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ENTRENCHING SUPPLY CHAIN RESILIENCE BEYOND BOUNDARIES: A DYNAMIC FRAMEWORK IN POST-COVID LANDSCAPE

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ABSTRACT

The unprecedented global impact of the COVID-19 pandemic has heightened the critical significance of supply chain resilience (SCR) within the contemporary supply chain landscape. The body of literature dedicated to SCR has significantly expanded since the early 2000s, with numerous scholars delving into the construction of SCR frameworks based on empirical studies and literature reviews. Despite the usefulness of these frameworks, there has been a notable absence of a generic framework that transcends industry and national boundaries, particularly in light of the disruptive events triggered by the COVID-19 crisis. This study employs the narrative literature review method to intricately integrate itself into the existing SCR literature, conducting a comprehensive analysis, identifying theoretical foundations and empirical discoveries, and synthesizing this knowledge into a cohesive and all-encompassing structure to formulate a conceptual framework for SCR. This generic framework is designed to accommodate the unique characteristics of various supply chains. While the empirical validation of this innovative framework remains pending, it presents a valuable opportunity for scholars to engage in scientific investigations on SCR, building upon the collective insights of their predecessors. Moreover, practitioners can leverage this framework to scrutinize and construct resilient supply chains capable of withstanding future disruptions.

Keywords

Supply chain resilience, SCRID framework, supply chain

INTRODUCTION

As the international network of supply and demand gets more intertwined, the role of the supply chain (SC) has become increasingly important in the past few decades. Unfortunately, SC is constantly challenged by disruptive events in many forms and scales. Natural calamities like the Gujarat earthquake of 2001, the Indian Ocean earthquake and tsunami in 2004, hurricane Katrina in 2006, and the tsunami in Japan in 2011 can cause catastrophic supply chain disruptions (SCDs) (Gou & Lam, 2019; Ivanov & Dolgui, 2021). Other man-made SCDs can be trade restrictions, labour strikes, system failure, harbour congestions, theft, fire, and explosions (Chowdhury et al., 2021). These potential types of SCD were investigated and ranked accordingly (Fan & Stevenson, 2018; Ho et al., 2015). These SCD events jeopardize critical infrastructures (Dynes, 2008), undermine operational activities, and impair performance (Hosseini, Ivanov, et al., 2019).

Although disease outbreaks have been regularly exacting contemporary supply chain management (SCM), the COVID-19 outbreak demonstrates that epidemics and pandemics can wreak upheaval nuisance to SCs worldwide (Queiroz et al., 2020). Epidemics and pandemics bring about enormous internal and external systemic threats to the entire SC ecosystem (Golan et al., 2020; Lin et al., 2020). SCs are facing greater challenges than ever before amid the COVID-19 epidemic (Ozdemir et al., 2022). No SC is prepared for COVID-19 as a global pandemic was viewed as an implausible event (Hilderink, 2020). Sherman (2020) submits that 94% of the Fortune 1,000 firms experienced SCDs caused by COVID-19. The SC impacts were observed at all levels and stages simultaneously (Gunessee & Subramanian, 2020; Paul & Chowdhury, 2020), rendering substantial disruption to the flow of SC (Chowdhury et al., 2021). Among the negative implications include diminishing SC's performance and efficiency (Guan et al., 2020; Ivanov, 2020a), international logistics disruption (Siche, 2020), supply shortage (Ozdemir et al., 2022), demand surges (Remko, 2020), triggering ripple effects across the SCs (Ivanov, 2020b; Ivanov & Dolgui, 2020), and revenue decreases (Ivanov & Dolgui, 2021). Ripple effects were witnessed when a suspension of operations in China caused manufacturing and retail supply disruptions in the United States (US) and Europe (Kinra et al., 2020). Akintokunbo and Adim (2020) submit that the tourism, aviation, automotive sectors, telecom, food, oil, construction, and healthcare industries are severely affected. No industry is exempted from this global-scale SCD (Belhadi et al., 2021). The heterogeneity of industry characteristics, demand, and supply patterns leads to heterogeneous impacts in different sectors (Sharma et al., 2020).

The COVID-19 pandemic has wrought unprecedented disruptions and challenges in the realm of SCM, reshaping the dynamics of global trade and commerce (Ryan et al., 2022). The outbreak led to widespread lockdowns, travel restrictions, and labour shortages, severely impacting the production, distribution, and transportation of goods (Butt, 2021b). SCs, traditionally built for efficiency and cost-effectiveness, faced vulnerabilities as demand patterns shifted, and uncertainties prevailed. The pandemic exposed the fragility of lean SCs, where minimizing inventory and relying on just-in-time strategies left little room for absorbing shocks (Alhawari et al., 2021). Businesses grappled with fluctuations in demand, supplier closures, and logistic bottlenecks, triggering a re-evaluation of SC strategies. The imperative for resilience and agility in SCs became apparent, urging organizations to reassess risk management practices, diversify sourcing strategies, and invest in digital technologies to enhance visibility and flexibility (Statsenko et al., 2023). As the global community navigates the ongoing challenges, the pandemic has catalysed a paradigm shift in SC thinking, emphasizing the need for robust, adaptable, and resilient SC frameworks to withstand future disruptions (Paliwal et al., 2023).

Scholars have consistently emphasized the imperative for organizations to cultivate supply chain resilience (SCR) to anticipate, respond to, adapt, and swiftly recover from supply chain disruptions (SCDs) (Jüttner et al., 2003; Ponomarov & Holcomb, 2009). While enhancing SCR capabilities allows firms to absorb and mitigate the impact of adverse disruptions (Scavarda et al., 2015), traditional supply chain optimizations have predominantly focused on efficiency, cost reduction, and inventory minimization, often neglecting the critical aspect of dedicating sufficient attention to SCR

(Dohale et al., 2021; Sodhi & Tang, 2009). The outbreak of the COVID-19 pandemic serves as a poignant reminder of supply chain vulnerability (SCV), prompting both governments and firms to take swift actions within a dynamic context (Ivanov & Dolgui, 2022; Sarkis et al., 2020). This elevates SCR to a central position in the realm of supply chain risk management (SCRM) (Spieske & Birkel, 2021). Existing literature reflects a substantial exploration of SCR within the scientific community, particularly in the aftermath of the COVID-19 outbreak (Naimi et al., 2022; Suryawanshi & Dutta, 2022). Shekarian and Parast (2021) contend that numerous review studies on SCR have been conducted in the past five years. Suryawanshi and Dutta (2022) identify the automotive, perishable goods, and electronics sectors as the most extensively researched areas. The COVID-19 pandemic has significantly impacted commodities such as oil, tourism-related services, food supply, and certain non-essential consumer goods, leading to substantial economic challenges in these sectors. Vanany et al. (2021) assert that SCR is pivotal for the sustainability and survival of firms. In a review paper, Naimi et al. (2022) underscore a prevalent theme in recent literature, which is the redesign of supply chains to fortify SCR.

