A Review on Mitigating Disruptions and Improving Resilience in Supply Chain Logistics

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Abstract: - Businesses need resilience in supply chain logistics to efficiently manage and minimize disruptions and maintain a smooth flow of goods and services. The present study aims to examine the elements influencing supply chain resilience to enhance overall supply chain performance. A thorough literature assessment served as the foundation for the study's methodology. Two methods were employed to examine the body of knowledge on supply chain resilience: first, databases and journals were searched using specific keywords; second, the publications' references were followed to find the literature that the databases and journals had not been able to locate. When building the sample for this analysis, only publications released after 2002 were included. This strategy provided 150 high-quality research articles that served as the basis for the literature evaluation reported in this study. The research article's conclusions state that manufacturers or businesses need to consider both internal and external factors when identifying and analyzing potential supply chain interruptions. To handle hazards that have been discovered, develop a comprehensive risk management plan and rank hazards according to likelihood and possible consequences. This information could prove vital for managers and supply chain experts in manufacturing companies with useful information that helps them improve the robustness of their supply networks. Moreover, because this study highlights the connection between supply chain resilience and an organization's overall performance, it occupies a significant position in the literature. The findings suggest that a company's reputation among supply chain partners and consumers is negatively impacted by frequent interruptions to business. This finding is consistent with the crisis literature, as stated by Coombs, which shows that a firm's reputation suffers more when it bears a larger portion of the blame for a crisis. The study emphasizes strategies for supply chain resilience, including diversifying suppliers, implementing robust risk management, enhancing transparency, investing in advanced technologies, fostering collaboration, and ensuring agility and flexibility in unforeseen disruptions.

Key-Words: - Supply chain resilience, supply chain risks, logistics, performance, manufacturing firms, prefabricated building systems.

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1 Introduction

Drawing from the wide range of supply chain disruptions, including those that are due to black-swan events, as well as their potential effects on a company's competitiveness and continuity, supply chain resilience, or SCRE, has drawn a lot of interest from researchers and practitioners alike, especially in the post COVID-19 era. Events that can seriously affect the supply chain's resilience include pandemics, labor disputes, information system malfunctions, and severe weather-related disruptions to routing operations, [1]. Supply chain managers are under increasing pressure to implement stronger measures to protect their supply networks against interruptions as a result of these difficulties, [2], [3]. The literature's current definitions of SCRE place significant emphasis on the multifaceted nature of resilience and its connection to the system's capacity to eventually return to a stable state, [4]. Improving capabilities continuously is necessary to build SCRE. To advance, SCRE needs data on its effectiveness and a comparative analysis with prior results through the use of particular performance metrics, [5]. It is recognized that to significantly impact SCRE formatting, capabilities need to be categorized and

integrated. A broad range of skills was assessed in significant SCRE research, [6]. Based on proactive, concurrent, and reactive methods, a literature analysis and classification of SCRE capabilities were conducted, [7]. Previous studies have focused on specific skills. While [8] emphasized redundancy and assessed the need for agility, [8] looked into visibility.

Performance metrics help companies evaluate and understand the risks in their supply lines [9]. They can also see how well resilience and risk mitigation strategies work [10]. Research scholars have studied many parts of supply chain resilience (SCRE), including density [11], stock level, service level, wait time, and costs. Still, there isn't much written about SCRE success indicators, its elements, and measuring supply chain resilience hasn't been given adequate attention in many studies. One problem is that not many studies have been done in this area. Figuring out how resilient a system is important for understanding how the supply chain responds and adapts to changes. Even though SCRE measures are useful, stress how important this line of study is and how it can give useful details about SCRE and its impacts. Measures of performance help businesses figure out how risky their supply chains are and how well their plans to make them more resilient and lower risk are working. A lot of different researchers have looked at different parts of Supply Chain Resilience Evaluation (SCRE). These have examined prices, stock levels, wait times, and service levels. Still, not much research has been done in this area, and not much has been written about how to measure SCRE success. The literature shows that there isn't a lot of study on SCRE. This shows the importance of more in-depth studies in this area. It is important to know how resilient a supply chain system is so that you can judge how well it handles and adapts to outages. Supply Chain Resilience Evaluation (SCRE) metrics are a useful study path that gives important insights into how SCRE works and its effects. So, more research needs to be done in this area to help us understand supply chain resilience better and figure out how to measure it. This will finally lead to better risk management techniques, [11].

Furthermore, despite the definitions offered by several studies, a comprehensive explanation that provides a clear understanding of resilient supply networks hasn’t received adequate attention. While some view resilience as a proactive effort to be ready for disturbances, others see it as a set of reactive abilities utilized after a disturbance. Based on the research by [11], acknowledged that given these differences, the confusion surrounding the concept is unsurprising. Currently, we rely on the definition provided by [12], a commonly cited definition in the supply chain resilience literature: supply chain resilience is "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function [13]. Calling for continuous flow processing with low inventory numbers, leveling and just-in-time manufacturing, and accurate transportation scheduling for cross-docking activities, all of which contribute to more cost-effective and responsive supply chains. Furthermore, the push to reduce costs has resulted in the outsourcing and offshore of numerous industrial and R&D operations, particularly from low-cost nations. These changes put a huge demand on undistracted operations and stable environments, but they also make them more vulnerable to disruptions, increasing the operational and financial effect of supply chain (SC) disturbances, [13]. Since more than 56% of global enterprises experience an SC interruption each year, businesses have begun taking SC disruptions more seriously. BCI-Business Continuity Institute, [14]. As a result, the requirement for creating robust SCs and developing contingency plans is vitally significant.

Climate change and human activity may both create supply chain disruptions. Since 1980, 212 catastrophes have occurred in the United States, resulting in around $1.2 trillion in damage [14]. The number of expensive catastrophes has climbed internationally, from less than 200 annually in the 1980s to more than 300 in the 2010s. Natural calamities like the Thailand flood and Japan's earthquake and tsunami have harmed firms' reputations and profits. Approximately 40-60% of small firms never reopen after a crisis, [15]. Recent examples of human factor disruptions include tariffs imposed on billions of products for US importers in 2018-19, particularly steel and aluminum, which caused import delays due to companies' inability to adjust their current customs clearance programs and absorb the additional cost. This significantly influenced US-China ties, with Chinese enterprises being the most affected. Furthermore, the aftermath of Brexit at the start of 2020 raises production failure risks for just-in-time automakers and others with comparable operations, [16]. The Syrian civil war has caused humanitarian logistics issues with refugee flows in Turkey and the EU, necessitating a shift in supply chain strategies from serving populations on the move to serving dispersed but static groups of people, such as refugee camps, [17].

Recently, a devastating coronavirus epidemic in a key industrial and transportation center in central China prompted lockdowns in Chinese (and many other) cities and companies, significantly limiting worldwide output and transportation routes, [18]. The literature has placed a strong emphasis on SC disturbances. It is a subject that is increasingly challenging the SC of goods and their focal firms since SCs have grown extremely complex and interdependent, and disruptions cause a snowball effect with major effects for all associated SC levels. This dissemination, known in the literature as the ripple effect [19], magnifies the effects of disturbances. Although firms are well aware of SC threats, over 80% are worried about SC resilience [20], [21], and over 60% say they have yet to create and implement appropriate SC risk management strategies [22].

As a result, risk management in SCs is an important issue in supply chain management, and it has been studied through reviews [23], case studies [24], and an analysis of management models [25] [26]. Related studies have shown a rich academic framework that stimulates research in the field by defining SC risk kinds, techniques for detecting and assessing them, and using the appropriate approaches to respond to them by combining theory with strategy and management practices [32]. The primary aim of this review is to investigate the elements influencing supply chain resilience to improve overall supply chain performance, facilitated by the mediation of supply chain resilience. This study offers insightful guidance to managers and experts in manufacturing companies that will help them improve the robustness of their supply networks. The findings of this review work will add to the body of knowledge on SCRes by clarifying how SCRes helps businesses build and preserve a favorable reputation. A thorough comparative examination of the benefits and drawbacks of the many sourcing techniques that improve supply chain resilience is lacking despite the literature's substantial exploration of these strategies. This study distinguishes itself by investigating the influence of variables such as flexibility, agility, collaboration, and redundancy on decreasing various forms of supply chain interruptions. It highlights the need for previously studied organizational techniques for handling specific disruptions, which include supply and demand, operational processes, control mechanisms, and environmental elements.

