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Abstract

Purpose: This study proposes a framework comprising supply chain (SC) resilience strategies to handle low-frequency high impact (LFHI) disruptive events. It also evaluates the impact of SC resilience strategies' implementation on the triple bottom line of SC sustainability.

Design/methodology/approach: A hybrid three-phased method is proposed to meet the research objectives of the study. In the first phase, the study employs the Delphi technique to select SC resilience strategies and SC sustainability dimensions. In the second phase, the Best–Worst Method (BWM) is employed to assess the relative weights of resilience strategies. Finally, in the third stage, summative Likert scoring is used to understand the impact of SC resilience strategies on the SC sustainability triple bottom line (3BL).

Findings: The outcomes reveal that firms give due importance to inter-organizational relationships and supplier nearness for supply continuity. In the sustainability context, the obtained scores proved that resilience strategies have the maximum impact on economic sustainability, followed by environmental sustainability.

Research limitations/implications: This is the first study that examines aspects of SC resilience strategies and quantifies their impact on the triple bottom line of SC sustainability. This study is specific to the automobile sector; sectoral diversity may expose similarities and dissimilarities in the approach.

Practical implications: The outcome establishes that supplier–manufacturer relationships need to be strengthened further to tackle any future uncertainties. Besides, supplier location decisions may also be revisited. The strategies proposed will aid SC managers to make informed decisions to prepare for uncertain events.

Originality/value: In the face of uncertain events, often SC's trade-off sustainability in pursuit of resilience. It manifests that resilience is a prerequisite for SC sustainability. While planning SCs, organizations often choose either sustainability or resilience. Thus, this study acknowledges the need to develop effective SC resilience strategies that are in harmony with the sustainability agenda.

Keywords: Supply Chain Resilience, Sustainable Supply Chain, Triple Bottom Line, Sustainable–Resilient Supply Chain, Best–Worst Method, disruptions.

1. Introduction

"There is nothing certain, but the uncertain", is what we least forget. In the last few decades, to gain a competitive advantage and pursue sustainability, SC managers have resorted to strategies such as globalization, offshoring, outsourcing, and lean principles (Haren & Simchi-Levi, 2020). These strategies have led to a synergy between flexibility, efficiency, cost reduction, and resource utilization (Raj et al., 2022). Unfortunately, this transition undermined the uncertainty and diminished the importance of SC resilience. In the recent past, disruptions due to supply–demand uncertainty, natural tragedies, social disturbances, terrorism, cyber-attacks, and financial crisis were mainly regional. Evidently, in case of disruptions, recovery has been managed with support from other regions. In the year 2019, COVID challenged this status quo (Haren & Simchi-Levi, 2020). Characterized by LFHI, COVID-19 is labeled as a black swan event with an unprecedented jolt to global supply chains. This speedy epidemic propagation has caused long-term disruption. COVID-19 has created chaos by fueling unpredictability, correlating risks (climatic as well as non-climatic), and amplifying impacts. Without any safeguards available to minimize the impact, nations closed their borders, imposed lockdowns, along with putting other restrictions. The consequences of COVID-19 restrictions are visible across all business verticals. The transition of SCs to sustainable SCs has been confronted with an acute shortage of labor, transportation restrictions, and halted material deliveries (Chowdhury et al., 2021; Haren & Simchi-Levi, 2020; Sarkis, 2020). Furthermore, supply shortages got amplified due to panic buying (Jones, 2020). The WTO predicted a trade decline between 13% and 32% in 2020 due to the pandemic (World Trade Organization, 2020). According to the United Nations Conference on Trade and Development, this event has effectuated shrinkage of US$ 50 billion in global value chain exports (UNCTAD, 2020). While dealing with supply shortages, the world also witnessed events such as USA–China trade war and ongoing Russia–Ukraine conflict (Haren & Simchi-Levi, 2020; Kilpatrick, 2022). A fusion of any such event with another LFHI event further intensifies the impact relative to any univariate event (Raymond et al., 2020). These LFHI events are highly uncertain, making it a complex challenge to manage SCs (Haren & Simchi-Levi, 2020). The resulting disruptions plague the supply networks, causing loss of competitive advantage, depriving profits, and even pushing some organizations toward bankruptcy and complete shutdown.

The automobile industry, which is the fastest-growing segment in the manufacturing sector, was also affected by an unprecedented COVID-19. In 2017, the automotive sector at its peak produced about 97 million units of vehicles globally. Consequently, global automotive manufacturers produced only 78 million vehicles in 2020 (Statista, 2022). It was a testing phase for the Indian automobile sector too. During 2013–2017, global automotive companies invested US$ 9.27 billion, establishing India as one of the world's largest automotive hubs (EMIS, 2018). As a result, in 2016 the auto sector accounted for 6.3% of India's overall gross value added. The automobile industry's contribution to India's GDP further soared to 7.5% in 2019 (Kumar & Shrimali, 2020). To meet the targets, almost 27% of automotive parts were imported from China (Raj et al., 2022). As an aftermath of COVID-19, automobile manufacturers in India faced large-scale interruptions with supply shortages and production discontinuity. Economic slowdown, uncertain demand, and government-imposed restrictions further aggravated the situation for companies already facing losses. In the financial year 2020, the Indian auto sector produced only 22.43 million units; the lowest output level in the last five years (EMIS, 2022). Under changing business conditions, Ford decided to cease its manufacturing in India. Considering the vehemence of the LFHI events as COVID-19, Sugirin and Mathew (2021) emphasized the need for greater resilience to bear such blows.

A recent literature review study by Glas et al. (2021) on purchasing and supply management reports insufficient research emphasizing LFHI events. Another review study by Chowdhury et al. (2021) highlights that the majority of research work performed during COVID-19 were inclined toward assessing its impact on SCs and creating resilience to manage those impacts. The studies proposing and testing the strategies to improve resilience, point out conflict or trade-offs with sustainability measures (Mari et al., 2014; Rajesh, 2018). In line with these arguments, Sarkis (2020) anticipated a crisis rebound to environmental sustainability efforts. The author highlighted the importance of social and economic sustainability with a vision for economic recovery. SC sustainability is an extensively researched area (Badri Ahmadi et al., 2017; Mari et al., 2014; Ortas et al., 2014; Sarkis, 2020), still, only a few studies have considered the triple bottom line (3BL) (Elkington, 2018; Faisal et al., 2017; Govindan et al., 2014; Narimissa et al., 2020; Tajbakhsh and Hassini, 2015). Most of these studies were conceived before COVID-19, hence did not consider the perspective of unprecedented LFHI events. A few studies have stressed that resilience is critical for sustainability under uncertainty (Chowdhury et al., 2021; Cutter, 2014; De Rosa et al., 2013; Mari et al., 2014). Certainly, organizations must develop effective strategies to design a resilient SC, with due appreciation for sustainability even under disruptions.

COVID-19 has revived the need for SC restructuring. Many SCs in pursuit of attaining sustainability have shifted their focus to resilience. Therefore, the first imperative of SCs is to identify strategies to ensure supply continuity during LFHI events. The industry is exploring alternatives such as dual sourcing, alternative factories, and substantial safety stocks (Gartner, 2020; Sarkis, 2020). This transformation may be expensive. The localization and nearshoring options require the government's support. At the same time, it is necessary to evaluate how the quest for resilience to tackle disruptions may impact sustainability goals. The sub-dimensions of 3BL need to be considered to have an all-inclusive assessment. The existing literature has addressed several SC issues but a comprehensive study of significant resilience strategies conducive to 3BL sustainability during LFHI is still untouched. To address this gap in the academic literature and to contribute to the SC resilience theory, this article proposes a framework that comprises strategies to build SC resilience to face LFHI events, without compromising on SC sustainability. Being committed to business continuity, the Indian automotive sector is considered apt for the research. Considering the above opportunities, this study aims at the following objectives:

1. To reconceptualize SC resilience for LFHI events.
2. To evaluate and prioritize resilience strategies to tackle unprecedented events.
3. To measure the impact of resilient practices on SC sustainability 3BL.

