

# ENABLERS FOR RESILIENT SUPPLY CHAINS IN THE CONTEXT OF COVID19 PANDEMIC- A REVIEW OF MAJOR DIGITAL TECHNOLOGIES

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**Abstract:** *The COVID-19 pandemic has posed many challenges to the organizations in terms of managing and adapting their supply chains to the changing environment. The traditional supply chain practices were found to be wanting in many aspects. This has brought in lot of emphasis on the need to digitize and digitalize the processes and supply chains. These strategies are expected to bring in visibility and adaptability among the supply chains, thereby enabling them to cope with the vulnerable environmental dynamics. The paper reviews the digital technologies that can serve as building blocks and foundational elements for organizations to embark on digitally transforming their processes and supply chains.*

**Key words:** *Digitization, Digitalization, Digital transformation, Digital technologies, Supply chains, Resilience.*

## Introduction

The term “supply chain management” arose in the late 1980s and came into widespread use in the 1990s. Prior to that time, businesses used terms such as “logistics” and “operations management” instead. A supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customers themselves(8). Supply chain management is the coordination of production, inventory, location, and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served. There is a difference between the concept of supply chain management and the traditional concept of logistics. Logistics typically refers to activities that occur within the boundaries of a single organization and supply chains refer to networks of companies that work together and coordinate their actions to deliver a product to market. Also, traditional logistics focuses its attention on activities such as procurement, distribution, maintenance, and inventory management. Supply chain management brings a systems approach to understanding key concepts of Supply Chain and managing the different activities needed to coordinate the flow of products and services to best serve the ultimate customer. This systems approach provides the framework in which to best respond to business requirements that otherwise would seem to conflict with each other ( 29).

Over the years organizations have realized the need to reach maximum number of customers quickly and at minimal costs not only within the country ,but across the globe. This led to global supply chains. Global supply chains are networks that can span across multiple continents and countries for the purpose of sourcing and supplying goods and services. Global supply chains involve the flow of information, processes, and resources across the globe. However, the global supply chains are prone to certain disadvantages such as longer lead times, reputational risks, fluctuation in exchange rates, communication

challenges, increased risk exposure, loss of control. The global supply chains are subjected to a high probability of localized disruptions because of several cultural, natural, and human made disasters leading to adverse effects on the supply chains performance.

In recent times, the global supply chains were subjected to shock which started in China during the beginning of 2020. Since the advent of COVID-19 pandemic the disruptions in terms of disorders and vulnerabilities in supply chains are more profound and continuing. The supply chains are forced to relook and rethink on strategies to evolve and respond to the changing environment characterized by lockdowns posing restrictions on social and economic interactions (15). Among several strategies digital transformation is considered by the supply chain executives to enable the supply chains resilient and successfully counter the negative consequences of supply chain disruption. Digital technologies such as Artificial Intelligence, Internet of Things, Robotics are extensively used to digitize the processes and supply chains with an objective to build resilience in the supply chains.

### **COVID 19 induced Disruptions in Supply Chains**

What began as a health scare in a single province in China has morphed into a global pandemic that has now spread to almost every country in the world, putting much of the global population in partial or total lockdown. Border restrictions and lockdown measures are causing a massive negative short-term impact on consumer spending, investment and disruptions to international trade and global supply chains, and the long-term impact remains uncertain(4). Organizations noted a significant increase in the number of supply chain disruptions during the past couple of years. COVID-19 was the major force in driving up the number of incidents, but other incidents such as Hurricane Laura, declining political stability, data breaches, cyber-attacks, inclement weather, and disruptions from sources other than COVID-19 were reported in the last couple of years(5).

In recent times, supply chains are experiencing severe challenges induced by epidemics and pandemics. The COVID19 pandemic has impacted global supply chains substantially. Significant adverse effects on finance, lead time, customer, and production performance have already occurred. The COVID-19 pandemic is an exceptional incident—a high-impact low-probability event—that exceeds in scale some of the largest disruptions in the past two decades, such as SARS in 2003 and H1N1 in 2009(39).