2 Literature Review

Academic studies have shifted their focus to the elements that influence supply chain resilience. Numerous academics have dived into this field, investigating aspects influencing supply chain resilience from the perspectives of vulnerability, capacities, and external forces. Certain authors discovered 58 characteristics associated with industrialized buildings, which were divided into 12 components such as adaptability, ability, and efficiency. They identified 37 characteristics related to the resilience of the prefabricated construction supply chain, with an emphasis on vulnerability, [27], [28]. Their research sought to build a more robust construction supply chain by identifying 41 essential capabilities such as flexibility, adaptability, efficiency, and visibility. It was explained by [29] considered extreme weather as a factor influencing construction supply chain resilience, proposing strategies to reduce vulnerability and enhance coping abilities with extreme weather [29]. [30], used questionnaires to investigate five important susceptibility factors: political change, market pressure, management, and financial and strategic vulnerability. [31], proposed building 4.0 technologies and shown their effectiveness in preserving supply chain resilience utilizing SmartPLS for data collection and structural equation modeling analysis. With the use of actual cases, [32] developed an index system for evaluating the resilience of the building supply chain. It has four components: prediction, absorption, adaptation, and recovery abilities. Unpredictable demand swings, short product life cycles, and changing customer expectations and tastes have all posed problems to supply networks. In response to these worries, the supply chain has become more complicated, which has led to an increase in volatility and unpredictability, [33]. In response to the adverse effects of disruptions in the supply network, both academic researchers and practitioners have emphasized the importance of crafting resilient supply chains capable of efficiently navigating and withstanding such disruptions, [34]. Supply Chain Risk Management (SCRM) entails identifying possible risk sources and executing effective measures through collaboration among community members of supply chain risk. The objective is to reduce the vulnerability of the supply chain, [34]. In response to this worry, supply chain resilience has recently gained more attention. Suggested, based on [35], that resilience is an essential skill many businesses use to supplement conventional risk management procedures. Resilience is at the center

of modern supply chain management theory, according to [36].

Researchers like [37], [38] used various methodologies, including literature analysis, interpretative structural modeling (ISM), DEMATEL, and SDM methods, to examine factors affecting the resilience of prefabricated building supply chains. They found significant impacts on resilience from production and construction, information sharing, logistics and transportation capabilities, and on-site assembly. Using Social Network Analysis (SNA) and System Dynamics Modeling (SDM) techniques, based on the report by [38] determined that on-site assembly is the weakest link in a supply chain and that the best course of action is preventive. In their study, [39] looked into how the cost of moving prefabricated parts affected resilience. They showed an optimization model for the trade-off between robustness and cost when transportation isn't working well, and there are delays. [39] created an index system with flexible inputs for production, research and development, risk management, and supply to study what makes a prefabricated building supply chain resilient. They found that visualizing information and understanding and dealing with risks were two important factors that contributed. The in-depth literature study [40] shows that research on the factors that affect supply chain resilience and prefabricated building supply chains (PBSC) has moved forward. This body of work gives the current study a strong theoretical foundation. However, different studies have found that the things that make PBSC resilient don't always match. This is because PBSC is different from traditional supply lines in many ways. Prefabricated Building Systems (PBSCs) are getting more attention from scholars because China is putting more effort into developing them. Even so, people still have different ideas about how long PBSC lasts and what it means, [41]. Also, we don't know much about PBSC resilience yet, and most studies on supply chain resilience have been done in the context of standard manufacturing supply chains. Considering the dynamic character of PB development in China and the unique features of PBSC that differentiate it from conventional supply chains, it is critical to determine and examine the aspects and/or factors impacting PBSC resilience, [41].

To develop efficient supply chain management techniques, a large number of research scholars have focused their attention on researching supply chain resilience in recent years. It is noted that the temporal sequence preceding, during, and following supply chain disruptions serves as the primary basis for assessment indicators for SCRE used by researchers. To improve overall supply chain resilience, these evaluations frequently center on the four concepts of "prediction, response, adaptation, and recovery", [42]. To sum up, prior studies on supply chain resilience have mostly focused on two key areas. It first required a theoretical and empirical investigation into the factors influencing a prefabricated construction supply chain's resilience. These studies revealed a wide range of factors, spanning multiple levels and types, that affect the prefabricated construction supply chain's resilience, creating a complex system. Secondly, the researchers used structural equations to confirm that these parts affect the resilience of the supply chain for prefabricated buildings. Still, these studies didn't always look at how different parts work together or how changes in these parts can affect how strong the supply chain for premade construction is. Building on earlier research, this study aims to learn more about the important factors that affect the resilience of the prefabricated building supply chain.

The negative consequences of several significant disruptions described by [42], [43] prompted us to investigate approaches to find supply chain solutions that are both efficient and robust to big disruptions. According to several data acquired by other studies, many businesses find it difficult to justify some costly techniques for mitigating supply chain disruptions that may not happen. This insight might explain why so few companies are taking dramatic measures to safeguard their supply networks. As a result, to encourage companies to safeguard their supply chains, "robust" solutions that fulfill two functions must be devised. First and foremost, these techniques should assist a company in lowering expenses and increasing customer satisfaction in normal conditions. Second, the same techniques should allow a company to continue operating during and after a significant interruption, [44]. This study identifies many resilient techniques and demonstrates how they might help a corporation flourish before, during, and after a severe disruption. Some of the underlying obstacles in selecting and implementing some of these effective solutions are also explored. Supply chain interruptions and the accompanying operational and financial risks are the most pressing worry for businesses competing in today's global economy. Existing research has verified the expensive nature of supply chain disruptions and provided useful insights into associated concerns such as supply chain risks, susceptibility, resilience, and continuity. In this conceptual note, we address a largely neglected

problem by asking and resolving the question of how and why one supply chain interruption is more severe than another. In doing so, we effectively argue that supply chain disruptions are inescapable and that all supply chains are intrinsically dangerous.

Using a multiple-method, multiple-source empirical research design, we derive novel insights, presented as six propositions, that link the severity of supply chain disruptions (i) to the three supply chain design characteristics of density, complexity, and node criticality, and (ii) to the two supply chain mitigation capabilities of recovery and warning. These findings add to current information about supply chain risk, susceptibility, resilience, and business continuity planning and call into question the appropriateness of adopting methods like supply base reduction, global sourcing, and sourcing from supplier clusters. In the disruption resolution process, procedural justice mitigates interactional and distributive justice in repairing damaged impressions of providers' (a) capacity, (b) compassion, and (c) integrity. Restoring lost trust may have a favorable impact on purchasers' future intentions to retain ties with suppliers [45], which are an important predictor of expected behaviors and volitions [46], [47]. This is because recouped buyer trust reflects purchasers' greater confidence that short-term injustices would be remedied to produce long-term benefits. Although the uncertainty associated with trust damage caused by supply chain disruptions raises the potential risk of the exchange, successful damaged trust mitigation increases the likelihood that buyers will regain confidence in their suppliers and carry the relationships forward with the undetermined endpoint. Because trust is positively connected with risk-taking [47], buyers are more willing to take chances when their suppliers successfully rebuild their confidence through disruption remedies than when they do not. Companies that successfully handle supply chain disruptions might gain a competitive edge by becoming more robust and responsive to market changes. They can respond swiftly to unexpected events, maintain consistency in product availability, and capitalize on opportunities created by rivals' supply chain breakdowns. In essence, mitigating disruptions is critical for the success of the supply chain as it enables companies to uphold customer satisfaction, reduce costs, preserve reputation, manage risks, maintain operational efficiency, meet regulatory requirements, and gain a competitive edge in the marketplace.

2.1 Key Factors Influencing Supply Chain Resilience

If something goes wrong in the supply chain, it needs to be able to quickly get back to how it should be. The stability of the process is an important aspect of supply chain management, [47]. An effective way to reduce the risk of supply chain disruption and ensure the proper functioning of the prefabricated building supply chain is to hold the supply chain in high levels of change, so a company must have flexibility and flexibility to remain viable, [48]. To ensure long-term sustainability and expansion of prefabricated buildings, it is important to identify and search for a solution that enhances the resilience of the supply chain of prefabricated buildings. This requires a thorough analysis of critical factors, understanding their efficiency, impact on supply chain security, and the relationships between them. Previous measures played an important role in the expansion and transformation of the construction sector, facilitating sustainable development. Beware the supply chain is critical, [49]. The prefabricated building supply chain is not a simple process or industrial chain. Instead, it is a complicated web of interactions between many people and steps. Also, worldwide events like pandemics and international unrest have worsened disruptions in the supply chain's upstream and downstream parts. Because of this, the supply line for prefabricated buildings is now more likely to be interrupted or even go down completely, [50].

