# Artificial intelligence for supply chain resilience: Learning from Covid-19


## Abstract

**Purpose:** Many supply chains have faced disruption during Covid-19. Artificial intelligence (AI) is one mechanism that can be used to improve supply chain resilience by developing business continuity capabilities. This study examines how firms employ AI and considers the opportunities for AI to enhance supply chain resilience by developing visibility, risk, sourcing and distribution capabilities.

**Design/Methodology:** We have gathered rich data by conducting semi-structured interviews with 35 experts from the e-commerce supply chain. We have adopted a systematic approach of coding using open, axial, and selective methods to map and identify the themes that represent the critical elements of AI-enabled supply chain resilience.

**Findings:** The results of the study highlight the emergence of five critical areas where AI can contribute to enhanced supply chain resilience; (i) transparency, (ii) ensuring last-mile delivery, (iii) offering personalized solutions to both upstream and downstream supply chain stakeholders, (iv) minimizing the impact of disruption, and (v) facilitating an agile procurement strategy.

**Originality:** The study presents the dynamic capabilities for supply chain resilience through the employment of AI. AI can contribute to readying supply chains to reduce their risk of disruption through enhanced resilience.

**Implications:** The study offers interesting implications for bridging the theory-practice gap by drawing on contemporary empirical data to demonstrate how enhancing dynamic capabilities via AI technologies further strengthens supply chain resilience. The study also offers suggestions for utilizing the findings and proposes a framework to strengthen supply chain resilience through AI.



**Keywords:** Supply Chain Design; Covid-19; Dynamic Capabilities; Supply Chain Resilience

## 1. Introduction

The Covid-19 virus has rapidly spread across the world and most countries have struggled to contain it. The impact of the Covid-19 pandemic continues to ricochet across globe despite the efforts made by governments, the public sector, and individual businesses to halt its detrimental effect on health and on the economy (Craven et al., 2020; Sarkis, 2020). Covid-19 is costing the lives of individuals, and from a business continuity perspective it is causing significant disruptions to the supply chains of countless different industries (Handfield et al., 2020). Many companies have reported significant supply chain disruption and openly share their stories of struggling to reconfigure distribution chains and networks (Mahajan & Tomar, 2021). Reports indicate how companies failed to develop contingency plans that could address the types of supply chain disruptions caused by phenomena such as Covid-19, and hence firms across the globe have reported the unpredictable delays experienced in receiving materials from a particular location due to inadequate supply chain information (Paul & Chowdhury, 2020). Other factors including consolidation of suppliers, reducing the cost of production and minimizing the risk have decreased available inventories and has led to the current state of scarcities (Dolgui & Ivanov, 2020; Wang-Mlynek & Foerstl, 2020).

It is important to recognize the challenges in today's supply chains that have led firms to this level of crisis. For instance, manufacturing has become extremely complex in terms of outsourcing components from multiple locations to assemble a single product. Consequently there is a substantial reliance on logistics, import, and export that in turn poses challenges in the case of disruption and highlights the requirement for smart decision making (Choi, 2020; Wamba et al, 2020b, Wamba et al., 2020c). Other challenges for sourcing organizations include distribution risk and shortages in the network (Dolgui & Ivanov, 2020). Distribution is a critical area where staffing of warehouses, direct distribution (de Koster & Warffemius, 2005), and responsive allocation have become important considerations in the era of Covid-19 (Butt, 2021).

Retail supply chains have also been impacted, wherein the demand for essential items has increased, but demand is subdued in other categories like luxury items, and this further challenges operating margins and existing business models (Pantano et al., 2020). On the consumer side, stocking essential supplies and over-the-counter medicines have stressed supply chains to their limits (Mahajan & Tomar, 2021; Muniz et al., 2020). This unnatural and unpredictable increase in

demand and supply, and the continually fluctuating environment, makes it difficult to respond adequately to this type of bullwhip effect.

Hence, our study examines the capabilities required to manage supply chains and the learning opportunities that the current situation of Covid-19 offers that can help firms to increase visibility and control in their supply chains. We have chosen artificial intelligence (AI) as a technological enabler to help to address problems associated with supply chain resilience, and to offer potential avenues to assist organizations in their journey towards long term sustainability. The reason for choosing AI is that it encompasses the features of machine learning, big data, and deep learning (Gupta et al., 2021; Wamba et al., 2020c; Dwivedi et al., 2019; Roh et al., 2019). For instance, machine learning helps to automate the contractual agreements with suppliers and thus strengthen the procurement strategy of the organization. Big data helps to improve the decision making capabilities of an organization and can therefore avoid redundancy throughout the supply chain (Baryannis et al., 2019; Dubey et al., 2020). Additionally, AI is capable of developing agent-based systems, genetic algorithms, and expert systems to facilitate demand planning, order fulfilment, network design, and inventory planning in conjunction with supplier systems (Muniz et al., 2020).

Covid-19 has forced many organizations to re-think and transform their supply chain models (Ivanov, 2020a). Dun & Bradstreet report how approximately 75 per cent of businesses, including services, manufacturing, wholesale, and retail, are connected to economies that have been severely impacted by the pandemic, such as China. Retailers around the world are struggling with how to respond to businesses, consumers, and workers. Therefore, business continuity, and longer-term economic sustainability, are both major challenges for many organizations at present. In summary, Covid-19 has exposed a myriad of weaker elements in the supply chain (Queiroz et al., 2020). We suggest that many of these can be addressed by using intelligent and logical technologies to improve existing supply chain capabilities.

The dynamic capabilities (DC) of an organization help to strengthen its supply chain. DC is the "ability of an organization to integrate, build and reconfigure in-house and outside competences to address the environment that is regularly changing" (Teece et al., 1997). However, there is a paucity of studies that apply DC as an approach to solve large scale supply chain disruption, for example disruption caused due to Covid-19 (van Hoek, 2020). Therefore, in this study, we have adopted the theoretical lens of DC to bridge the research-practice gap that currently exists in supply

chain management. To do this we gather and analyze empirical data from supply chain professionals to present a framework that can help in enhancing supply chain capabilities using AI. We have developed the following two research questions to frame the study:

RQ1: *What AI capabilities should be considered when designing and executing post-Covid-19 supply chains?*

RQ2: *How can AI capabilities be leveraged to improve supply chain resilience?*

The remaining paper is presented in six sections. Section 2 highlights the related literature, while section 3 discuss AI, supply chain resilience and dynamic capabilities. Section 4 presents the research design and section 5 displays the findings. Section 6 presents research propositions and develops a framework followed by conclusions drawn in section 7.

## 2. Literature Review

Firms have long recognized the importance of contingency planning, mitigating supply shocks, demand volatility, and making the workplace safer than ever to derive efficiency and effectiveness in supply chains (Ivanov, 2020b). Prior to the Covid-19 pandemic, supply chains were often lauded for their ultra-efficiency, sourcing strategies, and just-in-time capabilities (van Hoek, 2020). Further, evidence shows how pre-Covid-19, many consumers were opting for in-store purchases over online shopping as they could see, touch, and compare items. Unsurprisingly, online purchases have soared during Covid-19 and supply chain visibility is therefore arguably more important than ever (Butt, 2021; Queiroz et al., 2020). However many organizations were not prepared for the practicalities of fulfilling online orders, and planning processes were ill-equipped to respond to the sudden increase in demand as a consequence of Covid-19. For many supply chains it therefore rapidly became apparent that an increased level of supply chain resilience was required (Ivanov, 2021; Queiroz et al., 2020; van Hoek, 2020). Developing supply chain resilience in response to disruption poses challenges; on the one hand there is large amount of uncertainty and on the other a significant amount of data is generated (Wamba et al., 2020c). Hence, due to uncertainty and vast data it becomes very difficult for supply chains to achieve their desired degree of resilience (Ivanov, 2021). In consequence, many firms are making short term predictions and focusing on strengthening their supply chain capabilities (Sundarakani et al., 2020). To do this

firms need to regularly assess their levels of risk across multiple parameters (Dolgui & Ivanov, 2020).

Therefore, the application of intelligent technologies like AI can help firms to strengthen their supply chain resilience position. This is because the adoption of AI can act as a critical capability to devise better control mechanisms and to identify areas of disruption (Gupta et al., 2020: Wamba et al., 2020b; Dwivedi et al., 2019). AI based innovations can assist in real- time coordination and collaboration to enable supply chains to have improved visibility (Wamba et al., 2020c; Remko, 2020).

With the visibility capability of AI-based technologies, one can generate insights on how the whole chain can be affected by a particular phenomenon over a certain period of time (Bock et al., 2020). As there continues to be sudden surges in demand patterns during the pandemic, it becomes challenging for supply chains to meet their existing service level agreements with actors in the chain. These service levels are determined on the basis of dynamic capabilities, margins, and the location from which a company is operating (Defee & Fugate, 2010). Another critical issue is network planning and mapping in the supply chain, and this is a further area in which AI can assist the supply chain in terms of production, routes, and other linking nodes (Ivanov & Dolgui, 2020). AI can further improve the collaboration between contractors and suppliers in shaping the supply chain in unprecedented times. It offers the visibility of routes and accordingly, promises can be made to consumers (Datta, 2017). AI utilizes data science principles to handle the volume, velocity, variety, veracity, value, variability, and visualization of data for critical insights (Wamba et al., 2020a). Further, AI helps in tracking the performance of warehouses in terms of demand and shelf life. Inventory management has become critical in ensuring continuous supply during Covid-19 (Butt, 2021; Queiroz et al., 2020). AI offers a robust examination of stock levels and aligns associated activities accordingly. Supply chains are continuously expanding their geographic reach, particularly into areas that they have not served previously due to the pandemic, and therefore the examination of traffic, weather, and the optimal route is also a concern for companies. With the help of AI, firms can navigate different markets remotely and can take strategic decisions more accurately. The technologies of AI also help top management and employees to be up to date in terms of the skill set needed to mitigate emergencies and cross-cultural management in an organization (Dubey et al., 2018; Dubey et al., 2016; Dubey &

Gunasekran, 2015). AI facilitates environmental scanning and endurance in supply chains at the macro level (Baryannis et al., 2019) and offers the two-dimensional view presented in Figure 1. Literature suggests that companies focusing on supply chain resilience should develop their analytical capabilities in order to enhance their knowledge capabilities and decision making in extremely complex situations. In applying supply chain risk analytics, firms can be proactive and innovative in managing the risk along their supply chain (Queiroz et al., 2020). Disruptions and risk in the supply chain should be viewed as phenomena to understand, adapt and analyze; particularly with respect to the performance parameters required to navigate the current complex environment, advanced cyber threats and complex supply chain designs (Dolgui & Ivanov, 2020). Hence, AI based innovation has potential to fast-track the decision process by recognizing, experimenting, and analyzing novel solutions (Wamba et al., 2020b).