In navigating the extensive diversity of SCs, the development of a universal SCR framework becomes imperative, serving as a standardized and adaptable structure that transcends both industry and geographical boundaries. Such a framework not only offers a comprehensive and cohesive approach to mitigating disruptions, fostering agility, and enhancing overall SC robustness but also provides a unified strategy to effectively address the myriad challenges and uncertainties inherent in diverse SC contexts. Despite scholarly endeavours, a noticeable gap persists in the availability of a universal SCR framework capable of addressing the heterogeneity of SCs across various industries and countries. Many studies tend to focus on specific industries or countries, resulting in a proliferation of diverse SCR frameworks (Chowdhury & Quaddus, 2017; Kamalahmadi & Parast, 2016; Pettit et al., 2013). This paper adopts a structural approach by presenting a generic SCR conceptual framework applicable to multiple industries (Duchek, 2020).

In section two, an in-depth review of the extant literature on SCR, focusing on before and amid COVID-19, is delineated before discussing the theoretical gaps in SCR. Under section three, the research method employed in this study is deliberated. In section four, a generic SCR conceptual framework derived from the collective scientific findings is presented with supporting literature. Each dimension in the framework and its relationships and interactions will be discussed. In the final section, a summary of findings and future research directions are deliberated.

LITERATURE REVIEW

Supply Chain Resilience

The concept of resilience originated from multi-disciplines including engineering, ecology, psychology, and disaster relief (Walker & Salt, 2012). Holling (1973) was a pioneer in introducing resilience as the ability to assimilate changes. Since then, countless scholars adopted this concept in various fields (Folke, 2006). According to Bai and Ran (2022), SCR can be traced to Rice and Caniato (2003). SCR is defined as a system's ability to restore to its original condition within a reasonable time after experiencing disruptions (Christopher & Peck, 2004). Subsequent scholars expanded this definition to include absorbing changes, developing responses, preparedness, adaptability, and desired outcomes (Hohenstein et al., 2015; Lengnick-Hall et al., 2011; Piya et al., 2022; Ponomarov & Holcomb, 2009). In short, SCR is the capability of an SC to anticipate (Blackhurst et al., 2011), respond, and adapt to disruptions (Ambulkar et al., 2015; Wieland & Durach, 2021), minimize vulnerabilities impacts (Chowdhury & Quaddus, 2015), capitalize to gain advantages (Bahadori et al., 2020; Polater & Demirdogen, 2018), and recover to desired performance level (Ozdemir et al., 2022). SCR is a remedy for SCDs (Nikookar & Yanadori, 2022). SCR involves balancing resistance and recovery measures (Chowdhury & Quaddus, 2017; Christopher & Holweg, 2017). SCR can deliver vast benefits to firms including system performance enhancements (Pettit et al., 2010), improved market competitiveness (Ponomarov & Holcomb, 2009), market share increase

(Sheffi & Rice Jr, 2005), vulnerabilities reduction (Pettit et al., 2013), higher survival rate (Sá et al., 2020), faster recovery (Wieland, 2021), improved customer service, and higher profitability (Piya et al., 2022). Regarding the theoretical grounding, SCR studies are often related to dynamic capabilities (DC), the resource-based view (RBV), contingency theory, and organizational information processing theory (Bode et al., 2011; Dubey et al., 2019, 2021). Tukamuhabwa et al. (2015) used a complex adaptive systems (CAS) theory to study SCR.

SCR is a subfield of SCRM (Suryawanshi & Dutta, 2022) and thus examining SCR from an SCRM context can offer valuable insights into the understanding of SCR (see Figure 1). SCDs conventionally give rise to a spectrum of SC risks within an organization. These risks exhibit variability across organizations, contingent upon the inherent levels of SC robustness and vulnerability within each organizational context. The efficacy of SCR within an organization exerts a direct influence on both the robustness and vulnerability of its SC. The organizational SC vulnerability, in turn, delineates the requisite level of concerted efforts and strategic focus necessary for establishing an effective SCR framework. Lastly, the primary purpose of SCR lies in its construction to ensure that, in the event of SCDs, the organization can realize its desired outcomes swiftly and with minimal disruption across the entire SC, emphasizing a paramount concern for expeditious recovery and continuity.

