Strategically Prioritizing Type-Specific Innovations at the Stages of the Supply Chain Resilience Cycle: A Contingency Framework

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Faced with various disruptions and crises, supply chain decision-makers are eager to enhance their supply chain resilience (SCRES), and they have realized that innovation could be a powerful tool for enhancing SCRES. This paper investigates the relationship between innovation and SCRES by analyzing the types of innovation at the SCRES stages. We contend that innovation positively impacts SCRES if investment in type-specific innovation is strategically planned and prioritized. The proposed research framework demonstrates this relationship and guides how to prioritize type-specific innovation at each stage of the SCRES cycle. This research builds a foundation for future research on the interrelationship between innovation and SCRES. It offers supply chain practitioners a roadmap for investing in type-specific innovation at each stage of the SCRES cycle.

Keywords: strategic prioritization, types of innovation, supply chain resilience, continency framework

INTRODUCTION

A supply chain disruption could greatly impact all supply chain members and stakeholders, but it could be very challenging to predict and prepare for. A recent Accenture report showed that, in their ability to anticipate disruptions in their supply chains, only 22% of chief supply chain officers are "completely confident" (Reiss & Fata, 2021). Due to their uncertain nature, fierce competition, and limited resources, decision-makers must deal with supply chain disruptions more creatively. Innovation is a powerful tool for reacting to rapid changes and disruptive events in the business environment (Abbas, Ekowati, Suhariadi, Anwar, & Fenitra, 2023; Gölgeci & Ponomarov, 2015; Y. Kim, Choi, & Skilton, 2015). During the COVID-19 pandemic, garment producers started to make face masks, and carmakers switched to manufacturing medical ventilators (Wieland & Durach, 2021). Faced with new and unexpected situations, innovative and out-of-box solutions are the keys to mitigating and quickly recovering from supply chain disruptions. For instance, in responding to the global supply chain shortage in computer chips in 2021, Tesla navigated its supply chain with innovative solutions. They collaborated with their customers to deliver vehicles with nonessential parts missing, such as Bluetooth chips and USB ports. In addition, they reprogramed their software to support alternative chips within 2-3 weeks (Jin, 2022).

In academia, several researchers have also claimed the importance of innovation for SCRES. Francis and Bessant (2005) view innovation as an organizational capability critical for an organization's survival and growth. Kwak, Seo, and Mason (2018) develops a structural model of the positive relationship between supply chain innovation and risk management in which supply chain innovation is a construct that positively impacts both robustness and resilience. Gölgeci and Ponomarov (2015) find that innovation can support

SCRES through supply uncertainty and interdependence as moderating variables. Sabahi and Parast (2019) propose a conceptual model to demonstrate that innovation directly affects resilience and mediates resilience through knowledge sharing, agility, and flexibility.

Although the literature finds that innovation is critical for SCRES, most organizations cannot afford to invest in all types of innovation simultaneously due to resource constraints (Bruni, Bonesso, & Gerli, 2019; García-Piqueres, Serrano-Bedia, López-Fernández, & Pérez-Pérez, 2020; K. Kim, Lee, & Lee, 2023). Supply chain decision-makers must analyze the relative importance of different innovation types in distinct situations and contexts to strategically prioritize innovation investment at each SCRES stage. The recent literature has started to emphasize the importance of the types of innovation, and they contend that locking into one single type of innovation alone is misleading and a large failure (Bartoloni & Baussola, 2018; Geldes, Felzensztein, & Palacios-Fenech, 2017; Satell, 2017). Geldes et al. (2017) studies the impacts of technological or nontechnological innovations on an organization's performance. In addition, scholars have called for more in-depth investigations to explore different types of innovation and address them in business contexts to improve performance (Bruni et al., 2019; Tavassoli & Karlsson, 2015). Specifically, based on a systematic literature review, Sabahi and Parast (2019) calls for future research on the impacts of innovation types on SCRES.

Responding to the calls from academia and industry, this study aims to bridge the above research gap by developing a research framework to link these two important concepts, innovation and SCRES, by prioritizing different innovation types at each stage of the SCRES cycle. This work intends to build a theoretical foundation for understanding the dynamic nature of SCRES and provide innovation investment guidance at each stage. This study expands the innovation and SCRES literature by exploring the relative importance of innovation types across the stages of a supply chain resilience cycle. This approach provides a contingency approach for supply chain decision-makers to improve the SCRES capability of their supply chains. The value of this study is even more vivid for cases where the disruption lasts for a long time, such as during the years-long COVID-19 pandemic. To our knowledge, no study has investigated how to prioritize type-specific innovation at each stage of SCRES.

