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COVID-19 impact on sustainable production and operations management

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ABSTRACT

The global production and supply chain system is mostly disrupted due to widespread of the coronavirus pandemic (COVID-19). Most of the industrial managers and policymakers are searching for adequate strategies and policies for revamping production patterns and meet consumer demand. Form global supply chain perspectives, the majority of raw materials are imported from China and other Asian developing nations. The COVID-19 pandemic has broken the most of transportation links and distribution mechanisms between suppliers, production facilities and customers. Therefore, it is imperative to discuss sustainable production and consumption pattern in the post-COVID-19 pandemic era. Most of the prominent economies around the world enforced a total lockdown, and the focus has since shifted to surge in demand for essential products and services. This has led to a decline in demand for some nonessential products and services. The production and operations management challenges of the pandemic situations are discussed and adequately proposes policy strategies for improving the resilience and sustainability of the system. This paper also discusses the different operations and supply chain perspectives for handling such disruptions in the future.

1. Introduction

The United Nations (UN) launched the sustainable development agenda for 2030, which addresses the various on-going challenges related to environmental degradation, climate change, zero hunger, and other negative consequences of the different production processes [13]. The Goal-3 of UN 2030 Agenda for sustainable development discusses the "development of healthy life and promoting wellbeing for all ages". This situation of a pandemic would open new dimensions for the social sustainability of people and manufacturing organisations. Currently, most of the manufacturing and supply chain organisations are struggling to anticipate the negative consequences of COVID-19. Most of the global markets are shrinking, and industrial managers are searching for new materials and process methods to maintain production [2]. Notably, the COVID-19 outbreak significantly improves organisational environmental sustainability, albeit downsizing the consumer economy and raising challenges for the industrial workforce management.

Amidst COVID-19, global supply chain and manufacturing network moving through a very distressing stage. The Emerging Infectious Diseases (EIDs) such as Ebola, influenza, SARS, MERS, and most recently, Coronavirus Disease (COVID-2019) cause enormous disruption in goods production, people life, transportation, and stimulate civil unrest [10,13].

The International Committee on Taxonomy of Viruses named this acute disease as *Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)*. SARS-CoV-2 is originated in Wuhan city of China in December 2019 and soon spreads over the globe [16]. The World Health Organisation (WHO) declared COVID-19 as a pandemic and global health emergency in March 2020 [24]. The global spreading of COVID-19 causes numerous impacts on the sustainability of worldwide production and consumption of various commodities. The number of COVID-19 patients are increasing exponentially, now reaches a toll of more than 4 million and causes 2,82,244 death globally on 11th May 2020 (www.worldmeters.info). This resulted in national and global broader closure, shut down of many manufacturing units, markets, and other activities of the supply chain. In Asia, most infected countries are listed as Turkey, Iran, China, India, And Saudi Arabia (Source: https://www.ecdc.europa.eu/). The Fortune 2020 report claimed that 94% of the Fortune 1000 companies had been affected by COVID-19 driven supply chain disruption. After the normalisation of the COVID-19 situation, the manufacturing and transportation industry would find an opportunity for a sustainable transition and development in business processes [2].

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At the beginning of April 2020, the US federal government imposed the Defence Production Act of 1950 (DPA of 1950)[1] in the backdrop of such a demanding situation. Aim of the imposition of this act was to ramp up the production of essential goods instead of allowing the regular production schedules of factories in the USA. Such legislative measures forced companies to have a relook at and re-orientation of their commercial models.[2] The traditional production processes have been shifted to producing only the essential equipment under the DPA of 1950. This re-orientation is not only tedious but also costly for most of the business organisations.

As mentioned earlier, the post-COVID-19 period would push organisations to shift production and supply chain systems in a more sustainable way. Therefore, it is required to formulate adequate institutional and operational policies for overcoming the production losses and improving the consumption pattern, which would further boost the economy.