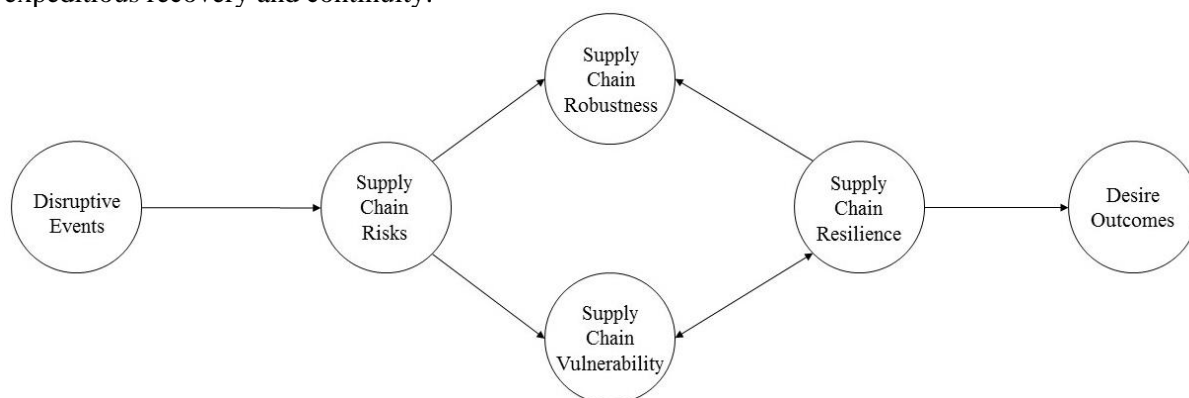


Figure 1. Role of supply chain resilience in supply chain risk management

Source: Author's construct

SCDs are usually triggered by disruptive events that diminish environmental stability and increase environmental dynamism (Bode et al., 2011). WEF (2012) identifies nineteen disruption triggers categorized under technological, geopolitical, environmental, and economic. Furthermore, Pettit et al. (2013) deliberate three types of SCD: production, supply, and demand disruptions. These disruptive events can impact SC directly or indirectly (causing ripple effects) (Scheibe & Blackhurst, 2018; Zhang et al., 2018). While these events cause disruptions, Sheffi (2015) highlighted the differences between global-scale disruptions and localized disruptions. SCDs usually exhibit low probabilities of occurrence, yet severe negative aftermaths on SC operations (Torabi et al., 2015). An SCD in a supply network can exponentiate into a systematic impact on the entire SC ecosystem (Scheibe & Blackhurst, 2018), and the COVID-19 pandemic is a classic example. Pandemics are not typical SCDs (Craighead et al., 2020), but rather disruptions with long-term effects, ripple effect propagation, and extreme unpredictability (Ivanov, 2017). SCDs caused by the COVID-19 pandemic are heterogenous (Vanany et al., 2021). SCDs pose risks to SC (Hosseini, Ivanov, et al., 2019; Ivanov, Dolgui, & Sokolov, 2018; Kinra et al., 2020) that demand attention (Naimi et al., 2022). In other words, SC risks are manifested in the form of SCDs (DuHadway et al., 2019). Fahimnia et al. (2018) categorize SC risks into disruption and operational risks. The former is mainly high impacts and low-frequency events, while the latter deals with ordinary operations hiccups (Hosseini, Ivanov, et al., 2019). Shekarian and Parast (2021) classify SC risks into demand risks, supply risks, process risks, control risks, and environmental risks. Hobbs (2020) found that retailers struggle to recognize the SC risks caused by COVID-19. This can be explained by the novel characteristics and implications of the pandemic. Ash et al. (2022) describe risk as an environmental element, while

resilience is a characteristic of SCs. SC becomes volatile, unpredictable, and complicated when interacting with these disruptions (Kamalahmadi & Parast, 2016).

SCDs may not be treated as high-priority risks if they do not cause negative impacts on SC. Global SCs, lean SCs, Single-supplier dependence, highly specialized SCs, Just-in-Time SCs, technology-dependent SCs, and perishable goods SCs are examples of SC configurations that exhibit a higher susceptibility to SCDs. SC robustness can cushion the impact of SCDs and maintain SC stability (Aastvedt et al., 2021; Wallace & Choi, 2011). SCR investments can strengthen SC robustness and together they can mitigate the impacts caused by events like the COVID-19 outbreak (Bai & Ran, 2022). Contrary, when SC risks meeting SC vulnerability, negative impacts are eminent (Chowdhury & Quaddus, 2017). In literature, SC risks are classified as vulnerabilities (Svensson, 2002), which include external pressures, resource limits, sensitivity, deliberate threats, SCD, and turbulence (Pettit et al., 2010). The SC's structural complexity and interdependencies enhance vulnerability due to the formation of the ripple effect (Ivanov & Dolgui, 2019).

Scholars argue that vulnerabilities and resilience are interconnected (Carissimi et al., 2022; Jüttner & Maklan, 2011). An increased SCR can reduce SCVs, and thus cushion the negative impact of SCDs (Colicchia et al., 2018; Li et al., 2020; Wieland & Wallenburg, 2012). Chowdhury and Quaddus (2015) argue that contemporary SC is becoming more vulnerable due to the intensification of SCDs. The COVID-19 pandemic causes long-term SCDs and exposes SCVs (Ash et al., 2022). SCDs and risks have an adversarial effect on a firm's success and growth (Belhadi et al., 2021), and thus it is paramount for SC to be resilient. SCR involves risk response strategies, future risk mitigations, and restoration efforts to eradicate these vulnerabilities (Aman & Seuring, 2021). SCR overcomes SCVs and decreases SC risks by enabling organizations to anticipate, respond to, and recover from disruptions, thereby minimizing the impact on operations and ensuring continuity (Heckmann et al., 2015). Conversely, effective SCR strengthens SCR by systematically identifying, assessing, and mitigating potential risks, fostering a proactive approach to handling uncertainties and disruptions in the SC. The firm's capacity to respond to disruption and soften its negative effects determines the SCR (Brandon-Jones et al., 2014).

Before COVID-19

Studies on SCR strategies have been a popular research theme since the early 2000s (Ali et al., 2021). Early studies on SCR concentrated on the capacity of SCs' adaptability and recovery during and after a crisis (Rice & Caniato, 2003). Subsequently, scholars' attention moved to pre-crisis examinations. Ponomarov and Holcomb (2009) emphasize building preparedness in SCs during disruptive events through proactive measures. In another study, risk anticipation before disruptive events was highlighted (Ponis & Koronis, 2012). Some scholars took a step further to deliberate elements to build SCR (Mandal, 2013). Nevertheless, Hohenstein et al. (2015) suggested firms can look beyond the SCD and leverage SCR to make the most of any post-crisis chances to increase customer satisfaction, market share, and financial success. Furthermore, SCR literature reveals that scientific efforts have been devoted to examining the various facets of SCR. López and Ishizakab (2019) studied the relationship between the locational decision in the offshore outsourcing process and SCR, while Pavlov et al. (2017) investigated SCDs that affect multiple components of SC at various locations. Levalle and Nof (2015) studied different forms of SC, including digital, service, and physical SCs, whereas Razmi et al. (2017) studied the causal relationship among SCR factors. The effectiveness of SCR in SMEs was investigated by Kamalahmadi and Parast (2016). Using SC adaptability and alignment to enhance SCR was empirically discussed by (Aslam, Khan, et al., 2020). SCR studies were conducted in diverse industries such as bio-gas (Qiao et al., 2013), transportation and logistics (Ramezani et al., 2013), automobile (Govindan, 2015), construction (Arashpour et al., 2017), IT and electronics (Amin & Zhang, 2013), medical supplies (Pishvae et al., 2012), manufacturing (Brandon-Jones et al., 2014), and ready-made garment industry (Chowdhury & Quaddus, 2015).

