

Influence of COVID-19 on Manufacturing Industry and Corresponding Countermeasures from Supply Chain Perspective

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Abstract: It is critical for the recovery of manufacturing industry against COVID-19 by analyzing its impact from supply chain perspective and exploring corresponding countermeasures. Firstly, this paper studies the initial impact caused by worldwide spread of the coronavirus, such as production disruption of raw material and spare parts, unsatisfied market demand due to setbacks in logistics, increasing bankruptcy risk for small and medium-sized enterprises (SMEs), and demand fluctuation enlargement. Secondly, the aftershock of COVID-19 is analyzed. With the trend of regionalization and digitalization, two-step countermeasures are proposed to help the recovery of manufacturing industry within the pandemic and better prepare for the post-COVID-19 world from supply chain perspective.

Key words: COVID-19, manufacturing industry, supply chain

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0 Introduction

The spread of COVID-19 has impacted global economics greatly. Industries like tourism, airline, and manufacturing industry have suffered in the first quarter. Unlike some “Black Swan” events^[1], COVID-19 also possesses the characters of “Grey Rhino” since the initial outbreak of the coronavirus and all the unprecedented countermeasures taken in China in February already delivered the signal to other countries^[2]. It is different from SARS that the continuous contagiousness of the coronavirus has imposed profound impact on manufacturing industry, since low-cost country sourcing, globalization and minimal inventory management have been key tenets of supply chain management for industries like auto, electronic, etc. Besides, the bankruptcy of Lehman Brothers would never pose such great damage without the long-term abnormal development of finance and real estate industry in the United States (US). Similarly, the outbreak and spread of COVID-19 could not cause such huge impact without the existence of other “Grey Rhino” events like the trade war between China and US, Britain leaving the European Union, etc. In order to cope with COVID-19, action like flight stop, import slowdown and outside activities restriction has been implemented in many countries. For

manufacturing industry, risks have risen including supply chain interruption due to production stop for raw material and spare parts, various setbacks in logistics, and the unknown timeline for recovery. With continuous escalation of the pandemic, condition has changed from supply and demand recession in China to global supply shortage under which supply chain interruption already happened in auto and semiconductor industry. The coronavirus has affected manufacturing industry in China, US, and Germany greatly. China’s manufacturing purchasing managers’ index (PMI) in February decreased to 35.7 with 14.3% lower than the PMI in January as reported from National Bureau of Statistics. According to IHS Markit, flash US manufacturing PMI in March was down to 49.2 which registered as the sharpest drop in output since August, 2009. The same index for Germany dropped to 45.7 as well.

Consulting firms and scholars have explored COVID-19’s impact on manufacturing industry. Particularly, industries like electronics, machinery and auto will be hit greatly. Due to necessary quarantine measures taken in place, the negative impact on countries which are regional industry chain centers will gradually spread to other countries and cause supply chain interruption. The volume and structure of demand have changed and the supply chain planning for manufacturing industry has been disturbed. Hence, analyzing how to cope with the pandemic and recover afterwards from supply chain perspective is quite necessary^[3]. Ivanov^[4] conducted a simulation-based analysis to predict both

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the short-term and long-term impacts of COVID-19 on global supply chains. This paper attempts to analyze COVID-19’s initial impact as well as its aftershock on manufacturing supply chain particularly. Then, a two-step approach is explored for the recovery during the pandemic and better preparation for post-COVID-19 period.

1 COVID-19’s Initial Impact on Manufacturing Supply Chain

There are two phases of initial impact caused by the outbreak and spread of the coronavirus. In Phase 1, the production was forced to pause in China and the global supply of raw material and spare parts was shrunk with the delay and decrease of export orders mainly in February and March. In Phase 2, the supply and demand in manufacturing supply chain are severely impacted with the continuous spread of COVID-19 globally. COVID-19 has caused plants shutdown in major manufacturing countries due to the action like lockdown, flight stop, outside activities restrictions, etc. Manufacturing supply chain has been or about to be interrupted for some products in industries such as auto, electronics and pharmaceutical industry. Also, market demand has shown great uncertainty and cannot be satisfied because of the logistics setbacks. Moreover, many small and medium-sized enterprises (SMEs) are at higher risk of bankruptcy than ever.