Prefabricated structures have much to offer regarding shortening construction schedules, improving quality, and reducing environmental effects. They are characterized by standardized design, factory manufacture, and mechanized construction, [50]. These benefits result from prefabricated building construction's industrialization, informatization, and environmental friendliness. Within the scholarly community, there has been a noticeable emphasis on examining the variables that impact supply chain resilience. Several researchers have examined supply chain resilience with vulnerability, capability, and external influences. For example, [50], [51], painstakingly determined and divided 58 pertinent characteristics of industrialized structures into 12 parts, including adaptability, capability, and efficiency. Their work extended to pinpointing 37 factors linked to the resilience of the prefabricated building supply chain, emphasizing vulnerability. They further outlined 41 essential factors for a resilient supply chain, emphasizing flexibility, adaptability, efficiency, and visibility.

Extreme weather was identified by [52] as a major element impacting the resilience of the building supply chain. They offered measures to reduce company susceptibility and improve their ability to handle harsh weather situations. A questionnaire-based study was performed to identify five important susceptibility factors: political change, market pressure, management, financial considerations, and strategic vulnerability, [53]. The research presented Construction 4.0 technologies, proving their potential to provide supply chain resilience through data collection and structural equation modeling analysis using SmartPLS, [54]. Additionally, [55] developed an evaluation index system for construction supply chain resilience, encompassing dimensions such as predictive ability, absorption capacity, adaptability, and recovery ability. This system was validated through real-case applications. Using a variety of research approaches, several researchers have verified and thoroughly examined the mechanisms behind each component impacting supply chain resilience. [56], created a conceptual model centered on resilience management to investigate variables influencing the resilience of the prefabricated construction supply chain. Production and construction have a big effect on supply chain resilience, and education and partnerships are very important for managing the changes that happen in production and construction. [57], [58], used a literature review and the Interpretative Structural Modeling (ISM) method to determine what makes the prefabricated building supply chain resilient. They found that better logistics and delivery capabilities and more information sharing between design companies and supply chains have a big effect on making supply chains more resilient. [59], developed a model to see how secure the supply chain for prefabricated buildings is. They used the Decision-Making Trial and Evaluation Laboratory (DEMATEL) and ISM methods. Their study helped us understand how things work and delved into key elements that impact the supply chain's security.

Social Network Analysis (SNA) and System Dynamics Modeling (SDM) were used to find that on-site assembly is the least stable part of a supply chain. They also found that prevention is the best way to go. [60], studied how resilient premade parts are and how much it costs to ship them, especially when problems and transportation aren't working well. They devised a solution method based on a reliability and cost trade-off optimization model. This gave managers of prefabricated component supply chains new ideas and ways to do things. [61], made an index system that included flexible resources, manufacturing, research and development, risk management, and supply flexibility to figure out how resilient a prefabricated building supply chain was. Their results emphasized important factors that played a role, like the ability to recognize and deal with risks and the importance of showing knowledge visually, [61].

Scholars have recently examined supply chain resilience (SCR) to develop effective supply chain management strategies. Previous research by both domestic and international scholars has predominantly focused on assessing influencing factors across the time sequence before, during, and after supply chain disruptions. This evaluation typically revolves around four key dimensions: prediction, response, adaptation, and recovery. These dimensions include factors such as restore ability, adaptability, responsiveness, predictive ability, sustainability, technological innovation, increased demand volatility, a reduced supplier base, heightened outsourcing, centralized distribution, specialized factories, and the globalization of the supply chain. To enhance the existing indicator system encompassing prediction, response, adaptation, recovery, technological innovation, increased demand volatility, reduced supplier base, heightened outsourcing, centralized distribution, specialized factories, and globalization of the supply chain, this study introduces the dimension of "sustainability." A comprehensive search was conducted across various databases, including Bing Academic, Google Academic, and Web of Science, which retrieved 300 articles. After a thorough screening using the established framework, only 52 articles were deemed relevant, identifying a total of 20 influencing factors. Table 1 (Appendix) provides a concise overview of these influencing factors, shedding light on the expanded dimension of sustainability within the context of supply chain resilience.

In the past decade, supply chain resilience (SCRes) has evolved into a crucial research focus, garnering significant literature attention, [61], [62], [63]. This increasing interest in SCRes stems from various factors. Companies have become more susceptible to disruptions due to the elongation (additional tiers), expansion (increased depth), and heightened complexity of their supply chains. Historical events such as the 2012 earthquake in Japan exemplify this susceptibility since it not only damaged Japanese and Asian markets but also generated shortages in the supply chains of linked businesses in Europe. Resilience is intimately tied to supply chain risk and vulnerability in the supply chain literature, reflecting the idea that it is difficult

to identify or mitigate all potential supply chain hazards, [64]. Among the various definitions of (SCRes) in the literature, the one proposed by [65] stands out as the most widely accepted. They define (SCRes) as "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at a desired level of connectedness and control over structure and function", [65].

The intersection of supply chain resiliency and sustainability represents a crucial area for advancement and enhancement in supply chain management, offering a comprehensive and cross-industry perspective. Sustainable supply chains, in particular, are susceptible to both anticipated and unforeseen changes, which may arise from factors such as rapid shifts in consumer behavior or the influence of non-organizational entities. Despite the imperative for simultaneously addressing resiliency and environmental sustainability in supply chain management, the existing literature falls short in considering these two aspects in the procurement context. Presently, a significant portion of the literature focuses on the supplier selection problem by separately examining green and resilience aspects. Essentially, there exists a gap in supply chain management, specifically within the supplier selection process, when it comes to dealing with the simultaneous integration of green development and resilience reinforcement. Consequently, there is a demand for an approach that guides managers in adopting environmentally sustainable practices without compromising the resiliency of the supply chain. The increased susceptibility of supply chains to unanticipated interruptions due to globalization has been an increasing obstacle for industrial decision-makers. Despite this, this important field of knowledge has received little attention, [66], [67]. A 2017 study examined terminologies and research projects pertaining to the enhancement of supply chain resilience. It uncovered a scarcity of quantitative studies aimed at improving supply chain resilience. [68], proposed a way to make decisions considering flexibility, diverse sources, strategic stock, and more to measure suppliers' resilience.

The observed capacity of some supply chains to recover more successfully from inevitable and unexpected shocks, as shown by situations such as Nokia and Ericsson, spawned a supply chain resilience discourse. The acceptance that not all hazards can be completely avoided is at the heart of supply chain resilience, [69]. Resilience is a proactive and all-encompassing strategy for controlling supply chain risks that supplements standard risk management tactics such as risk assessment, vulnerability analysis, and continuity planning. Supply chain resilience, as opposed to traditional strategies that require the identification and quantification of risks, can successfully overcome unanticipated interruptions and occurrences, [70]. Resilience in the supply chain is defined as an organization's ability to endure, adapt, and prosper in the face of change and uncertainty. It has been described as "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruption, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structures and function". This concept can be conceptualized as "shock absorption" between different stages of the supply chain, [70].

2.2 Supply Chain Resilience (SCRE)

Supply Chain Resilience (SCRE) is defined as the capacity to ensure the uninterrupted flow of the supply chain or swiftly restore it to its original or enhanced state in the face of sudden disruptions. Both domestic and foreign scholars have delved into understanding the factors influencing SCRE. [71], classified these aspects into five dimensions: information flow, logistics, capital flow, coordination degree, and enterprise integration and matching. Capability refers to the methods, technologies, and skills an enterprise needs to execute core functions in the supply chain environment. On the other hand, vulnerabilities are potential disruptions from external factors outside the supply chain's context that may hinder day-to-day operations.

