID-19, longer duration, bigger area, and larger scope. The sectors that are heavily affected by the disruptions are summarized and analyzed throughout the spectrum of GSCs from the supply sources to the final customers. Managerial insights relative to lack of visibility of disruptions in GSCs, response time windows, and delayed industry

responses to the COVID-19 are highlighted. This pandemic forces firms to reevaluate their GSCs and achieve efficiency and agility in the event of a disruption. A set of contingent-based continuity plans is provided to assist firms to equip themselves better to mitigate the risks by emphasizing visibility and responsiveness to disruptions in complex GSCs.

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