Global Supply Chain Management is considered as one of the key components of sustainability development of enterprises in a competitive market. But over the last couple of years, the unimaginable destructiveness of COVID-19 has had a devastating effect on population and global supply chains, which were woefully unprepared to face this huge challenge. China known as factory of the world has encountered a serious epidemic and has continued to shut down production activities, transportation disruption leading to the interruption of flow from raw materials to finished products all over the world. This has resulted in the increase in global prices of raw materials and intermediate supplies. While nearly all countries are trying to suppress the spread of the virus and reduce potential losses, there is still an ongoing crisis, because supply and demand have drastically fallen due to border restrictions. This led to mass production stoppages, substantial interruptions in actual goods flows, product mobility, and have affected the entire supply chain, thereby leading to operations shutdown, sales loss, late deliveries, and reputational loss and a worldwide shortage of essential products and services (28,15,45, 11, 36,46).

## Strategies to build supply chain resilience

The word “resilience” originally comes from the field of materials science. This refers to the ability of a system to recover its initial state after undergoing an elastic deformation without any changes in its nature (40). Due to market instability, environmental problems and manufactured disasters, the importance of incorporating this concept was emphasised in the operations management scenario (J48). In operations management, resilience is defined as organisational capabilities to face immediate changes in the environment with proactive and reactive actions (1,31). Resilience within organisations and across supply chains recognises the ability to absorb shocks in the form of extreme events and the adaptive capacity to adjust to new circumstances. To obtain adaptive capabilities to better respond to disasters, companies must develop proactive and reactive actions to overcome the impacts and remain competitive (15).

Supply chain resilience could be created according to four key principles: resilience can be built into a system before a disruption, a high level of collaboration is required to identify and manage risks, agility is essential to react quickly to unforeseen events and risk management culture is a necessity(10). Also literature has reported several resilience building strategies such as Supply Chain Reengineering, Supply Chain Collaboration, Agility and Supply Chain Risk Management Culture, building in redundancy or building in flexibility, developing the ability to move production among plants, using concurrent processes of product development, designing products and processes for maximum postponement of as many operations and decisions as possible in the supply chain, aligning procurement strategy with supplier relationships, flexible sourcing, demand-based management, strategic safety stock, total supply chain visibility and process and knowledge back-up, postponement, strategic stock, flexible supply base, make-and-buy trade-off, economic supply incentives, flexible transportation, revenue management, dynamic assortment planning , silent product rollover, Chain configuration, Chain control structure, Information system, Organization structure. inventory and capacity buffers, manufacturing network diversification, multisource, near shoring, product, platform, or plant harmonization, eco system partnerships, distribute inventory across multiple locations, understanding data, partnering with multiple suppliers, leverage different carriers, relying on logistics experts (51, 37, 44, 30, 47, 7, 14, 10, 19).

Significant supply chain disruption was caused by COVID-19, requiring leaders to right-size their operations and embrace digital capabilities. It is expected that the digital transformation will protect supply chains against future disruptions. Organizations from all industrial categories are doubling their investments in advanced technologies - from blockchain to artificial intelligence, to machine learning and intelligent automation– which has proven to be the lifeblood of the organization. Good supply chain management is about two things: reducing complexity and reducing uncertainty. Implementing new technologies allow a co-existence of digital enablers and humans across the different supply chain processes and activities that can help achieve these two goals. To that end, there are several approaches and technology solutions that can be used to provide precision visibility into supply chains. This enables real-time decision-making and responsiveness - which will likely be critical to how companies monitor and adapt to changes in customer behaviour and supply chain variability in the future(19).



The author highlights the strategy of digitally transforming the supply chains which is expected expecting to benefit organizations in terms of bringing in agility, flexibility, resilience, and transparency in all the activities of the supply chain in the prevailing context.

### **Digital Transformation of supply chains**

Several digital technologies are embedded in the organizational processes thereby transforming the analog supply chains into digital supply chains. Digital transformation is the integration of digital technology into all areas of a business, fundamentally changing the process of operating and delivering value to customers. It's also a cultural change that requires organizations to continually challenge the status quo, experiment, and get comfortable with failure (18). The pandemic has further fuelled the need for digital transformation of the processes with most of the organization favouring remote work force.

