

# ***How to Recover the Supply Chain under COVID-19 Period Through Recovery Its Resilience***

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**Abstract:** The paper describes how the COVID-19 pandemic led to a worldwide supply and demand crunch for medical supplies such as masks and Personal protective equipment (PPE), causing a break in the supply chain. The application of circular economy concepts to supply chains creates resilient supply chains by reducing dependence on external inputs and outputs to help business cope with unforeseen disasters. The resilient supply chain is enhanced by applying the "3R" principle of value recapture in the circular economy model, i.e. reduce, reuse and recycle, and also by drawing on economic models such as platform economy and sharing economy. The paper references are taken from academic databases such as Google Scholar, as well as online materials such as official websites and news websites, and publications such as Supply Chain Guide.

**Keywords:** COVID-19 pandemic, supply chain resilience, circular economy

## **1. Introduction**

COVID-19 is defined as the highest level of alert by the World Health Organization (WHO): public health emergencies of international concern [1]. Personal protective equipment (PPE) such as masks and N95 respirators have been identified by WHO as effective measures [2], resulting in a demand for PPE that is 100 times higher than normal and 20 times more expensive [3]. However, the resources available for manufacturing are not sufficient to meet the demand because of the restricted import and export of trade at national borders. This huge contradiction between supply and demand accelerated the break-up of the supply chain during COVID-19.

When faced with these potential disasters and difficulties, supply chain companies improve the industry's own resilience through the principles and models of circular economy (CE). The application of the circular economy model implies a fundamental change in stakeholder relations, breaking the concept of "end of life" that exists in linear economies [4]. Thus, the circular economy ensures the resilience of the supply chain (it is less dependent on external inputs and outputs and more resilient), creates new business opportunities, maximizes the use of resources in case of resource scarcity through the "3R" principle, reducing waste production and returning resources to the

production cycle. This allows for the sustainability and regeneration of resources in a short period of time to alleviate the sudden pressure of pandemics.

For example, the "3R" principle based on the circular economy model, i.e. reduce, reuse and recycle [5], creates more value from limited resources than the traditional linear economy model. For example, BYD has transformed its automotive company into the world's largest mask processing plant by using its complete manufacturing technology to design and produce 90% of its PPE line parts in-house [6].

The new crowns were not unfamiliar disasters, in SARS in 2005, and bird flu in 2009. These prior experiences set the stage for the fight against the COVID-19 pandemic. There are lessons to be learned from the previous disasters for businesses, social groups, and governments. In this paper, the authors will respond to how to retain lessons learned and adapt to better prepare for subsequent major disruptions.

In Section 2, the authors review the impact of the COVID-19 pandemic on the supply chain. In Section 3, the authors use the 3R principles of the circular economy model to analyze the responses of several manufacturing firms in response to the COVID-19 pandemic. In Section 4, the concepts of circular economy and circular supply chain are defined from the perspectives of business and stakeholder respectively, and studied from the perspective of elasticity. In Section 5, the successful cases of companies, social groups and governments responding to the COVID-19 pandemic are introduced and analyzed, and the results are summarized as replicable, ready and scalable circular economy models, and effective measures are concluded to deal with future disasters. Finally, in Section 6, the authors draw conclusions, contributions, limitations, and future research.

## **2. Supply Chain Collapse and Response During COVID-19 Pandemic COVID-19 Impact on the Supply Chain**

COVID-19 is a novel coronavirus that was discovered in 2019. Reviewing the timeline of COVID-19, in March 2020, the World Health Organization declared the novel coronavirus outbreak caused by COVID-19 as a public health emergency of international concern, which is the highest alert level of WHO [1]. According to the Global Health Organization, as of 5:01pm CEST, 11 August 2022, there have been 585,086,861 confirmed cases worldwide, including 6. 422,914 deaths [7].

According to the World Health Organization, COVID-19 is mainly transmitted between people in close contact with each other, and the virus can be transmitted from the mouth and nose of an infected person as small liquid particles when the person coughs, sneezes, speaks, sings, or breathes, thereby infecting another person with the virus [8].

To prevent the spread of the virus, governments have responded to the catastrophe caused by COVID-19 through different public health strategies, including keeping social distance, requiring masks, temporarily closing certain businesses (e.g., shopping centers, restaurants, entertainment facilities), and limiting public gatherings [9,10]. Some governments have instituted rather radical control measures, such as border closures and blockades, resulting in severe disruptions in supply chains [11].