There is extant literature identifying the various capabilities and enablers associated with SCR (Kamalahmadi & Parast, 2016). Brusset and Teller (2017) examined three SCR capabilities through the lens of internal processes, external practices, and integration. In a study, diversity, mobility, efficiency, flexibility, integration adaptability, reliability, and safety were identified as restorative SCR measures (Chen & Miller-Hooks, 2012). In another study, Gunasekaran et al. (2015) purport that agility, diversification, reshoring, diversifying supply sources, flexibility, and higher inventory help to build SCR. Chowdhury and Quaddus (2015) submit that relationship building with buyers and suppliers, responsiveness to customers, skill and efficiency development, demand forecasting, quality control, information and communications technology adoption, security system improvement, and backup capacity are good SCR strategies for the ready-made garment industry. Pettit et al. (2013) argue that personal security, empowerment, and collaboration with the government are effective SCR strategies during a pandemic. Alertness, agility, and preparedness are three pillars of SCR (Li et al., 2017). Hosseini, Morshedlou, et al. (2019) proposed classifying SCR capabilities into absorptive, adaptive, and restorative, each with specific objectives to respond to SCDs. Other SCR capabilities include SC visibility (Brandon-Jones et al., 2014), integration (Braunscheidel & Suresh, 2009), redundancy (Kamalahmadi & Parast, 2017), backup capacity (Pettit et al., 2013), velocity (Adobor & McMullen, 2018), financial strength (Tang, 2006), customer satisfaction, and market position (Zsidisin et al., 2005). A synergistic effect can be achieved with the integration of SCR and efficiency (Ivanov & Dolgui, 2019). Wang et al. (2018) took SCR strategies and classified them under awareness, estimation, and defence. Knowing SCR strategies is one thing, applying them to achieve the desired results is another. Performance objectives may have an impact on trade-offs between various investments, where robustness may assist SCs that significantly rely on dependability, whereas resilience may be more suited to firms that emphasize flexibility and speed (Brandon-Jones et al., 2014). Tan et al. (2019) indicated that contingency strategies work better for short-term SCDs while mitigation approaches are better suited for long-term SCDs.

Several scholars conceptualize SCR frameworks based on their empirical findings and literature reviews (Ali et al., 2017; Ehrenhuber et al., 2015). Kamalahmadi and Parast (2016) developed a framework based on collaboration, flexibility, SC re-engineering, agility, and SCRM culture development. Another SCR framework encompassing seven clusters of vulnerabilities and fourteen capabilities was introduced by Pettit et al. (2010, 2013). Chowdhury and Quaddus (2017) presented an SCR framework consisting of SC design quality, reactive capability, and proactive capability. SCR modelling entails many challenges due to the heterogeneity characteristics of SC and SCDs (Ribeiro & Barbosa-Povoa, 2018). These SCR frameworks provide theoretical groundings for future research.

Besides SCR frameworks, scholars also published literature on SCR's measurement and assessment (Chowdhury & Quaddus (2016). Soni et al. (2014) conducted a study on the SCR measurement index, while Spiegler et al. (2012) and Pettit et al. (2013) discussed measurement tools and methods for SCR assessment. Financial performance, market penetration, and customer service performance are good metrics of the desired SCR (Hohenstein et al., 2015).

Amid COVID-19

Even though pandemics are not new to SCM, the repercussion of the COVID-19 pandemic on SC is novel, unprecedented, and catastrophic. COVID-19 altered the business landscape (Ivanov & Dolgui, 2020), incapacitated SCM practices, and forced the formation of new norms in SC (Vanany et al., 2021). The novelty and unpreparedness for a major SCD like the COVID-19 pandemic restrain the readiness and responsiveness of SC (Ali et al., 2021). Many existing strategies and capabilities developed for pandemic disruptions are not serving their purposes amid COVID-19 (Belhadi et al., 2021). Firms are forced to act reactively and make real-time decisions (Kumar et al., 2021). This motivated researchers around the world orchestra study in different parts of the world with a common goal to find better ways to enhance SCR. Thus, since 2020, a sizable quantity of literature on the COVID-19 pandemic has been published in SC disciplines (Chowdhury et al., 2021). SCR research was conducted in many countries, including Indonesia (Vanany et al., 2021), France (Baz & Ruel,

2021), the United Kingdom (Ozdemir et al., 2022), United Arab Emirates (Butt, 2021a), Australia (Nikookar & Yanadori, 2022), India (Badhotiya et al., 2022; Dixit et al., 2020), Canada (Ash et al., 2022), Saudi Arabia (Alajmi et al., 2021), China (Bai & Ran, 2022), Iran (Yazdanparast et al., 2021), Italy (Carissimi et al., 2022), and Pakistan (Aman & Seuring, 2021). Industry-specific research was also mooted to enrich the SCR body of knowledge, including oil and gas (Piya et al., 2022), automotive (Yazdanparast et al., 2021), logistics service providers (Herold et al., 2021), food (Hobbs, 2020), pharmaceutical (Yarosan et al., 2021), grocery industry (Carissimi et al., 2022), manufacturing (Nikookar & Yanadori, 2022), retail (Butt, 2021a), the fashion industry (Dubey et al., 2020), medical supplies (Ash et al., 2022), tourism (Bai & Ran, 2022), automobile, and airline industries (Belhadi et al., 2021). Barbieri et al. (2020) analysed the COVID-19 epidemic's effects on SCs in various industries globally.

Furthermore, scholars use different methods and theories to investigate the new norm in SC caused by the pandemic to develop appropriate SCR strategies. The cognition, human capital, and social capital dimensions in dynamic managerial capabilities theory were used to investigate flexibility, responsiveness, and visibility as antecedents to SCR (Nikookar & Yanadori, 2022). Wen and Liao (2022) investigated SCR using attitudinal characteristics of the decision-making approach. In another study, Zamiela et al. (2022) explore multicriteria decision-making to investigate SCR enablers in healthcare SCs amid COVID-19. The CAS theory offers a systemic framework that encompasses the various components in the entire SC system and thus, providing a good understanding of the various SC actors in strengthening SCR (Yarosan et al., 2021). The Bayesian network approach was used to measure SCR effectiveness (Hosseini & Ivanov, 2020). In another study, Ozdemir et al. (2022) use SC velocity to measure SCR.

