

Strategic Intelligence of Small and Medium Enterprises Embedded in Global Supply Chains: A Framework for Resilience in the Face of Systemic Risks

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Abstract

This study highlights the challenges and resilience of SMEs embedded in global supply chains that are vulnerable to systemic risks. SMEs, constituting a significant portion of the global economy, have been largely overlooked in supply chain resilience literature. Faced with crises like the COVID-19 pandemic or geopolitical tensions, SMEs often adopt a wait-and-see approach, seeking to reduce uncertainty before making tangible commitments. Our proposed conceptual framework highlights strategic intelligence as a key dynamic capability to diminish uncertainty, reduce the waiting time for SMEs, and prompt them to commit tangible resources to restore balance in a new context. Three sub-capabilities of strategic intelligence are identified: supply network visibility, environmental sensing, and timely responsiveness. External moderating determinants, such as external social capital and government support, can also help overcome the limitations of SMEs' internal resources. This study calls for future empirical research to explore these relationships and address current gaps in the understanding of SMEs' supply chain resilience. It particularly encourages testing this model using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach. By focusing on strategic intelligence, inter-organizational resource sharing, and government support, it provides practical insights for managers and policymakers, emphasizing the importance of enhancing SME resilience in the face of systemic disruptions. This, in turn, contributes to the resilience of our economies in an increasingly complex and uncertain world.

Keywords: Resilience, supply chain, small and medium-sized enterprises, systemic risk, dynamic capabilities, strategic intelligence

1. Introduction

Small and medium enterprises (SMEs) embedded in global supply chains face a new reality characterized by a series of systemic risks. Several studies have revealed their lack of preparedness and proactivity in the face of these risks (Asgary, Ozdemir, & Özyürek, 2020; Crichton, 2006; Schaefer, Williams, & Blundel, 2011). This vulnerability exposes a significant weakness in our economies, which rely on global supply chains in which SMEs actively participate. They represent approximately 99% of the total number of businesses in the OECD region (OECD, 2017), contribute to over half of the GDP in some countries, and employ a significant portion of the workforce. Furthermore, SMEs promote competition, drive innovation, and provide a multitude of intermediate goods and services to other businesses. However, immersed in this new landscape, SMEs appear particularly vulnerable to uncertainty and the consequences generated by political tensions (such as Brexit, Sino-American rivalry, the war in Ukraine), the COVID-19 pandemic, or the increasing impact of climate change-related natural disasters.

In response to these systemic disruptions, the literature on supply chain resilience has significantly expanded in recent years, highlighting the importance of dynamic capabilities (DC). However, SMEs have been largely overlooked in this field, primarily due to the challenges in understanding the strategies and mechanisms that fuel the resilience of such businesses (Polyviou, Croxton, & Knemeyer, 2019; Scholten, Stevenson, & Van Donk, 2019; Ivanov, 2021; Kähkönen, Evangelista, Hallikas, Immonen, & Lintukangas, 2021). Moreover, by focusing on SMEs, a review of the literature reveals not only a scarcity of empirical studies, but also a lack of alignment between the limited resources of SMEs and the deployment of strategies and practices that induce resilience

(Battisti & Deakins, 2017; Sullivan-Taylor & Branicki, 2011).

The research question of this conceptual study thus exposes this gap between the limited resources of SMEs, enabling them to deploy proactive DCs, and the effective achievement of supply chain resilience in the context of systemic risks. The research aims, first and foremost, to briefly present the characteristics of systemic risks that define this new landscape. To open up new research perspectives, we will propose a conceptual model focusing on a specific DC - the strategic intelligence capability (SI) - that can enable SMEs to adopt suitable resilience strategies more rapidly and effectively. Recognizing that the initial lack of internal resources within SMEs may pose a barrier to this model, we will propose to go beyond this limiting framework by examining the potential role of external determinants in the relationship between the SI capability and supply chain resilience. Some previous studies have demonstrated the importance of incorporating external resources into SMEs from other organizations (Battisti & Deakins, 2017; Ramanathan, Aluko, & Ramanathan, 2022) or from governmental institutions (Braglia, 2022; Cradock-Henry, 2019; Prosser, Lane, & Jones, 2021), but few of them focus on supply chain resilience. Thus, Jia et al. (2020) emphasize that the role of external factors in the development of organizational resilience remains elusive to this day.