1.1 Production Interruption of Raw Material and Spare Parts

Global supply chain has been formed for many manufacturing industries with enterprises closely connected with each other. China, US and Germany have become regional manufacturing centers for North Asia, North America and West Europe, respectively. Meanwhile South Korea, Japan and Singapore have been important members for global value chain due to their in-

dustry or geographic advantages. These countries have contributed over 40% of total export of intermediate products, as shown in Fig. 1 (data source: UN Comtrade, KPMG). Plenty of plants in above countries are facing production interruption or delay due to COVID-19. In short time, a certain number of manufacturing enterprises which are deeply involved in global supply chain will be forced to shut down because of lack of raw material and spare parts supply.

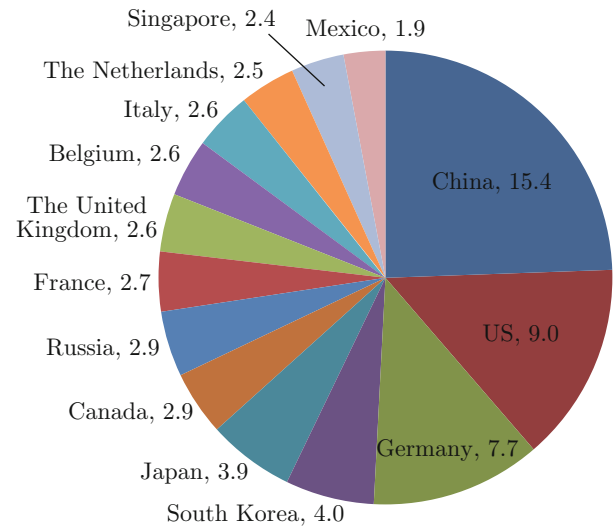


Fig. 1 Export proportion of intermediate products by main economies (%)

China imports a lot from countries which are deeply affected by COVID-19, as listed in Table 1 (data source: China Customs). Production may stop for key components such as integrated circuit, engine and chip in semiconductor, electronics and other industries due to the deteriorated situation in these countries.

On the one hand, China has become the center of global manufacturing and the biggest manufacturing

Table 1 China’s import from certain countries severely affected by COVID-19 in 2019

Country	Import amount × 10 ⁻⁹ /USD	Major intermediate products imported
South Korea	172.286	Integrated circuits, liquid crystal display panels
Japan	170.182	Integrated circuits, electrical capacitors, automatic gearshift and spare parts
US	121.341	Integrated circuits, yellow soybeans, petroleum
Germany	103.660	Auto spare parts, machines and mechanical appliances, controlling instruments & apparatus
Switzerland	26.549	Antisera and other blood fraction, machines and mechanical appliances, semiconductor modules
The United Kingdom	22.875	Petroleum, waste & scrap, engines
Italy	19.943	Leather products, valves
Iran	13.385	Petroleum, polyethylene, methanol
Spain	7.875	Copper ores & concentrates, polycarbonates

site for raw material and spare parts for many industries. China holds critical value to industries like machinery, telecommunication, precision instrument, etc. As the mostly affected city, Wuhan is also a major manufacturing center within China where large companies in auto and semiconductor industry have manufacturing sites, such as Foxcom, Dongfeng Motor Group, Honda, and General Motors. COVID-19 has severely affected Wuhan and spread out to other provinces like Guangdong, Zhejiang and Jiangsu where a great number of manufacturing enterprises are clustered. Enterprises within these areas have delayed or suspended the production since they are shortage of labors, raw material and spare parts. Hence, the output of cars, cell-phones and related intermediate products has decreased dramatically.

On the other hand, China is the main sourcing site for manufacturing industry. Plant shutdown or production delay within China poses great impacts on enterprises in related industries in other regions. According to the National Bureau of Statistics, new import and export order indexes in February were only 31.9% and 28.7% respectively. Although certain stock is kept, the decrease of China’s export will gradually affect downstream enterprises in other regions and lead to supply

interruption of raw material and spare parts for industries like machinery, auto, pharmaceutical industry, etc.