The rest of the article is organized as follows: the second section presents the literature review for identifying the supply chain resilience strategies, followed by SC sustainability dimensions. The third section discusses the novel methodology employed in this study by combining the BWM (Rezaei, 2015, 2016) and a summative Likert scoring method (Govindan et al., 2014) to address the study objectives. The fourth section presents the results, while the fifth section discusses them. The sixth section offers the conclusions. In the end, the managerial implications and limitations of the study are elaborated.

2. Literature Review

Over the last decades, a significant amount of research has been conducted in the field of supply chain management (SCM). A simple search of "supply chain management" in Scopus reveals 67,204 results. The COVID-19 pandemic acted as a catalyst for SCM research. A total of 12,914 SCM studies were conceived during 2020–2022 (March) only. While organizing the literature, we found that "SC Sustainability," "SC disruptions," and "Resilience" remained the focus areas of most of these studies (Fahimnia & Jabbarzadeh, 2016; Ivanov, 2018; Mari et al., 2014; Negri et al., 2021; Rajesh, 2018; Sharma et al., 2020). However, the literature focusing on the interaction of all three aspects is relatively limited (Sharma et al., 2020). Thus, this research has the potential to add value by offering effective strategies to design a resilient SC. In addition, it will support and appreciate the sustainability agenda in the face of LFHI events. Therefore, the literature related to SC resilience and SC sustainability is organized as follows:

2.1 Supply Chain Resilience

"Unexpected events often audit our resilience" (Weick & Sutcliffe, 2007). The SCM literature defines SC resilience as an ability to bounce back if hits or changes to survive (Belhadi et al., 2021; Mari et al., 2014). SC resilience empowers better risk management and gives an edge over competitors to drive advantages from disruptions (Sheffi & Rice, 2005).

The COVID-19 pandemic has exposed the brittleness of SCs due to interconnections passing through multiple countries across the globe at multiple tiers. The pandemic has exposed the world's dependence on China and the weaknesses of lean SC strategies like offshoring, single-source strategy, and just-in-time inventory (Deloitte, 2020; Sarkis, 2020). The cessation of China manufacturing and interruption due to international travel restrictions aggravated the situation, causing global chaos. These disruptions had repercussions on all SCs. However, several studies (Kovács & Sigala, 2021; Linton & Vakil., 2020) agree about the difficulty to anticipate global catastrophes such as COVID-19. Therefore, Linton and Vakil (2020) termed COVID-19 as a wake-up call to learn to operate in a highly volatile and uncertain environment.

Gartner (2020) reported a survey stating that only 21% of the participant companies considered themselves highly resilient, while 55% would like to achieve high resilience in the coming years. Therefore, sensible firms have started introspecting strategies to improve their immunity against unprecedented events. This has given thrust to supply resilience studies (Belhadi et al., 2021; Bryce et al., 2020). As a response to resilience building, production and associated supplies are likely to become more localized (Sarkis et al., 2020; Xu et al., 2020), requiring the reshoring of facilities (Ashby, 2016; Barbieri et al., 2020). However, mixed sourcing can strengthen immunity and enable quick recovery for SCs against such disruptions. To strike a balance between efficiency and resilience, some researchers (Kovács & Sigala, 2021; Linton & Vakil, 2020; Meena & Sarmah, 2013) have recommended multisourcing with diverse networks as a viable option. In pursuance of the resilience objective, studies have also suggested maintaining higher buffers (capacity and inventory) to deal with such jolts due to uncertain events (Bryce et al., 2020; Kovács & Sigala, 2021). In current SC scenarios, the performance of a firm is dependent on resources sourced from other organizations. Resource dependence offers a collaborative advantage to both buyer and the supplier (Paulraj & Chen, 2007). A high level of SC collaboration enhances SC resilience to deal with disruptions and disasters (Kovács & Sigala, 2021; Scholten & Schilder, 2015). Shared objectives can advance the consideration of circularity principles. These principles discourage waste, giving a chance of continuing production with the saved resources (Bag et al., 2020; Bernon et al., 2018; Nandi et al., 2021a, 2021b). Pimenta et al. (2022) suggest that a shift from a linear to a circular view can improve system resilience.

The next level of collaboration will be complemented by advanced technologies such as big data, cloud computing, wireless technologies, blockchain, and sensors (Fatorachian & Kazemi, 2021). In the manufacturing context, 3D printing capabilities of digital-to-physical transfer allow enhanced efficiency and improved responsiveness with ease of design and production (Nelissen, 2014). Indeed, these "Collaborative Technologies" together offer a high level of automation, process improvement, increased transparency, real-time information sharing, necessary traceability, and higher productivity for SC operations (Bag et al., 2020; Nandi et al., 2021a, 2021b; Wan et al., 2016). Firms are reconsidering their priorities and reconfiguring their strategies to develop competencies for extreme disruptions. However, the spread of automobile-sector SCs passing through visible and invisible levels (Xu et al., 2020) is a challenge. Synchronization throughout the chain is critical to the overall performance of the system. As evident from the above literature, extensive research is ongoing for testing and improving SC resilience. The unaddressed research question is: "Which supply chain strategy is most suitable to improve resilience?" In pursuit to address the above question, a total of six resilience strategies are presented in Table 1.

Table 1. Supply Chain Resilience Strategies

Resilience Strategy		Definition	Relevant Studies
R1	Collaboration	All SC stakeholders at different tiers work together to achieve shared objectives to prevent potential threats due to disruption.	(Belhadi et al., 2021; Scholten & Schilder, 2015; Tukamuhabwa et al., 2015)
R2	Collaborative Technologies	Technology-driven networks and digital ecosystems enable SC visibility, disruption identification, and real-time monitoring.	(Bag et al., 2020; Nandi et al., 2021a, 2021b; Nelissen, 2014; Wan et al., 2016)
R3	Circular Economy	Provide resources from materials/products at the end of life-recycled materials or extends the life cycle.	(Bag et al., 2020; Bernon et al., 2018; Nandi et al., 2021a, 2021b; Pimenta et al., 2022; Zhang et al., 2021)
R4	Reshoring	Enables consistent supplies in case of global disruption and lowers transportation costs (back shoring or nearshoring).	(Ashby, 2016; Barbieri et al., 2020; Sarkis et al., 2020)

R5	Diversified Multisourcing	Spread out multisource offers sourcing substitution in disruption.	(Linton & Vakil., 2020; Meena & Sarmah, 2013; Xu et al., 2020)
R6	Building Redundancy	Reserve buffer to meet customer demand with reduced stock-outs.	(Bryce et al., 2020; Jones, 2020; Tukamuhabwa et al., 2015)

Source: Authors' compilation.

2.2 Sustainable Supply Chain

The World Commission on Environment and Development stated: "Sustainable development is the development that meets the needs of the present generation without compromising the ability of future generations to meet their needs" (Brundtland, 1987). In a broader context, sustainability attempts to strike harmony among environmental, economic, and social dimensions (Elkington, 2018). Although the economic aspect has been the dominant driver, the environment is getting considerable attention over the last few decades (Mari et al., 2014; Ortas et al., 2014; Sarkis, 2020). The rise in social concerns has added additional emphasis to societal impact too (Badri Ahmadi et al., 2017). After 25 years, John Elkington may have recalled his concept of 3BL (Elkington, 2018), but it still seems relevant to being suitable to gauge comprehensive sustainability (Birkel & Müller, 2021; Hendiani et al., 2020; Sharma et al., 2020).