Accurate information flow and close corporate partnerships were highlighted as crucial for SCRE. [72], empirical research emphasized the significant impact of leadership's organizational ability, information transmission efficiency, customer relationships, collaboration between enterprises, and emergency management ability on SCRE. [73], the SLNA dynamic literature review method was utilized to identify information-sharing pairs that enhance supply chain resilience. [74], surveyed seven global companies, identifying 14 factors affecting supply chain disruption in the Purchasing and Supply Management (PB) domain and emphasizing the relationship between supply chain elasticity and performance improvement. [75], noted the increased likelihood of disruption in the complex contemporary supply chain environment. Based on surveys of 264 British companies, their conclusion highlighted that information resource

sharing can enhance supply chain visibility and overall performance. [76], employed SEM models, indicating that digital technology tools and proficiency in their application can enhance supply chain resilience. Companies must identify and assess potential risks at different nodes to establish resilience competencies and capabilities within the supply chain system. This involves evaluating the strength of their impact and the likelihood of occurrence. Various methods and strategies are employed by organizations to enhance resilience in their supply chains, as highlighted by [77], [78]. During the initial phase of the COVID-19 pandemic, some firms recognized the importance of maintaining inventory and production capacity buffers to enhance resilience. Others took advantage of underutilized production capacities to manufacture different products and medicines, diversifying their offerings, [79]. In contrast to relying on a single source of supply, organizations adopting multi-sourcing strategies experienced increased resilience benefits, as demonstrated by [78].

Over the past two decades, numerous businesses have been striving to embrace digitalization and advanced technologies in their operations. The concept of Industry 4.0 has recently gained prominence in the business market. Artificial Intelligence (AI) has emerged as a valuable technology for enabling effective communication between machines and devices used in various business processes, [97]. Given the complexity of tasks within the supply chain system, AI has been increasingly employed by firms to streamline operational activities, enhance speed, and improve accuracy when handling large volumes of data and information, [98], [99]. While using AI in business is not new, its potential and capabilities have gained recognition in recent years. AI can make agile and intelligent decisions within the supply chain system, helping to prevent and resolve issues. This effective use of AI contributes to improved service quality, ensuring safe and timely deliveries of products and services to customers, [100]. AI applications also facilitate computerized compliance, leading to cost reduction and efficient performance in the supply chain network [101], [102]; Furthermore, AI is crucial in enhancing predictive capabilities for demand estimation. Through AI bots, organizations can initiate customer engagement, allowing customers to track the status of product deliveries and interact with customer support teams, [103]. Automation through AI simplifies tasks in warehouse operations, and major companies such as Alibaba and Amazon utilize AI to increase productivity in the supply chain. Given the significance of every minute in the supply chain field, AI algorithms efficiently support cost and time minimization, improving delivery processes and routes, [104].

2.3 Metrics for Measuring Supply Chain Performance

Numerous companies have struggled to enhance the resilience of their supply chains, often due to their failure to establish the necessary performance metrics for optimizing efficiency, as noted by [105]. Table 2 presents a range of supply chain performance measurements identified in existing literature. In their efforts to boost organizational performance, [106] in their 2019 study delve into the realm of supply chain resilience. They construct a comprehensive set of metrics designed to enhance performance and fortify a supply chain against disruptions. Through their research, they introduced a supply chain resilience framework that incorporates these indicators. This framework is a valuable tool for supply chain management, enabling them to evaluate and effectively withstand disruptions. The metrics they propose offer a strategic approach to assess and improve the overall robustness of a supply chain, ensuring its ability to navigate challenges and maintain operational continuity. [107], focus on the ratio of total cost to lead time, addressing the shortfall of comprehensive performance measurements across industries for evaluating entire supply chains, [108] advocate for a concentration on production lead time and inventory holding costs. [109], emphasize that these measures should be easily understandable by all members of the supply chain and should offer minimal room for manipulation. Several researchers delve into the intricacies of supply chains, identifying key indicators to enhance performance and resilience. Additionally, [110], characterized visibility within a marine supply chain as a robust indicator of supply chain strength.

In Figure 1, the occurrence and prevalence of several indicators across diverse supply chains are illustrated, with collaboration emerging as the most frequently cited signal. Most of the examined publications emphasize that when an organization engages in collaborative efforts for mutual advantage, its supply chain gains heightened resilience. Following closely behind collaboration, flexibility emerges as the next influential indicator, followed by visibility, agility, SCRM culture, and other factors, in order of significance.

Table 2. Metrics for Evaluating Supply Chain Performance

Supply Chain Performance Measurement.	References
Proactive demand management, Total cost	[111]
Total quality, Business process, 'fit' and 'excellence' ideas	[112]
Stockholder satisfaction, Strategies, Processes, Capabilities, and Stakeholder contribution	[113]
Value (redefined their valuation methods to account for un-priced costs and benefits), Individual investment, Demand Forecast, and planning	[8]
Peak demand, Change in production plan, Power cuts (recovery to shutdown)	[67]
Current details on the event, instantaneous strategic choice, familiarity with operational assets, Recovering speed, Loss per time unit, a culture of excellence, efficient dialogue, Innovation, and Leadership.	[114]
Leadership, information sharing, and collaboration.	[115]
Cost, Turnover, Net profit, Market share, Customer loyalty	[98]
Total cost, Lead time ratio	[107]
Setup time, Manufacturing lead time, Order-to-delivery cycle time	[109]
Real-time assessment, Increased inventory level, Technological threats	[99]
Demand forecasting	[57]
Recovery to shutdown	[74]
Total cost, Manufacturing lead time	[100]
lead time reduction Quick rerouting of the specifications, development of alternative technologies, online safety, limitations on access, Customer loyalty, and brand equity.	[92]

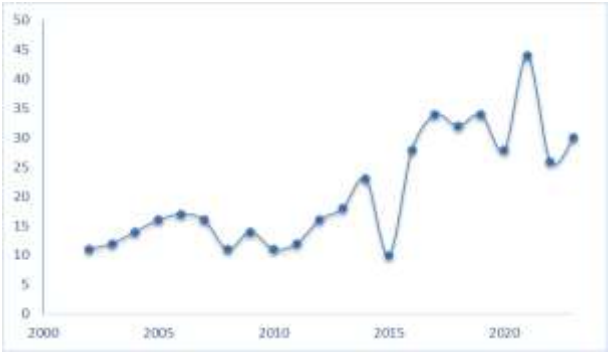

Fig.. 1: Distribution of papers by year

Resilience is a dynamic organizational capability that enhances the ability to respond effectively to disruptions, relying on the contributions of individuals, groups, and subsystems within the system. Consequently, companies seek resilience at an organizational level and within the framework of individuals, groups, and subsystems. The concept of resilience is a global concern, extending beyond specific countries. A summary of the various regions that this study has examined is given in Figure 2, which shows that 47% of the global supply chain as a whole is linked to the USA and India, and the remaining 53% is split between the UK, China, France, Portugal, Ireland, Australia, The Netherlands, Hong Kong, Singapore, UAE, Malaysia, Nigeria, Xiamen, and Germany.

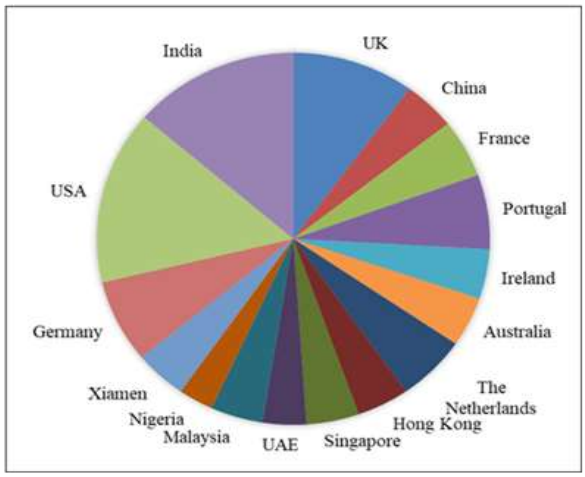

Fig.. 2: Size of supply chains from many parts of the world

Supply chains across diverse sectors have encountered disruptions, including the automobile sector [116], manufacturing sectors [117], the food supply chain [118], and the textile supply chain [101]. Additionally, disruptions have affected supply chains in the energy, IT, electronics, and chemicals sectors. Figure 3 presents an overview of supply chains from various sectors, indicating that 19% of the examined supply chains are associated with the manufacturing sector, 14% with the automobile sector, and the remainder with food, chemical, IT, electronics, transport, textile, marine, construction, healthcare, education service, and energy sectors. The definition of supply chain resilience encompasses three key components: anticipation, resistance, and recovery and response [119].