According to the World Health Organization, health workers should wear personal protective equipment (PPE) when entering the rooms of suspected or confirmed COVID-19 patients, and wearing masks is also considered an effective way to prevent COVID-19 [2,8]. So the biggest impact of the disaster caused by COVID-19 is in the healthcare industry. PPE, represented by disposable masks and N95 respirators, were procured by health care facilities during the pandemic in response to the increasing number of confirmed cases.

As the World Health Organization pointed out the demand for PPE was 100 times higher than the normal level and 20 times more expensive [3]. The shortage of supply and the huge demand caused severe disruptions in the PPE supply chain during the pandemic.

## 2.1. Disruption of Linear Economy Promotes Circular Economy

Linear economy generally follows the flow direction of "acquisition - manufacturing - disposal", which is a one-way business model. This is a one-way business model in which raw materials are manufactured into products based on resources, and the products flow in one direction along the supply chain to the hands of the stakeholder to be used, and eventually lose their use value and are discarded [12].

The drawbacks of linear supply chains were fully exposed during the COVID-19 pandemic, and the post-epidemic era leaves us more time to think about the circular economy model.

The circular economy (CE) is a framework of system solutions that plays an important role in addressing challenges such as global climate change and environmental pollution. CE is based on a transition to renewable energy and materials that separates economic activity from the consumption of finite resources. CE follows the "Eliminate waste and pollution", "Circulate products and materials" and "Regenerate nature" in the supply chain. Some scholars have also referred to CE's Principle as the "best practice". Some scholars also summarize the principles of CE as "3R", which means "Reduce", "Reuse" and "Recycling" [4]. It is a model that creates more value from limited resources than the traditional linear "production-disposal" model [5].

The "Reduce" aspect works mainly for the "circular seller", and the accelerated scaling up of CE will bring significant overall economic benefits, while helping companies to reduce their use of raw materials and be in a better position to combat climate change. It is estimated that the potential for material savings alone exceeds one trillion dollars per year [5]. LG's PuriCare wearable air purifier, introduced at IFA 2020, offers a new way to save the non-woven resources used to manufacture disposable masks and N95 respirators. When the filter cartridge fails, it only needs to be replaced with a new one, without the need to buy a new PuriCare [13].

"Reuse" can be seen during the COVID-19 pandemic, when large manufacturing companies with well-established industrial systems ventured into the PPE manufacturing industry, either under legal authorization or for financial profit, which was certainly a new experiment for them. U.S. automakers joined the sequence of producing PPE under the influence of the Defense Production Act Contract. According to a press statement from the U.S. Department of Defense, these manufacturing companies are expected to bring more than 1 billion N95 respirators to the United States in 2021 to meet the U.S. demand for approximately 140 million masks during the 90-day peak use period during the COVID-19 crisis [14]. In the UK, AE Aerospace modified its factory floor to produce mill components for ventilation equipment; Alloy Wire International reuse its machinery and equipment to manufacture springs for ventilators; AMTICO (floor manufacturer) upgraded its production line to produce masks for front-line workers; BAE Systems used its factory resources to produce and distribute over 40,000 masks; and BARBOUR (clothing company) repositioned itself to produce personal protective equipment for nurses [15]. In China, where the COVID-19 pandemic is at its worst in early 2020, Chinese automaker BYD announced the opening of the world's largest mask manufacturing plant. According to news from BYD's official website, one of BYD's high-quality mouthpiece production lines requires about 1,300 parts for various gears, chains, and rollers, 90% of which are BYD's own parts. BYD's human resources for PPE production consist of leaders from different business units and more than 3,000 engineers who work on R&D, design, and machining. BYD has built several PPE production lines in its factories using its own technology and resources (including raw materials and human resources), with a daily production capacity of 5 million masks and 300,000 bottles of disinfectant [16].

The technology of recycling disposable masks has been mastered by a French company called Plaxtil, which removes the metal nose clips from the recycled masks, exposes the textile material to UV light for sterilization, and mixes the treated fabric with special resins to produce other products

that respond to COVID-19, such as splash-proof masks. TerraCycle from the United States disinfected and sorted recycled masks and rubber gloves, polypropylene was processed into pipes, metal materials were melted and reused, and rubber granules were mixed into paint for painting basketball courts [17].

## 2.2. Supply Chain Resilience and Circularity Stress-testing Indicator Correlation

Table 1: Circularity Stress-Testing Indicator Correlation.