Targeting the research purposes, we raise the following two research questions:

1. Facing resource constraints, should decision-makers focus on distinct types of innovation at each stage of the SCRES cycle?
2. If so, how can the innovation types be prioritized at each stage?

To answer the above research questions, the remainder of the paper is organized as follows: we first identify the definitions and characteristics of the key concepts: innovation types (Section 2) and SCRES cycle stages (Section 3). In Section 4, framework development, we introduce the theoretical basis and propose a contingency framework through analyzing and prioritizing each type of innovation at the stages of the SCRES cycle. The conclusion, discussion, and future research directions are listed in Section 5.

TYPES OF INNOVATION

Analyzing the types of innovation is vital when studying their impacts on an organization's performance because it provides "a structured approach to examining the opportunity space for innovation" (Francis & Bessant, 2005, p. 172). There are different typologies of innovation. Henderson and Clark (1990) proposed a framework to classify innovation based on degrees of innovation. Considering the changes in core concepts and the linkage between core concepts and components, their framework contains four types of innovations: incremental, modular, architectural, and radical innovation. Wong and Ngai (2019), based on the resource-based view and the orientations of innovation, classified supply chain innovation into three types: logistics-oriented, marketing-oriented, and technological development-oriented innovations. Satell (2017) noted that "there is no one 'true' path to innovation" (Satell, 2017, p. 3) and proposed four types of innovation according to the clarity of problem definition and needed skills (domains): sustaining innovation occurs when both dimensions are well defined; basic research occurs when neither dimension is well defined; breakthrough innovation involves developing a new knowledge domain to solve a well-defined problem; and disruptive innovation involves using a well-defined knowledge domain to solve new problems.

One well-cited framework is the 4P taxonomy of innovation proposed by Francis and Bessant (2005). Their framework contains *Product, Process, Position, and Paradigm Innovation*. Organizations generate ideas for new products (product innovation), introduce new methods of production and service (process innovation), expand new markets (market innovation), and implement new business models to reengineer their organizations (paradigm innovation). Similarly, Tavassoli and Karlsson (2015) and Gault (2018) distinguished innovations by *product, process, marketing, and organizational innovation*. This 4P taxonomy also serves as the foundation when developing other innovation typologies. For example, product and process innovations are classified as technological innovations, and organizational and marketing innovations are nontechnological (Bruni et al., 2019).

Based on the above review and the aims of this research, we adopt the 4P taxonomy and investigate the impacts of all four main types of innovation on SCRES. The framework development section provides a detailed definition and analysis of each type of innovation.

STAGES OF THE SUPPLY CHAIN RESILIENCE CYCLE

SCRES is the ability of a supply chain to survive and grow through dealing with disruptions. A resilient supply chain could identify and mitigate potential disruptions, effectively respond to unexpected events, quickly recover from the nadir to the normal stage, and learn from the whole experience to improve future performance. A SCRES should be dynamic and continuous, requiring supply chain leaders to analyze multiple stages and adopt different strategies for various situations.

Analyzing SCRES through different stages of the continuous cycle provides a more detailed view and is thus well adopted in many studies. Kamalahmadi and Parast (2016) identified the three stages of SCRES: anticipation (anticipation and preparedness), resistance (maintaining control and deactivating perturbation), and recovery and response (reposition to disruption status or even a higher level). More comprehensively, the research framework developed by Ponomarov and Holcomb (2009) uses four stages: event readiness, efficient response, recovery, and organizational learning. Similarly, Hohenstein, Feisel, Hartmann, and Giunipero (2015) defined SCRES through four stages: preparation, responding, recovering and growing to a more desirable state. A recent study by Sawyerr and Harrison (2020) emphasized that the definition of SCRES has evolved from responding and recovering from disruptions to a more comprehensive system, which includes monitoring, mitigating, responding, recovering, and learning from disruptions.

Based on the analysis of the literature and the research purpose of this study, our framework adopts the four-stage SCRES cycle model: (1) identification and mitigation, (2) responding during the crisis, (3) recovery after the peak of the crisis, and (4) learning and improvement from the experience. This four-stage SCRES cycle emphasizes the dynamic and continuing nature of SCRES and provides a comprehensive and practical foundation for developing our framework in the next section.