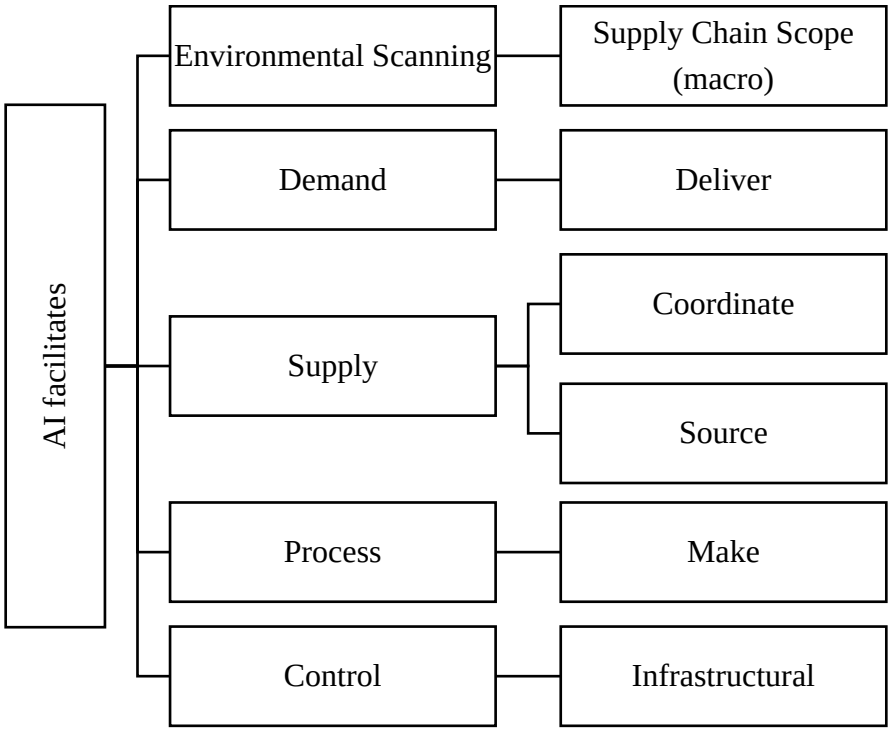


Figure 1: AI impact on different dimensions of Supply Chain resilience (Baryannis et al., 2019)

## 3. Critical Factors to Enhance Supply Chain Resilience

Artificial intelligence can be considered as a fundamental enabler that strengthens resilience capabilities in the supply chain (Dwivedi et al., 2019). Covid-19 has highlighted the importance of supply chain resilience, which has been clearly evidenced as companies struggle to find ways to balance demand and supply (Ivanov, 2021). This section discusses the critical factors of artificial intelligence, supply chain resilience, and dynamic capabilities in terms of their ability to enhance supply chain resilience.

### 3.1 Artificial Intelligence

Many organizations have been trying to adopt digitization of their processes for the last two decades, and recently Industry 4.0 has emerged as a business buzzword (Wollschlaeger et al., 2017). AI has long been recognized as one of the prominent technologies capable of enabling communication among devices and machines (Guzman & Lewis, 2020; Dwivedi et al., 2019; Schutzer, 1990). Since the supply chain involves a series of complex tasks, AI can simplify operations by solving problems at higher levels of speed and accuracy while simultaneously handling large volumes of data (Schniederjans et al., 2020). AI is not new, but its potential for vast applications, including supply chain management, has only been recognized more recently (Huin et al., 2003). AI has the potential to facilitate smart and agile decision making in the supply chain to anticipate problems. Hence, a proactive system of AI helps in enhancing the quality of service and in delighting customers through on-time and undamaged deliveries (Toorajipour et al., 2021; Wamba et al., 2020b). AI facilitates automated compliance that results in lower costs and the efficient functioning of a value chain network (Treleaven & Batrinca, 2017). AI also has a significant impact on enhancing the predictive capabilities required for demand forecasting in today's dynamic business environment. AI can be very efficient in the engagement of customers as interactions can be personalized by AI-driven bots. These bots can help in tracking the delivery status of an item and are further supported by echo users assisted by a customer support team (Huang & Rust, 2020). AI can help in simplifying tedious tasks in warehouse operations through automation. Companies like Amazon and Alibaba are already using AI-driven robots to enhance the productivity and efficiency of the supply chain (Ham, 2019). In the supply chain, every minute

and every mile matter and AI uses algorithms that can help in reducing time and costs by optimizing routes and deliveries (Wen et al., 2018).

### 3.2 Supply Chain Resilience

Supply chain resilience is the capability of a supply chain to cope with unforeseen, disrupting events and to recover quickly to its original level of performance, or to a new level required to maintain the expected operating, financial, and market performance (Adobor, 2020; Ponomarov & Holcomb, 2009). To build a resilient supply chain, firms need to identify and assess the nodes for risks, their severity, and the likelihood of occurrence, and how these risks can be detected (Dubey et al., 2017; Chang et al., 2015). Companies do adopt multiple strategies to keep their supply chains resilient. In the initial period of Covid-19, inventory and capacity buffers were identified as a source of resilience by some supply chains, whereas others have used underutilized production capacity for medicines and other related products (Queiroz et al., 2020; Wong et al., 2020). Some supply chains have also benefitted from resilience due to multi-sourcing strategies as compared to a single source of supply (de Sá et al., 2019). Covid-19 has also highlighted the importance of near-shoring to reduce the geographical reliance on global networks (Kano & Oh, 2020). In this way, local supply chains facilitate more control over inventory and transfer the product to the customer more quickly (Sundarakani et al., 2020). The more local the network, the more opportunities exist for the technology used in production to be harmonized more effectively to facilitate a seamless flow of products across the network (Singh et al., 2020). Hence, standardization of components for different products, especially those that are not critical and visible to the customer, simplify sourcing and thus enhance the degree of resilience. Aside from the core components, the supply chain ecosystem partnerships with contract manufactures and third-party logistics play a critical role in its resilience.

### 3.3 Dynamic Capabilities

Firm resources are a base for developing the capabilities of a firm, whereas capabilities are the direct source of competitive edge (Grant, 1991). This leads to the development of dynamic capabilities that define the ability of a firm to quickly adapt to changing business situations. This adaptation happens by aligning internal and external resources (Teece et al., 1997). Hence, dynamic capabilities refer to the capacity of a firm to intentionally create, extend, or transform its

resource base (Helfat et al., 2007). These capabilities may be internal or external and are closely related to resilience capabilities in supply chain literature (Kwak et al., 2018). Dynamic capabilities are known for scanning, analyzing, and mitigating risks by enabling resources and capabilities to ensure continuity of the business in a dynamic environment. The DC in supply chains can be viewed as knowledge processing and employing instruments to develop, protect, and extend the network to create value for customers (de Moura & Saroli, 2020). The role of dynamic capabilities has seen a steady increase in popularity in supply chains due to the increasing complexity of networks. Dynamic capabilities consider core competencies of a firm to extend the short term competitive position to further construct long term competitive advantage. In an emergency like Covid-19 where the world was experiencing significant uncertainty, dynamic capabilities are particularly suitable in developing supply chain resilience to build the long-term sustainability of an organization. Whilst there has been a lot of research on AI, its application in a SC context has received relatively limited research attention. Therefore we wish to understand how AI has been implemented in practice, and to highlight what we can learn from experiences of the Covid-19 pandemic in relation to supply chain management.

## 4. Research Design

To investigate the feasibility of artificial intelligence to develop supply chain resilience, our study adopted a qualitative case study and used the theoretical lens of dynamic capabilities advocated by existing literature (Gammelgaard, 2017). Dynamic capabilities was selected as an appropriate lens to examine supply chain resilience because AI can be used to improve responsiveness and agility in the supply chain (Wamba et al., 2020b). Further, qualitative research is a powerful tool to capture individual perceptions as it analyses thoughts and opinions to identify trends and insights (Fawcett et al., 2014; Gligor & Autry, 2012). The case based research method can also help to develop and test the theory (Dubois & Gibbert, 2010; Pagell & Wu, 2009; Gibbert et al., 2008; Eisenhardt, 1989). Therefore, following a detailed thematic analysis, our study develops five propositions leading to a framework representing AI enabled supply chain resilience capabilities. A structured research protocol is followed in our study and is presented in Figure 2. As the practical application of AI mechanism to improve supply chain resilience is relatively under-researched, our study offers contemporary insights into current practice.