The implications of COVID pandemic on sustainable production and consumption trends would be worthy to note, and hence, a considerable change is likely to be seen in the coming months and years. Haleem et al. (2020) highlighted the various academic research areas to combat the COVID-19 pandemic; the role of sustainable manufacturing is among one of them. The present COVID-19 outbreak affects the global and national production systems and trade on a larger scale. The availability and production of many essential items such as food, grocery, and pharmaceutical products are drastically reduced, and a huge mismatch between supply and demand is observed. In the meantime, the coronavirus pandemic is having a positive impact on the environmental side of production, due to shut down of many manufacturing units and significant reductions in logistics and distribution operations. However, the supply chain network showed poor resilience to this pandemic, and nearly 35% of the manufacturer reported its supply chain network failure due to global coronavirus pandemic (NAM, 2020). Fig. 1 shows the worldwide infection spread of the COVID-19.

Taking a cue from the CMIE's (Centre for Monitoring Indian Economy) estimates[3] about India's unemployment rate in the first week of May, which is around 27% (shot up from 8%); it can be inferred clearly that the lockdowns have put a tremendous strain on employment opportunities and job security in the country. It is worthy to analyses the progress of the Indian economy in the global context because, so far, India has been the fastest-growing emerging economy of the world. Unemployment figures here can indicate the grimness of the scenario elsewhere. Considering the case of developed economies like in the USA, the unemployment rate shot up to nearly 15% for April 2020.[4] The EU-27 countries are having imposing the varying degree of social distancing mandates owing to COVID-19. More than 230 million people are directly or indirectly affected due to the closing of nonessential shops, cancellation of various events, travel restrictions, and reduction in production in EU-27 and the United Kingdom.[5] The job crisis also impacts the economic viability of the nation.

1.1. The objective and research contribution

The global production and supply chain network widely affected due to COVID-19 spread. The manufacturing plants are shut down or working with reduced capacities. In addition to this supply chain of raw and finished goods is also disrupted due to trade and transport restrictions. Most of the COVID-19 is focuses on the perspective of medical science, whereas a clear production and operations management perspective of COVID-19 is absent. To address the above challenges and put forward to manage the production and operations of the supply chain networks. The main objective of this opinion paper is to identify the challenges faced by manufacturing and service organizations, and prospective research dimensions for handling post-pandemic situation.

The main contribution of this paper is to give a path-breaking idea to management researchers to deal with the pandemic situation in the current business setting as well as to make a contingency plan to control and revamp in such future events. This paper also recommended various pandemic control systems to improve the resilience and sustainability of the production system. This paper also discusses the sustainability perspective of the production and consumption of various goods and services during and post-pandemic situation. In the following section, pandemic control and the need for a production system is discussed along with the various stages of a pandemic.

2. Pandemic control and production system

The pandemic situation arises the demand for rare production items such as ventilators, gloves, face shields, masks, and sanitizers at a high rate. During this pandemic era, some of the manufacturing giants such as General Motors and Ford Motors turn their production system to support the need of society in terms of manufacturing ventilators. Therefore, a flexible manufacturing system is required to fulfil the requirement for such necessary items. National government institutions, manufacturing organisations, health institutions should be prepared in advance to tackle the pandemic situation to control the production of essential and nonessential items during a pandemic. This means that they should have sufficient buffer plans to address the availability of life saver stocks such as ventilators, vaccines, sanitizers, masks, and face shields.

The post COVID era opens an opportunity window for the sustainable business transition [2], and need to make supply and production system more resilient [19]. The COVID-19 situation creates a space for developing a flexible and resilient manufacturing system to maintaining the economic and social sustainability of the production process. Tan et al. [22] discuss the various decision support systems for developing a resilient production system. Ivanov [7] proposed a prediction model for measuring the impact of a pandemic on supply chain network and manufacturing resilience. The firm's supply chain network resilience and manufacturing resilience is required to tackle the epidemic or such disruptive events [6]. Due to such disruptive events, material shortage and delivery delays are seen in the downstream supply chain, causing the ripple effect and resulting in reduced performance in terms of service level, revenue, and process productivity [8,3]. Table 1 presents a snapshot of the leading worlds manufacturing companies' resilience and business support to overcome COVID-19 impact.