No.	Circularity Stress-Testing Indicator	Correlation	References
1	Does it increase the health resilience of the community?	Yes	[1]
2	Does it enhance business continuity?	Yes	[2, 6]
3	Does it yield justifiable present value from circular economy benefits?	Yes	[3]
4	Does it enable the business to flexibly adapt to disruptions and changes in societal needs?	Yes	[4, 5]
5	Does it create sustainability/shared value and stakeholder benefits/profits??	Yes	[6,7]

The COVID-19 pandemic influenced business not to proceed normally by affecting raw material production and logistics, which in turn led to the disruption of part of the supply chain and ultimately imposed a STRESS on the supply chain [18, 19]. FEMA's Supply Chain Resilience Guide states that a resilient supply chain is a key factor in protecting the lifeline of a community, both in terms of ensuring continuous community operations and protecting human health and safety [20]. COVID-19 pandemic is identified as an unpredictable supply chain crisis, and designing a resilient supply chain will ensure continuous supply and proactively identify the crisis quickly [21]. River Logic shares the same view, which describes that supply chain management systems in resilient supply chains ensure the continuity of a company's business by identifying and responding to foreseeable and unforeseeable risks in a timely manner [22]. Oak Spring University calculated the net present value (NPV) at 6% discount rate is 2655230 for the case of Lucent Technologies, proving the success of the company's supply chain redesign to enhance the management of the supply chain [23]. Siagian, H. and other scholars believe that supply chain resilience and flexibility are inseparable, and in resilient supply mid-chain, the management of development, production, suppliers, logistics and supply is optimized to enhance the flexibility of the supply chain by strengthening the response to changes in an uncertain environment to overcome fluctuating market demand fluctuations [24]. Tracelink believes that resilient supply chains have the ability to adjust as needed when conditions change supply chain structure and processes, thus increasing the flexibility of the supply chain [25]. A resilient supply chain will create shared value with suppliers in the community through localized sourcing, outsourcing, etc. [22]. River Logic believes that creating a resilient supply chain reflects to some extent the sustainability of the supply chain, for example, reducing offtake and other protection policies that may affect the resilience of the supply chain will contribute to a sustainable supply chain [26].

## 2.3. Build Sustainable Supply Chains

According to a McKinsey & Company survey of senior supply chain executives across a wide range of industries, the percentage of respondents who believe they should take steps to increase resilience in their supply chains to reach a sustainable supply chain is 75% in 2020, while 92% of respondents already agree with this statement in 2021 [27].

Moving toward a more sustainable supply chain has a variety of benefits for companies. Including long-term cost control, increased brand value, and risk reduction are often the top barriers to companies investing in more sustainable supply chains. More sustainable sourcing tends to increase costs, and companies are often reluctant to make sweeping changes to sourcing. According to the World Economic Forum, sustainable procurement can cut costs by up to 16% [28].

The main way for companies to reduce costs is to reduce energy use and waste. In the long run, choosing to buy more energy-efficient materials, from cars to appliances and lighting, can lead to greater savings. Using more energy-efficient materials is especially important for buildings, since 85% of life-cycle costs are operational costs. Using sustainable materials and buildings, while potentially costly up front, can create lasting sustainable value in the future. The concept of near-zero energy buildings (nZEB), for example, is a comprehensive area of research and design. The challenge now focuses on the development of positive energy buildings and smart grids capable of self-powering through the accumulation and exchange of energy from renewable sources [28].

Environmental, social and governance (ESG) indicators can be used to assess the sustainability of corporate supply chains [28]. EcoVadis makes is a rating agency that incorporates sustainable supply chains into corporate sustainability measurements. It incorporates ESG indicators of sustainable supply chains into the performance of supplier assessments, for example, by requiring suppliers to reduce CO2 emissions and respect the rights of protected employees [29].

Such standards are evolving rapidly: the compliance required by top multinational companies covers an increasingly wide range. As economies mature and develop, funds across Asia are adopting increasingly stringent ESG criteria to assess overall corporate sustainability that encompasses the supply chain.

In addition to this, supply chain risk management functions and processes are increasingly being adopted by large corporations in response to the need for increased resilience. Supply chain management works with manufacturing, procurement and suppliers to assess vulnerabilities at supply nodes and apply a robust risk mitigation framework as a response. Actions may include accelerating decentralization, deploying inventory closer to customers, or even advancing, and developing crisis response plans and capabilities [30].

#### **2.4. Enhance Supply Chain Resilience from Businesses, Social Enterprises, and Governments**

For manufacturing companies, while existing supply chain risk organizations typically focus on a narrow range of risks, such as logistics delays or supplier financial stability, the scope of the risk management function can be expanded to include factors such as prolonged disruptions in cross-border flows, or social and geopolitical disruptions. Managing these risks requires investments in improved business disruption forecasting capabilities, risk transfer mechanisms and crisis planning. It may also drive physical reconfiguration of the supply chain, particularly for critical components and raw materials. Similarly, improving the end-to-end digital capabilities of the supply chain requires an orchestrated view across nodes so that companies can connect these dots with the latest digital tools and capabilities. Autonomous planning systems with machine learning capabilities can forecast based on more factors and understand the "next normal" faster than traditional methods to build business continuity, retain cash, and enhance supply chain resilience [31].