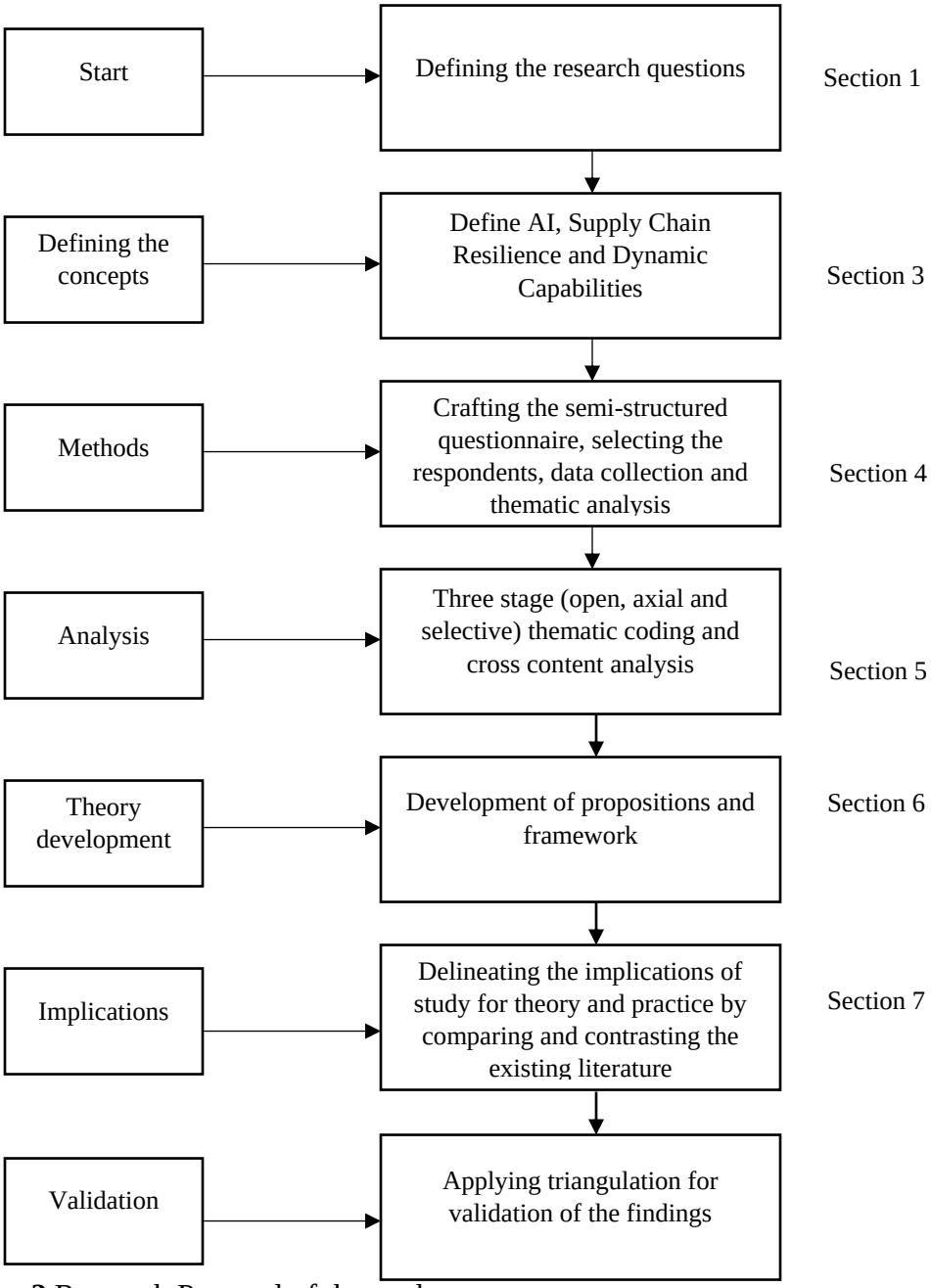


**Figure 2** Research Protocol of the study

### 4.1 Data Collection

To illicit the views of experienced professionals working in the supply chain and AI fields, we conducted in-depth interviews. We identified and contacted 215 supply chain and AI professionals via email and LinkedIn messages in May 2020 and provided a brief introduction to the research topic. After multiple reminders, 54 respondents replied and showed interest in sharing their views on the topic. However, of these, only 35 respondents finally agreed to be interviewed. Interviews were conducted in October and November 2020, telephonically and over internet-based calls because of the pandemic. To maintain confidentiality, we have anonymized the respondents (R1 to R35, R stands for Respondent, 1 to 35 are respondent numbers) and provide full details in Table 1.

**Table 1 :** Details of Interviewees

| Table 1. Interviewee Profile No. | Interviewee Code | Job title | Nature of work | Years of experience |
|---|---|---|---|---|
| 1 | R1 | Manager | Logistics & Supply Chain | 6-10 |
| 2 | R2 | Senior Manager | Logistics & Supply Chain | 6-10 |
| 3 | R3 | Senior Manager | Logistics & Supply Chain | 1-5 |
| 4 | R4 | Senior Manager | Supply Chain Consulting | >10 |
| 5 | R5 | Senior Manager | Manufacturing | 6-10 |
| 6 | R6 | Manager | Logistics & Supply Chain | 6-10 |

| | | | | |
|---|---|---|---|---|
| 7 | R7 | Consultant | Operations | 1-5 |
| 8 | R8 | Manager | Operations | 1-5 |
| 9 | R9 | Manager | Operations | 6-10 |
| 10 | R10 | Manager | Sales & Marketing | 1-5 |
| 11 | R11 | Demand Planner | Logistics & Supply Chain | 1-5 |
| 12 | R12 | Associate Consultant | Sales and Marketing | 6-10 |
| 13 | R13 | Senior Consultant | Logistics & Supply Chain | 6-10 |
| 14 | R14 | Senior Manager | IT services | >10 |
| 15 | R15 | Manager | Manufacturing | 1-5 |
| 16 | R16 | Supply Planner | Logistics & Supply Chain | 6-10 |
| 17 | R17 | Senior Consultant | IT Services | >10 |
| 18 | R18 | Engineer | Manufacturing | 1-5 |
| 19 | R19 | Senior Consultant | Consulting | 6-10 |
| 20 | R20 | Supply Chain Analyst | Logistics & Supply chain | >10 |
| 21 | R21 | Demand Planner | Manufacturing | >10 |
| 22 | R22 | Manager-Inventory | Warehouse Management | 6-10 |

| | | | | |
|---|---|---|---|---|
| 23 | R23 | Engineer | IT Services | 1-5 |
| 24 | R24 | Senior Engineer | IT Services | 6-10 |
| 25 | R25 | ERP Consultant | IT Services | 6-10 |
| 26 | R26 | Director | Supply Chain | >10 |
| 27 | R27 | Business Analyst | Strategy | 6-10 |
| 28 | R28 | General Manager | Supply Chain | >10 |
| 29 | R29 | Senior Vice President | Supply Chain | >10 |
| 30 | R30 | Consultant | Consulting | 1-5 |
| 31 | R31 | Manager | Sales and Marketing | 6-10 |
| 32 | R32 | Associate Consultant | IT services | 6-10 |
| 33 | R33 | Executive | Sales and Marketing | 1-5 |
| 34 | R34 | Manager | Distribution | 6-10 |
| 35 | R35 | Plant Manager | Manufacturing | >10 |

### 4.2 Data Analysis

All interviews were transcribed verbatim. To analyze the wealth of qualitative data collected, we extracted themes and subthemes using thematic coding (Gibbs, 2007) (see Figure 3). Interview transcripts were coded multiple times to ensure internal consistency (Miles et al., 2014) Where possible, and as themes emerged, they were compared with publicly available secondary source material. The method of triangulation helped us to analyze the research problem through different angles, providing an in-depth analysis of the situation, and enhancing data validity (Nightingale, 2020).

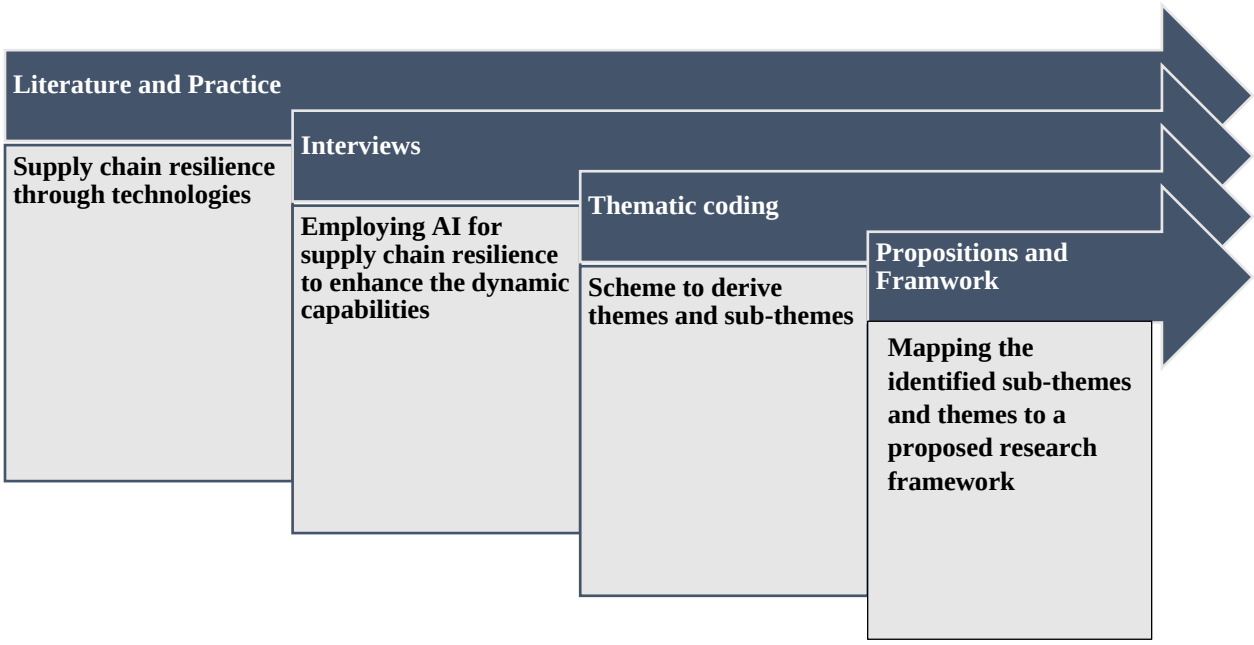


**Figure 3** Research Design

## 5. Findings

The section highlights the key findings, Five clear themes emerged from the empirical data; i) transparency, ii) personalized solutions, iii) procurement strategy, iv) last mile delivery and v) disruption and impact reduction. Each theme is now discussed in turn in the context of artificial intelligence enabled supply chain resilience.