The raging epidemic triggers the need for a better understanding of the immediate and long-term effects of any disruption than is currently the case in terms of SCR strategies, which are not often directly tied to individual risk events (Belhadi et al., 2021). Many researchers investigated the enablers and strategies of SCR during COVID-19 and their relationships and differences before COVID-19. Baz and Ruel (2021) found that SCR and robustness are effective disruption-mitigating strategies amid the COVID-19 outbreak. Innovation is an effective strategy to mitigate the pandemic impact and firm size significantly influences SCRM (Ozdemir et al., 2022). A study mapped out twenty-one SCR strategies, spanning five categories (flexibility, collaboration, agility, innovation, and redundancy) that were used to combat COVID-19 disruptions (Carissimi et al., 2022). Kamalahmadi et al. (2022) found that redundancy and flexibility can enhance SC responsiveness and thus improve SCR. The authors argue that backup suppliers' practice is better than flexible suppliers' practice in terms of service-level improvement and cost reduction. A study found that digitalization and lean mechanisms serve to build SCR (Trabucco & Giovanni, 2021). Zamiela et al. (2022) argue that collaboration, robustness, and redundancy are key enablers for SCR during COVID-19, but SCRM, SC design, and communication capabilities are comparatively less influential amid COVID-19. Dubey et al. (2021) offer effective petroleum industry-specific strategies such as safety stock planning, portfolio diversification, transportation, and flexible contracts to build efficient SCR. Li et al. (2020) found that automotive SC uses visibility, flexibility, and swapping suppliers to mitigate SCDs. Badhotiya et al. (2022) investigated the cardinal indicators in establishing SCR during COVID-19 and their interdependency. In another study, the interaction and relationship between fourteen SCD enablers in the oil and gas industry were investigated, showing security and government support are the two most important enablers capable of supporting other enablers (Piya et al., 2022).

There has also been literature focusing on offering theoretical contributions to the SCR field since 2020. Ivanov (2020b) proposed a novel notion called viable SC that integrated the concepts of sustainability and agility with SCR. In another paper, Ash et al. (2022) suggested a multi-period multi-objective distributionally robust optimization framework to curb pandemic disruptions. An industrial 4.0 and SCR framework was proposed by Spieske and Birkel (2021). Contrary, Kähkönen et al. (2021) reinforced the relevance of DC theory in SCR during COVID-19.

COVID-19 is not an SCD at the firm level but affects the entire nation and globe. While firms can invest to build their SCR capabilities, government support is also cardinal to the success of enhancing the overall SCR. Hong (2020) presented enhanced SC network connectivity, improved business environment and trade liberalization, reduced operational obstacles, and strengthened public policies and governance as recommendations to improve overall SCR amid the COVID-19 pandemic.

Theoretical Gaps

Even though SCR is a popular research theme, there are still knowledge gaps in this field (Bloom & Cadarette, 2019; Queiroz et al., 2020). The COVID-19 pandemic reveals the insufficiency of firms' preparedness in response to such major disruptive SCDs (Ivanov & Dolgui, 2020), calling scholarly attention to understanding SCR (Pournader et al., 2020; Queiroz et al., 2020). Queiroz et al. (2020) reveal that traditional SCR and risk knowledge are insufficient for combating long-term, global pandemic disruptions. The authors urge for new approaches (Ivanov, 2020a; Ivanov & Das, 2020; Ivanov & Dolgui, 2020) or extensions from existing ones. Reviews of the literature indicate that while there are SCR frameworks available, most of them are industry-specific and not all-encompassing. Different industries involve different drivers at different levels of importance (Piya et al., 2022). Furthermore, the heterogeneity characteristics of SC decision-making and capabilities nurture the heterogeneity of SCR (Nikookar & Yanadori, 2022). With the emerging importance of SCR, it is paramount to have a generic SCR framework capable of catering to different industry characteristics and needs, relevant to both before the COVID-19 era and the COVID-19 era.

RESEARCH METHODOLOGY

This investigation employs the narrative literature review method, a method characterized by a meticulous examination and synthesis of pertinent scholarly literature on SCR (Seow, 2023b). Through a rigorous review encompassing published articles, conference proceedings, books, and other academic sources, this study endeavours to comprehensively grasp the essential concepts, theories, and empirical findings associated with SCR (Onwuegbuzie & Frels, 2016). The overarching goal is to synthesize the collective insights derived from the literature, culminating in the development of a conceptual framework pertinent to a universal SCR framework (Baker, 2016). The narrative literature review approach facilitates a qualitative exploration of the subject matter, accentuating the richness of understanding and contextual insights derived from the extensive scholarly discourse on SCR (Baethge et al., 2019).

SUPPLY CHAIN RESILIENCE CONCEPTUAL FRAMEWORK

The Conceptual Framework

The landscape of SCR is richly documented in existing literature, providing a comprehensive knowledge repository for both scholars and practitioners. This study meticulously integrates into the corpus of SCR literature, conducting a thorough analysis, identifying theoretical underpinnings and empirical discoveries, and synthesizing this wealth of knowledge into a coherent and inclusive structure. Within the realm of extant literature, various terms such as indicators (Zamiela et al., 2022), enhancers (Shekarian & Parast, 2021), enablers (Naimi et al., 2022), strategies (Carissimi et al., 2022), determinants (Adobor & McMullen, 2018), antecedents (Nikookar & Yanadori, 2022), and drivers (Piya et al., 2022) have been attributed to factors contributing to SCR success. Despite diverse nomenclature, a meticulous examination reveals their fundamental similarity. Furthermore, most SCR frameworks in existing literature have been formulated with a fragmented-focus approach, often concentrating on specific aspects like driver-level or capabilities. These frameworks lack a comprehensive approach that evaluates all the essential dimensions crucial for establishing an effective SCR. With the overarching goal of developing an SCR conceptual framework transcending industry, nation, and SCDs, this study identifies paramount factors by diligently studying, analysing, and synthesising existing SCR frameworks. The resultant conceptual framework encompasses five

dimensions—strategies (S), capabilities (C), resources (R), integration and processes (I), and data and technological enablers (D)—which operate both independently and interdependently to establish SCR. This conceptual framework considers both ex-ante and ex-post aspects of SCDs (Iftikhar et al., 2021). Known as the SCRID framework, it caters to diverse industries and supply chain characteristics, grounded in theoretical foundations, empirical studies, and conceptual research (refer to Figure 2).