1.2 Unsatisfied Demand Due to Setbacks in Logistics

Logistics has become the weak spot for manufacturing industry after the breakout of COVID-19. As for domestic logistics in China, long-distance road transportation is mostly affected because of highway control. The demand for logistics services has dropped severely in short time because of the pandemic. More importantly, the quarantine policy has led to the supply decrease of drivers and trucks since the major source is from countryside in provinces like Hubei, Jiangxi, Henan, Shandong, etc. According to the statistics from China Federation of Logistics and Purchasing, logistics promising index has dropped to 26.2 with 23.7% decrease compared with that in January.

Starting from March, lockdown action has been seen in some major manufacturing countries as well as countries which are international logistics hub due to the global outbreak of COVID-19, as listed in Table 2 (data source: news). Measures including air flight control, import and export restriction, and stricter commodity inspection have caused four challenges for international logistics which are demand recession due to order

Table 2 Lockdown measures announced by countries due to COVID-19 until March 16, 2020

Country	Character	Measure
US	Manufacturing country	National emergency starting from March 13, city lockdown announced in Philadelphia, Dallas, Ohio, etc.
Belgium	Manufacturing country	Nationwide lockdown starting from Marth 18 to April 5 (tentative)
France	Manufacturing country	Nationwide lockdown starting from Marth 17 and restrictions of outside activities for at least 15 days
Italy	Manufacturing country	Nationwide lockdown starting from Marth 10
Spain	Manufacturing country	Nationwide lockdown for 15 days starting from March 14
Egypt	Logistics hub	All flights in and out Egypt suspended starting from March 19 until March 31
Poland	Logistics hub	All foreign airplanes forbidden and international railways shutdown starting from March 15
Latvia	Logistics hub	All cross countries transportation including air, sea, road and railways suspended starting from March 17 until April 14

cancellation or requirement of delayed shipment; cost increase for airfreight, haulage and distribution; supply shortage due to air flight cancellation; lower efficiency due to longer time needed for commodity check and road transportation. Hence, a large portion of market consumption of electronic products, cars and fast-moving consumer goods (FMCGs) cannot be satisfied.

Also, ocean shipping demand dropped sharply since many international trade contracts have been cancelled or new ones could not be signed in time. According to the data from Trading Economics, the Baltic Dry Index dropped from 1 000 to 411 on February 10 which is the lowest since April 2016. Meanwhile, the ship owner

might not be willing to dock at ports due to the off-board forbidden or restricted for staff and stricter examination procedure. And this can lead to the shipping route change, which certainly causes longer lead-time for international logistics.

1.3 Increasing Bankruptcy Risk for SMEs

The business has been hard for many SMEs due to slowdown of global economic these years. With the outbreak of COVID-19, these companies are facing higher bankruptcy risks.

Firstly, it is harder for SMEs to get permit to resume production. The recovery rate for SMEs is relatively smaller than that for big companies due to high

standard required for the facility and working condition which many SMEs cannot meet. Long time shutdown will impact SMEs' operation and result in bankruptcy due to their limited working capital reserve. As shown in Fig. 2, over 80% of investigated companies do not possess enough capital for 3 months' operation according to the survey from China Association of Small and Medium Enterprises.

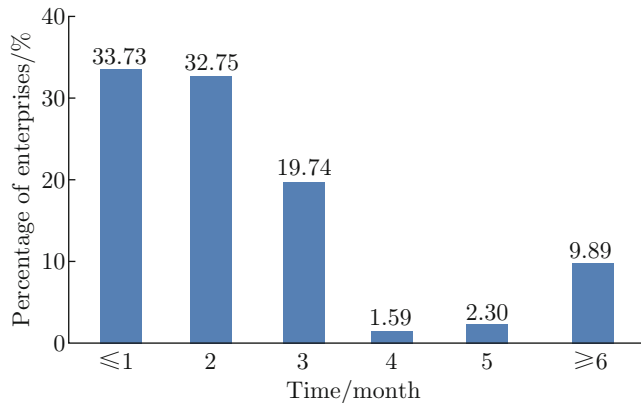


Fig. 2 SMEs' survival period with their own capital reserve

Secondly, the operation cost has increased because of the continuous spread of COVID-19. The raw material cost has also increased because of limited supply from upstream for industries like semiconductor and medicine. Meanwhile, logistics cost has increased because of supply decrease and higher demand from the market especially for last-mile delivery. Also, it would cost more money to hire workers these days. According

to 58 City' research, the average salary for production line worker is 5 197 RMB/month which is 9.78% higher than last year's.