### 5.1 Transparency

Transparency was identified as critical by respondents of the study, and refers to the visibility of data related to inventory, delivery, etc. across supply chain partners to ensure efficiency and the reduction of the impact of possible disruption. The exchange of data and timely information increases the coordination and trust among supply chain partners. The transparency and visibility of the data are important and affect the performance of a supply chain, and can be responsible for both building and breaking the SC relationship (Murfield & Tate, 2017; Maghsoudi

and Pazirandeh, 2016). Table 2 displays the related quotes and axial codes pertaining to the theme of transparency.

Table 2: Themes and codes identified under “Transparency”

| **Interviewee Code** | **Axial Code** | **Supporting indicative quotations from interviews and open code** |
|---|---|---|
| R4 | Sensing the demand at retailers end | *We are focusing on an AI tool that tells the demand of the end retailer. From there we can predict the demand of our customers and map with our product planning. Scanning of barcode data at the retailer can be used for predictive analysis.*<br>*Open Code: Retailers' demand can be mapped using smart technology and can be used for better product planning.* |
| R2 | Demand Forecasting | *AI is helping in the supply chain as it can forecast the demand in a much accurate way. AI helps in analyzing the data and converting it into an intelligent forecast and even helps in improving sales strategies.*<br>*Open Code: AI brings an accurate forecast to firms.* |
| R14 | Invoicing | *AI is helping to send the invoicing details automatically to the customer once the invoice is generated and also the customer can see the live status of the truck with the delivery time counting various factors like traffic and weather in long-distance*<br>*Open Code: Smart technology brings automation in invoicing* |

| | | |
|---|---|---|
| R29 | Tracking shipments | *Tracking carrier has become easy using the latest technologies. AI also helps in predicting the time of shipments, variation in shipping time, and if any risk is associated based on the trend analysis.*<br>*Open Code: Live tracking of shipments and predicting risks with the help of AI tool brings better planning and coordination among stakeholders.* |

### 5.2 Personalized solutions

Personalization helps firms in reaching out to a greater number of market segments and in solidifying their brand. Customers tend to purchase from firms that consider their preferences and deliver the product of their choosing. It also develops trust between the buyer and the seller. New communication mechanisms like virtual chatbots are being deployed to enhance the communication between parties. Brands that personalize and take into consideration the customer's preferences tend to generate greater return on investment and 10 per cent more sales than those that do not personalize (McKinsey, 2018). Table 3 displays the quotes and axial codes related to personalized solution.

Table 3: Themes and codes identified under "Personalized solutions"

| **Interviewee Code** | **Axial Code** | **Supporting indicative quotations from interviews and open code** |
|---|---|---|
| R4 | Virtual chatbot | *AI helps in installing a virtual chatbot to solve the customer query without being engaged with the employee, be it the live status of the order, the shipment of an* |

| | | |
|---|---|---|
| | | *order, or the tentative delivery time of the order. Also, firms take the benefit of fetching exact customer requirements and preferences using this medium.*<br>*Open Code: Digital communication mediums resolve customer queries and help firms in understanding customer choices.* |
| R21 | Understanding consumer behavior | *AI is giving data to analyze the pattern of consumer behaviors on how the market behaves for different channels like e-commerce, general trade, and modern trade. This further helps to design supply chain strategy in the upcoming time for different channels.*<br>*Open Code: Consumer buying pattern helps in framing supply chain strategy* |
| R9 | Inventory Planning | *Personalization is carried out using AI helps to understand the next buying pattern, whether bulk purchase to keep stock in advance is necessary or smaller inventory would suffice.*<br>*Open Code: AI-enabled personalization leads to effective inventory planning* |
| R12 | Understating market patterns | *The future outcomes and market patterns can be generated using predictive analytics using AI tool., Data can be analyzed using unparalleled computing power to figure out future demand, or to understand the buying behavior of the customer base. Accordingly, effective* |

| | | |
|---|---|---|
| | | *manufacturing and supply chain strategy can be developed for better performance.*<br>*Open Code: Understanding market patterns with the help of AI leads to better supply chain planning.* |

### 5.3 Procurement Strategy

An effective procurement strategy brings better control of resources, cost optimization, and efficient supplier management. A procurement strategy refers to identifying the right supplier, designing supply contracts, supplier management, etc. An effective procurement strategy not only brings the cost of procurement down (Knudsen, 2003), but also develops and enhances trust among supply chain partners by managing the relationship with suppliers, and controls overall inventory. Table 4 displays the quotes and axial codes related to the procurement strategy.

Table 4: Themes and codes identified under "Procurement Strategy"

| **Interviewee Code** | **Axial Code** | **Supporting indicative quotations from interviews and open code** |
|---|---|---|
| R24 | Spend Analysis | *Using AI, spend visibility of the firm increases, helps in expediting the decision making process by using classified spend data, and saves both time and money by reducing the human intervention.*<br>*Open Code: Spend analysis saves time and cost, hence increases efficiency and speed.* |
| R21 | Vendor Management | *AI helps in the identification of local vendors as global vendors are not feasible for many items. AI is helping through Vendor management tools (vendor* |

| | | |
|---|---|---|
| | | *assessment, audit support, credit management, etc.) to make an effective and resilient supply chain from local vendors.*<br>*Open Code: Effective vendor management leads to resilience in the supply chain.* |
| R19 | Supplier Risk Management | *AI could be a great help in identifying the risk associated at the different junctures of the supply chain and can provide the solutions using its ability to analyze the data, figure out the source of risk and increase transparency across supply chain partners.*<br>*Open Code: Identification and mitigation of risk leads to transparency and resilience in the supply chain.* |
| R17 | Contract management | *Contract management is essential to bring the cost of supply down significantly. AI helps in analyzing the different legal contracts available, reads it, and makes a decision appropriately. A good contract acceptable to both the parties will result in fruitful and long-term relations and provide the desired stability to the supply chain.*<br>*Open Code: Effective contract management enhances the coordination among supply chain partners and makes it more stable.* |

### 5.4 Last mile delivery

Arguably, the most critical part of logistics is last mile delivery wherein the customer evaluates the service quality based on the timely delivery of items (Mangiaracina et al. 2019). The key objective of last mile delivery is to deliver the product in the fastest possible way to the consumer. Last mile delivery is often less efficient and more expensive (Macioszek, 2017) due to maintaining the required services levels and to achieve target set. Also, consumers always look for alternatives if their product is not delivered on time. Table 5 displays the quotes and axial codes related to last mile delivery.

Table 5: Themes and codes identified under "Last mile delivery"

| **Interviewee Code** | **Axial Code** | **Supporting indicative quotations from interviews and open code** |
|---|---|---|
| R27 | Predictive analysis | *In last mile delivery, AI plays a great role by accurately managing the most complex data related to routes, network, traffic, etc. It may also produce data models focused on predictive analysis. This way it will help to ensure quick fixes and safe last mile delivery as well.*<br>*Open Code: Predictive analysis model helps in route planning and ensures quick last mile delivery* |
| R29 | Managing workforce | *Manage the workforce diligently or launch them at closer to operational locations to ensure that we do not expose them too much and make resources available on demand. Deploying the workforce smartly concerning the* |

| | | |
|---|---|---|
| | | *requirement of the region ensures faster delivery.*<br>*Open Code: Management of workforce ensures resource availability and quick delivery* |
| R16 | Paperless technique for delivery force | *Paperless technique during this pandemic time was effective in saving time as well as keeping our staff safe from any infections. With the help of technology, the smooth and timely delivery of items was ensured without much human interventions.*<br>*Open Code: Paperless process saves time and speeds up the delivery.* |

### 5.5 Disruption and impact reduction

Supply chain disruption can be caused by various factors including delivery delay, demand and supply related problems, natural disasters or a global pandemic like Covid-19. Disruption can lead to the poor performance of a supply chain (Alora and Barua, 2020). It is therefore essential to identify the potential risks and types of disruptions that may occur in the future and can lead to the most severe outcomes. Reducing the impact of disruption can be achieved by making the system capable of matching market demand or supplying what is demanded (Papadopoulos et al. 2016). Table 6 displays the quotes and axial codes related to disruption and impact reduction.

Table 6: Themes and codes identified under "Reduce disruption impact"

| **Interviewee Code** | **Axial Code** | **Supporting indicative quotations from interviews and open code** |
|---|---|---|

| | | |
|---|---|---|
| R22 | Automated warehouse | *Warehouses with warehouse management system installed have robots working with full automation and no manual intervention. Artificial intelligence improves efficiency and thereby reduces human error*<br>*Open Code: Automation improves the efficiency of warehouse management.* |
| R35 | Robotic process automation | *RPA/Robots can be assigned to do the regular process and thereby, the work for the humans can be more strategic and tactical.*<br>*Open Code: AI brings robotic automation that enhances the process speed and efficiency.* |
| R32 | Supply chain flexibility | *AI in forecasting, works on historical data to create forecasts. To orient it for the disruption we need to make sure that it has relevant real-time data at all times. Many firms outsource the work of doing market research and data collection. So this sort of preparation makes your supply chain flexible and more responsive to changing trends and you can handle disruptions better.*<br>*Open Code: Flexible supply chains can handle disruptions better.* |
| R 11 | Sales and Operations Planning | *AI tools can be used to fetch the exact demand from the market by analyzing trends, can be helpful in optimization of resources, reduce inventory level, and for* |

| | | |
|---|---|---|
| | | *enhancing the service level of the organization. The real-time update across supply chain partners will enhance collaborated planning that would lead to achieving resilience in the supply chain.*<br>*Open Code: Error-free Demand planning and dissemination of information to partners lead to better collaboration and supply chain resilience.* |

After following a thematic coding approach, we extracted multiple open codes from the interview data. After careful analysis back and forth within and between the codes we identified axial codes that were collapsed to form selective codes. In summary, our study finds five selective codes as presented in Table 7.