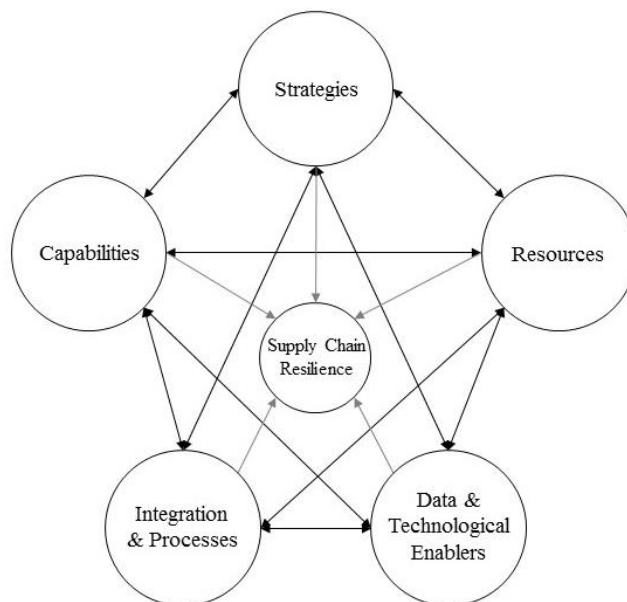


Figure 2. *The SCRID conceptual framework*

Source: Author's construct

Strategies

While there is no consensus definition for strategy (Chaffee, 1985), literature tells us that strategy consists of elements of a plan with conscious intended actions (Mintzberg, 1987), purposeful actions (Drucker, 1974), deployment of resources (Chandler, 1962), and achieve goals under uncertainty (Barad, 2018). Thus, strategy can be defined as a plan with a conscious choice of actions that deploy resources to achieve purposeful goals under uncertainties. When SCDs arise, uncertainties follow suit. SCR focuses on firms' ability to rebound and restore SC stability or form new stability. Just like any other business decision, SCR building begins with setting the right strategies to achieve the desired results. Some scholars refer to them as phases. Some scholars identify anticipation, response and recovery, and resistance as three phases to classify SCR indicators (Adobor & McMullen, 2018; Badhotiya et al., 2022; Singh et al., 2019), whereas Kochan and Nowicki (2018) called their three phases as readiness, response, and recovery. Ali et al. (2017) coined their three phases as resilience, resilience strategies, and resilience capabilities. Other scholars purport a four-phase approach including response and recovery, readiness, reap to integration, and flexibility (Vanany et al., 2021), and readiness, response, recovery, and adaptation (Stone & Rahimifard, 2018). Besides the phase classification approach, some scholars prefer to classify these SCR factors into categories of strategy. Carissimi et al. (2022) and Ivanov et al. (2017) identify redundancy, flexibility, agility, collaboration, and innovation as the five categories of resilience strategies. Ivanov and Dolgui (2019) argue that systems, process, control, and recovery are the four categories of SCR to epidemic outbreaks.

Despite the varied terminology employed, whether described as phases or categories, these terms fundamentally encapsulate the comprehensive strategies a firm intends to adopt in response to SCDs. Consequently, the strategy stands out as the inaugural factor in the SCRID framework. The strategic dimension underscores the development of SCR strategies rooted in available resources, capabilities, and the dynamic nature of the environment. The inherent diversity in business and operational characteristics necessitates a varied array of strategies. Therefore, the overarching principle is to cultivate well-defined resilience strategies that align with business needs and available resources as

well as are actionable. The careful selection of SC strategies plays a pivotal and direct role in determining SCR, making them an indispensable and critical component of an effective SCR framework. The encouragement of a strategic amalgamation is advocated, as the implementation of an apt combination of resilience strategies can significantly enhance SCR (Shashi et al., 2020).

SCR strategies are generally divided into proactive strategies that focus on building resilience capabilities and reactive strategies that emphasize response and recovery after SCDs (Naimi et al., 2022). The proactive or reactive nature of the strategy is normally guided at the time of introduction (Kilubi, 2016), but the same strategy can be defined differently by different firms (Stone & Rahimifard, 2018), making the distinction increasingly blurred (Roscoe et al., 2020). Nonetheless, proactivity enables firms to withstand disruptions with minimum interruptions (Hosseini, Ivanov, et al., 2019) and thus, they are efforts to enhance SC robustness. Keeping buffer stock (Sheffi & Rice Jr, 2005) and incorporating redundancy (Wieland & Wallenburg, 2013) are common proactive strategies.

Capabilities

The capabilities dimension is constructed and grounded on the DC theory. The capacity to integrate, create, and reconfigure internal and external talents to respond to environment dynamism is referred to as DC (Teece et al., 1997). DC offers firms opportunities to gain competitive advantages as it involves repetition and collectively forms tacit knowledge of a firm (Winter, 2003). DC involves sensing, seizing, and reconfiguring resources according to the environment (Helfat et al., 2009; Teece, 2007; Teece et al., 1997). Regardless of SCDs, every firm has its unique SC serving its business operational goals. Under normal circumstances, SC managers build capabilities that can support SCR when needed. At times of SCDs, DC is critical for firms to build and implement their SCR strategies. Thus, Kähkönen et al. (2021) submit that DC theory can be used to study firms' SCR amid COVID-19.

Extant literature tells us a long list of essential capabilities to build SCR (López & Ishizakab, 2019). These include flexibility (Parast et al., 2019), responsiveness (Carvalho et al., 2012), innovation (Ozdemir et al., 2022), readiness (Chowdhury & Quaddus, 2017), robustness (Zamiela et al., 2022), re-engineering (Naimi et al., 2022), respond and recover (Vanany et al., 2021), visibility (Nikookar & Yanadori, 2022), agility (Piya et al., 2020), redundancy (Aastvedt et al., 2021), knowledge and risk management culture (Zanon et al., 2021), and security (Ivanov et al., 2019). Some of these capabilities are interrelated like agility is closely associated with responsiveness (Durach et al., 2015; Shekarian & Parast, 2021). Alignment of strategies and capabilities in the way of the most probable, effective, and economical considerations is a good approach to SCR (Ambulkar et al., 2015). Firms need to build a set of capabilities to establish SCR (Ali et al., 2017). SCR capabilities are closely knitted to the other four dimensions and thus each firm can have its unique combination of SCR capabilities (Azadeh et al., 2014). Hence, the underlying principle of capabilities is to develop internal and external capabilities suitable and relevant to the SC goals of the firm.