Thirdly, market demand has decreased. A certain number of people expect lower incomes in near future or even losing jobs. The consumption budget will be cut down accordingly. Also, the restriction of outside activities has suppressed the consumption as well. Furthermore, international trade income would also be reduced because of the cancellation or pause of many foreign trade orders.

A great number of SMEs are on the edge of bankruptcy due to shrinking orders, increasing operation cost and limited capital reserve. If the risk escalates, systemic financial crisis may occur. Furthermore, unemployment rate will be higher if SMEs' bankruptcy risks cannot be properly controlled since they account for majority of the employment.

1.4 Higher Fluctuation of Supply and Demand

COVID-19 has posed different impacts on different industries. Global economics has been negatively impacted and consumers' confidence has been down. Besides products which are necessary for daily life and protection against the virus, other consumption can be suppressed because of expected income decrease and unemployment risk. As shown in Table 3, both the supply and demand in industries like auto, textile and electronics will be decreased in short time. As for semiconductor industry, market supply is greatly impacted because of the outbreak of the coronavirus in Japan and South Korea. As for FMCGs, the demand for products will differ from kind to kind.

Table 3 COVID-19's impacts on supply and demand of different industries

Industry	Representative product	Supply	Demand	Influence
Electronics	Smart phone	↓	↓↓	Consumption decrease
	Computer	↓	↓↓	Consumption decrease
Auto	Oil-fueled automotive	↓↓	↓↓↓	Consumption decrease
	New energy vehicle	↓↓	↓↓↓	Consumption decrease
Semiconductor	Chip	↓↓	↓	Supply shortage
	Memory	↓↓	↓	Supply shortage
FMCG	(1) Products for COVID-19 protection and food with long quality-guarantee period (masks, disinfectant, tinned and frozen foods, etc.)	↑↑	↑↑↑	Supply shortage
	(2) Daily necessities from oversea market (infant milk powder, diaper, etc.)	↓↓	↑↑↑	Supply shortage
	(3) Daily necessities (soy sauce, food, etc.)	↑	↑	Supply and demand balance
	(4) Other FMCGs (wine, beverage, lipsticks, etc.)	↓	↓↓	Consumption decrease

Note: ↓ means decrease; ↑ means increase.

Within the period, the demand for products used for COVID-19 protection and food with long quality-guarantee period increases dramatically. The shortage

of these products happens in almost every sales channel in many countries. Due to the restriction of outside activities, daily purchase mainly relies on online channel

or one-stop shopping from time to time. Hence, panic purchase happens. Also, people stock up on daily necessities which are purchased from overseas, such as infant milk powder and diaper. Meanwhile, the consumption of products used for social activities is decreased and the purchase of relatively high-value products will be on hold.

2 COVID-19's Aftershock on Manufacturing Supply Chain

The impact is kept pumping with the globally continuous escalation of COVID-19. Even though the timeframe and extent of COVID-19's full impact are not fully revealed yet, the pandemic has already posted profound ramifications to manufacturing supply chain in two ways.