Table 7: Summary of Findings

| **Selective Code** | **Axial Code** | **Combined meaning of Open Codes** |
|---|---|---|
| Transparency | Demand forecasting | A highly complex environment originated due to Covid-19 and required access to real time data from multiple stakeholders to balance supply and demand. AI can support this realignment. |
| | Sensing the demand at retailer end | |
| | Invoicing | |
| | Tracking shipments | |
| Personalized solutions | Understanding consumer behavior | Consumer behavior and changing market patterns lead supply chains to develop digital platforms, such as virtual chatbots, and enhance their information processing capabilities to improve supply chain |
| | Virtual chatbot | |
| | Understating market patterns | |

| | | |
|---|---|---|
| | Inventory planning | resilience. AI can facilitate firms in providing personalized solutions. |
| Procurement strategy | Vendor management | Supply chain cost is directly related to the strategic sourcing capabilities of an organization. AI can assist supply chain professionals to develop the robust network design that is required to reduce supply chain risk. |
| | Spend analysis | |
| | Contract management | |
| | Supplier risk management | |
| Last mile delivery | Managing workforce | During Covid-19, firms are exposed to multiple constraints ranging from maintaining social distancing, paperless delivery and managing the supply chain operations with minimum workforce. AI can facilitate in developing predictive analytics to achieve the required degree of resilience in a supply chain. |
| | Predictive analysis | |
| | Paperless technique for delivery force | |
| Reduce disruption impact | Robotic process automation | The greatest challenge for many supply chains is to adapt and adjust to highly uncertain demand scenarios, whereby dynamic sales and flexibility in operations planning are required. Automation can reduce the impact of disruption caused by catastrophic events (e.g. Covid-19). |
| | Automated warehouse | |
| | Sales and operations planning | |
| | Supply chain flexibility | |

## 6. Development of Propositions

Our study adopted a semi-structured interview methodology to collect contemporary empirical data. This approach offered exciting insights and implications for developing dynamic capabilities through AI that further assist in strengthening supply chain resilience during periods of uncertainty, for example during the Covid-19 global pandemic. In drawing on this conceptualization, we offer a further contribution by developing propositions for further research based on our study, which are now discussed and presented.

During the current pandemic, the focus of organizations and supply chains has been on ensuring that the demand forecast is correct during this period of disruption, demand fluctuation and uncertainty. Firms have faced significant challenges because of a sudden drop in product demand; this unpredictability has impacted on the ability to develop accurate forecasts. According to R 11 " *In the pre-Covid era the major task used to be forecasting the yearly demand, which we used to decide on at the start of the financial year. But Covid practically hit in March 2020, especially in India, so the demand fell drastically and the previous forecast was useless. We had to adjust to the conditions and do the forecasting process all over again with the help of supply chain partners, especially retailers and accordingly build up inventory."* Retailers are the supply chain actors who frequently communicate and connect with customers. They therefore play a key role in the supply chain by identifying the customer's preferences and providing information about potential customer segmentation. Real-time updating of such data with the help of AI will speed up this process, and will allow firms to make changes to their manufacturing and distribution scheduling to create transparency throughout the supply chain. According to R 33 **"***AI technologies help in understanding customer demand more precisely and inform the changes in customer requirements in uncertain conditions like Covid-19. This can help to cater to large number of customers in short span of time. With the help of AI, the supply chain will get more automated and efficient, which in turn would help in the transparency of the entire network".* These insights lead us to the following proposition:

P1: *Under extremely uncertain conditions, for example Covid-19, it is crucial for supply chain actors to have access to actual demand data originating from the retailer and in such situations AI can play a critical role in aligning demand and supply to avoid the impact of disruption.*

Covid-19 has forced firms to reconfigure their supply chain structures due to sudden changes in the demand for consumer products i.e. healthcare products, personal protective equipment, toilet

paper, food items etc. (Flynn, 2021). During the pandemic it became quite a challenge to maintain the right amount of inventory stock (of raw material and finished goods) to fulfil unpredictable customer demand. According to R 33 " *Apart from fetching the right forecast, there is a focus on demand and purchasing patterns, since inventory buildup and capacity build up could cost extensively and firms fear what they will do with extra capacity post-Covid 19. Hence, AI can be helpful in predicting and maintaining the system and protecting it from disruption".* The impact of disruption can be avoided to a large extent if a mechanism to reach out to customers in real time is available. Firms are embracing diverse ways to reach out to their existing customers, as well as potential customers, to enhance the interaction frequency as well as improve the service level. Interaction with customers will result in acquiring demand sets, gaining insights into preference changes, and will lead to providing personalized solutions. In the words of R 26 "*AI-based supply chains will facilitate better customer-centric solutions as AI will be studying the personal behavior of the client as well as incorporating their needs and requirements from their lifestyle and providing a better solution that is much more personalized."* Therefore, to develop dynamic capabilities the personalized solution approach with identification of key supply chain processes and reconfiguration of resources are necessary for firms to quickly adjust the system to instill resilience (Chowdhury and Quaddus, 2017). The above discussion leads us to the following proposition:

P2: *During periods of prolonged supply chain disruption, technology such as AI can be used by firms to increase their information processing capabilities to improve resilience in the supply chain by synchronizing manufacturing and inventory planning.*

Supply chain contracts play a vital role in conducting business operations and procuring materials, particularly in highly uncertain and volatile environments because they reduce the risk of loss for any one party. Due to Covid-19, supplier contracts, and trade contracts have been impacted significantly due to lockdown and travel restrictions. The situation is further exacerbated as supply chain contracts can become a complex legal issue in highly uncertain periods, for example during Covid-19. Identification of the right supplier and maintaining the relationship results in more profitable and stable supply chains. Therefore, it is recommended by experts to develop and invest in local suppliers to achieve more resilience in the supply chain, as R 28 notes "*Procurement is more deeply done by connecting to vendors locally by detecting the demand and AI helps in finding*

*the local vendors meeting the business requirements. For instance, in the pre-Covid 19 era we used to have a daily supply of raw materials to follow just-in-time. However, in Covid-19 it has reversed where rather than us, we were expecting our suppliers to have inventory capacity, so whenever we require the raw material, the supplier is able to provide".* In terms of dynamic capabilities, organizations dynamically make shifts in their procurement strategy to reflect the change in demand patterns. According to R 31 "*AI analyses the market demands and thereafter aligns to supply operations. During Covid-19, the usage of AI further considers the capabilities of the stakeholders and take the clues from local suppliers to offer superior demand management".* These highlights lead us to the following proposition:

P3: *Under conditions of uncertainty AI can assist in identifying the most efficient suppliers in local geographies, which in turn reduces supply chain risk due to the sourcing emphasis on resilience.*

The Covid-19 pandemic has increased the demand for, and engagement in, online retailing and has accelerated the shift towards a more digital world. Online shopping has increased significantly during the various phases of Covid-19 lockdown. As a result, firms have been forced to change their delivery operations either by hiring 3rd party "last mile delivery" services or by establishing new "last mile delivery" operations in their own organizations. The challenge has not only been the last mile delivery, but also ensuring the safety of employees and delivery partners as front line workers. According to R 12 "*We have developed tracker tools to ensure the safety of our employees and these tools regularly provide data to the plant that an employee is healthy to work according to the symptom checker*".

With the increase in customer expectation of high-speed delivery, organizations have optimized the delivery process and delivery routes consistently to remain competitive. AI and leading-edge technologies will be critical to the next generation of supply chain management due to their ability to respond so quickly. Last-mile delivery is considered the most expensive logistics process and accounts for nearly 50 per cent of overall shipment delivery cost (McKinsey, 2018). Predicting the feasible delivery routes with the help of AI-enabled technology based on data related to traffic mapping, the resources (workforce, vehicles, etc.) required for delivery, and the fluctuation in demand of a particular region reduces supply chain risk (Sundarakani et al., 2020). Further, the digitization of processes improves transparency and agility in the delivery process. According to

R 7 " *Due to physical distancing due to Covid 19, we are consistently working towards paperless techniques for our delivery force. Physical data is being converted into the digital forms and updated through software applications, which leads to improvements in delivery lead time significantly*". The above discussion leads us to the following proposition:

*P4: In instances where social distancing is required AI facilitates the digital delivery of products to customers at the right time and in the right quantity which improves customer satisfaction.*

Covid-19 has heightened volatility, uncertainty, and unpredictability (Singh et al. 2020a). It has forced business units to opt for flexible systems or systems that can change their shape and pace according to the situation (Singh et al. 2019) and that the system that can handle business shocks (Singh et al. 2020b). Dynamic capabilities, for example the automation of different supply chain processes (procurement, warehouse, delivery, etc.) can enhance the efficiency of a system and can quickly adjust to change. According to R14 "*The automated supply chain management system and location based tracking tools can help firms to reveal desperately needed end to end information about the status of goods and suppliers. Pre-Covid, supply lines were designed keeping stable production in mind, but now Covid 19 has exposed the vulnerabilities of complex global supply chains*." Due to these requirements we need a flexible system that can adapt and mould based on the changes in the environment. Adaptability of the system can make it shock-free, or shock absorbing, and more resilient. The above discussion leads us to the following proposition:

*P5: During periods of uncertainty, for example Covid-19, AI can offer a higher degree of flexibility and automation that allows firms to quickly adjust to the changing environment and enables supply chains to improve performance by mitigating the risk of disruption.*

Based on the five propositions, we develop a framework presented as Figure 4 that can be further explored and tested through an appropriate organizational and grounded theory approach.