SC stakeholders work in collaboration to improve overall SC efficiency by laying hold on all the perspectives of the 3BL (Faisal et al., 2017). The effective implementation of environmental sustainability practices reduces resource consumption through energy saving, emissions as well as waste minimization practices (recycling, reuse, etc.), thereby improving social well-being, reducing costs, and translating in terms of financial performance (Ortas et al., 2014). In recent years, consumers have also started preferring companies having socially responsible behavior. Human rights, employment practices, social connections, worker health, and labor safety are a few variables defining organizational social responsibility status (Badri Ahmadi et al., 2017; Faisal et al., 2017). Attracting environmentally and socially conscious customers can be beneficial for financial gains. The economic dimension works to ensure the economic viability of organizations through a long-term sustainability approach to improve quality, better asset utilization, and increase revenue (Björklund et al., 2012; Rashidi et al., 2020). While tackling these dimensions, managers often face and decide the trade-off between efficiency, responsiveness, and sustainable policies (Rajesh, 2018).

The vast SCM literature has focused on one or the other dimension of SC sustainability (Badri Ahmadi et al., 2017; Mari et al., 2014; Ortas et al., 2014; Sarkis, 2020). However, the 3BL of SC sustainability is a comparatively less researched area. A few studies have acknowledged and considered the 3BL within the SC context (Faisal et al., 2017; Govindan et al., 2014; Narimissa et al., 2020; Tajbakhsh & Hassini, 2015). For example, Govindan et al. (2014) investigated the impact of lean, resilient, and green SCM practices on supply chain sustainability. The authors selected only three resilient SCM practices to quantify their impact directly on the 3BL. The study could have given more conclusive outcomes if the sub-dimensions of sustainability 3BL were considered. A study by Tajbakhsh and Hassini (2015) reviewed the theme to propose a comprehensive set of sustainable performance measures linking supply chain stakeholders. The proposed framework needs further testing to produce useful insights. Faisal et al. (2017) integrated the 3BL into supplier selection. Although it considered the sustainability subdimensions, it is specific only to supplier selection, and the overall SC perspective is not considered. Furthermore, these studies did not consider the perspective of unprecedented LFHI events. The SC sustainability 3BL subdimensions were accumulated from the literature, and the sustainability-related subdimensions were categorized under 3BL as detailed in Table 2.

Table 2. Supply Chain Sustainability Dimensions and Subdimensions

Sustainability Dimension	Sustainability Subdimensions	Relevant Studies
Environmental Dimension (S1)	• Reusability of Products • Reverse Logistics and Waste Minimization • Environment Management and Policies • Emission Minimization • Energy Efficiency and Renewable Energy • Resource Consumption Reduction	(Hendiani et al., 2020; Kumar & Garg, 2017; Kumar & Goswami, 2019; Narimissa et al., 2020; Rajesh, 2018; Rashidi et al., 2020)
Economic Dimension (S2)	• Quality • Operational Cost Reduction • Delivery Reliability • Lead Time Reduction • Flexibility • Asset Utilization	(Faisal et al., 2017; Hendiani et al., 2020; Kumar & Goswami, 2019; Narimissa et al., 2020; Rashidi et al., 2020)
Social Dimension (S3)	• Social Welfare and Development, Community Connection, and Support • Employment Practices • Work Safety and Labor Health • Education and Training of Employees • Ethical Behavior • Information Disclosure	(Kumar & Garg, 2017; Narimissa et al., 2020; Rashidi et al., 2020)

2.3 Sustainable–Resilient Supply Chain: Research Gaps

Sustainability has become a primary focus for SCs and resilience is one of the critical factors to pursue efficient and effective sustainable development (Lebel et al., 2006). The need to strengthen societal and system resilience only comes to the forefront during disruptions and calamities (Sheffi & Rice, 2005). Reimagining the SC seems inevitable to prepare for the competitive future market. As established in Section 2.1 (Table 1), the researchers have come up with strategies to build SC resilience. The majority of the studies have considered SC resilience strategies as a standalone option. All the strategies may not be equally effective for the Indian automobile sector and their implementation may also face sectoral intention, policy, and resource constraints. For automobile sector aspirations, it is a must to determine the most appropriate resilience strategies. Studies also contended that during unexpected situations, SCs often drop sustainability (Mari et al., 2014; Rajesh, 2018). This means no development strategy can be termed sustainable if it is not resilient (Cutter, 2014). It is thus necessary to consider a combination of resilience and sustainability (Ivanov, 2018; Negri et al., 2021). However, most of the studies have restricted their theme either to SC sustainability or resilience (Ivanov, 2018; Negri et al., 2021), with only a few selected studies investigating the combination of both (Fahimnia & Jabbarzadeh, 2016; Ivanov, 2018; Mari et al., 2014; Negri et al., 2021; Raj et al., 2022; Rajesh, 2018; Sharma et al., 2020). Among these studies, only a handful of resilience–sustainability integration studies have considered the collaborative 3BL perspective (Govindan et al., 2014; Ruiz-Benitez et al., 2019). Although some studies have investigated the impact of uncertainties and disruptions on SCs (Cutter, 2014; De Rosa et al., 2013; Mari et al., 2014), COVID-19 has fueled interest in further strengthening sustainable–resilient SCs under LFHI events (Belhadi et al., 2021; Bryce et al., 2020). Nevertheless, research on the combination of resilience and sustainability for LFHI events is in its development stage (Ivanov, 2018; Negri et al., 2021).

The reviewed literature divulges the scope for research by collating the sustainable and resilient SC perspective for LFHI events such as COVID-19. This limitation in the literature motivated the researchers to search for answers to the below questions, which complement the objectives of the study presented in Section 1.

a. What are the strategies considered by the manufacturing sector to improve resilience?
b. Which supply chain strategy is most suitable to improve resilience?
c. What is the impact of supply chain resilience strategies on sustainability (3BL)?
d. Which supply chain resilience strategies have the maximum contribution toward sustainability (3BL)?

2.4 Proposed Sustainable–Resilient Supply Chains Framework

The future of SCs will depend upon the successful management of trade-offs in the principles and practice of SC sustainability and resilience (Rajesh, 2018). These trade-offs may be tuned according to market demand and stakeholders' needs. A narrative literature review followed by the Delphi technique was used to identify and select the SC resilience strategies and SC sustainability dimensions. The six strategies for SC resilience with alphanumeric codes (R1–R6) are placed below Figure 1. The strategies are particularly selected given the situation before the pandemic and the challenges faced to tackle the disruption (Belhadi et al., 2021; Bryce et al., 2020). To plug the gaps evolved through the literature review, this research study investigates and prioritizes the strategies (Table 1) to strengthen SC resilience for any future LFHI events.

Before the pandemic, the sustainability agenda was at the core of almost every organization. SC stakeholders were working toward SC sustainability (Faisal et al., 2017). However, the disruptions forced them to focus on resilience and somehow the sustainability perspective was sidelined. It is thus important to keep a balance between resilience and sustainability for long-term business continuity. This study keeps sustainability at the core and assesses the impact of resilience strategies on SC sustainability 3BL. The study builds on an agenda to transform SCs into sustainable–resilient supply chains. A generic model proposed for a sustainable–resilient SC is shown in Figure 1.