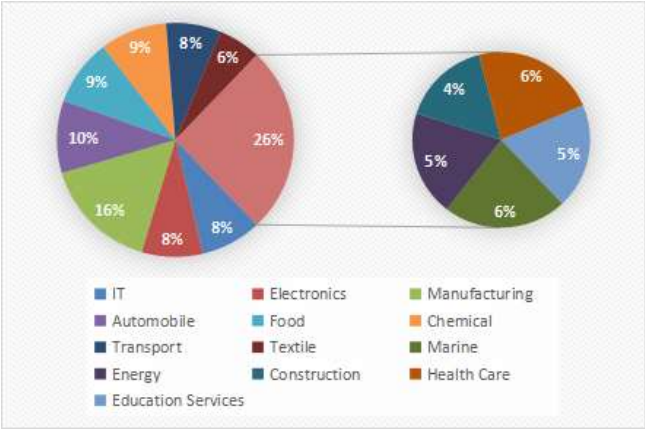

Fig. 3: Distribution of Supply chains from Different sectors

2.4 Risk Assessment and Planning in Supply Chain

Customer expectations and interests constantly change in today's highly competitive and dynamic market, increasing the risk of supply chain disruptions. A company's supply network must be resilient to flourish in this difficult market. Many firms recognize that to create a strong and adaptive supply chain, it is critical to evaluate its performance regularly. In today's quickly changing corporate world, supply chains are more vulnerable to risks caused by reasons such as increased globalization, higher consumer demands, environmental unpredictability, and the incidence of both internal and external risk events, [120], [121], [122]. Scholars and industry experts stress the critical importance of developing the capability to manage risks and disruptions in the supply chain for companies to compete in today's increasingly turbulent and unpredictable marketplace effectively, [123], [124]. Several literature reviews have explored Supply Chain Resilience (SCRES). [124], SCRES were investigated utilizing a Systematic Literature Review (SLR) technique, with a concept mapping framework used to achieve conceptual clarity. Their primary focus was defining SCRES, identifying critical aspects, and investigating managerial methods. They identified three fundamental characteristics of SCRES: resilience phases, resilience methods, and the required competencies. Notably, the research focused mostly on the ability to recover and adapt, with less emphasis placed on anticipating and learning from experience. [125], employed a logic framework to systematically evaluate 228 peer-reviewed publications, resulting in a focused analysis of SCRES literature and its link to outcomes. They saw a change in SCRES research from defining to assessing resilience. The study noted an increase in empirical studies but highlighted a scarcity of field studies, longitudinal research, studies using secondary data, and theoretical frameworks explaining SCRES phenomena.

In their Systematic Literature Review (SLR) of 67 studies, [126] highlighted four phases of Supply Chain Resilience (SCRES): readiness, response, recovery, and growth. Their findings indicated that researchers predominantly concentrated on response and recovery in the face of unexpected disruptions, with comparatively less attention given to readiness and growth. The literature's commonly referenced elements associated with SCRES encompassed supply chain flexibility, redundancy, collaboration, and agility. Also, [126], built a theory on supply chain robustness as a part of SCRES by looking at 94 works in this area. They found less network complexity, visibility, and a focus on risk management were the most important factors in predicting supply chain stability. This study is different from others because it looks at how Supply Chain Resilience (SCRES) enhancers like flexibility, agility, cooperation, and redundancy affect the decrease of different types of supply chain disruptions. The study stresses the importance of organizational practices that have been studied before in handling certain types of disruptions. These practices include supply and demand, process, control, and the environment. The study used a thorough five-step method to gather and look at peer-reviewed journal articles written from 2000 to 2023. Part of the process was coming up with research questions, finding relevant studies, picking and judging articles, analyzing and synthesizing them, writing up the results, and putting them to use. The next section examines Supply Chain Risk Management (SCRM) and offers a framework for categorizing various risks. This is followed by a thorough analysis of SCRES and an investigation into the critical functions performed by adaptability, agility, teamwork, and redundancy as vital SCRE boosters.

Many approaches are used in the literature to classify supply chain risks: (1) the viewpoints on corporate governance, financial risk, and multi-level complex systems [127], [128]; ((2) macro and micro risk [128]; (3) operational and catastrophic risks; (4) disruption and operational risks [129], [130]; (5) internal and external disruption risks availability [131]. Nonetheless, studies by [117], [118], [127] demonstrate disagreements in classifying and defining every type of supply chain disruption risk. This study expands on previous research classifications by defining five supply chain disruption threats, as shown in Appendix in Figure 4.

The two main components of demand risk are (1) the potential for variations between actual and expected demand and (2) possible interruptions to the smooth flow of goods and information within the network or between focal firms and the market. Demand risk is influenced by various factors, including erratic or unexpected demand, inaccurate or incomplete customer information about orders or demand amounts, unusual delays in customer payments, changes in the market, inaccurate forecasts, and creative competitors. The two main components of supply risk are (1) the potential for changes in the timeliness, quality, and quantity of incoming supplies and (2) the potential for disruptions in the information and product flow

throughout the network, especially upstream of the focal firms. Supply chain managers aim to foster strong supplier relationships while lowering the cost of managing multiple vendors.

Supply risks are caused by poor logistics performance on the part of suppliers, including problems with supplier quality, abrupt supplier failures, potentially as a result of bankruptcy, poor logistics performance by logistics service providers, fluctuations or shortages in supply market capacity, difficulties with outsourcing and globalization, supplier commitment issues, and a host of other factors. Process risk is the possibility that the anticipated quality and quantity won't be reached in the allotted time. This risk category covers the capacity, timeliness, and quality risks associated with internal operations and incoming and outgoing logistics. Process variability and flow variability are the two forms of unpredictability that give rise to process risk in a manufacturing system. Process risk is also associated with disruptions in domestically held assets and the dependability of infrastructure, transportation, and communication systems. Process risk can also result from technical problems (like machine breakdowns, bottlenecks, rigid processes, unreliable equipment, and lengthy setup times), disruptions in the external IT infrastructure (like computer viruses or software bugs), disruptions in the internal IT infrastructure (like labor strikes, fires, explosions, or industrial accidents), or operator ugliness. Network risk is the term used to describe the presumptions, guidelines, protocols, and practices that dictate how an organization keeps control over its operations. This is also known as control risk. This kind of risk is influenced by variables like order quantities, batch sizes, safety stock regulations, and the protocols controlling asset and transportation management. If the direct competitor of the client company demands that the relationship be broken, a vertically integrated supplier can be exposed to control risk. Other examples of control or network risk factors include asymmetric power connections, a lack of cooperative planning and forecasting, and inadequate visibility throughout the supply chain.
"environmental risk" refers to external risks that can harm a business. Examples of these risks include those that influence specific value streams (such as product contamination) or any link or node in the supply chain vulnerable to accidents, intentional actions, extreme weather, or natural disasters. Political upheaval, terrorism, conflict, disease outbreaks, natural disasters, social unrest, political grievances, economic downturns, and technical developments are just a few of the many causes of environmental risks.

As illustrated in Figure 4 (Appendix), this study suggests classifying discrete risk aspects in a supply chain. One of the main concerns in supply chain risk management (SCRM) is identifying organizational capabilities that improve a company's capacity to react rapidly to supply chain disruptions, [132]. Using the classification of the sources of risk in a supply chain presented in Figure 5 (Appendix), this study explores how businesses may lessen the adverse effects of supply chain disruptions by investing in organizational skills, a topic addressed under Supply Chain Resilience (SCRES).

3 Research Methodology

We performed a critical literature survey for this study to examine the body of knowledge on supply chain resilience. A literature review aims to understand significant problems and obstacles in a particular topic, as well as the field's present state and theoretical advancements [8]. Two steps made up the strategy we used to gather the pertinent publications: first, we used targeted keywords to search databases and journals; then, we tracked the references of the publications we had found in the first step to locate the literature that the databases and journals had not been able to identify. We only considered papers published after 2002 while creating the sample for this investigation. We also provided evidence for the choice of 2002 as the study's beginning year since, before that year, there was not as much discussion about resilience in general and supply chain resilience in particular. Phase 1 of this study's research methodology, "Search Databases and Journals," is depicted in Figure 5 (Appendix). We claim that the caliber of the literature review research's data sources affects its effectiveness. Following [25], we used the Academic Journal Guide (AJG) 2017, a quality ranking from the Association of Business Schools (ABS), UK, to search for high-quality research papers. General Management (GM), Operations Management (OM), and Operations Research and Management Science (OR/MS) are evaluated by the ABS Journal Guide (2015). We searched and compiled supply chain resilience research using Business Source Complete, Engineering Research Database, Taylor & Francis Online, Google Scholar, and Emerald.