FRAMEWORK DEVELOPMENT: INNOVATION TYPES FOR THE STAGES OF THE SCRES CYCLE

According to the different natures and characteristics of innovation types and the distinct goals and requirements of the SCRES cycle stage, we develop a theoretical framework to support decision-makers in prioritizing innovation types at different stages to improve resilient performance even under resource constraints.

Theory Basis: Contingency Theory

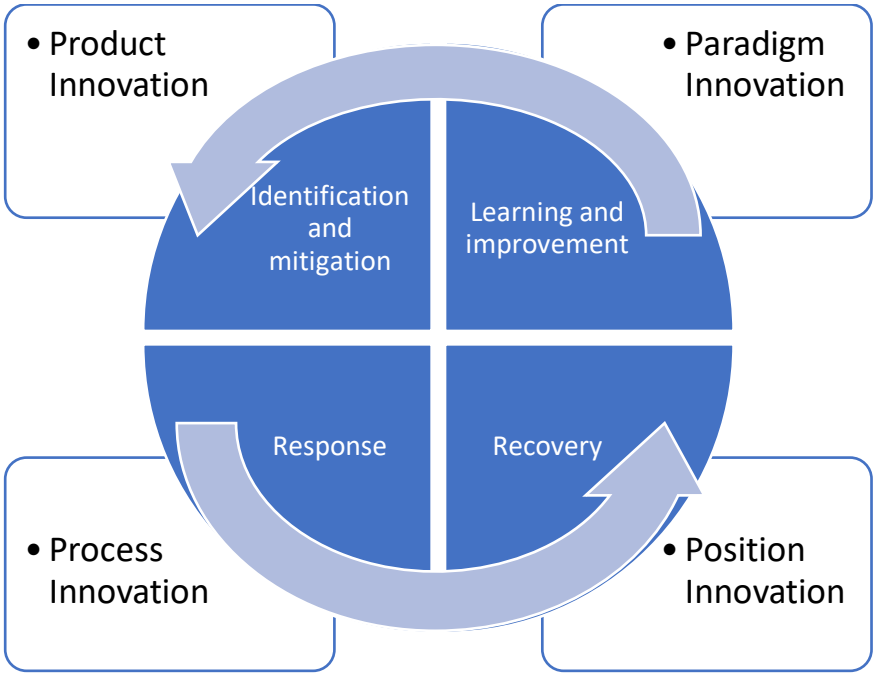
We introduce contingency theory as the theoretical basis of our research framework. Contingency theory is a major theoretical lens in the research on organizational strategies and operations management (Boyd, Takacs Haynes, Hitt, Bergh, & Ketchen, 2012; Sousa & Voss, 2008). Centering around the concept of *fit*, contingency theory emphasizes matching and alignment between an organization's strategies and external and internal conditions (Smith, Jayaram, Ponsignon, & Wolter, 2019; Zajac, Kraatz, & Bresser, 2000). Contingency theory claims that there is no one-size-fits-all method for leading an organization; thus,

decision-makers must be flexible and adaptive to the constantly changing environment to maximize organizational performance (Boyd et al., 2012; Donaldson, 2001). The various aspects of the environment, named contingency factors, influence organizational structures and business strategies (Zajac et al., 2000). The contingency factors include both internal factors, such as the resources and experience of an organization, and external factors, such as natural disasters and regulatory changes outside the organization (Childs, Turner, Sneed, & Berry, 2022). Ketokivi and Schroeder (2004) grouped contingency factors into three categories: strategic goals, environmental contingencies, and institutional effects. Sousa and Voss (2008) considered four broad categories: national context and culture, firm size, strategic context, and other organizational context variables.

Contingency theory is appropriate for the research questions of this study because it emphasizes the importance of strategic alignment between organizational priorities and contextual conditions at the SCRES stages. Given the unprecedented nature of disruptions, such as the COVID-19 pandemic, contingency theory is helpful for decision-makers to effectively respond to dynamic situations (Childs et al., 2022). SCRES deals with a highly dynamic environment where changes are consistent and unexpected. Contingency theory suggests that supply chain leaders in this dynamic environment must choose from a toolbox containing multiple innovation strategies to fit in a particular situation for the best SCRES performance.