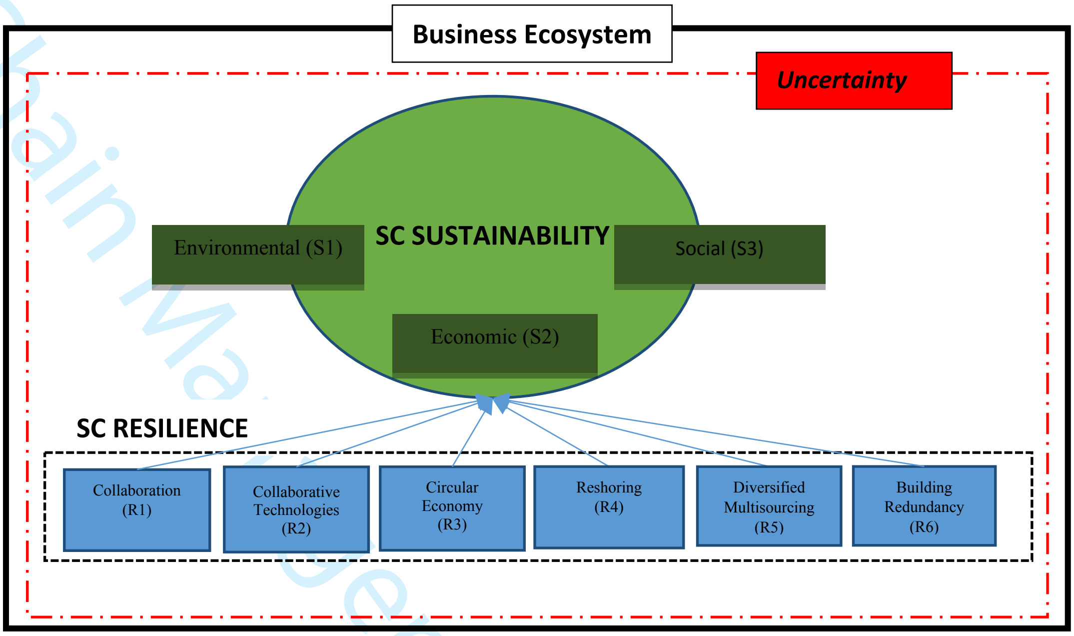

Figure 1. Sustainable–Resilient Supply Chain Framework

3. Methodology

A hybrid three-phased method is proposed to meet the research objectives of the study by reconceptualizing SC resilience for LFHI events, evaluating and prioritizing resilience strategies to tackle unprecedented events, and measuring the impact of resilient practices on SC sustainability 3BL. The research methodology followed in this study is explained in Figure 2. The first phase involves the finalization of the SC resilience strategies and SC sustainability dimensions through extant literature review and discussions with the experts. In the second phase, the BWM was applied to assess the relative weights of resilience strategies to tackle disruptions under uncertainty. In the subsequent phase, summative Likert scoring was used to understand the impact of SC resilience strategies on SC sustainability and its dimensions.

3.1 Finalization of the SC Resilience Strategies and SC Sustainability Dimensions

Based on the narrative literature review, resilience strategies were identified. The Delphi technique was used with a panel of two academics and two SC professionals. Three rounds of discussions were carried out. In the first round, the definition and application of the strategies were discussed. In the second round, a consensus was obtained on five strategies, except "circular economy." In light of the latest research (Nandi et al., 2021b; Pimenta et al., 2022), the role of the circular economy concept for SC resilience was further deliberated. It obtained approval in the third round. After deliberations and confirmation from the panel, a total of six resilience strategies (Table 1) were incorporated into the framework. During the discussions, a list of sustainability-related subdimensions categorized under 3BL was also taken up. There were multiple terms used interchangeably in the literature to refer to the same dimension, thus logical grouping was conducted. Through discussions, the experts approved 18 sustainability-related subdimensions, which were categorized under 3BL as detailed in Table 2.

3.2 Best–Worst Method (BWM)

The BWM is a recently developed multicriteria decision-making (MCDM) technique that provides relative weights using distinctively structured comparisons. The distinctive features of BWM are as follows:

- The BWM limits the number of pairwise comparisons to only 2n−3, whereas a widely used analytical hierarchy process (AHP) necessitates n(n−1)/2 pairwise comparisons.
- Through fewer pairwise comparisons, the overall consistency of the process and the results are also improved.
- The review of BWM literature discloses its wide application (Mi et al., 2019; Singh et al., 2022). The BWM has been successfully employed in various studies for addressing issues such as supplier segmentation, sustainability, risk management, identifying technology enablers, efficiency evaluation of university-industry PhD projects, evaluation of scientific outputs, firms' R&D evaluation, selection of biomass conversion technology, selection of residential grid storage technology, selection of electric vehicle, green human resource management, and for other applications. The BWM has also been successfully employed in studies for SC applications (Badri Ahmadi et al., 2017; P. Kumar et al., 2021; Munny et al., 2019; Wan Ahmad et al., 2017).

Table 3. Linguistic Scale for Pairwise Comparison for Best–Worst Methodology

1	Equally important
2	Somewhat between Equal and Moderate
3	Moderately more important than
4	Somewhat between Moderate and Strong
5	Strongly more important than
6	Somewhat between Strong and Very Strong
7	Very strongly important than
8	Somewhat between Very strong and Absolute
9	Absolutely more important

Considering the advantages and rising popularity, BWM is deemed fit to compute the weightage and rank the SC resilience strategies. In BWM, the distinctive structure is obtained by comparing (a) best and other attributes and (b) other attributes and worst attributes (Rezaei, 2015, 2016) using a scale of 1–9 (Table 3). The consistency and reliability of the obtained weights are confirmed through a consistency ratio represented as CR (Rezaei, 2015, 2016). In these cases, a higher level of consistency is associated with a value reaching zero. Rezaei has given nuanced details of BWM in his introductory studies (Rezaei, 2015, 2016). For the sake of brevity, those details are not reproduced here. The steps followed for BWM analysis are summarized in Figure 2 and an illustration is provided in the supplementary file (Appendix A).