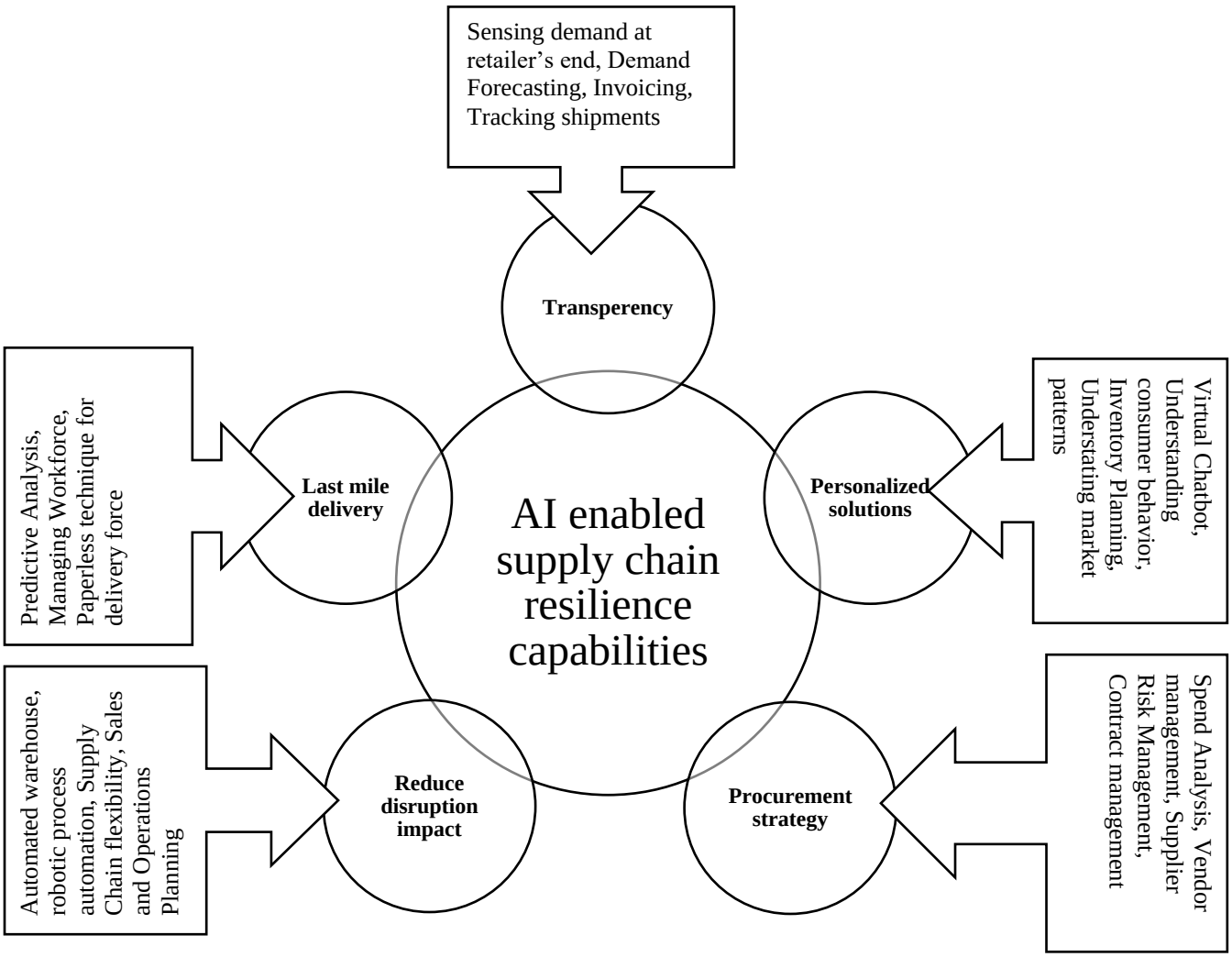


Figure 4: AI enabled supply chain resilience capabilities

### 7.0 Discussion and Implications

Our study offers interesting and useful findings to advance debates on: supply chain resilience, Covid-19 and artificial intelligence from a dynamic capabilities perspective. In adopting the lens of dynamic capabilities, we offer theoretical advances through the integration of operations management and information systems. The importance of theory development in operations management through qualitative research has been highlighted in earlier studies (Narasimhan, 2014; Barratt et al., 2011). Recent studies have examined the role of emerging and intelligent

technologies in the design and development of responsive supply chains, thus enhancing their capabilities to ensure business continuity (Russell & Swanson, 2019; Pettit et al., 2013). Hence, we conceptualized DC as an appropriate lens to observe and critique the implications for theory and practice for supply chain management that are emerging during Covid-19.

### 7.1 Implications for theory

In this study, we offer a three-fold contribution to existing literature. First, by drawing on the insights of experts in supply chain management with experience of working during the Covid-19 pandemic, we have discovered the practical issues faced during uncertain and extremely difficult conditions. Through our discussions with experts we have seen how firms and supply chains have boosted their resilience by adopting intelligent technologies. We have witnessed a gap between the theory and practice of logistics in the Covid 19 context. For instance, most of the supply chain managers we interviewed were in favour of holding inventory not only in their own firms but also with their suppliers, which is in contrast to academic emphasis on Just in Time (van Hoek, 2020).

Second, based on the open, axial, and selective coding of the qualitative data, we have developed and presented five propositions developed from the views of supply chain professionals and their experience during Covid-19. These propositions provide a state-of-the-art foundation for further research. As per our propositions, the transparency of a supply chain can build resilience when supply chain actors are capable of tracking their shipments, have the correct invoicing to drive the operations and utilize AI to forecast demand (Ivanov, 2021; Queiroz et al., 2020). Further, AI can be viewed as a tool in understanding market and consumer requirements, which can assist in designing and offering personalized solutions. As procurement and strategic sourcing are often perceived as the back-bone of a supply chain, AI can support in effective contract management, thus developing understanding and reducing the impact of supplier risk management (van Hoek, 2020; Sundarakani et al., 2020). During Covid-19, one of the most difficult tasks for e-commerce has been the last mile delivery, where problems such as workforce shortages and the requirement to adopt digital and paperless delivery have proven challenging. AI can be used to address and optimize the workforce to ensure last mile delivery by developing AI driven innovation and technologies to improve flexibility, automation and strategic planning, thus strengthening the capability of organizations to reduce the impact of risk (Dolgui & Ivanov, 2020; Wamba et al., 2020b). Our study supports the findings of existing studies that have utilized DC theory, which

highlight the role of AI in enhancing organizational performance and supply chain resilience by connecting stakeholders in real time (Dubey et al., 2020; Dolgui & Ivanov, 2020). Complementary theories such as resource-based view and organizational information processing can be applied to test our propositions further. Third, by drawing on the five propositions we have developed a five-dimensional framework representing the components of AI-enabled supply chain resilience capabilities that have gained increasing importance due to Covid-19. Our study appreciates the role of DC in AI facilitated resilience for supply chains in complex situations of extremely high uncertainty (e.g.Covid 19). Hence, our study offers interesting avenues for further work examining how supply chains can improve resilience by developing adequate capabilities that can reduce the risk and impact of disruption in uncertain situations, such as Covid-19. In identifying and addressing these key gaps in practice, we answer the research questions posed at the outset of our study: *What AI capabilities should be considered when designing and executing post-Covid-19 supply chains? How can AI capabilities be leveraged to improve supply chain resilience?* In drawing on our propositions and five-dimensional framework, businesses can equip and enhance their capabilities to meet the challenges arising when a pandemic like Covid-19 or other disasters strike.

### 7.2 Implications for practice

The study offers unique opportunities for supply chain practitioners to employ AI technologies to strengthen the resilience required to respond in dynamic situations, such as Covid-19. These AI-enabled capabilities can be helpful not only to the focal firm but also to supply chain actors as co-ordination becomes critical in Covid-19 impacted supply chains. However, before deciding to employ AI in the supply chain professionals need to consider (i) existing sensing capabilities (ii) how to capture the multi-directional information, and (iii) the degree of re-configuration required on the basis of the impact of a Covid-19 like pandemic on their supply chain. Practitioners must analyze the logistical capabilities required for ensuring last mile delivery are consistent with social distancing and how AI-driven technologies can enhance effectiveness. Inventories and their importance were discussed in significant detail during our interviews, therefore the appropriate level of inventory for ensuring the continuity of the supply chain is necessary and AI can help in

offering accuracy and transparency to enhance the overall efficiency at firm, supplier, distributor and retailer nodes. Apart from additional safety and the pressure to reduce costs, supply chain professionals may also consider the application of AI for identifying and analyzing trends to realign the supply chain capabilities that emerged due to Covid-19. As compared to a traditional setting, an AI-enabled environment offers the scope for enhancing the capabilities of the stakeholders upstream as well as downstream to avoid the bullwhip effect; such capabilities are crucial in a situation like Covid-19. In this way the adoption of AI will not only enhance the company readiness and resilience to cope with uncertainty but will also facilitate the customer experience that in turn drives business growth even during situations such as Covid-19. Supply chain professionals can consider the elements highlighted in the proposed framework and link them to their AI adoption approach and continuously assess against this framework to gauge the benefits in terms of supply chain resilience capabilities during and post-Covid 19 era.

### 7.3 Limitations and scope for future research

The concept of dynamic capabilities is based on two classic systems i.e. strategic management and marketing, in the form of resource-based and market positioning. Dynamic capabilities specifically develop on the basis of choices that organizations make for their internal activities and are considered based on external factors such as markets and number of competitors. To develop the AI-based infrastructure one needs to check the compatibility of existing infrastructure and scope for supply chain resilience capability. Whilst our study offers clear theoretical and managerial contributions, it is not without limitations. For example, our study utilizes a relatively small number of respondents and hence only their views are captured. Further work may consider a larger sample across a broader range of industries and geographical reach. From the findings, it is evident how AI can influence the different aspects of supply chain resilience and there is potential for future studies to examine and investigate the social media driven AI capabilities that can direct the supply chains to align with customer requirements (Wamba et al., 2019). Future studies may explore the role of AI from the perspective of organizational information processing theory and resource-based view to develop the required degree of resilience in uncertain times such as Covid-19. Additionally, future research can adopt a mixed-methods approach to further validate the

findings of our study (Chan et al., 2016). Further work may also compare pre and post-Covid changes in supply chain resilience. Our study considers the region-specific orientation of supply chain professionals that can be verified with multi-country studies in the future. Forthcoming studies may employ an explanatory approach to test the proposed framework. Further research can be conducted to test the different supply chain resilience approaches enabled by intelligent technologies in different industries and find the commonalities in terms of how AI facilitates the supply chain resilience capability in a certain group of industries. In summary, our study provides many avenues for interesting, topical and contemporary further work.