2. Methodology

This literature review article aims to provide an in-depth analysis of the role of SI in enhancing the resilience of SME supply chains against systemic risks. It also seeks to better identify the challenges SMEs face in terms of resilience, as well as the resources (both internal and external) enabling SMEs to better deploy their SI capability. Previous research emphasized the significance of SI's sub-capabilities (e.g., visibility, detection capability, and seizing) in enhancing companies' resilience in volatile business environments (DuHadway, Carnovale & Hazen, 2019; Swink, Gallo, Defee, & da Silva, 2023; Ozanne, Chowdhury, Prayag, & Mollenkopf, 2022). However, it did not offer an integrative framework for these various sub-capabilities of SI. Furthermore, while supply chains' DCs have been addressed in empirical articles, a prior examination of dedicated reviews on the subject reveals both a scarcity of reviews focusing on supply chains facing systemic risks and that those available have either focused on the humanitarian sector facing disasters or on topics only partially relevant to our research focus (Polater, 2020).

Determining the focus and scope of a literature review is of paramount importance as it consequently affects the authors' research spectrum. It is therefore crucial to formulate clear and well-defined research questions from the outset (Denyer & Tranfield, 2009; Polater, 2020). Initially, the general research question of this study is determined as follows: How does SI contribute to resilience against systemic risks for SMEs dependent on global supply chains? The following sub-research questions have also been formulated to provide further insights into our study:

QR 1: What characteristics define systemic risks and what are their specific impacts on SMEs in the current context?

QR 2: How can SI help SMEs strengthen their resilience against systemic risks, despite their limited resources?

QR 3: What is the role of external determinants, such as external social capital and governmental support, in the relationship between SI and SME supply chain resilience?

To address these research questions, a literature review was conducted over the past 20 years, focusing on renowned electronic databases such as ABI/Inform Global, Business Source Premier, Google Scholar, and Web of Science. The first two databases specialize in administration sciences, while the two others are more general and frequently updated. Keywords used to identify literature are presented in Table 1, chosen based on their relevance to the objective of this article. Manual searches were also conducted by examining reference lists of selected articles, as well as citations and related articles in appropriate journals. This approach ensured comprehensive coverage of existing literature. Selection criteria allowed only relevant works specifically addressing the role of SI dimensions in strengthening SME supply chain resilience against systemic risks to be included. Selected articles were then examined in detail and synthesized to identify key themes, emerging trends, and research gaps in the field. Based on this, a conceptual framework was developed to guide the theoretical contribution of this article, highlighting the links between SI, SME supply chain resilience, and external determinants such as social capital and governmental support.

Table 1. Search strings

| | |
|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Strategic intelligence & dynamic capabilities | Strategic intelligence OR Business Intelligence OR Sens* OR seiz* OR diagnostic OR detect* OR recognition of new opportunities OR recognizing new opportunities OR Visibility OR knowledge management OR information sharing OR dynamic capabilities |
| Internal/external factors | Resource* OR RVB OR Collaborat* OR social capital OR partner* OR institution* OR government support OR |
| Integration into GSCs | Global supply chain* OR supply chain* OR supply network* OR global supply network* OR GSC* |
| Systemic risk | COVID-19 OR COVID OR coronavirus OR corona virus OR pandem* OR disaster OR geopolitic* OR trade war OR political risk* OR commercial war OR terrorism OR nationalism OR Brexit OR tension* OR war OR deglobalization OR De-globalization OR crisis OR recession OR financial crisis OR environmental crisis OR climate change OR earthquake OR tsunami OR typhon OR hurricane OR bottleneck OR logistic crisis OR global supply chain crisis OR major disruption OR systemic risk |

Note. * is a wildcard character in the search process, meaning the search includes any form of the term, e.g., “tension” and “tensions”, or “detecting” and “detection”, etc.