Based on the concept of *fit* between the types of innovation and the stages of the SCRES cycle, we use contingency theory to propose a framework for dynamically prioritizing type-specific innovation strategies throughout the whole SCRES cycle. This proposed framework will not claim to be the best solution or exclude other types of innovation at a certain stage. Instead, it emphasizes the importance of *fit* by proposing one way of allocating innovation priority and strategic focus at these stages, considering the nature and characteristics of innovation types and SCRES stages. The framework is summarized in Figure 1, followed by the detailed analysis in Sections 4.2-4.5.

FIGURE 1
FRAMEWORK OF INNOVATION PRIORITIZATION BASED ON THE SCRES CYCLE



Product Innovation at the Monitoring and Mitigation Stage

Product innovation refers to introducing a new product or a variety of an existing product (Francis & Bessant, 2005; Tavassoli & Karlsson, 2015). Compared with regular product improvement, product innovation is a key element of strategic planning, and it could help organizations gain monopoly positions (Bruni et al., 2019).

Monitoring and mitigation are challenging due to supply chain disruptions' unpredictable and unknowable characteristics (Kamalahmadi & Parast, 2016). During the normal period when most processes operate smoothly, supply chain members have little incentive for any changes, and optimism takes over the organization. Product innovation could bring the needed dynamics into the routing operations of existing supply chains by introducing new requirements and demands related to product innovation. The supply chain network and its ability to adjust its structure are tested and challenged during product innovation. Although it will lead to some changes and uncertainties at a controllable level, product innovation serves as a stress test to bring new perspectives to the existing system. It encourages a supply chain to continuously monitor, identify, and mitigate the areas of potential vulnerabilities.

In addition, high levels of collaboration willingness are critical for risk identification and mitigation (Christopher & Peck, 2004). Supply chain members could generate and share awareness of emerging issues during new product development. New products' potential higher future profit motivates participation and collaboration among supply chain members. The long-lasting and continuous nature of product innovation (Tavassoli & Karlsson, 2015) could maintain this high-level collaboration at the monitoring and mitigation stage, which requires continuously dealing with possible disruptions regularly.

The above analysis indicates that product innovation is a powerful tool at the monitoring and mitigation stage, and we propose the following:

Proposition 1: *Supply chain decision-makers should focus on product innovation at the identification and mitigation stage.*

Process Innovation at the Response Stage

Process innovation introduces new methods of production and service to improve the operation of existing sequences of activities through optimization and waste reduction (Francis & Bessant, 2005). Process innovation could reduce production costs, increase quality, and increase conformance (Tavassoli & Karlsson, 2015). When supply chain disruptions occur, supply chain leaders need to make instant decisions to stop the "bleeding" and survive. The benefits of waste reduction and increasing productivity through process innovation could optimize an organization's bottom line in a relatively short time, which is critical for a supply chain at the response stage when financial security is normally the highest priority.

A small number of supply chain members could cause supply chain disruptions. Process innovation allows a supply chain to completely switch its dependence on the affected members to the other, unaffected ones quickly so that the supply chain can quickly get out of the mud. Faced with global supply chain shortages, Tesla Inc. switched to nontraditional processes, such as delivering cars missing nonessential parts and changing their programs to use different chips from different suppliers, solving their supply chain disruptions quickly (Jin, 2022).

Furthermore, process innovation allows the supply chain to quickly meet the newly emerged demands of customers. During disruptions, customers can dramatically change their demands, which requires a new way to deliver existing products and services. At the beginning of the COVID-19 pandemic, many grocery stores collaborated with third-party companies such as InstaCart to provide a completely new product delivery process. This process innovation in the grocery industry met the immediate demands of customers that emerged during the disruption.

The above analysis indicates that process innovation is a powerful tool at the response stage, and we propose the following:

Proposition 2: *Supply chain decision-makers should focus on process innovation at the response stage.*

Position Innovation at the Recovery Stage

Marketing position innovation refers to extending to new markets, reestablishing market segmentation (Johne, 1999), changing the contexts of products and services, and rebranding the image and identity of an organization (Francis & Bessant, 2005). By improving the mix of target markets and choosing the best served segment, market position innovation could increase the popularity of products and services among customers, change the existing markets, and create new markets and profit generation opportunities (Johne, 1999; Tavassoli & Karlsson, 2015).