Most of the global manufacturing leaders are relatively resilient enough to shift their production strategy to pandemic based requirements—the Indian government proposing various financial incentives for developing MSMEs in the post COVID era. The COVID-19 contagion can be reduced by promoting and following the social distancing at sites, hygiene, and use digital platforms for business meetings [16].

The next significant challenge among nations is related to the scheduling of the trained medical personnel, work allocation, and vehicle scheduling for the medical personnel as well as infected peoples. In the real world, it is quite challenging to produce the necessary items before a pandemic outbreak [25]. Thus, an event like COVID-19 also puts a strain on the workforce to adjust to the new regime of a man-

[1] https://www.whitehouse.gov/presidential-actions/memorandum-order-defense-production-act-regarding-3m-company/.

[2] https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/rapidly-forecasting-demand-and-adapting-commercial-plans-in-a-pandemic?cid=other-eml-alt-mip-mck&hlkid&c93338622c1d49f6ac15c68e0d8fefba&hctky=11555736&hdpid=8cdeaa7b-203f-4a53-8bda-b4a19877f22e.

[3] https://www.thehindu.com/business/indias-unemployment-rate-rises-to-2711-amid-covid-19-crisiscmie/article31511006.ece.

[4] https://www.theguardian.com/business/2020/may/10/unemployment-due-to-covid-19-is-surely-worth-more-than-a-footnote.

[5] www.mckinsey.com/~/media/McKinsey/Industries/Public%20Sector/Our%20Insights/Safeguarding%20Europes%20livelihoods%20Mitigating%20the%20employment%20impact%20of%20COVID%2019/Safeguarding-Europes-livelihoods-Mitigating-the-employment-impact-of-COVID-19-F.ashx.