2.1 Transformation from Globalization to Regionalization

Nowadays, supply chain has been globally designed and optimized to identify proper lead time with the lowest operation cost for many manufacturing industries. However, the risk of delivery delays emerges greatly because of the dependency on remote sources and more complex logistics network caused by globalization^[5]. Also, anti-globalization remains as enduring feature worldwide and seems to dominate among some developed countries. Over the past months prior to the pandemic, the trade war between China and US has intensified the international trade tensions. According to A.T. Kearney, the US manufacturing import ratio fell to 12.1 in 2019 which was firstly declined since 2011. The imports of manufactured goods in 2019 have decreased 7.2% from 14 low-cost countries in Asia with a particularly sharp decline from China. With the rise of protectionism, coupled with increasing cost in less-developed countries and new financial barriers, the reshoring increases. The change of machine tool consumption is good evidence. According to the 2019 world machine tool survey from Gardner Intelligence, despite a globally overall consumption reduction of 13.5%, China's figure dropped 25.3%. However, the consumption in Mexico increased 9.1%, and the consumption in US only declined 1.6%.

With the continuous spread of the coronavirus, regionalization can be the new normal of manufacturing supply chain after the crisis. On the one hand, the weakness in current model of global manufacturing has been fully revealed. The recovery of manufacturing supply chain is not likely to be achieved shortly because of unsynchronized recovery pace among the global and continuous restrictions of international flight. On the other hand, the COVID-19 can pose backlash against globalization and aggregate the decoupling afterwards. According to the forecasts by the World Trade Organization, the International Civil Aviation Organization,

and the United Nations Conference on Trade and Development, the pandemic will cause 13%—32% decline in merchandise trade, 44%—80% drop in international flow of people in 2020, and 30%—40% reduction in investment and trade during 2020 to 2021. The trust between China and western countries is diminishing together with the decline of flow of people, fund and trade. Multinational companies will seek to build manufacturing sites and supply network nearby the end market and form regionalized supply chain.

2.2 Acceleration of Supply Chain Digitalization

Digital technology and analytics can assist companies to navigate the crisis and better prepare to serve the market. Back in 2011, Procter & Gamble (P&G) used cloud-based software to maintain a digital map for its supply chain to capture real-time information and mitigated the disruptions in cost-effective manner during Hurricane Sandy in 2012. To some extent, the supply chain digitalization has been on the agenda for quite some time. However, the progress is not promising in manufacturing industries due to the reasons such as high investment, bureaucracy, and reluctance to change.

Now business is operated in a new context of flux with constant change of external environment which happens on a daily basis due to the pandemic. Digital supply chain will be the prerequisites to success within the pandemic and afterwards to improve the smartness and responsiveness of supply chain. Technologies such as cloud and big data have already played an important role in the supply chain operation for many industries to anticipate customer's needs, mitigate uncertainty and resume operations quickly during crisis. The trend would continue because of the necessity and all the benefits gained from every easy and low-cost digital initiative like cloud-meeting.

With more matured development of big data and artificial intelligence as tools coupled with wider adoption of cloud-based technology and radio frequency identification in 5G environment, COVID-19 can spur a leap to the supply chain digitalization for manufacturing industries.

3 Countermeasures for Recovery of Manufacturing Supply Chain

Although production has been gradually resumed in China since March, the situation may be not that promising in some particular companies, industries or regions. Many enterprises may face the second wave of impact due to shortage of key materials and decrease of export orders from oversea caused by the continuous spread of COVID-19. Also, there will be profound changes to economy and social life after the pandemic. Hence, a two-step corresponding action is

needed including immediate response to address the most pressing impact in order to maintain smooth supply chain operation, and enhance the resilience of the manufacturing supply chain in order to recover and thrive in the post-crisis world.

3.1 Responding to Crisis and Ensuring Business Continuity

Companies have to address the most immediate and pressing challenges caused by COVID-19, and ensure the continuous business operation among all supply chain members. By ensuring employees' safety, supporting their supply chain partners and maximizing the usage of favorable policies implemented within the period, the supply chain operation is expected to be gradually recovered at some extent.

3.1.1 Adjusting Work Mode and Taking Necessary Precautions During Operation Recovery

Remote work mode can be adapted, such as working from home, online meeting and e-bidding. In China, on-line telecommuting was adopted in over 18 million companies by more than 300 million people in February. Unlike industries such as information technology or consulting, remote work mode can only be applied to non-manufacturing departments like research & development, human resources, and finance in manufacturing enterprises with the assistance of smart devices and integrated security system. As for manufacturing related work as well as logistics operation where staff are required to be on the scene of manufacturing site, strict protective measures can be taken as listed in Table 4 to help to create a safe working environment during the pandemic.