The most difficult struggle-to-survive time has passed at the recovery stage, but the supply chain has not yet fully functioned normally. The key task at this stage is to regain confidence and reputation from customers and supply chain members. Because preexisting relationships could be dramatically damaged during disruptions, supply chain decision-makers must creatively develop new marketing strategies to rebuild their images and enhance their relationships with customers and supply chain members.

In addition, the nadir of disruptions has weakened or eliminated some competitors, and a supply chain in the recovery stage will face a completely new market situation. Market position innovation could convert a crisis to an opportunity by enhancing market expansion, reorganizing market segments, and taking advantage of the vacuum of the market to gain more market shares and enter new markets.

The above analysis indicates that process innovation is a powerful tool at the recovery stage, and we propose the following:

Proposition 3: *Supply chain decision-makers should focus on position innovation at the recovery stage.*

Paradigm Innovations at the Learning/Improvement stage

Paradigm innovation, also called business model innovation or organizational innovation, is viewed as the most complex type of innovation, but it has the potential to significantly improve an organization's performance (Abbas et al., 2023; Ganter & Hecker, 2013). It fundamentally changes an organization's business practices and routines (Bruni et al., 2019; Gault, 2018). Introducing new corporation strategies, implementing management and control systems, and reestablishing internal or external network structures are examples of paradigm innovations (Tavassoli & Karlsson, 2015). The characteristics of paradigm innovation were described by using key words such as "exploration", "learning", and "self-reflection" (Francis & Bessant, 2005).

Resilient supply chains pursue the achievement of a "desired state", which indicates that the supply chain will not only recover and return to the predisruption state but also reach a higher level of resilience and overall performance (Bruni et al., 2019; Kamalahmadi & Parast, 2016). Supply chain disruptions require additional fundamental changes, which paradigm innovation could offer through reestablishing the complete business model to cope with this new competitive environment (Satell, 2017).

At the learning and improvement stage, supply chain leaders must collect and consider all stakeholders' inputs for long-term decision-making. Paradigm innovation can foster interactions between internal and external parties (Birkinshaw, Hamel, & Mol, 2008). Additionally, paradigm innovation is a "fertile ground" for other types of innovation (Volberda, Van Den Bosch, & Heij, 2013). Innovation culture and dynamics can be created among supply chain members, which is beneficial for learning and improvement through better communication and collaboration (Ogrenci, Alpkan, Karacay, & Bulut, 2023; Tavassoli & Karlsson, 2015).

The above analysis indicates that, compared with other types of innovation, paradigm innovation could most benefit an organization in successfully competing in the post-disruption stage. We thus propose:

Proposition 4: *Supply chain decision-makers should focus on paradigm innovation at the learning and improvement stage.*

DISCUSSION AND CONCLUSION

Responding to the calls for a better understanding and practical guidance about the relationship between innovation investment and SCRES, this paper proposed a contingency framework based on analyzing the types of innovation and the stages of the SCRES cycle. This framework demonstrates that investment in innovation could improve SCRES and provides insights into how to prioritize type-specific innovation at each stage of the SCRES cycle. Realizing the different characteristics of innovation types and the distinct goals and requirements of the SCRES cycle stage, this study investigates the innovation type-specific relationship between innovation and SCRES, which bridges the supply chain resilience and innovation literatures by proposing a new research framework based on theoretical and practical evidence of how each type of innovation can affect supply chain resilience.

Because of the exploratory nature of this study, many other possibilities could be investigated in future studies. This study does not intend to specify the type of innovation in a certain stage, excluding the other types of innovation. Instead, we contend that with limited resources, an organization should prioritize some types of innovation in the context of different stages of the SCRES cycle. Thus, future research is encouraged to provide additional insights and propose other alternative frameworks for analyzing other factors of innovation and SCRES, such as analyzing other typologies of innovation (Ariss & Deilami, 2012; Henderson & Clark, 1990; Satell, 2017) and considering the different causes and lengths of supply chain disruptions.

Overall, this study explores the relationship between innovation and SCRES by analyzing the characteristics of innovation types and SCRES stages and provides a roadmap for prioritizing the type of innovation at each stage of the SCRES cycle. The proposed framework provides a foundation for future research and supports supply chain practitioners with a roadmap to strategically develop corresponding innovation strategies at each stage of the SCRES cycle.

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