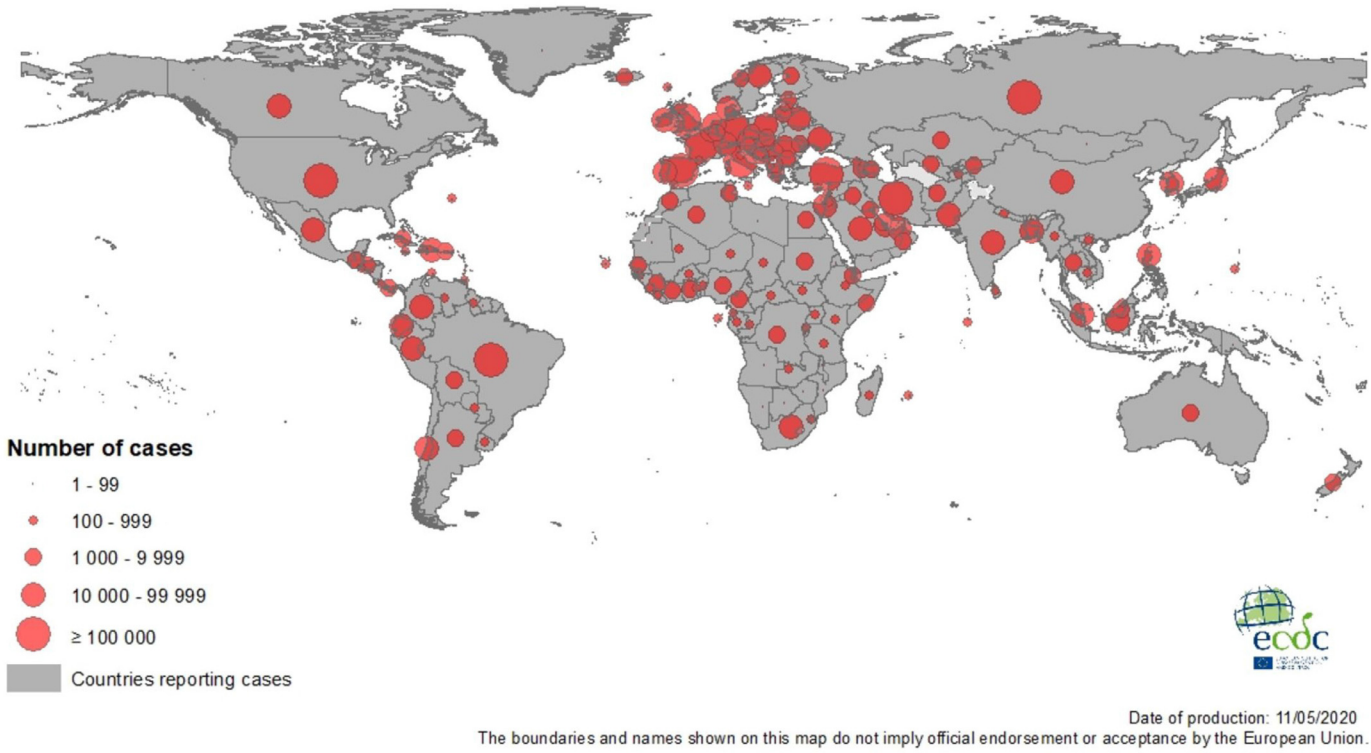

Fig. 1. Geographical distribution of COVID-19 cases over the globe, as on 11th May 2020
(*Source:* https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases, accessed on 11th May 2020).

Table 1
World's leading manufacturing companies before and during COVID-19.

Companies	Industry	Before COVID-19 manufacturing	During COVID-19 manufacturing
Ford	Automobile manufacturing	Vehicles	Respirator and ventilators
Tesla	Automobile manufacturing	PV Cells and vehicles	Ventilators
Airbus	Aircraft manufacturing	Aircraft	Ventilators
Zara	Fashion	Apparel	Surgical masks
Bacardi	Alcohol	Rum	Hand Sanitizers
Gucci	Apparel	Clothing	Masks
Indian Ordnance Factory	Defence	Defence equipment	Ventilators

Source: World Economic Forum, 2020b; [11].

ufacturing process. This has been complemented by numerous changes such as changes in production process and methods, and standard operating procedures to maintain social distancing at the workplace. This puts an additional strain on achieving productivity targets of employees, as extra time is needed in order to follow the new regime. Therefore, an optimal and real inventory and work allocation is required for the different phases of the pandemic. The previous researchers classified EID pandemic phases as follows [14,18];

- Preparedness to tackle a pandemic
- Nature and impact of a pandemic
- Response measures to pandemic
- Evaluation of the pandemic

The above steps need further focus to develop a more resilient production and supply chain system. Each phase of pandemic control is explained as follows;

2.1. Preparedness to tackle a pandemic

Many production and service organisations are establishing preparedness plans to deal with the pandemic situation. The stocking of necessary items and raw materials are required to fulfil customer demand during the pandemic. The organisations should focus more on essential items production and ensure their supply to meet the unexpected disruption. The WHO also released the various preparedness guidelines, during COVID-19 spread in China. The WHO developed a framework for COVID-19 preparedness and responses, which emphasis more on livelihood potential and reduced the morbidity and mortality rate of COVID-19. The stocking of personal and protective equipment (PPE) is required, and most of the countries are facing a shortage of PPE during pandemic outbreaks [17]. Swaminathan et al. [21] reported that the appearance, transmissibility, and attack rate of an influences pandemic is uncertain.

During the early infection spread of the pandemic, suspects are referred to the hospitals for isolation, diagnosis, and to measure the infection rate of the epidemic. Key production strategies are required to procure the adequate amount of PPE, ventilators, and other surgical equipment for sufficiently handling the pandemic situation [24]. Also, a liable transportation and logistics infrastructure is required to meet consumer demand. Hale and Moberg [5] recommended that reconsideration of policies related to sourcing, inventory planning, transport planning, and production planning to reduce the impact of such pandemic are crucial. The various mitigation strategies such as postponement, strategic stock,

flexible supply base, flexible transportation, and dynamic assortment planning of disaster responses are discussed by [23].