3. SMEs in the New Landscape: Rethinking Supply Chain Resilience

3.1 The Emergence of the Black Swan: Characterizing Systemic Risks

Despite its importance, the concept of systemic risks remains ambiguous in its definition. However, Nassim Taleb, through the concept of "Black Swan" (2007), identified key elements of this notion. He describes Black Swans as catastrophic, unpredictable, and highly destructive events (Aggarwal & Bohinc, 2012; Knemeyer, Zinna, & Eroglu, 2009; Simchi-Levi., Schmidt & Wei, 2014; Zhu, Krikke, Caniels, & Wang, 2017). A similar perspective is presented by the World Economic Forum (2012), which describes systemic risks as unexpected events that spread and intensify due to network fragility. Systemic risks can thus be defined as the potential threat of a sudden disruption affecting a system, amplified by the interconnection of network members. Colon & Hochrainer-Stigler (2023), focusing on global supply chains, associate it with a highly interdependent globalized economy that intensifies the negative consequences of crises. This perspective emphasizes the notion of contagion among actors (Elsinger, Lehar & Summer, 2006; Schwarcz, 2008 ; Kane, 2010), leading to major disruptions, financial losses, shortages, physical harm to supply chain actors, and even temporary or permanent blockages in certain parts of the supply chain (Tierney, 1997; Sheffi, 2005; Fujimoto, 2011; Todo, Nakajima & Matous, 2013).

Another aspect of systemic risks lies in its sudden and unpredictable nature. Businesses must be prepared to face major disruptions that they cannot anticipate. For businesses operating within global supply chains, these risks are particularly devastating, as demonstrated by recent disruptions (Miroudot, 2020; Miroudot & Nordström, 2020; Moradlou, Reefke, Skipworth & Roscoe, 2021; Witt, 2019). This period has been marked by four major systemic crises: political or geopolitical, health, economic, and environmental. These crises have exposed the vulnerability of global supply chains to systemic risks. The manifestation of systemic risks is multifaceted, taking on several forms and bringing about profound transformations within global supply chains. Political crises, such as Brexit (Roscoe, Skipworth, Aktas, & Habib, 2020; Casadei & Iammarino, 2021; Moradlou et al., 2021) or major trade conflicts (Fusacchia, 2019; Wang & Hewings, 2020), along with Russia's invasion of Ukraine and subsequent Western sanctions (Simmons, Culkin & Davies, 2022), illustrate the increasing uncertainty faced by businesses integrated into these global networks. Health crises, such as the COVID-19 pandemic, have exposed deep vulnerabilities by causing massive disruptions in supply chains. This global pandemic has redefined the questioning of international supply chains (Ivanov, 2021), triggered an increase in downstream demand, and led to a global economic slowdown (Coveri, Cozza, Nascia, Zanfei, 2020; Gölgeci, Yildiz & Andersson, 2020; Handfield, Graham & Burns, 2020; Sajjad, 2021; Strange, 2020). In addition to these two primary risks, economic crises have the main impact of drastically reducing the demand for goods and services, generating widespread financial instability, and causing major disruptions in trade flows (Dooley, Yan, Mohan, & Gopalakrishnan, 2010; Juttner & Maklan, 2011). It is important to note that these economic crises can be closely linked to other systemic crises, such as geopolitical conflicts or natural disasters and pandemics, which can also affect businesses embedded in global supply chains (Bouiyour, Selmi, Hammoudeh & Wohar,

2019; Caldara & Iacoviello, 2018; Ozili & Arun, 2020). Furthermore, our contemporary era is characterized by rising environmental challenges, such as natural disasters, largely intensified by climate change (Montshiwa, 2018; Stecke & Kumar, 2009; Tenggren, Olsson, Vulturius, Carlsen & Benzie, 2020). When this type of risk manifests, it exerts significant pressures on businesses due to disruptions of production, energy, and communication infrastructure. Businesses interconnected in global supply chains are affected beyond the directly impacted region, leading to significant secondary economic disruptions (Tenggren et al., 2020; Tokui, Kawasaki & Miyagawa, 2017). This new landscape compels businesses embedded in global supply chains to reconsider the determinants that structure their networks in order to achieve greater resilience against catastrophic disruptions. However, long-term supply chain resilience research strategies and the profound reconfigurations they entail do not necessarily yield significant short-term economic results (Sarkis, 2020; Shih, 2020). Finally, for SMEs with limited resource capital, engaging in new strategies to address a highly disruptive context can be challenging.