Table 4 Protective measures to be taken at manufacturing sites

Location	Measure	
	Common	Customized
Production line		Introducing automated devices
Warehouse	Staff/visitor registration, health declaration, regular temporary check, timely sanitization, CCTV monitor, wearing mask, wearing protective suit (if applicable and necessary)	Introducing automated devices, pick-up/delivery inspection and registration (vehicle/visitor)
Cafeteria		Separated seat, meal take-out
Elevator		Tissue/plastic wrap prepared for the usage of pushing elevator's button

With the implementation of these measures in many industries in China, the average recovery rate for industrial enterprises above designated size reached to 98.6% and the average rate for SMEs reached to 76% on March 28 with average 1% increase daily in March according to the statistics from the Ministry of Industry and Information.

3.1.2 Providing Aid to Supply Chain Partners

It is essential to secure the production recovery for companies which are critical to global supply chain for both China and other countries in order to minimize the total impact. For an example of Lenovo, the spare parts of ThinkPad carbon laptop come from many countries. The laptop cannot be manufactured in Hefei plant if any of these components are not made or shipped to China in time. Hence, core companies need to be aware of the recovery status of other supply chain members and help them when necessary.

By providing financial and non-financial assistance to supply chain members, the core companies can facilitate smooth supply chain recovery instead of individual resurrection. As the global leading machinery company, Sanyi Group has established "Sanyi Mode against COVID-19" alliance with more than 200 suppliers, and provided advance payment and concessionary loans to

partners who have suffered severely with the pandemic. Also, millions of masks as well as other protective materials have been given to domestic and overseas suppliers as reported on the company website. As a result, Sanyi Group has been one of the first companies who resumed operation in February. Similar aid has also been provided by other leading manufacturing companies such as Xugong Group and Haier.

3.1.3 Maximizing the Benefits of Government Policies to Resume Operation

Policies to cope with the impact have been taken in almost all affected countries to stimulate the economy in some developed countries already. As reported on Consumer News and Business Channel (CNBC), US president Donald Trump signed a coronavirus relief bill of 2×10^{12} USD to cope with the impact caused by COVID-19. British government also issued 33×10^{10} GBP of government-backed loans and guarantees. Japan also unveiled an economy stimulation plan worth of 20% of its GDP.

More and more stimulus plans and policies can be expected from country to country in following months. There are three types (supply type, environment type and demand type) of policy tools which have been implemented to cope with COVID-19^[6]. As shown in

Table 5 (data source: announcement and news from government websites), initiatives in all three areas have been announced to support companies to recover in China. Enterprises, especially the SMEs, should closely monitor the announcement of these policies and maximize the usage of them.

Normally, the SMEs in manufacturing industry are facing more difficulties to get finance aid due to lack of credit and limited collateral^[7]. With the increasing

number of countries affected by the coronavirus, global economy is deteriorating, which may lead to further decrease of credit limit provided to enterprises^[8]. As a result, funding is more likely to be cut off and SMEs go bankruptcy, which can jeopardize the continuous operation of the whole supply chain. Hence, it is critical for the SMEs to maximize the usage of extra liquidity issued during the pandemic to facilitate their business operation.

Table 5 Policies (partially) in place which are aimed to help to cope with COVID-19