Industry 4.0 technologies provide manufacturers with decision support, such as cyber-physical systems (CPS), Internet of Things (IoT), and cloud computing, which can complement human decision making with decentralized decision making techniques [32].

The introduction of new technologies by manufacturers will help companies to gain in the long term. Whether through more accurate forecasting, reduced downtime, or faster delivery and turnaround times, information systems for the end-to-end supply chain will help companies eliminate

inefficiencies, improve responsiveness to disasters, and significantly reduce supply chain operating costs [33].

For stakeholders close to product use, according to information from the EcoVadis website, 85% of consumers are more likely to buy from a company with a reputation for sustainability than from a neutral company [29]. Consumer preference for sustainable companies will expand sales of their products and also provide support from downstream in the supply chain to support manufacturers in advancing sustainability in their supply chains.

The UN Global Compact supports manufacturers' sustainability at the macro policy level and lists ten principles (covering human rights, labor, environment and anti-corruption) to guide companies in making sustainable changes [34]. The U.S. Environmental Protection Agency launched the Supply Chain Guidance to provide information to organizations interested in reducing supply chain emissions, and the Climate Leadership Awards to honor organizations that contribute to sustainable supply chains [35].

### **3. Multiple Ways to Enhance Supply Chain Resilience**

In this section, the authors will analyze measures that companies can take to enhance their supply chain resilience during the COVID-19 pandemic, in terms of the raw materials, labor and management segments of the supply chain.

#### **3.1. Material Advantages to Support the Rapid Transformation of Enterprises**

Under the impact of a pandemic, some companies are unable to reach their expected sales, which can lead to a buildup of production materials. By transitioning to socially desirable materials (such as PPE), companies can not only solve the buildup of surplus materials, but also provide a new way of thinking to enhance supply chain resilience in response to a disaster

As COVID-19 spreads around the world, there is an unprecedented demand for PPE. According to The Business Research Company report, the global medical device market reaches nearly \$456.8 billion in 2020, growing at a compound annual growth rate (CAGR) of 3.5% since 2015. The market is expected to grow from \$456.8 billion in 2020 to \$62 billion in 2025, a growth rate of 7.7% [36]. In contrast, the value of the U.S. sportswear market declines by 9.3% in 2020 compared to the previous year [37]. Meanwhile, according to Technavio's monitoring of the athletic footwear market, growth is expected to decline by \$10.23 billion from 2020 to 2024. As a result, several sportswear companies, including Nike, have ventured into the production of PPE products to reduce the impact of raw material inventory buildup on the supply chain and corporate profits [38]. Nike announced on its official website that it has been trying to produce PPE in order to help medical personnel who lacked protective gear during the outbreak. Nike will try to modify the raw materials used in shoe manufacturing to produce protective masks and electric dust filter respirators. The elastic sole material of Nike Air series sneakers was used for the protective masks, while the elastic band came from recycled materials. [39] Although in comparison to other industries that are also producing masks, Nike is not as good as BYD or Apple in terms of both capital advantage and supply chain perfection, but it is important to know that Nike, which is already focused on apparel, footwear and other businesses, has more advantages in terms of material supply. Therefore, the enterprise according to the characteristics of raw materials and their own situation to choose the appropriate response strategy when disaster strikes, may be a good way to enhance the resilience of the supply chain.

For reduce, business focuses on reducing production materials by reducing the production process or improving the reusability of the product, such as replacing parts of the product. In addition, some companies choose to upgrade features to turn disposable products into reusable ones, such as LG's electronic masks [13]. For reuse, large companies with greater manufacturing capacity can reuse

excess capacity during the COVID-19 pandemic, and they only need to make some adjustments to their equipment to produce other products and produce goods that society needs. Shanghai General Motors Wuling (SGMW) is the largest manufacturing company in Guangxi, with revenue reaching 100 billion yuan in 2019, it is also the only over 10 billion manufacturing enterprise in Guangxi, and the production line of masks has already started production. Among them, the dust-free workshop is reconstructed by Guangxi Construction Group, and 14 mask production lines have been established, including 4 N95 mask lines and 10 ordinary medical protection mask lines, which can completely reach more than 1.7 million after the project is put into operation, helping to alleviate the local supply and demand tension of masks [40]. This is not the case for smaller-scale producers. Because their own production capacity is not sufficient to allow them to produce what they need within their companies while converting excess capacity into other products. the COVID-19 pandemic has strained the supply and demand for raw materials, and recycling is seen as a method of value recapture can help companies solve raw material shortages by recycling used products and extracting the needed raw materials through technological means to improve supply chain resilience. The National Waste and Recycling Association (NWRA) has sent a letter to the U.S. House of Representatives urging them to consider the role of The National Waste and Recycling Association (NWRA) has sent a letter to the U.S. House of Representatives urging them to consider the role of recycling in providing "supply chain resilience" to the U.S. economy [41].