3.2 Supply Chain Resilience: Toward Agile and Sustainable Resilience

Indeed, the manifestation of systemic risks, due to their scale, results in widespread disruptions in global supply chains. It leads to physical damage to production networks, amplifies supply and demand volatility, increases supply lead times and costs, and generates significant contextual uncertainty (Casadei & Iammarino, 2021; Golan, Jernegan & Linkov, 2020; Roscoe et al., 2020; Dooley et al., 2010; Juttner & Maklan, 2011; Belhadi et al., 2021; Chen, Wang & Zhong, 2021; Kahiluoto, Mäkinen, & Kaseva, 2020). In response to these challenges, the concept of supply chain resilience emerges.

Supply chain resilience refers to the ability of a supply chain to prevent, absorb, and recover from an unforeseen disruption, and even improve its performance after a crisis (Belhadi et al., 2021; Christopher & Peck, 2004; Dubey et al., 2021; Ivanov, 2020; Juttner & Maklan, 2011; Li, 2020; Melnyk, Closs, Griffis, Zobel & Macdonald, 2014; Polyviou et al., 2019). This resilience is both reactive and proactive, enabling the supply chain to respond to disruptions while preparing for uncertain events (Golan et al., 2020; Handfield et al., 2020).

The complexity of supply chain resilience lies in the constant balancing act between cost-based efficiency (lean management proponents (Thomas et al., 2015) and security-based physical reconfigurations of the supply chain (Demmer, Vickery & Calantone, 2011; Purvis et al., 2016) as well as its practices (Skipper & Hann, 2009; Hong, Huang & Li, 2012; Lavastre, Gunasekaran & Spalanzani, 2012; Herrmann & Guenther, 2017; Gölgeci et al., 2020; Miller, 2021; Ramanathan, Aluko & Ramanathan, 2022). Achieving this balance sustainably should not be seen as a static state but rather as a perpetual process of preparation, information gathering and processing, resource and operation transformation, enabling the congruence of the business and its supply chain with a changing environment.

3.3 SMEs' Wait-and-see Attitude: An Uncertainty Resolution Stage

Faced with the realization of complex systemic risks, resource-constrained SMEs often initially adopt what Roscoe et al. (2020) define as a "passive or wait-and-see strategy." Through this stance, SMEs initially refrain from making any tangible and challenging commitments (such as relocation, inventory expansion, diversification) because their lack of knowledge about the new context prevents them from making informed decisions (Figueira-de-Lemos & Hadjikhani, 2014). The focal point of this strategy lies in the efforts made by SMEs to reduce this uncertainty. In this regard, Pflug and Romisch (2007) clarify that, before being able to manage systemic risks (deploy adaptation and reconfiguration strategies), they must be measured, which is itself a challenge. In the context of a systemic crisis, uncertainty is measured by the gap between the information available to the business at the time of the event and its capability to develop and implement an appropriate response strategy.

To achieve this, SMEs will "commit to intangible resources to gain knowledge about the disruptive event, establish relationships with stakeholders (supply chain, institutional environment, policymakers, and their representatives, etc.), and reduce contingent uncertainty" (Clarke & Liesch, 2017; Figueira-de-Lemos & Hadjikhani, 2014). Once the company has gained sufficient knowledge about the ins and outs of this crisis context, it can then adopt a reactive or proactive position by making tangible commitments that will enable the recovery of its supply chain and, ultimately, achieve resilience. A first observation to make at this stage is the need for SMEs to enhance the efficiency of these intangible resources in order to reduce the time they are immobilized in a wait-and-see stance. This would mitigate the effects of uncertainty on their supply chain operations and increase their responsiveness and proactivity in the face of systemic crises.