Policy type	Targeted area	Example
Supply type	Financial aid/subsidy	(1) Central Bank: reduction of the reserve rate for small and medium sized banks and the interest rate of excess deposit reserve in Central Bank (2) Guangdong Province: decreased interest rate for small-amount loan (3) Jiangsu Province: opening green channel for the intellectual property pledge financing (4) Wuhan: 2×10^{10} RMB fund to support SMEs
	Human resource support	(1) Shenzhen: no more than 300 000 RMB subsidy to each human resource agency to help to recruit talents (2) Nanjing: 300 RMB/person subsidy to enterprises to recruit and train unemployed personal due to COVID-19
	Infrastructure & information support	(1) Central government: national service platform (2) Hunan Province: cloud platform for SMEs (3) Shanghai: Shanghai enterprise service cloud
	Legal support	(1) Shanxi Province: free legal consulting and training for import and export legal issues
	On-line service support	(1) Shenyang /Shanghai: online application and approval for government related procedure
Demand type	Government purchase	(1) Guangzhou: 100% advance payment to purchase on the fight against COVID-19, exceeding 30% advance payment for all government purchases during the pandemic (2) Rizhao: reserving exceeding 30% purchase quota dedicated to SMEs
	Trade protection	(1) Ministry of Commerce: providing services for issuing force majeure certificate, bridging the demand and supply for foreign trade enterprises (2) Jiaying: import subsidy for COVID-19 protective materials which are used locally and 30% subsidy for cross-border promotion fee
Environmental type	Legal regulation	(1) All provinces: legislation for COVID-19 prevention and control
	Tax relief/reduction	(1) Announcement No. 8, 2020 of the Ministry of Finance and the State Administration of Taxation (2) Announcement No. 5, 2020 of the State Administration of Taxation
	Social benefit collection delay/reduction	(1) Shanghai: postponing the adjustment of social security payment base (2) Suzhou: delay of social benefit collection for deeply affected enterprises

3.2 Enhancing Supply Chain Resilience in Post-COVID-19 World

Even though manufacturing companies are busy dealing with immediate shocks currently, they also need to think beyond firefighting plan and start to prepare for the post-crisis world to recover and thrive afterwards. COVID-19 has amplified the drawbacks of complex and closely collaborated global manufacturing supply chain and indicated its lack of resilience. Supply chain resilience is to be enhanced to improve its responsiveness to unforeseen shocks^[9].

(1) Improving supply chain visibility. The supply chain disruption caused by the coronavirus has under-

scored the necessity of end-to-end visibility of the entire manufacturing supply chain. To do so, the panic buying of toilet paper in Australia can be avoided if consumers had the visibility of the inventory levels. However, most companies are having difficulties of possessing end-to-end visibility when managing a multi-tiered supply chain nowadays. With the acceleration of digital supply chain stimulated by COVID-19, technologies such as radio frequency identification and block chain can be implemented to enhance information sharing and improve the visibility in the supply chain^[10]. With better bridge of the physical and the digital information, real-time visibility can be achieved in the network

and help to build a more robust supply chain.

(2) Managing supply chain planning with intelligent analyses and simulations. It is hard but critical for enterprises to do a better job of supply chain planning like what P&G did during SARS. With economic stimuli announced in many countries, there are strong needs for infrastructure, auto and electronics, which can help the rebound of many manufacturing industries. Companies should better plan to avoid the bull-whip effect with all the irrational consumer behaviors and stimuli announced during the pandemic^[11]. Agile and smart supply chain planning is essential to minimize the disruption and help to balance the severe volatility of supply and demand caused by “Black Swan” events.

In the era of big data, recalibrating and optimizing supply chain planning with extensive data digging and analysis is critical for business success. However, planners do not have enough time or skill-set to do their job better with considering all the massive variables instead of their own experience and tuition. In order to overcome this, intelligent analytical and simulation tools can be beneficial. Firstly, planners can quickly collaborate and understand the impact of stimulants from both internal and external with the help of a data-sharing platform in the digitalized supply chain. Secondly, scenario planning can be done with the leverage of the predictive power of artificial intelligence and help to anticipate the uncertainties better. A wide range of possible scenarios can be computed as a basis for better planning. Then, the sourcing strategy is to be re-evaluated and supply network can be redesigned accordingly with the aid of dynamic programming to create a more resilient supply chain.

4 Conclusion

Assessing COVID-19’s impacts from supply chain perspective and exploring countermeasures is critical for manufacturing industry. Interruption of raw material and spare parts, setbacks in logistics and demand fluctuation are gradually intensified within the period. Also, the manufacturing supply chain is likely to become regionalized and digitalized in the post-crisis world. As such, two-step countermeasures are sug-

gested in this paper. The first step is to ensure the continuous supply chain operation at present. The second step is to enhance supply chain resilience for better preparation to recover and thrive afterwards.

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