## 8.0 Conclusion

Our study adopts the lens of DC to investigate the potential of AI to develop supply chain resilience during Covid-19. In considering DC, we have demonstrated how AI can improve supply chain resilience and support organizational survival in a complex and uncertain environment. Moreover our study develops and presents a framework demonstrating supply chain resilience capabilities. Our study responds to the underdeveloped debates of the current Covid-19 time period; debates focused on how to utilize AI as a dynamic capability of an organization to strengthen supply chain resilience. AI can be helpful in addressing pressing supply chain concerns, such as improving transparency through continuous monitoring, ensuring last mile delivery of essential household items, maintaining a dynamic procurement strategy, offering personalized solutions and mitigating the disruption caused due to Covid-19. In summary, our study presents in-depth investigation and findings of employing AI enabled platforms and systems to improve supply chain resilience during extreme events such as Covid-19.

**Declaration:** The authors declare that there is no conflict of interest.

Barbieri, D.M., Lou, B., Passavanti, M., Hui, C., Lessa, D.A., Maharaj, B., Banerjee, A., Wang, F., Chang, K., Naik, B.,Yu, L., Liu, Z., Sikka, G., Tucker, A., Mirhosseini, A.F., Naseri, S., Qiao, Y., Gupta, A., Abbas, M., Fang, K., Ghasemi, N., Peprah, P., Goswami, S., Hessami, A., Agarwal, N., Lam, L., and Adomako,S. (2020), "A survey dataset to evaluate the changes in mobility and transportation due to COVID-19 travel restrictions in Australia, Brazil, China, Ghana, India, Iran, Italy, Norway, South Africa, United States", Data in Brief. doi: 10.1016/j.dib.2020.106459.

Barbieri et al., 2020: The article is recently published and therefore page range is not avliable, therefore DOI is given.

Belhadi et al., 2021: The article is recently published and therefore page range is not avliable, therefore DOI is given.

Braun and Clarke, 2020: The article is recently published and therefore volume, page range is not avliable, therefore DOI is given.

Butt and Ahmad, 2020: The article is recently published and therefore volume, page range is not avliable, therefore DOI is given.

Grida et al., 2020: The article is recently published and therefore page range is not avliable, therefore DOI is given.

Handfield, R.B., Graham, G. and Burns, L. (2020), "Corona virus, tariffs, trade wars and supply chain

evolutionary design", International Journal of Operations and Production Management, Vol. 40 No. 10, pp. 1649-1660.

Jabbour et al., 2020: The article is recently published and therefore page range is not avliable, therefore DOI is given.

Khan et al., 2020: The article is recently published and therefore page range is not avliable, therefore DOI is given.

Norouzi et al., 2020: The article is recently published and therefore page range is not avliable, therefore DOI is given.

Paul, S.K. and Chowdhury, P. (2020), "A production recovery plan in manufacturing supply chains for a high-demand item during COVID-19", International Journal of Physical Distribution and Logistics Management,Vol. 51 No. 2, pp. 104-125.

Sarkis, J. (2020), "Supply chain sustainability: learning from the COVID-19 pandemic", International Journal of Operations and Production Management., Vol. 41 No. 1, pp. 63-73.

Sharma et al., 2020: The article is recently published and therefore page range is not avliable, therefore DOI is given.

Sodhi, M.S. and Tang, C.S. (2020), "Supply chain management for extreme conditions: research opportunities", Journal of Supply Chain Management, Vol. 57 No1,pp. 7–16

**References**


Adobor, H. (2020). Supply chain resilience: an adaptive cycle approach. *International Journal of Logistics Management*, 31(3), 443-463.

Alora, A. and Barua, M.K. (2020). The effect of supply chain disruptions on shareholder wealth in small and mid-cap companies. *Supply Chain Management*, https://doi.org/10.1108/SCM-05-2020-0200

Alvesson, M., & Sandberg, J. (2011). Generating research questions through problematization. *Academy of Management Review*, 36(2), 247-271.

Barratt, M., Choi, T. Y., & Li, M. (2011). Qualitative case studies in operations management: Trends, research outcomes, and future research implications. *Journal of Operations Management*, 29(4), 329-342.

Baryannis, G., Validi, S., Dani, S., & Antoniou, G. (2019). Supply chain risk management and artificial intelligence: state of the art and future research directions. *International Journal of Production Research*, 57(7), 2179-2202.

Butt, A. S. (2021). Strategies to mitigate the impact of COVID-19 on supply chain disruptions: a multiple case analysis of buyers and distributors. *International Journal of Logistics Management.* DOI: 10.1108/IJLM-11-2020-0455

Chan, H. K., Wang, X., Lacka, E., & Zhang, M. (2016). A mixed-method approach to extracting the value of social media data. *Production and Operations Management*, 25(3), 568-583.

Chang, W., Ellinger, A. E., & Blackhurst, J. (2015). A contextual approach to supply chain risk mitigation. *International Journal of Logistics Management*, 26(3), 642-656.

Choi, T. M. (2020). Innovative "Bring-Service-Near-Your-Home" Operations under Coronavirus (COVID-19/SARS-CoV-2) Outbreak: Can Logistics Become the Messiah?. *Transportation Research Part E: Logistics and Transportation Review*. DOI: 10.1016/j.tre.2020.101961

Chowdhury, M. M. H., & Quaddus, M. (2017). Supply chain resilience: Conceptualization and scale development using dynamic capability theory. *International Journal of Production Economics*, 188, 185–204.

Craven, M., Liu, L., Mysore, M., & Wilson, M. (2020). COVID-19: Implications for business. *McKinsey & Company*. Available at –https:// www.aedcr.com/sites/default/files/docs/mckinsey-full_article.pdf.pdf.pdf (Accessed on 5th Jan, 2021).

Datta, P. (2017). Supply network resilience: a systematic literature review and future research. *International Journal of Logistics Management*, 28(4), 1387-1424.

de Koster, M. D., & Warffemius, P. M. J. (2005). American, Asian and third-party international warehouse operations in Europe. *International Journal of Operations & Production Management*, 25(8), 762-780.

de Moura, G. B., & Saroli, L. G. (2020). Sustainable value chain management based on dynamic capabilities in small and medium-sized enterprises (SMEs). *International Journal of Logistics Management*. DOI: 10.1108/IJLM-01-2020-0044

de Sá, M. M., de Souza Miguel, P. L., de Brito, R. P., & Pereira, S. C. F. (2019). Supply chain resilience: the whole is not the sum of the parts. *International Journal of Operations & Production Management*, 40(1), 92-115.

Defee, C. C., & Fugate, B. S. (2010). Changing perspective of capabilities in the dynamic supply chain era. *International Journal of Logistics Management*, 21(2), 180-206.

Dolgui, A., & Ivanov, D. (2020). Exploring supply chain structural dynamics : New disruptive technologies and disruption risks. *International Journal of Production Economics*. DOI: 10.1016/j.ijpe.2020.107886

Dubey, R., & Gunasekaran, A. (2015). Education and training for successful career in big data and business analytics. *Industrial and Commercial Training*, 47(4),174-181

Dubey, R., Gunasekaran, A., Altay, N., Childe, S. J., & Papadopoulos, T. (2016). Understanding employee turnover in humanitarian organizations. *Industrial and Commercial Training*, 48(4), 208-214.

Dubey, R., Gunasekaran, A., Childe, S. J., & Papadopoulos, T. (2018). Skills needed in supply chain-human agency and social capital analysis in third party logistics. *Management Decision*, 56(1), 143-159.

Dubey, R., Gunasekaran, A., Childe, S. J., Bryde, D. J., Giannakis, M., Foropon, C. & Hazen, B. T. (2020). Big data analytics and artificial intelligence pathway to operational performance under the effects of entrepreneurial orientation and environmental dynamism: A study of manufacturing organizations. *International Journal of Production Economics*. DOI: 10.1016/j.ijpe.2019.107599

Dubey, R., Gunasekaran, A., Childe, S. J., Papadopoulos, T., & Fosso-Wamba, S. (2017). World Class Sustainable Supply Chain Management: critical review and further research directions. *International Journal of Logistics Management*, 28(2), 332-362.

Dubois, A., & Gibbert, M. (2010). From complexity to transparency: managing the interplay between theory, method and empirical phenomena in IMM case studies. *Industrial Marketing Management*, 39(1), 129-136.

Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A., Galanos, V., Ilavarasan, P. V., Janssen, M., Jones, P., Kar, A. K., Kizgin, H., Kronemann, B., Lal, B., Lucini, B., … Williams, M. D. (2019). Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management.* DOI: 10.1016/j.ijinfomgt.2019.08.002

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, 14(4), 532-550.

Fawcett, S. E., Waller, M. A., Miller, J., Schwieterman, M., Hazen, B., & Overstreet, R. (2014). A Trail Guide to Publishing Success: Tips on Writing Influential Conceptual, Qualitative, and Survey Research. *Journal of Business Logistics*, 35(1), 1-16.

Flynn B., Cantor D, Pagell D., Dooley KJ and Azadegan A. (2021). From the Editors: Introduction to Managing Supply Chains Beyond Covid-19 - Preparing for the Next Global Mega-Disruption" *Journal of Supply Chain Management*, 57 (1), 3–6

Gammelgaard, B. (2017). The Qualitative Case Study. *International Journal of Logistics Management*, 28(4), 910-913.

Gibbert, M., Ruigrok, W., & Wicki, B. (2008). What passes as a rigorous case study?. *Strategic Management Journal*, 29(13), 1465-1474.

Gibbs, G. R. (2007). Thematic coding and categorizing. *Analyzing Qualitative Data*, 703, 38-56.

Gligor, D. M., & Autry, C. W. (2012). The role of personal relationships in facilitating supply chain communications: A qualitative study. *Journal of Supply Chain Management, 48*(1), 24-43.

Grant, R. M. (1991). The resource-based theory of competitive advantage: implications for strategy formulation. *California management review*, *33*(3), 114-135.