The search terms used in supply chain risk management, such as "supply chain resilience," "resilient supply chain," “Risk Assessment in supply chain," "supply chain performance," and " Risk in

Supply chain," were based on Insight and Science Direct in addition to prestigious journals in OM, OR/MS, and GM. Phase 2: Monitor Publications Sourced in Phase 1 for References. The first strategy was looking for papers in a few journals that scored highly in the three management categories listed according to ABS rankings. We performed a second-stage search to discover relevant research published as book chapters or conference proceedings to ensure all related papers were included in the search. Every study paper we examined had links that we checked to see if they led us to more relevant papers. This helped us determine if there was any important study that our literature review had missed.

Using two different search methods, the first search turned up about 150 studies. To make this sample even better, we made sure that works released in areas that weren't related to organizational and supply chain resilience (like material resilience) were left out. This approach led to 150 high-quality research articles that were used as the basis for the study's literature review.

4 Results and Discussion

According to this report, managers must be thoroughly aware of the many SCRES enhancement aspects to address all supply chain disruption risks effectively. The study determined that the key components of each type of SCRES enhancer to mitigate demand disruption risks include manufacturing flexibility, process agility, and collaborative relationships; supplier flexibility, multiple sourcing, and collaborative relationships to mitigate supply disruption risks; process flexibility to mitigate process disruption risks; collaborative communication to mitigate control disruption risks; and operational and logistics flexibility to mitigate environmental disruption risks. The present study has revealed that the significance of many aspects of supply chain agility and redundancy in managing risks associated with either demand disruption or environmental disruption has not been extensively explored in previous research. The critical roles that supply chain redundancy and agility play in reducing the risk of either a process or a control interruption have not been studied. Determining the optimal SCRES technique to address different types of disruption risks would be challenging without an awareness of these linkages. Research in the future may focus on addressing these problems. According to this analysis, 75% of the publications examined how reducing disruption risks affected SCRES. This was followed by 35% that looked at supply disruption risks, 30% that looked at environmental disruption risks, 12% that looked at process disruption risks, and 9% that looked at enhancing resilience in supply chain logistics. Process and control disruption risks have received less attention than demand disruption risks in most of the research, which has examined the effects of these risks on SCRES. Furthermore, while a few studies have examined the concurrent impact of two or three distinct types of supply chain disruption risks on SCRES, including [4], [108], [111], to the best of our knowledge, no studies have examined the concurrent impact of all of these disruption risks on SCRES. It is suggested that these correlations be investigated further.

This study evaluated many different sources to find descriptions of supply chain resilience. We looked at demand, supply, process, control, and environmental risk. We aimed to find the most important parts and factors that make supply chains and transportation resilient. To clarify any confusion about what supply, demand, process, control, and environmental risk mean, we looked at the research and came up with clear definitions for each. To come up with complete definitions for each idea, we looked back at earlier definitions, found themes that kept coming up, and then combined these themes. As presented in [113], the model in the field of supply chain risk has been used as a starting point for more research on supply chain resilience. While most research has looked at the influence of demand disruption risks on SCRES, less emphasis has been paid to the impact of process and control disruption risks. Furthermore, several studies, including [8], [121], and [129], have investigated the simultaneous effect of two or three different types of supply chain disruption risks on SCRES; no studies have been conducted to investigate the simultaneous impact of these types of disruption risks on SCRES. Further research is suggested to discover these linkages.

This study examined the development of supply chain resilience principles as reported in the pertinent literature, starting with their framework. We looked closely at the framework's elements in our research and how these ideas have changed over time. Our comprehensive data analysis developed a more complex and dynamic supply chain resilience model. This required a thorough analysis of the framework's components, a thorough assessment of the body of prior research, and identifying any present gaps in the body of literature. In our research, we present various avenues for future exploration in the field of supply chain resilience. Specifically, within the realms of supply chain redesign and reengineering, a pivotal and as yet

unanswered question pertains to the relative significance of organizational resilience.

The ways that Supply Chain Resilience (SCRE) affects several reputation traits, including financial performance, service quality, dependability, and company attractiveness, are explained in depth in this paper. There will be an extensive explanation of the mechanisms that connect SCRE to various reputation qualities. A key factor in helping businesses achieve and maintain positive financial performance is supply chain resilience or SCRES. Our results show that companies may protect their financial health by taking a proactive stance in the supply chain. A manager emphasized how information scarcity, or lack of visibility, affects response times and how it greatly impacts financial performance. The manager clarified that if the required information is not obtained on time, commodities may arrive in the nation without the required paperwork, which might damage the company's reputation and result in extra expenses for distributors, port authorities, and shipping lines.

According to our research, SCRE also contributes to an increase in the reputation of service quality. All businesses are vulnerable to supply chain interruptions, but how much of an impact they have on the quality of their services depends on how resilient their supply chain is. "The majority of people within a supply chain context understand that things go wrong and that most systems are set up to deliver 99 percent levels of service and quality, so the thing can go wrong," said one of the respondents when asked how they make sure they provide a decent service in the face of interruptions. SCRES improvers to cope with demand disruption risks; supplier flexibility, multiple sourcing, and collaborative relationships to cope with supply disruption risks; process flexibility to cope with process disruption risks; collaborative communication to cope with control disruption risks; and operational and logistics flexibility to cope with environmental disruption risks. This study discovered that just a few studies have looked at the critical impact of various characteristics of supply chain agility and redundancy in dealing with demand or environmental disruption concerns. No studies have been undertaken to evaluate the critical roles of supply chain agility and redundancy in dealing with process or control disruption concerns. Without knowing these linkages, it would be difficult to determine the optimum SCRES strategy for dealing with various types of disruption threats.

This study shows the importance of supply chain resilience (SCRE) in building organizational resilience. Focusing on proactive and reactive capabilities is crucial for businesses looking to position themselves as trustworthy suppliers. Understanding that business settings are inherently unstable and unpredictable; companies need to show that they are dedicated to keeping their word to be seen as reliable and consistent partners. A manager emphasized the need for planning by pointing out the possible damage to one's reputation that may arise from unforeseen interruptions. He said that keeping excess inventory allowed them to meet obligations even in the face of unforeseen circumstances. He underlined the importance of meeting customer expectations by stressing the need to maintain an adequate stock level to fulfill scheduled delivery dates for make-to-order products. Businesses may not be able to avoid supply chain interruptions, but they could get better at withstanding the ones they have already experienced. Consumers value companies that can bounce back from setbacks quickly, but they also expect these businesses to learn from their mistakes and will be better equipped to handle such setbacks in the future. "It also has the potential to impact the end customer if they arrive for their product and it's unavailable," emphasized a manager, highlighting the possible ramifications. These circumstances may lead to issues and subpar service; the severity of the effects depends on how frequently they occur." Our study makes a substantial contribution to our knowledge of the critical role that supply chain resilience, or SCRE, plays in creating and preserving a favorable reputation for a company. In line with research [131], [132], which highlights the significance of resilience in protecting business performance, we claim that SCRE can improve corporate reputation. Moreover, our results clarify the complex mechanism by which many SCRE aspects impact a company's reputation. Notably, our research casts doubt on the notion that increased reputation is invariably the result of reactive resilience. The findings suggest that a company's reputation among supply chain partners and consumers is negatively impacted by frequent interruptions to business. This finding is consistent with the crisis literature, as stated by [122], which shows that a firm's reputation suffers more when it bears a larger portion of the blame for a crisis. We look forward to sharing the full research results at ICPR, and our ongoing data analysis process promises further discoveries.

5 Conclusion

This study looked at the essential topic of reducing interruptions and improving resilience in supply

chain logistics. Following a thorough analysis of the current literature, we discovered a multitude of ideas and methodologies targeted at tackling these difficulties against risk management tactics to technological advancements, it is clear that firms may use a wide range of measures to protect their supply chains against interruptions. Unstable environments make supply networks vulnerable to disruptions. Supply Chain Resilience (SCRE) has become a popular risk mitigation strategy during the past decade. Despite its acknowledgement, SCRE's benefits to enterprises are uncertain. This article illuminates how SCRE helps firms build and maintain a good image and positive reputation. We analyzed the literature on supply chain resilience from 2000 to 2023 to examine its history and evaluate organizational resilience definitions and principles. We then redefined enterprise and supply chain resilience to represent distinct resilience levels. This study presents restrictions on the conclusions and ramifications. First, the influence of a supply chain's restoration ability—which this study examined—relates to its capacity to adjust to disturbances, maintain performance, and move fast to make changes. Key indicators include resilient resources, learning capacities, and cash reserves. There is a lack of understanding of the fundamental components of supply chain resilience and their interrelationships, the connections between risks and their effects on supply chain management, and the approaches for handling these important problems. Future studies should test the suggested model empirically, according to the implications.