2.2. Nature and impact of pandemic

The spread of COVID-19 has already been disrupted supply chains globally in several ways, including:

1. Weakening demand for several types of products (Automobile products, public transport, and textile products)
2. Skyrocketing demand for select companies or their product (thermal scanners, ventilators, face masks, sanitizers, PPE, and essential food items)
3. Failure of supplies and uncertainty in raw material supply
4. Impacting ability to ship and receive products on time due to shortages and logistics bottlenecks
5. Ensuring workforce capacity to assemble and ship products

To deal with above-mentioned issues, a smooth production plan is required for the pandemic period. This involves that manufacturing firms should be more resilient and flexible to produce the essential items to meet customer demand. Artificial intelligence (AI) based production technologies are recommended to produce granular COVID-19 maps that enable individuals to decide what places to avoid, companies to manage risk, and governments to deploy resources. AI-based manufacturing is an excellent option to promote digital production during pandemic [9].

Partnering with government agencies is required to develop drugs to reduce the severity of COVID-19 illness and treat infections, possibly leading to a vaccine. Application of advanced technologies such as AI, 3D printing, Data analytics, Robots, Cyber-physical systems can help in developing a decentralising production system. Digital manufacturing would help to maintain social distancing during the production process, and consequently controls the worker's movement. For instance, *Kiva* robots are used for warehousing to keep the items in the palace and help in loading and unloading. Even, many of the hospitals are using robots for delivering drugs and monitoring COVID-19 patients.

Similarly, the food and essential items delivered in cities can be regulated using technology such as drones, consequently, prevent direct contact in the delivery of the products.

2.3. Response measures to pandemic

The control of Emerging Infectious Diseases (EID) outbreak is based on the proposed measures adopted at global, national, regional, or even community level. Reducing the infection and reproduction rate of spread, mortality rate, and improving the immunisation capacity is the main focus of any containment effort. The spread of the COVID-19 can be controlled by imposing countrywide lockdown or quarantine programs.

The immediate response to any pandemic requires a robust and resilient medical supply chain. The medical and pharmaceutical manufacturers should focus on developing vaccines, antiretroviral drugs, and complementary medical supplies. The supply of drugs and medical equipment also needs resilient cold chain management.

The pandemic situation created infectious healthcare waste and need proper disposal [12]. The transportation and disposal site selection is a typical problem in the post-pandemic situation. The reverse logistics companies should handle the dangerous medical waste carefully and dispose of in a way that they do not pose a risk of infection to waste handling personnel. The disposal of medical waste needs the proper handling and disposal system to reduce the chances of infection and improve the social sustainability of the pandemic outbreak [15].

2.4. Evaluation of the pandemic

The evaluation phase of a pandemic is the most critical and needs proper mitigation strategies [23]. The evaluation of any epidemic can be viewed from the perspective of future manufacturing strategies adoption, contract policies, and network design to support the industry viability. Due to the COVID-19, most of the global or local manufacturing industries (automobile, transport, pharmaceutical, food, etc.) need to revive their production capacity and raw material sourcing. The revamping of the industry also needs further support from national and regional governments. For instance, the Indian government is aiming to boost their self-reliance in the manufacturing sector and extending their support to the Micro, Small, and Medium Enterprises (MSMEs) through various financial and nonfinancial incentives. The COVID-19 is significantly slowing down the global trade (including transport and manufacturing) of the various countries because most of the trade routes are disruptive or diverted due to the pandemic. Fig. 2 shows the impact of COVID-19 on the global trade of the top 15 affected countries.

In view of such impacts, this is the right time for industries to adopt and implement industry 4.0 and digital technologies in manufacturing. The deployment of robots in the medical system can reduce the risk of COVID-19 spread and ensures better monitoring of patients.

The service supply chain is highly impacted due to the spread of COVID-19. Most of the service industries, such as logistics, hospitality, restaurants, and tourism, observed a reduction in demand. Service organisations should use digital technologies for handling customer services. The digital technologies implementation in the service industry helps to reduce the chances of the contagion of the COVID-19. Table 2 highlighted the seminal works focused on various production, logistics, and coordination systems to overcome the impact of COVID-19.