Gupta, S., Modgil, S., Bhattacharyya, S., & Bose, I. (2021). Artificial intelligence for decision support systems in the field of operations research: review and future scope of research. *Annals of Operations Research*. DOI: 10.1007/s10479-020-03856-6

Gupta, S., Modgil, S., Gunasekaran, A., & Bag, S. (2020). Dynamic capabilities and institutional theories for Industry 4.0 and digital supply chain. *Supply Chain Forum: An International Journal*, 21(3), 139-157.

Guzman, A. L., & Lewis, S. C. (2020). Artificial intelligence and communication: A Human–Machine Communication research agenda. *New Media & Society*, *22*(1), 70-86.

Handfield, R. B., Graham, G., & Burns, L. (2020). Corona virus, tariffs, trade wars and supply chain evolutionary design. *International Journal of Operations & Production Management*, 40(10), 1649-1660.

Helfat, C. E., Finkelstein, S., Mitchell, W., Peteraf, M. A., Singh, H., Teece, D. J. and Winter, S. G. (2007) Dynamic Capabilities: Understanding Strategic Change in Organizations. Malden, MA: Blackwell.

Huang, M. H., & Rust, R. T. (2020). Engaged to a Robot? The Role of AI in Service. *Journal of Service Research*. DOI: 10.1177/1094670520902266

Huin, S. F., Luong, L. H. S., & Abhary, K. (2003). Knowledge-based tool for planning of enterprise resources in ASEAN SMEs. *Robotics and Computer-Integrated Manufacturing*, *19*(5), 409-414.

Ivanov, D. (2020a). Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. *Transportation Research Part E: Logistics and Transportation Review*, 136, 101922.

Ivanov, D. (2020b). Viable supply chain model: integrating agility, resilience and sustainability perspectives—lessons from and thinking beyond the COVID-19 pandemic. *Annals of Operations Research*. DOI: 10.1007/s10479-020-03640-6.

Ivanov, D. (2021). Lean resilience: AURA (Active Usage of Resilience Assets) framework for post-COVID-19 supply chain management. *International Journal of Logistics Management.* DOI: 10.1108/IJLM-11-2020-0448

Ivanov, D., & Dolgui, A. (2020). Viability of intertwined supply networks: extending the supply chain resilience angles towards survivability. A position paper motivated by COVID-19 outbreak. *International Journal of Production Research*, 58(10), 2904-2915.

Kano, L., & Oh, C. H. (2020). Global value chains in the post-COVID world: Governance for reliability. *Journal of Management Studies*, *57*(8), 1773-1777.

Knudsen, D. (2003). Aligning corporate strategy, procurement strategy and e-procurement tools. *International Journal of Physical Distribution & Logistics Management*, 33(8), 720-734

Kwak, D. W., Seo, Y. J., & Mason, R. (2018). Investigating the relationship between supply chain innovation, risk management capabilities and competitive advantage in global supply chains. *International Journal of Operations & Production Management*, 38(1), 2-21.

Macioszek, E. (2017). First and last mile delivery – problems and issues. Scientific and Technical Conference Transport Systems Theory and Practice, Springer, Cham and Katowice, pp. 147-154

Maghsoudi, A. and Pazirandeh, A. (2016). Visibility, resource sharing and performance in supply chain relationships: insights from humanitarian practitioners. *Supply Chain Management*, 21(1), 125-139

Mahajan, K., & Tomar, S. (2021). COVID-19 and Supply Chain Disruption: Evidence from Food Markets in India. *American Journal of Agricultural Economics*, *103*(1), 35-52.

Mangiaracina, R., Perego, A., Seghezzi, A. and Tumino, A. (2019). Innovative solutions to increase last-mile delivery efficiency in B2C e-commerce: a literature review. *International Journal of Physical Distribution & Logistics Management*, 49(9), 901-920.

McKinsey (2018). Thinking inside the subscription box: New research on e-commerce consumers. Available at- https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/thinking-inside-the-subscription-box-new-research-on-ecommerce-consumers# (Accessed on 1st Dec, 2020)

Miles, M.B., Huberman, A.M. & Saldana, J., (2014), *Qualitative data analysis: A methods sourcebook* Sage: Thousand Oaks, CA.

Min, H. (2010). Artificial intelligence in supply chain management: theory and applications. *International Journal of Logistics: Research and Applications*, 13(1), 13-39.

Muniz, L. R., Conceição, S. V., Rodrigues, L. F., de Freitas Almeida, J. F., & Affonso, T. B. (2020). Spare parts inventory management: a new hybrid approach. *International Journal of Logistics Management*. DOI: 10.1108/IJLM-12-2019-0361

Murfield, M. L., & Tate, W. L. (2017). Buyer and supplier perspectives on environmental initiatives. *International Journal of Logistics Management*, 28(4), 1319-1350.

Narasimhan, R. (2014). Theory development in operations management: Extending the frontiers of a mature discipline via qualitative research. *Decision Sciences*, 45(2), 209-227.

Pagell, M., & Wu, Z. (2009). Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars. *Journal of Supply Chain Management*, 45(2), 37-56.

Papadopoulos, G.A., Zamer, N., Gayialis, S.P. and Tatsiopoulos, I.P. (2016). Supply chain improvement in construction industry. *Universal Journal of Management*, 4(10), 528-534.

Paul, S. K., & Chowdhury, P. (2020). A production recovery plan in manufacturing supply chains for a high-demand item during COVID-19. *International Journal of Physical Distribution & Logistics Management*. DOI: 10.1108/IJPDLM-04-2020-0127

Pettit, T. J., Croxton, K. L., & Fiksel, J. (2013). Ensuring supply chain resilience: development and implementation of an assessment tool. *Journal of Business Logistics*, *34*(1), 46-76.

Ponomarov, S. Y., & Holcomb, M. C. (2009). Understanding the concept of supply chain resilience. *International Journal of Logistics Management*, 20(1), 124-143.

Queiroz, M. M., Ivanov, D., Dolgui, A., & Fosso Wamba, S. (2020). Impacts of epidemic outbreaks on supply chains: mapping a research agenda amid the COVID-19 pandemic through a structured literature review. *Annals of Operations Research*. DOI: 10.1007/s10479-020-03685-7

van Hoek, R. (2020). Research opportunities for a more resilient post-COVID-19 supply chain – closing the gap between research findings and industry practice. *International Journal of Operations and Production Management*, 40(4), 341–355.

Russell, D. M., & Swanson, D. (2019). Transforming information into supply chain agility: an agility adaptation typology. *International Journal of Logistics Management*, 30(1), 329-355.

Sandberg, J., & Alvesson, M. (2011). Ways of constructing research questions: gap-spotting or problematization?. *Organization*, 18(1), 23-44.

Sarkis, J. (2020). Supply chain sustainability: learning from the COVID-19 pandemic. *International Journal of Operations & Production* Management, 41(1), 63-73.

Schniederjans, D. G., Curado, C., & Khalajhedayati, M. (2020). Supply chain digitization trends: An integration of knowledge management. *International Journal of Production Economics*. DOI: 10.1016/j.ijpe.2019.07.012

Singh R.K., Modgil, S. and Acharya P (2019). Assessment of flexible supply chain using system dynamics modelling: A case of Indian soap manufacturing firm. *Global Journal of Flexible System Management*, 20(1), 39-63.

Singh R.K., Modgil, S. and Acharya P (2020). A Template Based Approach to Measure Supply Chain Flexibility: A case study of Indian Soap Manufacturing firm. *Measuring Business Excellence*, 24(2),161-181.

Singh R.K., Modgil, S. and Acharya P (2020). Identification and Causal Assessment of Supply Chain Flexibility. *Benchmarking: An International Journal*, 27(2), 517-549.

Sundarakani, B., Pereira, V., & Ishizaka, A. (2020). Robust facility location decisions for resilient sustainable supply chain performance in the face of disruptions. *International Journal of Logistics Management.* DOI: 10.1108/IJLM-12-2019-0333

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, *18*(7), 509-533.

Toorajipour, R., Sohrabpour, V., Nazarpour, A., Oghazi, P., & Fischl, M. (2021). Artificial intelligence in supply chain management: A systematic literature review. *Journal of Business Research*, *122*, 502-517.

Treleaven, P., & Batrinca, B. (2017). Algorithmic regulation: automating financial compliance monitoring and regulation using AI and blockchain. *Journal of Financial Transformation*, *45*, 14-21.

Wamba, S. F., Dubey, R., Gunasekaran, A., & Akter, S. (2020a). The performance effects of big data analytics and supply chain ambidexterity: The moderating effect of environmental dynamism. *International Journal of Production Economics*, *222*, 107498.

Wamba, S. F., Edwards, A., & Akter, S. (2019). Social media adoption and use for improved emergency services operations: the case of the NSW SES. *Annals of Operations Research*, *283*(1-2), 225-245.

Wamba, S.F, Queiroz, M. M., Wu, L., & Sivarajah, U. (2020c). Big data analytics-enabled sensing capability and organizational outcomes: assessing the mediating effects of business analytics culture. *Annals of Operations Research.* DOI: 10.1007/s10479-020-03812-4

Wamba, S.F., Bawack, R. E., Guthrie, C., Queiroz, M. M., & Carillo, K. D. A. (2020b). Are we preparing for a good AI society? A bibliometric review and research agenda. *Technological Forecasting & Social Change.* DOI: 10.1016/j.techfore.2020.120482

Wang-Mlynek, L., & Foerstl, K. (2020). Barriers to multi-tier supply chain risk management. *International Journal of Logistics Management*, 31(3), 465-487.

Wen, J., He, L., & Zhu, F. (2018). Swarm robotics control and communications: imminent challenges for next generation smart logistics. *IEEE Communications Magazine*, *56*(7), 102-107.

Wong, C. W., Lirn, T. C., Yang, C. C., & Shang, K. C. (2020). Supply chain and external conditions under which supply chain resilience pays: An organizational information processing theorization. *International Journal of Production Economics*. DOI: 10.1016/j.ijpe.2019.107610