The study widely discusses sourcing options that improve supply chain resilience, but a complete comparative examination of their pros and cons is lacking. Future researchers should use empirical and analytical methods to study the effects and relative importance of alternative techniques. This study helps manufacturing business practitioners and managers increase supply chain resilience. The study emphasizes the link between supply chain resilience and organizational effectiveness. This analysis emphasizes the need for firms to identify and assess supply chain disruptions, including internal and external reasons. Understanding and mitigating supply chain disruptions is crucial for businesses to maintain efficiency and resilience. Supply chain disruptions can halt production, delay deliveries, and impact customer satisfaction. By identifying potential disruptions, whether they stem from internal issues like machinery breakdowns or external factors like natural disasters, businesses can take proactive measures to minimize downtime. Certain disruptions may arise due to regulatory changes or compliance issues within the supply chain. By identifying these potential disruptions early on, businesses can ensure compliance with relevant regulations and avoid costly penalties or legal issues. A comprehensive risk management strategy should be developed and ranked according to the likelihood and effect of handling identified risks. Our literature study produced a framework for supply chain resilience's guiding principles and elements for improvement. This study should serve as a foundation for future research on supply chain resilience.

As revealed from the literature review, collaboration is the most vital strategy for dealing with control disruptions, while flexibility is the most important strategy for dealing with demand, supply, process, and environmental disruptions. A framework is then created to identify the right antecedents in enhancing resilience to various forms of supply chain disruptions. This study discovered that understanding the many characteristics of SCRES enhancers is critical for managers to deal with each type of supply chain disruption risk. This study identified manufacturing flexibility, process resilience, and collaborative relationships as important dimensions of each type of SCRES enhancer to cope with demand disruption risks; supplier flexibility, multiple sourcing, and collaborative relationships to cope with supply disruption risks; process flexibility to cope with process disruption risks; collaborative communication to cope with control disruption risks; and operational and logistics flexibility. This study discovered that just a few studies have looked at the critical impact of various characteristics of supply chain agility and redundancy in dealing with demand or environmental disruption concerns. These strategies include diversifying supplier bases, implementing robust risk management protocols, enhancing transparency and communication across the supply chain, investing in advanced technologies such as IoT and AI for real-time monitoring and predictive analytics, and fostering stakeholder collaboration. Additionally, the conclusion underscores the importance of agility and flexibility in adapting to unforeseen disruptions and the necessity of continuous evaluation and adaptation of resilience measures to navigate evolving challenges in the global marketplace effectively. However, despite the quantity of information accessible, it is critical to remember that the environment of supply chain logistics is always changing, and new disruptions may occur in the future. As a result, ongoing study and adaptation are required to

guarantee that supply networks remain strong and resilient in the face of unanticipated events.

- Organizations should adopt sophisticated technologies like blockchain, IoT (Internet of Things), and AI (Artificial Intelligence) to improve supply chain visibility, traceability, and predictive capabilities.
- Encouraging collaboration and fostering open communication among supply chain partners can facilitate quicker response times and better decision-making during disruptions.
- Employing strategies such as dual sourcing, multi-sourcing, and establishing redundant supply routes can help mitigate the impact of disruptions by ensuring alternative sources of supply.
- Companies should prioritize investments in strengthening their supply chain networks over cost minimization, understanding that resilience is a competitive advantage in today's uncertain business climate.
- Conducting scenario planning exercises and risk simulations can help organizations prepare for various disruption scenarios and develop contingency plans accordingly.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the authors used Quillbot tools, in order to paraphrase and proofread. After using this tool/service, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

MA, MK, and ZA conceptualized the paper and participated in the screening and extraction of articles. MA wrote the original draft with input from MK and ZA. MK and ZA reviewed the original draft and edited the manuscript.

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The authors declare that there are no conflicts of interest associated with the preparation of this manuscript.