Digitization, digitalization, and digital transformation are frequently used interchangeably, and it is critical to understand each notion. Digitization is the process of transforming information from a physical format to a digital version. While digitalization is the practice of utilizing technology to enhance corporate processes. In a nutshell, digitization relates to information, whereas digitalization relates to processes.(22) Digitization refers to the internal optimization of processes (e.g., work automation, paper minimization) and results in cost reductions. Conversely, digitalization is a strategy or process that goes beyond the implementation of technology to imply a deeper, core change to the entire business model and the evolution of work(20). The digital supply chain is the sequence of processes involved in the production and distribution of a commodity; with the processes using electronic tools, systems, devices, and resources that generate, store or process data for – wait for it – establishing an airtight and ever-advancing supply chain thus improving customer service and sustainable performance of the organisation. (23,6,26)

### **Technological enablers for digital transformation**

Information and Communication technologies form the core of digital supply chains. They are enabled by a plethora of emerging, disruptive, and state of the art technologies and tool sets such as Internet of Things, Cloud Computing, Block Chain, Artificial Intelligence, Predictive Analytics, Machine learning, Robotics, Robotic Process Automation, Additive Manufacturing, Virtual Reality, Augmented Reality, Drones, Autonomous Vehicles, Cyber Physical Systems, Data Lakes, Deep Learning and Visualization tools(27,21,25,24).

Each of the above-mentioned technologies play a crucial role in digitizing and digitalizing various phases of supply chain. However, this work highlights the role of five major technological tool sets in transforming the analog supply chains to digital.

#### **Internet of Things(IoT):**

The IoT is not a single technology, but an innovative alliance of several complementary technologies united to bridge the gap between the digital and the physical world. It is broadly available technology and widely used to perform diverse roles in managing supply chains

including linking information with vendors; gathering real-time progress data from vendors; providing visibility on parts and raw materials; generating real-time quality/maintenance data; inventory tracking, information sharing, and joint ordering; quality monitoring and quality-controlled logistic; enabling enhanced reverse logistics; and capturing product data while in use to generate operational efficiencies and maximise revenue opportunities. Sensor technologies are also becoming increasingly ubiquitous in logistics, enabling real-time interaction between the vehicle and its environment, and contributing to faster speeds and vehicle platooning to reduce journey times, congestion and increase existing infrastructure capacity. IoT and big data analytics in a logistics aid to improve driver safety, operational efficiency, and environment. Availability and analysis of IoT-enabled real-time data ultimately allow stakeholders to make better operational decisions and enhance strategic outcomes at both supply chain and firm-level(13, 3). IoT technologies are used in various areas of supply chains such as Global Positioning systems, Automatic Identification Systems, Vehicle telematics, Radio frequency identification, smartsensors, camera-based systems, and smart phones(3).

### **Blockchain:**

Companies face increased uncertainty, challenges, and constraints, due to globalization, higher customer expectation, market competition, supply chain complexity and uncertainty, which call for coordination and cooperation across the supply chains (inter- and intra- supply chains) and the needs for information technology. However, supply chains often are fragmented with internal competition, limited information exchange and price negotiations occurring behind closed doors. This often result in challenges and constraints, such as high operation costs or capacity shortage, which could be resolved by the Blockchain revolution.

In a blockchain network, all the parties can simultaneously share and record the blocks, which must be verified and validated by all users in the network. Blocks are linked by the cryptographic hash function. Every transaction is trackable by examining the block information linked by hash keys. Blockchain advocates claim transparency, speed, accessibility, and non-falsifiability as the cornerstones of this new paradigm (50).

Supply chain management covers multiple stages of a product life cycle and often involves the participation of various stakeholders. The multiple stages and the variety of participants in the supply chain make it a highly interconnected network that is difficult to manage. Furthermore, supply chain management is challenged not only by the requirements on record-keeping but also by the requirements associated with a particular industry. In response, different blockchain frameworks and consensus algorithms have been proposed to address concerns in specific industries and products(42). A blockchain can make tracking items and transactions in the supply chain radically faster and simpler by an estimated 85 percent when used in conjunction with IoT technology, cutting administrative and logistics timelines in shipping. A blockchain can be used in SCM to identify the players performing every action. The blockchain facilitates valid and effective measurement of the outcomes and performance of the key SCM processes. Once the input tracking data are on a blockchain ledger, they are immutable. Other suppliers in the chain can also track shipments, progress along the way and deliveries (17).