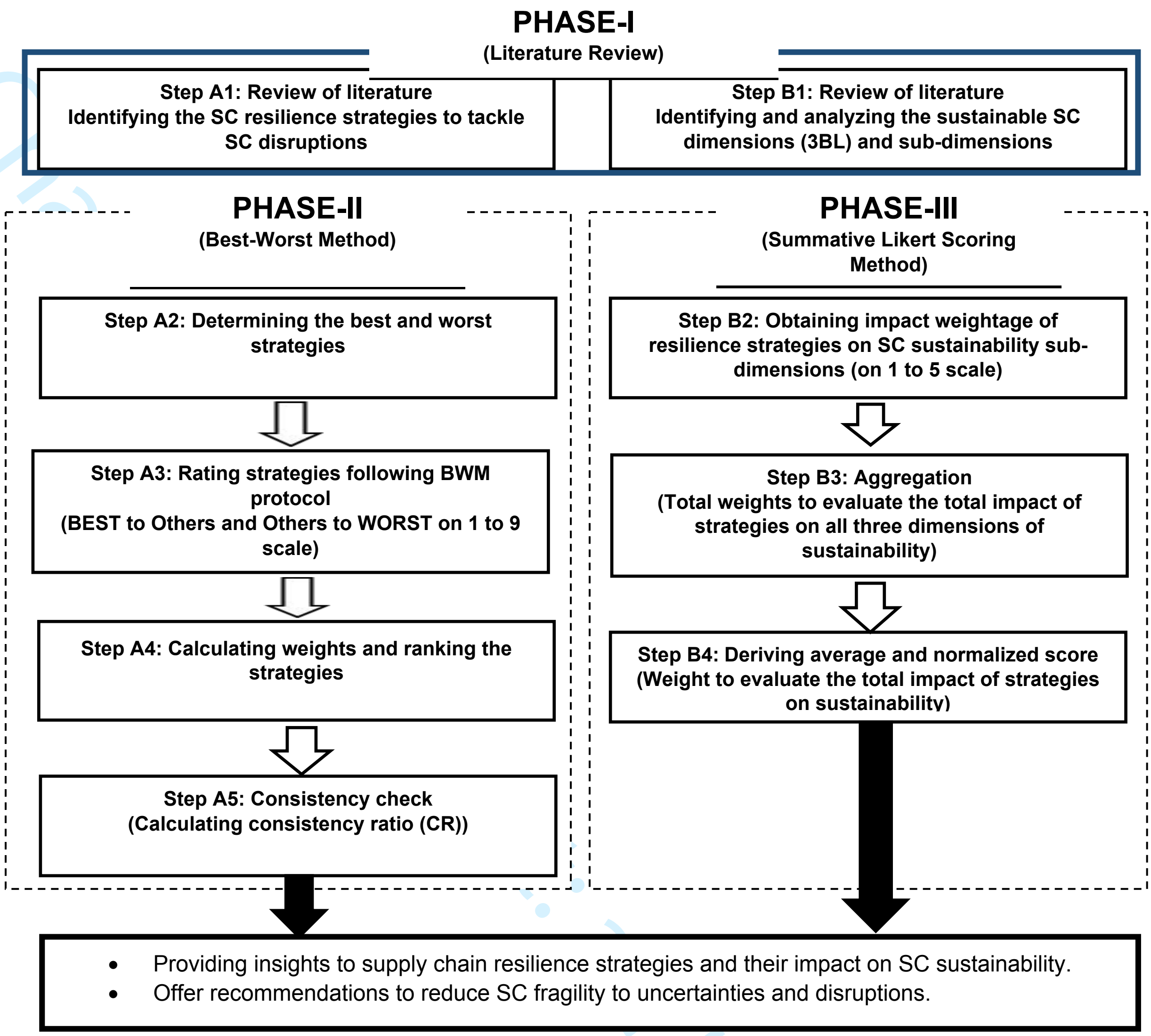

Figure 2. The Proposed Methodology

3.3 Summative Likert Scoring Method

Due to the multifaceted character of the proposed framework (Figure 1), following a "traditional" survey approach for collecting data would have been lengthy and exhaustive. Thus, for getting appropriate responses without causing fatigue to the participants, it was necessary to keep it simple and less time-consuming. Appraising the requirement, the Likert scale survey has been considered the most effective method to quantify the impact of SC resilience strategies on the SC sustainability dimensions (Govindan et al., 2014). A Likert 5-point scale was used to attribute values to the research variables. Value 5 signified "extremely high" impact of the strategy on the sustainability dimension, whereas value 1 acknowledged that the strategy does not impact the sustainability dimension (Govindan et al., 2014).

Aggregated scores were calculated for deriving the impact level of each resilient strategy respectively on each subdimension of the SC sustainability dimensions. To access the total effect of each resilience strategy, a cumulative score was calculated, which aggregated the impact of each resilience strategy on sustainable SC dimensions. Finally, the cumulative scores of resilience strategies were aggregated to calculate the overall impact of the respective strategy on the sustainable SC. The supplementary file provides the process details (Appendix B).

3.4 Data Collection

A questionnaire was devised for data collection by considering the research objectives and literature. The questionnaire consisted of three parts. The first part requested participants' details but only willingly and voluntarily. In the second part, a BWM comparison matrix was provided, followed by a third part containing a semi-structured questionnaire to obtain their responses about the impact of resilient strategies on SC sustainability dimensions (see the supplementary file, Appendix C). The questionnaire was pretested by two SC professionals and academicians. Comments received during pretesting ensured the content validity and clarity of the questions.

An information sheet (with purpose, requirements, and terms for participation) and a questionnaire format were shared via electronic mail with potential participants from the automotive sector and academia. The use of electronic mode eased the participation of automobile companies located at different locations. Anonymity and confidentiality were committed to encouraging the respondents to participate.

The share of the manufacturing sector to India's GDP was 15% in 2018 of which 49% contribution was made by the Indian automotive manufacturing sector (Kumar & Shrimali, 2020). Given the impact of the pandemic, the Indian GDP growth of 6.5% in 2018 got marginalized to −6.6% in 2020 (World Bank, 2021). The automobile sector is currently planning its recovery from the effects of the COVID-19 pandemic and focusing on developing resilience for any such future disruptions. Automaker corporations are considered drivers for automotive SC sustainability (Govindan et al., 2014); they propagate their concerns and commitments to the suppliers to achieve sustainability targets throughout SCs. Consequently, automotive manufacturers, suppliers, and academicians are considered key players in automotive SC research and implementation. The expert panel for this study selected from both industry and academia formed a befitting group to represent the sector. A minimum of 10 years of experience in Indian automobile manufacturing was the inclusion criterion for the industry experts.

Thirty experts were contacted and invited to participate. A success rate of almost 47% was achieved with 14 experts expressing consent for their participation (see the supplementary file, Appendix D, Table D1). In the context of MCDM, a small number of expert responses are better than "cold-called" respondents. Studies suggest a minimum necessary condition of seven to eight expert responses (Kamaruzzaman et al., 2018; Saaty & Ozdemir, 2003). Many BWM studies even keep five as the minimum response criteria (Kusi-Sarpong et al., 2019; Talib et al., 2019). In our study, 14 experts with an average experience of 18 years made their contribution. They belong to leading car manufacturers as well as leading commercial vehicle manufacturers in India. Three experts were from multinational automobile manufacturers with manufacturing facilities in India for more than 20 years. Also, the tier-1 suppliers included in this study supplied to more than one manufacturer. In addition, the inputs from the academicians added the research perspective to the study. Thus, responses from 14 experts with vast experience in the automobile industry, especially from the operations and SC domain, fulfilled the necessary methodological conditions of the study. However, two experts participated in Phase I only. Thus, Phase II only included responses from the remaining 12 experts. The participants were requested for an online meeting with one of the authors to assist in understanding and attempting the questionnaire. Nine experts confirmed the appointments, while the others were contacted telephonically for their queries. The experts deliberated the roles of different factor constituents and provided their responses in a predefined format for analysis.

4. Results

4.1 The BWM: Computation of Relative Weights of Supply Resilience Strategies under Extreme Uncertainty

All six SC resilience strategies were put to test to find the relative weightage using BWM. The experts were asked to identify and report the best (strong influencer) and the worst (weak influencer). The individual responses are summarized in Table 4.

Table 4. Best and Worst Decision Strategy as Identified by Experts

SC Resilient Strategies	Determined as Best by Expert	Determined as Worst by Expert
Collaboration (Supplier–Manufacturer)	3, 12, 13	-
Collaborative Technologies	2, 9, 10, 11, 14	-
Circular Economy	-	1, 2, 5, 7, 8, 9, 10, 11, 12, 13
Reshoring	1, 5	3
Diversified Multisourcing	4, 6, 7, 8	-
Building Redundancy	-	4, 6, 14

The majority of the respondents marked “Collaborative Technologies” as the best strategy. Table 4 shows that the implementation of “Circular Economy” principles is the worst strategy among all resilience strategies. The individual weights provided by the 14 experts for BWM analysis were compiled and the average of the weights ($W_{avg.}$) is presented in Table 5. The obtained CR of 0.140 indicated a very consistent comparison (Wan Ahmad et al., 2017). Based on the average weightage, the strategies were ranked as follows:

$$R2 > R1 > R4 > R5 > R6 > R3$$

Table 5. Relative Weights of Supply Resilience Strategies

	SC Resilience Strategies	Rank	Average Weightage ($W_{avg.}$)	Consistency Ratio (CR)
R1	Collaboration	2	0.206	0.140
R2	Collaborative Technologies	1	0.248	
R3	Circular Economy	6	0.072	
R4	Reshoring	3	0.195	
R5	Diversified Multisourcing	4	0.173	
R6	Building Redundancy	5	0.107	

As evident from Table 5, investing in advanced “Collaborative Technologies” ($W_{avg.}$: 0.248) and enhanced “Collaboration” ($W_{avg.}$: 0.206) emerged to be the top priority for organizations to deal with disruptions. The next in order are “Reshoring” strategies with a criterion weightage of 0.195, "Diversified Multisourcing" ($W_{avg.}$: 0.173), and "Building Redundancy" ($W_{avg.}$: 0.107). Evidently, the implementation of "Circular Economy" principles earned minimum weight ($W_{avg.}$: 0.072) among all resilience strategies.