Resources

Besides DC, RBV has been extensively used to explain SCR (Aslam, Blome, et al., 2020; Yao & Fabbe-Costes, 2018; Yu et al., 2019). The resource dimension is grounded on the RBV. Barney (1991) submits that firms can use the resources available to develop strategies to gain a competitive advantage. SCR can provide a competitive advantage to a firm when other players are struggling to manage the negative impacts on SC caused by SCDs (Kauppi & Hannibal, 2017). Physical capital, organizational capital, and human capital are resources (Barney, 1991). RBV covers the utilization of resources and capabilities (Mandal et al., 2016). Firms do not have unlimited resources (Mandal et al., 2016) and therefore, they have to develop SCR based on what they have. In many instances, the SCR of a firm can be explained by scrutinizing its resources. Larger firms tend to have more resources available for SCR, whereas SMEs usually struggle to deploy resilience strategies due to limited resources (Chowdhury & Quaddus, 2017). Some researchers refer to financial availability as

a form of capability (Chowdhury & Quaddus, 2015; Pettit et al., 2013; Seow, 2023a) because capability is a form of resource. During SCDs, financial performance may be eroded, making less available resources (Karwasra et al., 2021).

Besides internal resources under RBV, SCR enhancement can also involve leveraging external resources. Two typical external resources are the SC actors in the network and government support. In contemporary SC, network actors are interconnected and interdependent and thus, there is a higher alignment of objectives to motivate the alignment of actions (Aman & Seuring, 2021). Government support appears as an SCR driver in multiple papers (Aastvedt et al., 2021; Ali et al., 2021; Singh et al., 2018). Government financial incentives and support programs are very helpful to firms to mitigate the negative impacts caused by COVID-19 (Ali et al., 2021). The government's development direction can also support the building of SCR as witnessed in Saudi Arabia (Alajmi et al., 2021). Political instability and limited infrastructure in emerging economies can hamper SCR development (Parmigiani & Rivera-Santos, 2015; Rehman et al., 2020). Given that resources are typically limited and scarce, constructing an effective SCR requires firms to adeptly acquire and leverage all accessible resources. It's essential to recognize that the availability of resources varies from one firm to another.

Integration and Processes

SCR drivers like SC network design (Miah et al., 2014; Sinha & Kohnke, 2009), integration (Brusset & Teller, 2017; Tan et al., 2017), information sharing (Faisal, 2010; Hosseini, Ivanov, et al., 2019; Soni et al., 2014), trust (Sahay, 2003; Soni et al., 2014), and collaboration (Hosseini, Ivanov, et al., 2019; Scholten & Schilder, 2015) frequently appear in SCR literature. SC should be carefully planned to respond to SCDs, and adaptive SC network architecture might build a more resilient network (Marques et al., 2020). SC network design deals with structuring the SC to increase resilience (Ash et al., 2022). Hence, a resilience SC needs to integrate other network actors and this should begin with SC network design. Integration can deliver high-quality customer service at low cost and fast speed by being efficient and effective in the flows of value chains, information, money, and choices (Tan et al., 2017). Most importantly, integration enables SC to combat SCDs (Brusset & Teller, 2017). Integration involves both vertical and horizontal integrations. Sharing reliable and real-time information lowers risk and enhances SCR capacity (Hosseini, Ivanov, et al., 2019). Trust is an antecedent to integration and it can further foster collaboration among network actors. Information sharing, transparency, visibility, and partnerships across SC are effective collaboration initiatives to enhance SCR (Kilubi, 2016). Instead of grouping them as capabilities, they are better positioned under the integration and processes dimension in the SCRID framework because all these drivers focus on connecting network actors in a meaningful way so that there can be resilience in the SC. Firms can formulate SC networks suitable to their business needs. The collective SCR of network members can reduce the negative impacts of SCDs (Craighead et al., 2007).

The SC of a firm usually involves many segments and when network actors integrate their SCs, complexity occurs. Therefore, it is cardinal for firms to map out their SC processes. These processes not only enable firms to manoeuvre effectively in the complex environment but also enable firms to identify weak links to enhance SCR. This can be part of the bigger SCRM process mapping (Ozdemir et al., 2022). One integral part of the SCR process lies in assessment and measurement. SCR can be measured in various modes, such as impact reduction (Rose, 2004), recovery cost (Vugrin et al., 2011), response and recovery time (Sheffi & Rice Jr, 2005), and deviation level (Holling, 1973). Firms can opt for measurement methods feasible to their contexts.

Data and Technological Enablers

Data is perhaps the single most core element in SCR. Without data, firms are blind and crippled from making reasonable judgments. In modern SC, most data are stored in technological enablers, making both inseparable. Data is core to the data-driven decision support system known as the digital twin technological framework (Ivanov & Dolgui, 2021). The success of SCRM is becoming more

dependent on data analytics and simulation modelling (Ivanov & Dolgui, 2021). Visibility capability relies heavily on data connectivity (Brandon-Jones et al., 2014). Most importantly, data can be used to evaluate vulnerabilities (Choi & Lambert, 2017) and improve SCR (Choi et al., 2016). Data accuracy is fundamental to SCR and ignorance of this can lead to disastrous outcomes (Ivanov & Dolgui, 2021).

When reliable data is in place, different technological enablers and tools can be used to build SCR. Technologies and tools often appear in SCR literature as one of the factors contributing to SCR (Barcaccia et al., 2020; Idris et al., 2021; Jain et al., 2017; Rahimi & Abadi, 2020; Ratnam & Dominic, 2016; Stone & Rahimifard, 2018). Robust optimization, distributionally robust optimization, robust programming, and stochastic programming can be used to build SC modelling for SCRM (Ash et al., 2022; Suryawanshi & Dutta, 2022). Firms can also incorporate suitable technological enablers and tools to build their SCR, such as artificial intelligence algorithms (Suryawanshi & Dutta, 2022), systems of systems (Choi, 2018), system-cybernetics frameworks (Ivanov, Dolgui, Ivanova, et al., 2018), blockchain (Clauson et al., 2018), digitalization (Schneiderjans et al., 2020), automation and robotics (Ralston & Blackhurst, 2020), digital twin, and integrated decision-support system (Ivanov & Dolgui, 2021). Investment in technologies can make SC autonomous and more intelligent (Piya et al., 2022) and this can significantly strengthen SCR (Dubey et al., 2018).