### **3.2. Shared Workforce to Compensate for Labor Shortage in Supply Chain—Aim to Build up Resilience**

During covid-19 period, many countries carry out the lockdown policies, which makes companies faced with a shortage of labor. Under this situation, scarce resources become more strained, accompanied with labor shortage, the balance of supply chain had been damaged, nobody produce the output, cost of production will dramatically increase and slow down the rate of production. Human resources have become one of the important problems to be solved under the epidemic. Without intentional recovery, industries cannot resume work by themselves. Thus, the sharing of employees began to occur, and the B2B economic model of sharing employees began to be widely used [42].

The B2B economic model in sharing employees enables the direct connection between companies, excluding the participation of third parties, So the main benefit is that it has the flexibility to reasonably balance the labor demand in different firms in the market. Simply means to share some employees from firms with labor surplus to firms with labor shortage. It is not a fixed model, human resources can choose to join the company or not based on the labor demand of the company. This new economic model can quickly recover and adapt to the current shortage of labor in the supply chain [43].

Hema, a market in China, used this sharing employees' economic model. Hema specializes in fresh food and has integrated modes of supermarket, catering, e-commerce and logistics, the biggest difference with traditional retail is that Hema uses advanced technologies such as big data, mobile Internet and automation to achieve the optimal matching among people, goods and stores [44].

Because of this digital power, staffs in Hema cannot satisfy the online demand and face for the labor shortage problems, many consumers cannot complete their orders. Their supply chain had been disrupted and lose its resilience. So, Hema decide that people who used to be in transportation positions have been transferred to part-time jobs. Also recruit other companies staffs to take the job.

In this shared employee economy, employees do not have a mandatory working time, so their hours are more flexible. Therefore, the employee sharing mode greatly reduces the cost of labor distribution between the third-party human resource companies, and also gives employees more choices. They can choose to cooperate with Hema during peak order periods and carry out logistics delivery during low peak periods, which greatly reduced the pressure of the labor shortage in Hema.

This solution effectively solved for labor shortage problem, it can recover in a short time and continuously convey labor to the market to enhance the resilience of supply chain.

But employee sharing is not yet a perfect solution, because it faces many problems, for example, how to allocate wages properly, how to solve the labor contract problem, and the legal issues related are still need to be solved. But from the pandemic we can see sharing workers will also start to become a mainstream economic model for society.

### **3.3. Digital Technology to Enhance Supply Chain Management**

The spread of COVID-19 has had a significant impact on supply chain operations, and commercial enterprises need to take a holistic approach to managing their supply chains to enhance their resilience. In order to create enough flexibility to prevent the disruptive impact of future contingencies, commercial enterprises have also considered developing digital management platforms that leverage advanced technologies such as big data, IoT technologies, and artificial intelligence to ensure end-to-end transparency in the supply chain [45].

Big data analytics take advantage of data aggregation to identify or address risks faster, provide accurate predictions to eliminate waste, and reduce operational costs [46]. JD Logistics has improved the accuracy of demand forecasting and increased the Volvo parts order fulfillment rate to over 95% based on forecasting with optimized algorithms based on historical data from each node of Volvo logistics demand, lifecycle data, vehicle network, regional distribution, and network structure [47].

The Internet of Things (IoT) optimizes supply chain management with the help of embedded sensors, software, and electronic devices that enable goods on the Internet enabling companies to track and monitor various assets in real time [46]. SF Holding helped an industrial park in Hangzhou, China, to build a IoT intelligent IoT management platform for unified - access and management of all devices, solving the problem of numerous devices and confusing authority data management in large industrial parks, realizing the realization of real-time monitoring of devices, automatic alarming of abnormalities, improving the management efficiency of the park It also ensures the security of the park [48].