4.2 Summative Likert Scoring Method: Impact of Resilience Strategies on Supply Chain Sustainability

To meet the third research objective, this section identifies the impacts of SC resilience strategies on the SC's sustainability 3BL (social, economic, and environmental). The experts were asked to allocate values using a 5-point Likert scale to quantify the impact of the proposed SC resilience strategies on the 3BL dimensions of SC sustainability.

4.2.1 Impact of SC Resilience Strategies on Environmental Dimensions of SC Sustainability

Table 6 shows that the experts consider "Circular Economy" ($S_{Nor.}$ = 0.192), "Reshoring" ($S_{Nor.}$ = 0.175), and upgrading "Collaborative Technologies" ($S_{Nor.}$ = 0.170) as the top three resilience strategies with the highest impact on environmental sustainability. "Building Redundancy" representing buffers has a weak impact ($S_{Nor.}$ = 0.136) on it.

Table 6. Impact of SC Resilience Strategies on Environmental Sustainability

SC Resilience Strategies → / **SC Environmental Sustainability Dimensions ↓**	Collaboration	Collaborative Technologies	Circular Economy	Reshoring	Diversified Multisourcing	Building Redundancy	**Avg. Score ($S_{av.}$)**	**Nor. Avg. Score ($S_{Nor.}$)**
Reusability of Products	32	41	50	34	34	29	36.667	0.150 (6)
Reverse Logistics and Waste Minimization	45	48	51	47	41	34	44.333	0.181 (2)
Environment Management and Policies	46	34	45	41	41	34	40.167	0.164 (3)
Emission Minimization	36	40	44	45	36	32	38.833	0.159 (5)
Energy Efficiency and Renewable Energy	44	41	44	42	38	31	40.000	0.163 (4)
Resource Consumption Reduction	42	46	48	48	44	40	44.667	0.183 (1)
AVERAGE SCORE ($S_{av.}$)	40.833	41.667	47.000	42.833	39.000	33.333		
NORMALIZED AVERAGE SCORE ($S_{Nor.}$)	0.167 (4)	0.170 (3)	0.192 (1)	0.175 (2)	0.159 (5)	0.136 (6)		

Regarding the impact of resilience strategies, the maximum impact is on the "Resource Consumption Reduction" ($S_{Nor.}$ = 0.183) and "Reverse Logistics and Waste Minimization" ($S_{Nor.}$ = 0.181) dimensions of environmental sustainability. Accordingly, "Reusability of Products," with a normalized average score of 0.150, is the least impacted environmental dimension.

4.2.2 Impact of SC Resilience Strategies on Economic Dimensions of SC Sustainability

Economic excellence is a priority for every organization (Björklund et al., 2012). "Collaborative Technologies" ($S_{Nor.}$ = 0.191) and "Collaboration" ($S_{Nor.}$ = 0.183) showed maximum impact on SC economic sustainability (Table 7). The experts consider "Circular Economy" ($S_{Nor.}$ = 0.140) a weak contender for economic sustainability.

As indicated in Table 7, it is evident that resilience strategies with a normalized average score of 0.185 have the maximum impact on "Delivery Reliability." Next in line are "Operational Cost Reduction" ($S_{Nor.}$ = 0.175) and "Lead Time Reduction" ($S_{Nor.}$ = 0.167). The SC resilience strategies have the least impact on "Quality" and "Asset Utilization."

Table 7. Impact of SC Resilience Strategies on Economic Sustainability

SC Resilience Strategies → / SC Economic Sustainability Dimensions ↓	Collaboration	Collaborative Technologies	Circular Economy	Reshoring	Diversified Multisourcing	Building Redundancy	Avg. Score ($S_{av.}$)	Nor. Avg. Score ($S_{Nor.}$)
Quality	50	49	35	45	39	36	42.333	0.156 (5)
Operational Cost Reduction	50	53	48	55	44	36	47.667	0.175 (2)
Delivery Reliability	52	58	38	51	54	48	50.167	0.185 (1)
Lead Time Reduction	47	56	34	50	43	43	45.500	0.167 (3)
Flexibility	51	50	32	45	51	40	44.833	0.165 (4)
Asset Utilization	48	46	41	42	38	32	41.167	0.152 (6)
AVERAGE SCORE ($S_{av.}$)	49.667	52.000	38.000	48.000	44.833	39.167		
NORMALIZED AVERAGE SCORE ($S_{Nor.}$)	0.183 (2)	0.191 (1)	0.140 (6)	0.177 (3)	0.165 (4)	0.144 (5)		

4.2.3 Impact of SC Resilience Strategies on Social Dimensions of SC Sustainability

As depicted in Table 8, the top three resilience strategies with the maximum impact on social sustainability are "Collaboration" ($S_{Nor.}$ = 0.200), "Collaborative Technologies" ($S_{Nor.}$ = 0.175), and "Reshoring" ($S_{Nor.}$ = 0.175). Notably, like the case of environmental sustainability, "Building Redundancy" accumulated the lowest average score ($S_{Nor.}$ = 0.143).

Table 8. Impact of SC Resilience Strategies on Social Sustainability

SC Resilience Strategies → / SC Social Sustainability Dimensions ↓	Collaboration	Collaborative Technologies	Circular Economy	Reshoring	Diversified Multisourcing	Building Redundancy	Avg. Score ($S_{av.}$)	Nor. Avg. Score ($S_{Nor.}$)
Social Welfare and Development/Community Connection and Support	46	36	38	40	42	33	39.167	0.165 (4)
Employment Practices	44	41	36	43	40	35	39.833	0.168 (3)
Work Safety and Labor Health	46	46	34	42	32	32	38.667	0.163 (5)
Education and Training of Employees	55	49	33	41	33	35	41.000	0.173 (1)
Ethical Behavior	46	36	42	44	39	34	40.167	0.169 (2)
Information Disclosure	47	41	32	39	36	34	38.167	0.161 (6)
AVERAGE SCORE ($S_{av.}$)	47.333	41.500	35.833	41.500	37.000	33.833		
NORMALIZED AVERAGE SCORE ($S_{Nor.}$)	0.200 (1)	0.175 (2)	0.151 (5)	0.175 (2)	0.156 (4)	0.143 (6)		

The above outcome further got its validation because the six resilience strategies considered in this study had a maximum impact (0.511) on the "Education and Training of Employees," "Ethical Behavior," and "Employment Practices" dimensions of social sustainability.

4.2.4 Overall Impact of Respective SC Resilience Strategy on SC Sustainability

The average value from the shaded cells in Tables 6, 7, and 8 are reproduced in Table 9. The average scores of the individual sustainability dimensions were added to provide evidence of the overall impact of the SC resilience strategies on SC sustainability. Based on the achieved scores, the rankings are presented in parentheses along with the calculated average score.