APPENDIX

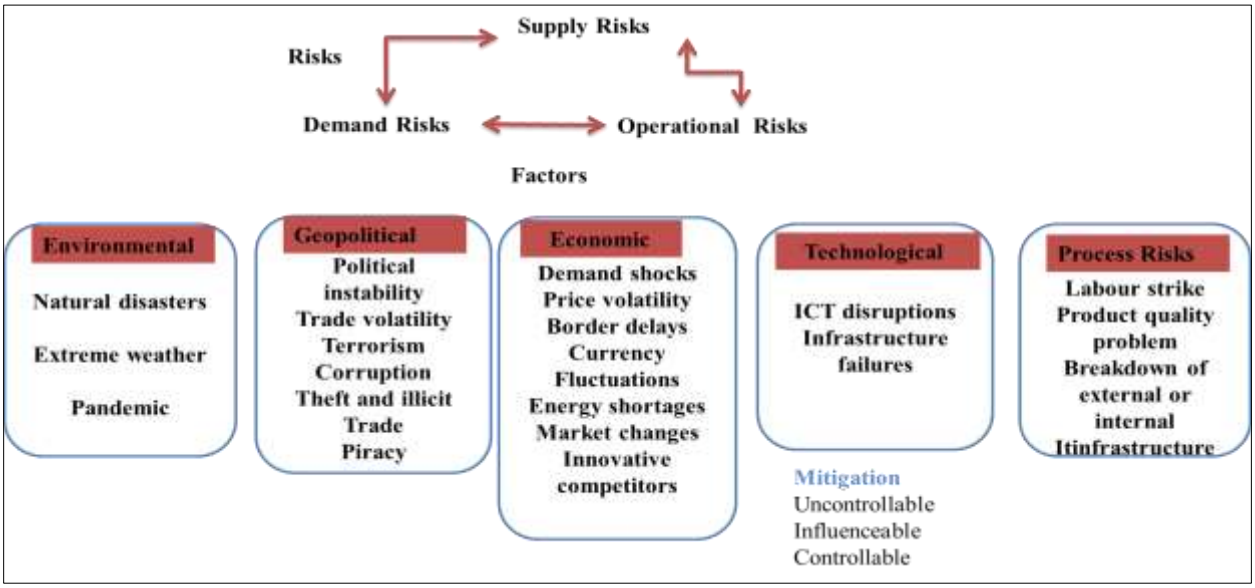

Fig. 4: Supply chain sources of risk

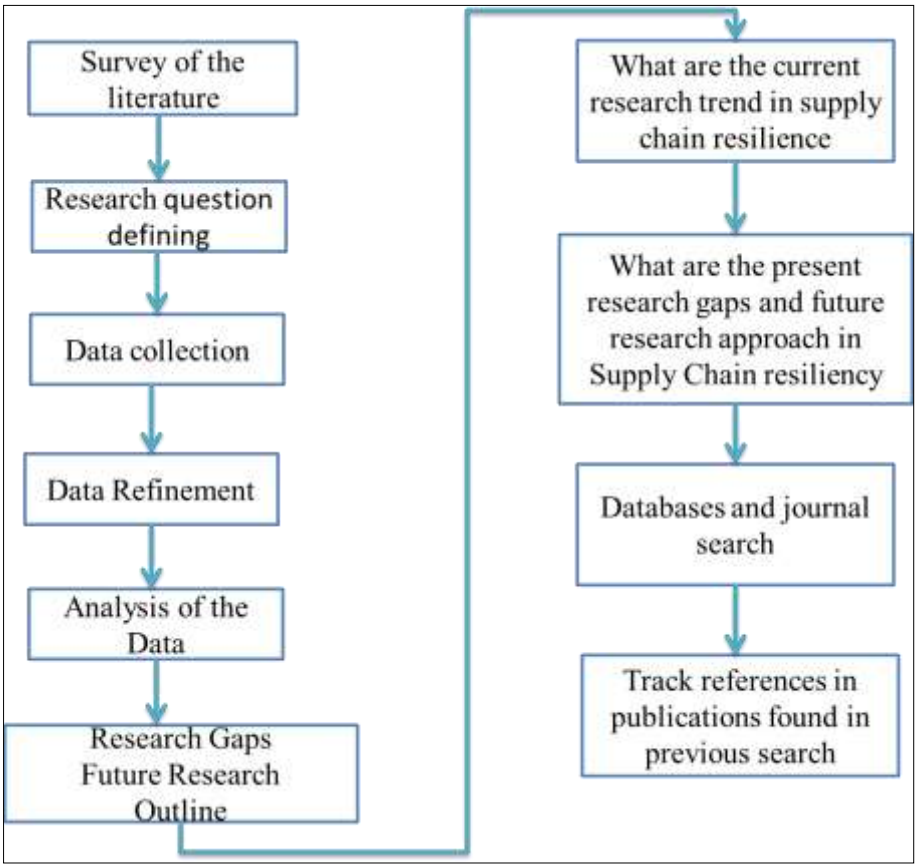

Fig. 5: Research Methodology Approach

Table 1. Indicators for assessing business product supply chain resilience

Dimension	Description	Evaluation indicator	Reference
Restore ability	• The "restore ability" of a supply chain refers to its ability to adapt to disruptions, sustain performance, and implement measures quickly. Key indicators include financial reserves, learning capabilities, and resilient resources. • Top management's sustainability beliefs are crucial for bolstering supply chain sustainability. Integrating sustainability indices into business operations signals companies to embrace green technology, as seen in Wal-Marts sustainable seafood supply. • Establishing sustainability indicators in business performance management can facilitate sustainable practices.	• Financial reserve, • Risk Assessment and Management, • Resilient resources, • Inventory Management • Technology Integration	[33], [40], [37], [80]
Adaptability	• Supply Chain Resilience (SCR) is crucial for responding to market demand in critical situations. Strategic deployment of surplus inventory and substitutable capacity is essential, especially in bottlenecks. • Using big data analysis and analytics provides a competitive advantage in green supply chains. Investing in infrastructure development and process management can reduce information lead times and enhance reliability. • Implementing inventory redundancy, product substitutability, and digital infrastructure contributes to sustainability and innovation. • By prioritizing these adaptability factors, organizations can strengthen their supply chain resilience, ensuring they are well-equipped to navigate the challenges posed by dynamic and unpredictable business environments.	• Material redundancy • Replaceability. • Digital infrastructure construction	[38], [80]
Responsiveness	• Encouraging high levels of coordination amongst entities in the business supply chain is necessary to maintain the quality of products from production to the final client. • As demonstrated by IKEA's demand for environmentally friendly practices from its suppliers, which are in line with IKEA's environmental strategy, collaboration helps reduce uncertainty by effectively allocating risks. In the face of risks, agility emerges as a key factor in Supply Chain Resilience (SCR), according to [65]. • Organizations can improve their supply chain resilience and more adeptly handle the difficulties presented by disruptions in today's ever-changing business landscape by concentrating on five responsiveness elements.	• Collaboration capability • Agility	[61], [80], [81], [82]
Predictive ability	• The increasing complexity and susceptibility to disruptions in supply chains within the business sector are evident, driven by the rapid pace of global markets and evolving market dynamics. • The pivotal role of information processing capabilities and technology cannot be overstated, extending across enterprises, cooperatives, and individual farmers. • Enhancing organizational informationization, regulating information connectivity, ensuring resource availability, and establishing traceability mechanisms all contribute to minimizing the impact of risks and fortifying the overall resilience of the supply chain. • By integrating these predictive ability factors, organizations can proactively enhance their supply chain resilience, making them better equipped to navigate uncertainties and disruptions in the dynamic business environment.	• Informatization level	[51], [80], [82], [83]
Sustainability	• Sustainable supply chain management is defined as "the management of material, information, and capital flows, as well as cooperation among companies along the supply chain while taking into account goals from all three dimensions of sustainable development, namely economic, environmental, and social, which are derived from customer and stakeholder requirements." • Integrating sustainability into the factors influencing supply chain resilience is essential for creating a resilient and environmentally responsible supply chain. Sustainability helps mitigate environmental impacts and contributes to long-term	• Green Sourcing and Procurement, • Circular Supply Chains, • Environmental policy, • Reducing Emissions, • Supply Chain Transparency,	[48], [49], [80], [84], [85], [86]

Dimension	Description	Evaluation indicator	Reference
	business viability.	• Social Responsibility, • Business sustainability goals	
Technological innovation	• Technological innovation may help organizations grow; we will investigate the impact of technological innovation on the relationship between digital transformation and operational resilience in port firms. Besides altering the corporate environment, digital technology has altered the company model and revolutionized firm strategy. • technology innovation is a key way to make supply lines more resilient by dealing with many problems and unknowns. The supply line is more resilient when new technologies are used.	• Technology, Predictive Analytics, • Block-chain Technology, • Additive Manufacturing, • Cyber-security Measures, • Supply Chain Analytics Platforms.	[87], [88]
Increased demand volatility	• A big threat to the strength of the supply chain is rising demand instability. When organizations try to handle and adapt to changing demands, they need to think about a lot of different factors and methods. • Adopting new technologies, working together along the supply chain, and making long-term plans are all things that are needed to handle and adapt to changing market conditions. • Having multiple suppliers for important parts or goods makes the supply chain more resilient because problems with one supplier or location are less likely to cause disruptions.	• Scenario Planning and Risk Management, • Investment in Technology and Automation, • Inventory Optimization	[89], [90]
Reduced supplier base	• Reducing the supplier base can positively and negatively affect the supply chain's resilience. It's critical to weigh various elements thoroughly and implement procedures to reduce potential dangers. • A more robust partnership can be fostered by enhanced communication and collaboration with a smaller supplier base, resulting in a better awareness of each other's strengths and potential obstacles. • To lessen the impact of future interruptions, implement risk mitigation methods like dual-sourcing essential components or creating backup plans. • Geographic diversification lowers the risks from disruptions that occur locally, like natural disasters, shaky governments, or changes to the rules.	• Supplier Diversification, • Supplier Relationship Management, • Strategic Inventory Management	[58], [59]
Globalization of the supply chain Increased outsourcing	• Globalization makes it easier for supply networks to be more diverse. This lowers the risk of being too dependent on one area or country. • It's getting harder to manage and coordinate actions that happen in different parts of the world, so we need better ways to communicate and work together. • A global supply chain can help you reach more customers, cut costs, and get better deals as your business grows. Focusing too much on lowering costs could make supply lines that are streamlined and consolidated less flexible, which would make them more likely to break down. • More and more, supply lines are going global, but this brings new problems and issues that could make supply systems less reliable. • Companies need to come up with plans that let them use the benefits of a foreign supply chain while also planning for and taking care of the risks that come with it. • In order to do this, you need to use cutting-edge technology, encourage teamwork, and make backup plans for when things go wrong.	• Information Technology Integration, • Supply Chain Visibility, Resilience Planning, and Risk Mitigation.	[91], [92]
Specialized factories	• Specialized factories often have a lot of experience and knowledge when it comes to making certain things or parts. If specialized companies depend too much on each other, especially if they are all in the same area, they might be more likely to be affected by problems. • When making a certain type of product, specialized companies	• Expertise and Specialization, • Economies of Scale, • Supply Chain Complexity, • Supplier	[56], [93], [94]

Dimension	Description	Evaluation indicator	Reference
	may be able to get economies of scale and work more efficiently. Because of a high level of specialization, production lines may not be as flexible, making it harder to adapt to changes in demand or problems in the supply chain. • Sometimes, specialized factories have to use strict quality control measures because the things they make have special needs. If there is a problem with specialized manufacturing, it might be hard to keep the quality of the product the same. This could lead to problems in the supply chain. • Firms want to take a broad approach in order to make the supply chain more stable when specialized manufacturers are involved. • This means spending money on technology that lets you see what's going on in real-time, working on your communication and teamwork, getting supplies from a variety of places, making backup plans, and doing risk assessments to find and fix any weaknesses in the way you make things that are specific to your needs.	Relationships.	
Centralized distribution	• Having distribution organized can often lower holding costs and make it easier to keep track of stock. There could be problems throughout the supply chain if there are issues at the central transport center. This could lead to delays and lost stock. • Costs can go down when shipping is centralized because of better transportation and economies of scale. If you try to cut costs too much, you might not have enough backup plans. This would make the supply chain more likely to have problems in the hub, which is where most of the spread happens. • To make the supply chain more resilient in a centralized delivery model, businesses should carefully weigh the benefits of efficiency and redundancy, spend money on technology that lets them see what's happening in real-time, and make detailed backup plans.	• Efficient Inventory Management, • Improved Visibility, • Reduced Redundancy, • Flexibility and Adaptability.	[95], [96]