Warehouse Management System (WMS) is the software that controls and supports warehouse functions, which can track shipments, perform cycle counts, and assist users in optimizing inventory systems. JD Logistics uses WMS and a proprietary transportation management system (TMS) to monitor and manage the entire process of inventory, labor, and data transfer across the warehouse network, thereby improving inventory visibility and operational efficiency through real-time vehicle and commodity tracking and automated third-party carrier screening and billing to help customers achieve greater inventory visibility and operational efficiency. It helps customers achieve more comprehensive and refined transportation process management through real-time vehicle and commodity tracking and automated third-party carrier screening and cost settlement [49]. At the same time, the connection of WMS with RFID technology facilitates tasks such as inventory management and asset tracking. For example, RFID readers scan the digitally encrypted data in RFID tags, transmit and exchange the data, and then upload the recorded information to the WMS. sF Holding takes advantage of the automatic batch and rapid identification of RFID to speed up the efficiency of the flow of goods throughout the supply chain and improve the efficiency and accuracy of the inventory of items [50].

## **4. Conclusion**

This paper addressed the key problem for supply chain during the pandemic period, which is the lack of resilience of supply chain. Then we proposed four multiple events and methods to enhance supply chain resilience and evaluate its effectiveness. Based on the research, different economic modalities



such as sharing economy, platform economy, circular economy can use to increase the resilience of supply chain and avoid its disruption, and then achieve for the goal of sustainability. Meanwhile, government and some other state public institutions can also help the company recovery itself intentionally.

All of these solutions have their limitations because they are just a set of tactic that rapidly used and published out of the covid-19 outbreak. They haven't been comprehensively considered, for example, what is the future of these solutions, will it change or not. So, based on the summary of each solutions, it can predict that covid-19 is a long, continuous and prevailing disease, so if a company want to recover its supply chain, they have to compensate for the limitation of each solutions. Also try to make the combination of all these mentioned modalities can then choose for the best way to recover its resilience, and to continuous production and make the supply chain be actively.

## References

- [1] World Health Organization. *Coronavirus Disease (COVID-19). WHO Coronavirus (COVID-19) Dashboard*. Retrieved from: <https://covid19.who.int/> (accessed on 12 August 2022).
- [2] World Health Organization. *Coronavirus disease (COVID-19): Masks*. Retrieved from: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-COVID-19-masks> (accessed on 13 August 2022).
- [3] United Nations News. *Coronavirus: demand for face masks creates shortfall for those in real need*. Retrieved from: <https://news.un.org/en/story/2020/02/1056942>.
- [4] Kuo, T.-C.; Chiu, M.-C.; Chung, W.-H.; Yang, T.-I. *The circular economy of LCD panel shipping in a packaging logistics system*. *Resour. Conserv. Recycl.* 2019, 149, 435–444. (Farooque, Zhang et al. 2019)
- [5] The Ellen MacArthur Foundation and McKinsey & Company. (2013). *Towards the Circular Economy: Accelerating the scale-up across global supply chains* (p. 16). *World Economic Forum*.
- [6] BYD official website news. *Byd Opens World'S Largest Face Mask Manufacturing Plant*. Retrieved from: <https://en.byd.com/news/byd-opens-worlds-largest-face-mask-manufacturing-plant/>.
- [7] World Health Organization. *Coronavirus Disease (COVID-19). Timeline: WHO's COVID-19 response*. Retrieved from: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!> (accessed on 12 August 2022).
- [8] World Health Organization. *Coronavirus disease (COVID-19): How is it transmitted*. Retrieved from: <https://www.who.int/news-room/questions-and-answers/item/coronavirus-disease-COVID-19-how-is-it-transmitted> (accessed on 13 August 2022).
- [9] Xie, K., Liang, B., Dulebenets, M.A., Mei, Y., *The impact of risk perception on social distancing during the COVID-19 pandemic in China*, *Int. J. Environ. Res. Publ. Health* 17 (17) (2020) 6256.
- [10] Khorram-Manesh, M.A. Dulebenets, K. Goniewicz, *Implementing public health strategies—the need for educational initiatives: a systematic review*, *Int. J. Environ. Res. Publ. Health* 18 (11) (2021) 5888.
- [11] Moosavi, J., Fathollahi-Fard, A. M., & Dulebenets, M. A. (2022). *Supply chain disruption during the COVID-19 pandemic: Recognizing potential disruption management strategies*. *International journal of disaster risk reduction : IJDRR*, 75, 102983. <https://doi.org/10.1016/j.ijdr.2022.102983>.
- [12] IGI Global. *What is Linear Economy*. Retrieved from: <https://www.igi-global.com/dictionary/operationalization-of-circular-economy/75076#:~:text=An%20economy%20based%20on%20%E2%80%98take-make-dispose%E2%80%99%20is%20called%20as,manufactured%20is%20very%20high%20in%20this%20economy%20>.
- [13] Adrian Gibbons. *Electronic Face Masks are a Fashionable High-Tech Trend*. Retrieved from: <https://www.allaboutcircuits.com/news/electronic-face-masks-are-a-fashionable-high-tech-trend/>.
- [14] U.S. Department of Defense news. *Domestic N95 Mask Production Expected to Exceed 1 Billion in 2021*. Retrieved from: <https://www.defense.gov/News/News-Stories/Article/Article/2215532/domestic-n95-mask-production-expected-to-exceed-1-billion-in-2021/>.
- [15] Ibn-Mohammed, T., Mustapha, K. B., Godsell, J., Adamu, Z., Babatunde, K. A., Akintade, D. D., ... & Koh, S. C. L. (2021). *A critical analysis of the impacts of COVID-19 on the global economy and ecosystems and opportunities for circular economy strategies*. *Resources, Conservation and Recycling*, 164, 105169.
- [16] Davide Perillo. *The circularity of disposable masks*. Retrieved from: <https://www.eni.com/en-IT/circular-economy/recycling-covid-masks.html>.
- [17] Knut Aliche, Ed Barriball, Vera Trautwein. (2021, November 23). *How COVID-19 is reshaping supply chains, from McKinsey & Company* Retrieved from: <https://www.mckinsey.com/business-functions/operations/our-insights/resetting-supply-chains-for-the-next-normal>.