The workforce requirement and their planning are also a crucial part of the post-pandemic era.[6] The PwC report highlighted some practical measures to improve the worker's sustainability in the manufacturing industry.[7] The PwC report also highlighted the proactive application of automation technologies such as autonomous materials movement, industrial internet of things, collaborative robotics helps to reduce the worker density throughout their operations.

The pandemic situation is significantly improving the carbon emission, environmental pollution; while at the same time posing significant challenges for the social and economic viability of business activities. Therefore, it is required to assess the environmental, social, and economic impact of a pandemic on business processes. The pandemic situation impact on the development of human capital is discussed as follows;

2.4.1. Impact of COVID-19 on organisational workforce management for better sustainability

The COVID-19 is having a crucial impact on the re-joining of the industrial workers. The manufacturing and service organisations should prepare for the long-haul impact of the COVID-19. The pandemic situation forces working with a reduced workforce or limited workforce, which reduces the productivity of the manufacturing process. Therefore, to improve the human side of the manufacturing process, adequate safety measures are required. The post-pandemic production system requires considering the social distancing at the workplace and adopts regular health monitoring for the workforce.

2.4.2. Adopt virtual capability building programs

Improving the virtual capability of the workforce could lead to the digital fitness of the work pattern. The organisations whether manufacturing or in service should focus on the training and coaching for the staff to become resilient.

2.4.3. Urgently review of human resources policies for social sustainability

The manufacturing and service organisations should focus on the review of HR policies for retaining existing workforce, hiring new work-

[6] https://www.prnewswire.com/news-releases/impact-of-covid-19-on-the-global-manufacturing-industry-2020-301042150.html.

[7] https://www.pwc.com/us/en/library/covid-19/coronavirus-impacts-industrial-manufacturing.html.