Table 9. Impact of SC Resilience Strategies on SC Sustainability

SC Resilience Strategies → / SC Sustainability 3BL ↓	Collaboration	Collaborative Technologies	Circular Economy	Reshoring	Diversified Multisourcing	Building Redundancy	Avg. Score ($S_{av.}$)	Nor. Avg. Score ($S_{Nor.}$)

Environmental Sustainability	40.833 (4)	41.667 (3)	47.000 (1)	42.833 (2)	39.000 (5)	33.333 (6)	40.778	0.325 (2)
Economic Sustainability	49.667 (2)	52.000 (1)	38.000 (6)	48.000 (3)	44.833 (4)	39.167 (5)	45.278	0.361 (1)
Social Sustainability	47.333 (1)	41.500 (2)	35.833 (5)	41.500 (3)	37.000 (4)	33.833 (6)	39.500	0.315 (3)
AVERAGE SCORE ($S_{av.}$)	45.944	45.056	40.278	44.111	40.278	35.444		
NORMALIZED AVERAGE SCORE ($S_{Nor.}$)	0.183 (1)	0.179 (2)	0.160 (5)	0.176 (3)	0.160 (4)	0.141 (6)		

According to these average values, “Collaboration” had the highest impact on SC sustainability with an average score of 45.944. The impact of “Collaborative Technologies” on SC sustainability was 45.056, whereas the impact of “Reshoring” was 44.111. The top three resilience strategies (Table 5) obtained maximum scores for their impact on SC sustainability. “Diversified Multisourcing” and “Circular Economy” reflected the same score of 40.278. Finally, the overall impact of “Building Redundancy” is least on the SC sustainability with an average score of 35.444.

The influence of these strategies is maximum on “Economic Sustainability” (score: 45.278), followed by “Environmental Sustainability” (score: 40.778). The impact of resilience strategies seems low on social sustainability, as it accumulated an average score of 39.50 only.

5. Discussion

5.1 Supply Resilience Strategies under Extreme Uncertainty

The emergence of “Collaboration” as a top priority reinforces the applicability of resource dependence theory and dynamic capability view (DCV) under uncertainty, requiring firms in different roles and at various tiers to rely on each other for achieving their objectives (Paulraj & Chen, 2007; Xiao et al., 2019). The results are consistent with the outcome of Xiao et al. (2019), which indicates that focal manufacturers should advance their interdependent relationships with their suppliers to acquire complementary resources and capabilities in a wider supply network. Furthermore, the research outcome corroborates the findings of Burgos and Ivanov (2021), who mentioned that collaboration and digitalization were two important pillars for SCs’ resilience improvement. Indeed, the transformation to Industry 4.0 is led by technology to assist in managing diverse networks, achieving transparency, increasing information sharing, and optimizing resource consumption with a high level of responsiveness and with minimum human intervention.

The COVID-19 pandemic has exposed the world’s dependence on China (Deloitte, 2020). More than 5 million firms were directly and/or indirectly dependent on Wuhan, China, for their supplies (Braw, 2020). Thus, many firms are looking for local sources to improve their response to disruptions (Barbieri et al., 2020; Xu et al., 2020). Evidently, “Reshoring” is coming out as a viable option. It will support employment to soothe economic recovery. As a result, automobile industries must encourage the development of localized SCs to achieve improved SC resilience. Most nations have realized that local and shorter SCs are potentially effective strategies to improve SC resilience (Thilmany et al., 2021). The high-impact disruptive events may simultaneously affect the proximity; the outcomes reflect that firms should prefer multiple sourcing with a diverse network. This finding aligns with the findings of Meena and Sarmah (2013): firms should prefer multiple sources to reinforce their supply continuity in the face of disruptions, with reduced risk of regional disruptions.

Amid disruption, companies with minimal inventory were at significant risk. Although the top four strategies together have a cumulative weightage of 82%, the outcome of this study hints that "Building Redundancy" is also an important SC resilience criterion. The outcome complements Bryce et al. (2020), suggesting that companies need to plan and maintain inventories to deal with jolts due to uncertain events similar to COVID-19. "Circular Economy" in the SC is ranked as the sixth among SC resilience strategies. The automotive sector has integrated circularity, with vehicles built for longevity and repair (World Economic Forum, 2020). However, the concerns regarding the collection of used goods for reprocessing, the determination of recycling value, and the need for industrial symbiosis within the entire ecosystem constrain circularity contribution (Zhang et al., 2021).

5.2 Impact of Resilience Strategies on Supply Chain Sustainability

The automotive sector is considering design for assembly and design for disassembly to facilitate serviceability and enhance vehicle longevity (World Economic Forum, 2020). Furthermore, the perusal of this practice can be a driver to achieve end-of-life objectives, complementing the "Circular Economy." The priority for "Reshoring" highlights that proximity manufacturing will reduce the strain on the environment by (a) reducing transportation, (b) providing better control and transparency, and (c) bringing uniformity in environmental policies (Ashby, 2016; Sarkis, 2020). Consequently, the impact of these facilities on the local environment and return on investment (Barbieri et al., 2020) may be a matter of concern and can be a scope for future study. The third strategy, implementing "Collaborative Technologies" is a requirement in this environment-conscious digital era. It significantly reduces waste using additive manufacturing while optimizing energy consumption, inventory, and transportation utilizing IoT and aiding technologies (Esmaeilian et al., 2020). Contrarily, "Building Redundancy" representing capacity and inventory buffers are treated as degraders of environmental sustainability (Rajesh, 2018; Sarkis, 2020). As a result, automotive companies may not prefer high-capacity buffers and inventory but would prefer time buffers to replace inventory with information. "Reusability of Products" is reported to have the least impact on resilience strategies. The reasons as stated by the experts are quality issues and acceptance challenges with reused automobile parts.

In the context of economic sustainability, "Collaborative Technologies" and "Collaboration" are at the top ranks. It shows that a common objective and close association with suppliers are necessary for improving economic performance which aligns with the study by Sarkis (2020). Further, virtual reality technologies can help manage operations at a distance in real-time and advanced manufacturing reduces waste by optimizing resource utilization. In nutshell, "Collaborative Technologies" and "Collaboration" complement each other, leading to the economic sustainability of the companies. The outcome establishes the "Circular Economy" as a weak contender for economic sustainability. As cited by the participants, the probable reason for automotive manufacturing is the challenge to implement circularity in full spirit. SC resilience strategies have the least impact on "Quality" and "Asset Utilization".

Social sustainability is also in limelight for the last few years. Closer collaboration and more transparency with collaborative technologies enforce the propagation and implementation of automakers' commitments to their suppliers to achieve sustainability targets throughout their SCs. Nearby supplier facilities further ease the assessment of the desired implementation. The outcome endorses a case study by Ashby (Ashby, 2016) that suggests that proximity SCs improve ties, increase supplier visibility, and better respond to sustainability. Notably, similar to the case of environmental sustainability, "Building Redundancy" is not considered an apt strategy for social sustainability, resulting in wasted resources and energy (Ivanov, 2018). The six resilience strategies considered in this study had a maximum impact on the "Education and Training of Employees," "Ethical Behavior," and "Employment Practices" dimensions of social sustainability. As stated by experts, companies often impart skill training and perform corporate social responsibility (CSR) activities at their supplier's facilities. The top-emerged strategies will further strengthen the relationship. The "Information Disclosure" dimension is at the lowest position, which is quiet surprising considering collaborating technologies among the top strategies.