### **Robotics:**

The early forms of robotics in the supply chain tend to be rigid, inflexible, and mechanised with large form factors. Their roles are mainly in the material handling arena and range from the simple pallet jacks and forklifts. Later forms tend to be more automated and included the conveyor belts and Automated Storage and Retrieval Solutions (ASRS). The technological advancements in robotics today have produced robots that are flexible, versatile, and customizable. The demand of the marketplace and the boom of e-commerce has resulted in the next wave of technology innovation in Artificial Intelligence (AI) or robotic automation applications leveraging on cloud computing and IoT. Out of these innovations is the Automated Guided Vehicles (AGV), an ASRS goods-to-man picking solution that is essentially a robot that utilises barcodes, QR codes, etc., to navigate the warehouse. This system improves efficiency and accuracy in storing and picking of goods. (32)

Robotic Process Automation(RPA) can automate critical yet repetitive processes, driving increased efficiency, error reduction and faster throughput(35). RPA can aid in supply chain functions such as procurement, purchase order management, monitoring and managing inventory, reviewing contracts, freightmanagement, processing returns and refunds, managing invoices, etc.

### **Artificial Intelligence:**

Artificial intelligence(AI) has been equipped with computing techniques that support selecting large quantities of data from logistics and supply chain. AI brings the supply chain with an appropriate intellect, which can reduce the operating costs and manage inventory. By the combination of AI and machine learning, companies are getting new insights into different areas, which comprise warehouse management, logistics, and supply chain management. AI can streamline every aspect from demand to inventory to supply with minimal human input. Supply-chain leaders use AI-powered technologies to make efficient designs to eliminate waste , real-time monitoring, and error-free production, minimizing bottle necks and facilitate lower process cycle times.Applications in SCM include inventory control and planning, transportation network design,purchasing and supply management, demand planning and forecasting,order picking problem, customer relationship management. Easier access to data records, along with future predictions and feedback from customers AI can also help in designing and promoting products. AI can also catalyse the mechanical process, including transport and logistics(43,12,38,33).AI is an industry 4.0 technology that can revolutionise many industries and fields. As such, almost all the fields of SCM, as well as its subfields, are prone to being influenced by AI(49).

### **Additive Manufacturing:**

The emergence of Additive Manufacturing (AM) processes and their adoption in manufacturing industrywill inevitably have supply chain implications. It is predicted to result in lower inventories and increased agility in supply chains due to AM by calling for the emergence of a “demand chain.” The emergence of consumer-centric business models and its growth is fuelled with the advent of AM. It is also reported that total supply chain costs, ton-kilometres per customer, transport costs and the number of production sites will all be improved by AM adoption(9).There is a significant impact of AM on different stages of supply chain such as product design, sourcing materials, make the product,logistics and maintenance.(34).AM significantly impacts supply chain structures, inventories,



manufacturing strategies, transport times, component lead times and customer responsiveness(52).

The current economic pressures have been challenging manufacturing SMEs that play a complicated role in the Supply Chain (SC); and innovation in the manufacturing supply chain which requires new approaches and technologies. Additive Manufacturing (AM) is considered by research studies as pioneering and disruptive technology that can drive such a transformation (41). There is an increasing need for supply chains that can rapidly respond to fluctuating demands and can provide customised products. This supply chain design requires the development of flexibility as a critical capability. To this end, firms are considering Additive Manufacturing (AM) as one strategic option that could enable such a capability(2). COVID 19 context enables manufacturers and customers to build products closer to home and with the required specifications by leveraging Additive Manufacturing.

### Conclusion

The underlying justification for organizations to embrace the philosophy of global supply chain was challenged by the recent pandemic and other climatic and behavioural factors. Also, the concepts of operations management such as lean manufacturing and just in time were questioned. Organizations realized the need to make their supply chains resilient to manage the risks posed by the pandemic. In this direction several de-risking strategies were thought of by the leaders. One among those strategies which supply chain leaders have been exploring is digital transformation of supply chains.

The Digitization brings about a Supply Chain 4.0, formed by technologies such as IoT, big data analytics, 3D printing, cloud computing, robotics, blockchain, augmented reality, and artificial intelligence(16). Most digital technologies provide possibilities for efficiency gains and customer intimacy. However, there is no single technology that will deliver “speed” or “innovation” as such. The best combination of tools for a given organization will vary from one vision to another. The successful implementation of digital transformation strategy is a function of right mind set of the employees and the prevailing organizational practices. Technology alone will not lead organizations through successful digital transformations. The success depends on the organizations ability to figure out business strategy before deciding upon investment, securing confidence of insiders, designing customer experience from the market-in perspective. Lastly the organization culture needs to promote agile decision making, and organic flat structures for promoting innovation culture.

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