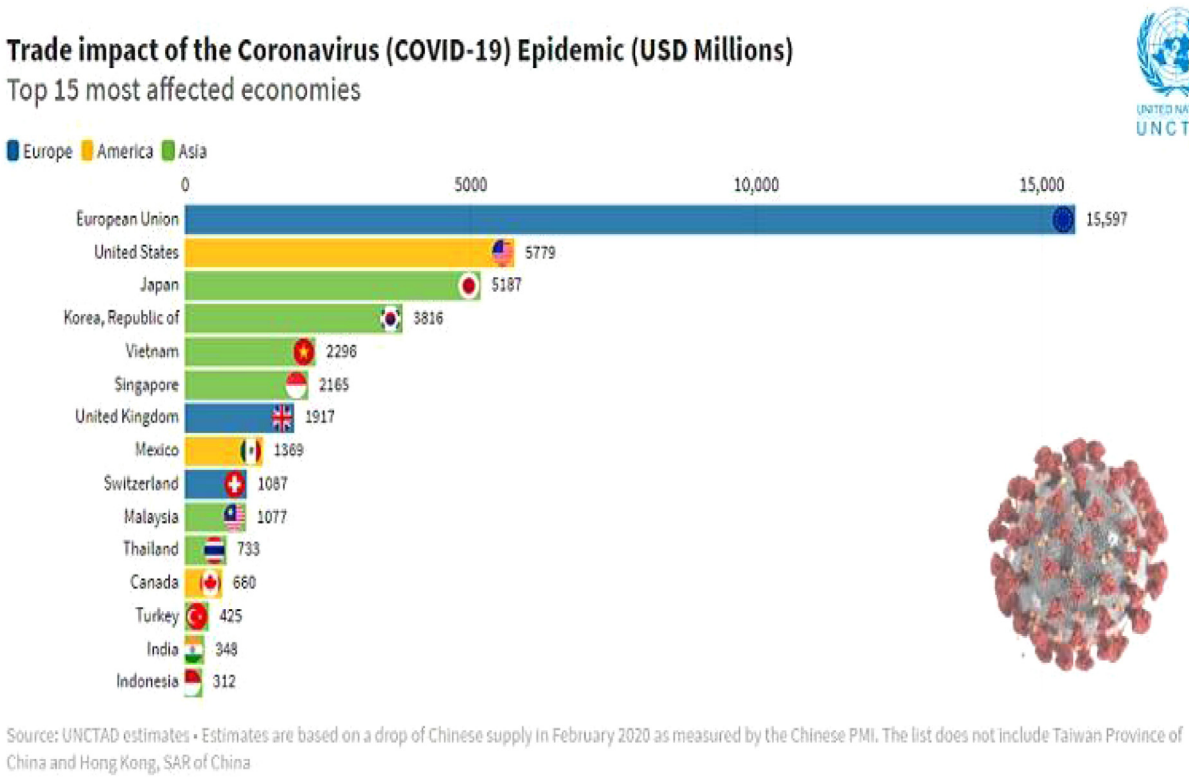

Fig. 2. Impact of COVID-19 on global trade on the top 15 countries
(*Source:* https://unctad.org/en/pages/newsdetails.aspx?OriginalVersionID=2297).

Table 2
Key studies focusing on COVID-19 impact on production and supply chain management.

Author (s)	The objective of the study	Nature of paper	Industry
Govindan et al. [4]	Develop a decision support tool for demand management in the healthcare supply chain in COVID-19 pandemic	Analytical	Healthcare
Shokrani et al. [20]	Development of alternative supply chain and distributed manufacturing in response to COVID-19	Case Study	Medical face shields
Yu et al. [26]	How pharmaceutical supply chain sustains in the COVID-19 crisis?	Perspective	Pharmaceutical supply chain
Ivanov [7]	Predicting the impact of COVID-19 on global supply chain	Analytical	Global supply chain
Sarkis et al. [19]	COVID-19 role in the transition to sustainable supply chain production	Viewpoint	Production and supply chain
Cappelli and Cini [1]	COVID-19 impact on short food supply chain	Perspective	Food supply chain
Madurai Elavarasan and Pugazhendhi [11]	Technological strategies to support society and environment from COVID-19	Conceptual	Healthcare
Javaid et al. [9]	Application of industry 4.0 to handle the COVID-19 pandemic situation	Viewpoint	Manufacturing industry

force, compensation & benefits, and learning and development policies to support the current situation as well as reduce the impact of pandemic on future workforce training and development patterns.

2.4.4. Employee health and wellbeing

Organisations should focus on workforce wellbeing, mental health, and health monitoring practices. A regular temperature scanning and regular health check-up reduce the impact of COVID-19 impact on implant operations.

2.4.5. Knowledge sharing

The organisations should continuously communicate the organisational measures and actions taken against COVID-19. Organisation should also create a digital workplace for the future. The knowledge management about the social distancing, personal hygiene, and use of masks at sites reduces the impact of COVID.

3. Learning's

The management of sustainable production and consumption of the essential and nonessential goods and services is a complex decision problem for industry managers and policymakers during the pandemic situation. Authors of this manuscript put their opinion in a way to improve the sustainable production and consumption trends of products and services in a supply-chain context. The policymakers and industrial managers would be benefited from the below recommendations.

3.1. Recommendations for the policy makers and practitioners

3.1.1. In production domain

- The global and national production policies should be revised. The government needs to support the production system by providing adequate incentives in future policies.
- Current production facilities should shift to digital manufacturing (or industry 4.0 based manufacturing), and promote the digital technologies such as AI, 3D printing, Robots, Cyber-physical systems, Digital manufacturing, Blockchain, etc. for production of goods.
- A strong coordination mechanism is required among and between stakeholders such as government, manufacturers, medical institutions, NGOs, and possibly military agencies to better control the infection rate of such pandemic.
- The present pandemic situation would boost the application of digital manufacturing in the healthcare and FMCG sector.
- The pandemic control can be handled with the adoption of a robust information technology management system to share the real-time production and consumption patterns.