Relationships & Interactions

The five dimensions in the SCRID framework serve as an antecedent to another dimension as well as the consequence of that dimension. Since strategy deals with the deployment of resources to achieve goals, the availability of the other four dimensions influences the choice of strategy. SCR strategies are dependent on the strength of capabilities or resources one possesses (Swanson & Santamaria, 2021). Capabilities under DC involve the deployment of resources (Helfat et al., 2009). The success of capabilities building is dependent on strategic direction, talents, resources, tools, and SC actors. At the same time, capabilities also greatly influence the development of the other four dimensions. Strategy is about resource deployment. Internal capability, integration network, and data are forms of resource (Barney, 1991). The other four dimensions determine the resources available and resources are used to build the other dimensions to form resiliency. Technological advancement fosters collaborative efforts among network actors to improve resiliency (Arya et al., 2015; Chakraborty et al., 2014). While integration and processes seem to be more closely related to data and technological enablers, strategies, capabilities, and resources are impacting and dependent on these two dimensions.

Due to the interwoven relationship of these five dimensions, they collectively work towards resiliency building in SC. The dynamism of these five dimensions with each other and other components in the SCRM can be explained by the CAS theory (Arrow et al., 2000). CAS argues that a system has the dynamic ability to adjust and develop in response to environmental changes (Choi et al., 2001; Day, 2014; Nair & Reed-Tsochas, 2019). CAS purports that interactions among dimensions in the SCRID framework and their evolving environment take place and these provide learning opportunities to accumulate valuable experiences (Schiffing et al., 2020). A CAS is seen as adaptive and complex due to its diversity, ability to change depending on experience (Holland, 2006), and capacity to anticipate the effects of novel actions or activities (Yarosan et al., 2021). This is what we observed in SC managers dealing with SCDs, especially during the COVID-19 pandemic. Their inexperience in handling SCDs caused by the pandemic does not prohibit them to learn and improvise. Yarosan et al. (2021) adopted CAS to examine and explain pharmaceutical SCR during COVID-19 disruptions.

CONCLUSION AND FUTURE RESEARCH DIRECTION

In the contemporary landscape of SCs, network actors are intricately interconnected, rendering SCs more susceptible to SCDs. Disruptive events have the potential to initiate cascading effects within the supply network, leading to instability, volatility, and inefficiency in SC operations. Against this backdrop, the significance of SCR within SCRM has become increasingly pronounced since the 2000s. Global literature on SCR has proliferated, delving into various facets such as the theoretical foundations of SCR, determinants of resilience, resilience frameworks, and methods of measurement. The unprecedented COVID-19 pandemic in 2020 brought about new uncertainties and challenges for SCs worldwide, placing immense pressure on SC managers to navigate operational chaos for which they were unprepared. This crisis prompted scholars and practitioners to reevaluate SC knowledge considering the new norms imposed by the pandemic, leading to both validations of previous studies and novel scientific discoveries. Despite numerous attempts to propose theoretical frameworks for SCR, a generic framework capable of accommodating the diverse characteristics of existing SCs was conspicuously absent. This paper addresses this theoretical gap by introducing the SCRID framework, designed to be sufficiently generic to accommodate the varied traits of contemporary SCs. The SCRID framework also rectifies shortcomings in existing SCR frameworks, which often focus on singular aspects rather than adopting a comprehensive perspective on SCR development.

The SCRID framework encompasses five dimensions that operate both independently and interdependently with one another. While SCR strategy often takes precedence in scholarly literature, the delineation between SCR strategies and capabilities has been obscured. The SCRID framework makes a distinctive definition between strategies and capabilities, even though they maintain interconnectedness. The strategies dimension concentrates on leveraging resources to achieve purposeful goals amid uncertainty, while the capabilities dimension draws on the DC theory, focusing on the capacity to integrate, create, and reconfigure the SC for resiliency. The resources dimension underscores the effective utilization of available resources to construct SCR, enabling firms to establish a competitive advantage. Resilience drivers such as government support and financial availability are categorized under this dimension due to their resource characteristics. Recognizing the intertwined nature of contemporary SCs, the importance of integration and processes has been elevated to a dimension in SCRID. Resilience drivers such as integration, collaboration, information sharing, and trust function to support building an integrated SC system capable of contributing to SCR. Acknowledging the critical role of data, the fifth-dimension data and technological enablers, grouping technologically driven resilience drivers that function as tools for SCR. The development of the SCRID framework is rooted in solid theoretical foundations, offering a meaningful synthesis of previous scholarly findings by reclassifying past literature's insights. Serving as a guiding beacon for SCR construction beyond national and industry boundaries, the SCRID framework is constructed upon collective SCR findings, albeit within the confines of the reviewed literature.

Although the SCRID framework is constructed based on collective findings in SCR literature, it has yet to undergo empirical testing. Scholars and practitioners are encouraged to embrace the SCRID framework for examining existing SCR phenomena, particularly in the post-COVID era, and utilize it to formulate new SCR systems for firms. Currently, there is a dearth of literature investigating the relationship between SCDs and practices aimed at enhancing SC performance, and the SCRID framework can serve as a valuable framework to address this research gap. Researchers can validate the universal applicability of the SCRID framework by applying it in various SCD contexts, and future studies can leverage the framework to explore the dynamism within each dimension when confronting different types of SCDs. Scientific inquiries can also concentrate on unraveling the dynamic interactions among the five dimensions, as elucidated under CAS. While firms may encounter similar SCDs, the diverse learnings within firms can lead to distinct dynamic effects. Notably, research on SMEs' SCR is limited, and the SCRID framework provides a foundational basis for investigating how SMEs navigate SCR. Furthermore, the SCRID framework can be employed to examine various SCR strategies adopted under different resource constraint scenarios,

such as comparing firms' strategies under varying levels of government support. Additionally, the framework can be applied to investigate different approaches to SCR implementation.

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