Putting together all the dimensions of sustainability, "Collaboration," "Collaborative Technologies," and "Reshoring" have maximum impact on SC sustainability. The outcome has reestablished the discourse around close collaboration among suppliers and manufacturers to nurture Sustainable–Resilient SCs (Sharma et al., 2020). The quality management at separate locations, difficulty to offer economies of scale, and increased transportation factors diminish the resilience benefits associated with "Diversified Multisourcing". Similarly, the collection of used goods, the determination of recycling value, and the need to revamp the whole system dimensions constrain the implementation of circularity principles (Zhang et al., 2021). Finally, the overall impact of "Building Redundancy" is the least on SC sustainability. This reinforces the conclusions reached by Ivanov (2018) that building redundancy while supporting SC resilience may negatively affect the environmental and economical commitments of firms. The influence of the resilience strategies is maximum on "Economic Sustainability" followed by "Environmental Sustainability" Economic and environmental dimensions are dominant drivers of sustainability. In developing countries, social sustainability lacks driving power (Mani et al., 2015) as it is considered a deterrent to growth.

6. Conclusions

The study contributes to knowledge and the advancement of the SCM theory by integrating the resilience and sustainability (3BL) aspects for SCs confronted by disruptions. Previous SCM research has addressed many SC issues, but insufficient attention has been paid to the SC resilience strategies for LFHI events. Considering that under distress, firms often compromise on their sustainability aspects, it is important to measure the impact of resilience strategies on SC sustainability. We answered the call to Sustainable–Resilient SCs, such integration has not been considered in previous research. This study provides a more holistic framework for Sustainable–Resilient SCs for LFHI events. The novelty of the proposed framework lies in the consideration of SC resilience along with the 3BL of SC sustainability in the face of COVID-19 disruptions.

Expert participants were mainly selected from the automotive manufacturing industry, which has a contribution of nearly 5% to 10% to the GDP of industrial nations (Saberi, 2018). The automobile industry's contribution to India's GDP is 7.5% (Kumar & Shrimali, 2020). Based on the results from the BWM, investment in collaborative technologies (R2) emerged as the best resort to strengthen SC resilience. It further substantiates the need for better collaboration (R1) and reshoring (R4) as a safeguard against global disruptions. The less scope for furthering circularity principles in the sector due to the complications and anticipated higher cost pushed "Circular Economy" (R3) as an unattractive SC resilience strategy. The implementation of the top three strategies will support the sustainability agenda too. The influence of all resilience strategies is the maximum on economic sustainability, followed by environmental sustainability showing that social sustainability is often marginalized. The adoption and pursuance of considered strategies would also support social sustainability, requiring the realization and commitment of the sector. In a conclusion, supplier–manufacturer relationships need to be further strengthened and supplier location decisions may be revisited in the light of available technologies to meet SC resilience without compromising sustainability to survive and tackle any future uncertainties.

7. Implications and Contributions

7.1 Theoretical Implications

The COVID-19 pandemic crisis unleashed many challenges and demanded an immediate response from organizations worldwide. Although the immediate reactions attempted to pacify the situation, they also exposed the fragility of SCs. The pandemic highlighted the pressing need to improve SC resilience in such uncertainties. Furthermore, it also hinted that organizations might sacrifice sustainability under such eventualities. Therefore, the SC domain demands multidimensional research comprising both the sustainable and resilient facets. This study attempts to answer the available research question: "What combination of strategies is most appropriate for advancing Sustainable–Resilience SCs for LFHI events?" To do this, the study proposed a framework comprising six SC resilience strategies that organizations may follow to face disruptions due to extreme uncertainties and quantified their impact on SC sustainability goals. The study shows that COVID-19 has significantly provoked the thought process of SC researchers and professionals. Companies are developing new strategies to improve resilience for such LFHI events.

The outcome of this study advances the SC theory, by proposing a descriptive and prescriptive framework for enhancing SC resilience without trading off sustainability. Through the lens of the SC theories, this study adds to the academic discourse in the field. The resource-based view (RBV) theory advocates the accumulation of resources and capabilities at the organizational level for competitive advantage. In the context of SCs, the DCV theory considers this organizational accumulation as a counter-weapon to deal with adversities. However, the present SCs are not self-sufficient but dependent on a complex network of interconnections to fulfill their requirements. This means that the cause of SC distress and its impact is spread across the entire supply chain network. This study manifests the outcome of Chowdhury and Quaddus (2017) that the expansion of organizational boundaries to the entire supply chain is essential to develop resilience against LFHI events. Henceforth, building social capital derived from interorganizational relationships is obligatory to improve SC resilience rather than focusing on the self. The emergence of "Collaboration" and "Collaboration Technologies" as top resilience strategies substantiates the need to build adaptive capacity through social capital. In the context of proactive resilience, Dovers and Handmer (1992) emphasized the role of adaptive capacity to create a system that is capable of adapting to dynamic conditions. Better interorganizational relationships will improve the alignment of goals, streamline the flow of information, and have higher resilience (Gölgeci & Kuivalainen, 2020).

Humanitarian SC offers a suitable reference point for SC under disruptions. Using a complex adaptive systems theory for building relief SC resilience, Day (2014) proposed supply-base flexibility, trust-building with stakeholders, shorter path length, and a high level of path redundancy. The outcome of this study with reshoring and diversified multisourcing considered relevant for SC resilience tows a similar line. Although reshoring and diversified multisourcing are considered beneficial, it warrants further research to assess the benefits. Definitively, the national policy analysis may unveil the challenges associated with the reshoring. The study will also be beneficial for classroom teaching to show how the trade-off between sustainability and resilience occurs. Academics can further deliberate the role of each resilience strategy and sustainability dimension.

7.2 Practical Implications

This study offers significant practical implications to aid SC planning and preparation for LFHI disruptions. The first recommendation, particularly for automobile companies, is to analyze their SCs and identify the possible reasons for disruptions. They must accept that a resilience-building exercise needs a top-down approach. Hence, the desire of top management is instrumental to strengthen collaboration with players of their SCs. The use of complementing technologies for uninterrupted information flow demands resources and long-term commitment.

Second, the call for localization looks like a very desirable option for increasing self-resilience. Automobile companies should support the development of localized SCs through reshoring to achieve improved SC resilience. Third, the over-reliance on a single supplier intensifies the risk. Thus, firms should go for multiple sourcing with a diverse network to fortify their supply base in the face of disruptions. Maximum order quantity can be procured from the supplier offering a high price discount, and suppliers promising lesser failure probability may be engaged with small order quantities to balance the cost and resilience (Meena & Sarmah, 2013). Moreover, the decision to maintain minimum inventory must be revisited considering both supply and demand. For the implementation of circularity principles, industrial symbiosis within the ecosystem is lagging. Future expansion of the electric vehicle market may change the scenario and make it beneficial for the auto sector in the coming times.

In the sustainability context, disruptions direct more attention to economic dimensions with little concern for environmental aspects and marginalization of social sustainability. Our framework synthesizes the link between the two important concepts of SC resilience and sustainability, which is a base for progressing SC restructuring. Overall, the top three SC resilience strategies have the maximum impact on SC sustainability. The outcome can aid SC managers in selecting and evaluating the set of SC resilience strategies that meet their sustainability commitments.

7.3 Research Limitations and Future Research Directions

Building on this study, researchers can further Sustainable–Resilient SC research. This research primarily included experts from automotive manufacturing; sectoral diversity may expose similarities and dissimilarities in the approach. Furthermore, the current policies, workforce availability, and the support of the governments will be important aspects to look at. A large-scale and comprehensive research opportunity is there with respect to this topic. The outcomes only express the experience-based inputs from the professionals while being in crisis to ensure normal business operations. However, it will be interesting to perform a longitudinal study and compare the outcomes with a post-COVID recovery period. Also, the researchers can take a lead from this work for the future SCs scenario building in the context of a specific strategy for a specific sector. Organizations should work to improve their SC resilience and devise a mechanism to balance it with their sustainability goals. Considering the importance of Sustainable–Resilient SCs, this study lays the foundation for future researchers as the topic will retain its importance in the coming times.

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