3.1.2. Consumption domain

- The COVID-19 situation creates large variation in the consumption of essential items. Therefore industry managers should consider the demand for essential items during the pandemic.
- The lockdown in various parts of the world triggers the demand for online deliveries of products, especially food and grocery items, which is becoming an additional cause of food waste in such pandemic. This calls for the need to evaluate policies for waste management.
- Due to restricted movements, the consumption of fossil fuels is reduced significantly. This results in improving environmental sustainability.
- The COVID-19 period also increases the adoption of social media, which can be crucial for businesses to evaluate the behaviour and consumption trends of customers.
- Due to uncertainties, consumers are also piling the essential commodities during a pandemic, which may put additional pressure on managing customer demand. Therefore, business organisations need to plan for supply decisions in terms of capacity, workforce, inventory etc. to ensure smooth supply from customer's perspectives. Finally, the impact of supply chain disruptions should be analysed from the perspective of people.

3.1.3. Supply chain and logistics domain

- Apart from minimising cost, inventories, and increased asset utilisation, it is an opportunity for managers to transform from supply chain networks to Digital Supply Networks (DSNs). The DSNs helps to develop end-to-end visibility, collaboration, responsiveness, agility, and resilient supply chain and logistics.
- The DSNs inclusion not only limited to any industry or sector but even extended to the company to company with a formulation of a resilient and flexible strategy. The specific aim of DSNs includes reducing supply chain risk and preparing organisations to quickly adjust and recover from such disruptions.
- The distribution centres and warehouses can be equipped with robots and automated guided vehicles for loading and unloading of the goods, to maintain the social distancing.
- Develop a manufacturing network strategy fit for alternative sourcing options for raw material, suppliers and logistics service providers etc. for mitigating such disruptions.
- Develop more resilient (proactively and reactively) transportation and distribution systems to meet the escalated production and consumption demand.
- The COVID-19 helps in improving the environmental sustainability of the supply chain. However, environmental sustainability is not enough to address the post-pandemic business scenario. The researchers and policymakers should focus on developing economic-ecological-social sustainable and resilient supply chains. The resilient supply chain should consider social wellbeing (job security) and health and safety practices during and post COVID-19.

4. Concluding remarks

The global world faces a distressing time to combat COVID-19, and this is to be considered as the most significant disruption in the last three industrial revaluations. The COVID-19 situation has forced the manufacturing organisations to pause the production system for a longer time and search for sustainable solutions to ensure smooth supply and operations from both the businesses and the customers' perspectives. The production and services organisations need to be sustainable and resilient to handle the present situation as well as learn for such future pandemic.

This opinion paper discusses various supply chain and logistics, and production and consumption issues during and post COVID era. Among major contributions, one of the observations is how the supply chain and production system deal with a pandemic. The production system needs to revive and look for the right sourcing of the raw materials. Second, observation is relating to how business organisations should deal with safe and secure workforce management. Third, this work focuses on the inventory management of the commodities because of the products produces at a larger scale, but due to the pandemic, there is no demand and vice versa. Fourth, the authors made a clear recommendation to use of digitalisation in the pandemic era that improves the social distancing and social wellbeing.

The manufacturing plants should shift their manufacturing capabilities to digital manufacturing to reduce the number of workforces and consonantly reduces the chances of the pandemic situation. The transportation industry severely faces a shortage of drivers and vehicle connectivity. Therefore an optimise supply chain network is required to serve more manufacturing plants. This opinion paper recommended the various strategies to improve the resilience and sustainability of the production and logistics process.

The pandemic situation reduces global carbon emissions and improves environmental sustainability; however, at the same time, businesses and people all across the globe are struggling in terms of job downsizing, workers' safety and mental health issues, and financial burdens due to production losses and closure of sites. In view of these considerations, this opinion paper aims to address critical aspects of sustainable production and consumption of products and services in the context of COVID-19. This paper also directed to future researchers to identify the critical success factors, inhibitors, and drivers to handle the pandemic situation and propose policy frameworks for improving the resilience of production and operations processes.

Declaration of Competing Interest

For this study no conflict of authorship are found.

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