- [18] Reyes, A. *Supply-Chain Stress: The Pursuit of Resilience*. Retrieved from: <https://www.asiaglobalonline.hku.hk/sources-supply-chain-stress-pursuit-resilience>.
- [19] McKinsey & Company. (2020). *Why now is the time to stress-test your industrial supply chain*. Retrieved from: <https://www.mckinsey.com/business-functions/operations/our-insights/why-now-is-the-time-to-stress-test-your-industrial-supply-chain>.
- [20] U.S. Department of Homeland Security. (2019). *Supply Chain Resilience Guide (P.7.)*
- [21] Abdullahi, M., Aigbogun, O., Ahmad, R., Ehido, A., Fawehinmi, O., Ibeabuchi, C. & Xing, M. (2022). *A supply chain resilience model for business continuity: The way forward for highly regulated industries*. *Uncertain Supply Chain Management*, 10(1), 1-12.
- [22] Azar, A., Ghatari, A., Hajiaghaei-Keshteli, M., Taghipour, A., Khazaei, M. & Rameza-ni, M.. (2022). *Creating Shared Value and Strategic Corporate Social Responsibility through Outsourcing within Supply Chain Management*. *Sustainability*. 10.3390/su14041940.
- [23] Oak Spring University. *Lucent Technologies: Global Supply Chain Management Net Present Value (NPV) / MBA Resources*. Retrieved from: <https://oakspringuniversity.com/frontpage/npvcase/19205-supply-chain>.
- [24] Siagian, H., Tarigan, Z. J. H., & Jie, F. (2021). *Supply Chain Integration Enables Re-silience, Flexibility, and Innovation to Improve Business Performance in COVID-19 Era*. *Sustainability*, 13(9), 4669. MDPI AG. Retrieved from <http://dx.doi.org/10.3390/su13094669>.
- [25] Tracelink News. *Supply Chain Resiliency*. Retrieved from: <https://www.tracelink.com/agile-supply-chain/supply-chain-resiliency>.
- [26] Riverlogic News. *Supply Chain Resilience vs. Flexibility, Sustainability, & More*. Retrieved from: <https://www.riverlogic.com/blog/supply-chain-resilience-vs-flexibility-sustainability-more>.
- [27] Aden Group. *Serious about sustainability? Don't overlook your supply chain*. Retrieved from: <https://www.adenservices.com/en/blogs/supply-chain-sustainability/>.
- [28] *The Sustainability.io*. *Supply Chain Sustainability – Activate ESG and Sustainability through the supply chain*. Retrieved from: <https://www.thesustainability.io/supply-chain-sustainability#:~:text=One%20of%20the%20important%20steps%20to%20activate%20ESG,and%20to%20figure%20out%20opportunities%20for%20cost%20efficiency>.
- [29] *EcoVadis official website*. *About EcoVadis*. Retrieved from: <https://ecovadis.com/suppliers/>.
- [30] Viglioglia, M., Giovanardi, M., Pollo, R., & Peruccio, P. P. (2021). *Smart District and Circular Economy: The Role of ICT Solutions in Promoting Circular Cities*. *Sustainability*, 13(21), 11732. MDPI AG. Retrieved from <http://dx.doi.org/10.3390/su132111732>
- [31] Alonso-Muñoz, S., González-Sánchez, R., Siligardi, C., & García-Muiña, F. E. (2021). *New Circular Networks in resilient supply chains: An External Capital Perspective*. *Sustainability*, 13(11), 6130. <https://doi.org/10.3390/su13116130>.
- [32] Aliche, K., Gupta, R., & Trautwein, V. *Resetting supply chains for the next normal*. McKinsey & Company. Retrieved from: <https://www.mckinsey.com/business-functions/operations/our-insights/resetting-supply-chains-for-the-next-normal>.
- [33] Sarkis, J. (2021), "Supply chain sustainability: learning from the COVID-19 pandemic", *International Journal of Operations & Production Management*, Vol. 41 No. 1, pp. 63-73. <https://doi.org/10.1108/IJOPM-08-2020-0568>.
- [34] United Nations Global Compact. *The Ten Principles of the UN Global Compact*. Retrieved from: <https://www.unglobalcompact.org/what-is-gc/mission/principles>.
- [35] U.S. Environmental Protection Agency. *Supply Chain Guidance*. Retrieved from: <https://www.epa.gov/climateleadership/supply-chain-guidance>.
- [36] *The Business Research Company Report*. *Medical Devices Market 2021*. Retrieved from: <https://www.thebusinessresearchcompany.com/report/medical-devices-market#:~:text=Medical%20Devices%20Market%20Size%20The%20global%20medical%20devices,billion%20in%202025%20at%20a%20rate%20of%207.7%25>.
- [37] P. Smith. *Annual growth of the sports apparel market value in the United States between 2020 and 2021*. Retrieved from: <https://www.statista.com/statistics/1198876/annual-growth-of-the-sports-apparel-market-us/#statisticContainer>.
- [38] Technavio Research. *Technavio analysis. Sports Footwear Market 2020-2024*. Retrieved from: <https://www.businesswire.com/news/home/20201110005166/en/Sports-Footwear-Market-2020-2024-Athleisure-Product-Segment-Witness-Maximum-Growth-Technavio>.
- [39] CBS News. (2020). *Nike repurposing sneakers to create face shields for health care workers*. Retrieved from: <https://www.cbsnews.com/news/nike-face-shield-repurposing-air-max-sneakers-to-create-ppe-health-care-workers-coronavirus-hospitals/>.
- [40] Yang, L. (2020). *SAIC-GM-Wuling joint suppliers to switch production masks to fight the epidemic together*. Retrieved from: <https://www.bjnews.com.cn/detail/158096885115423.html>.
- [41] Taylor, T. (2021). *NWRA ties recycling into supply chain resiliency*. Retrieved from:

<https://www.recyclingtoday.com/article/nwra-congress-recycling-supply-chain-manufacturing-resilience-usa/>.

- [42] Cheng, L., Xuefeng, H., Xiny, T.&Yingxue, T. (2022). Analysis of changes in organizational loyalty of shared employees in the post-epidemic era and research on countermeasures. *Modern Business* (18), 93-95. doi:10.14097/j.cnki.5392/2022.18.022.
- [43] Chen Z. (2021). Sharing Employee: B2B Employment Model in the Era of Coronavirus Disease 2019 and Implication for Human Resource Management. *Frontiers in psychology*, 12, 714704. <https://doi.org/10.3389/fpsyg.2021.714704>.
- [44] Hanying Z., Xiaoting Z. Analysis and Countermeasures of Hema's New Retail Model Development based on Cost Reduction and Rapid Expansion and "New Retail Leader" [J]. *Management and Management*, 2020 (8) :8 0-8 1.
- [45] Accenture News. Building supply chain resilience: What to do now and next during COVID-19. Retrieved from: <https://www.accenture.com/gb-en/about/company/coronavirus-supply-chain-impact>.
- [46] The Singapore Institute of Purchasing and Materials Management (SIPMM) News. Digital Technologies for an Effective Supply Chain. Retrieved from: <https://publication.sipmm.edu.sg/digital-technologies-an-effective-supply-chain/#:~:text=%20Digital%20Technologies%20for%20an%20Effective%20Supply%20Chain,whereby%20layers%20of%20material%20builds%20up...%20More%20>.
- [47] JD Logistics Inc. (2021). 2021 Environmental, Social and Governance report (p. 27).
- [48] S.F. Holding Co., Ltd. Introduction to IoT Smart IoT Management Platform. Retrieved from: <https://www.sf-laas.com/valet/4544>.
- [49] JD Logistics Inc. (2021). 2021 Environmental, Social and Governance report (p. 28).
- [50] S.F. Holding Co., Ltd. Introduction to UHF RFID. Retrieved from: <https://www.sf-laas.com/valet/3239>.