4. Strategic Intelligence: A Sustainable Resilience Capability for SME Supply Chains?

4.1 From Wait-and-see to Action: The Catalyzing Role of Strategic Intelligence

Firstly, supply chain visibility, a key concept in management, represents the ability to access information within the supply chain (Caridi, Crippa, Perego, Sianesi & Tumino, 2010; Juttner & Maklan, 2011). Supply chain visibility encompasses all operational activities of customers and suppliers (Barratt & Oke, 2007; Swaminathan & Tayur, 2003). This capability enables a focal company to monitor accurate information about upstream and downstream inventory, demand and supply conditions, production, and purchases (Christopher & Lee, 2004; Christopher & Peck, 2004; Lee, So, Tang, 2000). In a broader sense, visibility is measured based on the quantity and quality of information available to the focal company, compared to all potential exchanged information (Caridi et al., 2010). This information follows different routes, and the focal company's goal is to visualize all three flows of the supply chain: upstream, at the focal level, and downstream (Mubarik, Kusi-Sarpong, Govindan, Khan & Oyedijo, 2021). The issue of the scope of visibility is crucial within the supply chain and has been emphasized by several authors (Basole & Bellamy, 2014; Mubarik et al., 2021; Tang et al., 2009). They argue that increased visibility allows for a faster identification of risks. Visibility offers several advantages to companies integrated into complex supply chains. At the supply chain level, visibility builds trust, preventing overreactions from different parties, unnecessary interventions, and ineffective decisions in a risk event situation (Christopher & Lee, 2004; Juttner & Maklan, 2011). From the focal company's perspective, visibility appears in the literature as a capability that allows companies to gain flexibility and better redeploy their procurement and production strategy in the face of systemic disruptions (Gardner & Cooper, 2003; Mubarik et al., 2021). For the focal company to have relevant information and be aware of its position and interdependence within the supply chain, it can identify and, therefore, limit bottlenecks exacerbating disruptions (Gardner & Cooper, 2003; Juttner & Maklan, 2011; Mubarik et al., 2021). However, developing visibility presents a set of challenges. The first is the cost of a supply chain diagnosis (Norwood & Peel, 2020; Shih, 2020). Additionally, the availability and quality of information can be compromised by some supply chain actors' reluctance to disclose sensitive information (Juttner & Maklan, 2011; Norwood & Peel, 2020). Lack of understanding of the supply chain makes companies particularly vulnerable to major systemic crises, as Norwood & Peel (2020) have highlighted.

Secondly, environmental detection capability, in correlation with visibility (Lee & Rha, 2016), can be defined as a company's ability to capture changes in a new environmental context, detect signals from suppliers and competitors (Teece, 2007), and interpret changes leading to faster and more effective strategic repositioning (Akpan, Johnny & Sylva, 2021; Lee & Rha, 2016; Lengnick-Hall & Beck, 2005; Martinelli, Tagliazucchi & Marchi, 2018; Mikalef & Pateli, 2017). In general, environmental detection capability refers to the use of different information and knowledge to understand the main problems and unmet service needs (Akpan et al., 2021). Detection allows companies to capture the changes required in their resource base in the face of a dynamic event, such as a systemic crisis disrupting the supply chain. Martinelli et al. (2018), in their study on the impact of DCs and social capital of retail entrepreneurs in the Emilia earthquake, found that companies that had deployed an environmental detection and interpretation capability in the pre-disaster period tended to apply it even more intensively following a highly disruptive event. This capability is not only proactive but has proven useful at every stage of disruption. Detection capability affects the company's ability to quickly grasp change, which then affects the company's ability to reconfigure in a resilience-oriented manner (Kahkonen et al., 2021).

Lastly, seizing, which is the ability to make timely decisions, allows the development of new opportunities by creating decision-making procedures and structures (Lee & Rha, 2016; Teece, 2007; Teece & Pisano, 1994). Akpan et al. (2021) demonstrated that seizing capability was positively associated with supply chain resource realignment. Therefore, it implies a capability that is useful for resilience in a dynamic environment. To demonstrate its full effectiveness, two conditions must be met. The first determinant of the effectiveness of seizing is the quality of information available to the company from its environment (i.e., synergy between visibility and detection). Seizing capability is thus understood in the literature as resulting synergistically from the two previous capabilities (Akpan et al., 2021; Kahkonen et al., 2021; Teece 2007). The second condition for an efficient seizing capability lies in its temporal component; the seizing must be done at the right moment. An opportunity for reconfiguration detected too late will not allow the focal company to prepare or mitigate the effects of supply chain disruption. According to Min and Kim (2022), resource realignment will deliver the full potential of its advantages to the company only if done in a timely manner. Thus, in highly disruptive supply chain events, the seizing capability can help companies react quickly and accurately to detected threats and opportunities. Kahkonen et al. (2021) used this capability as a performance measure for a company in making strategic decisions in the face of a systemic crisis (in this case, COVID-19). According to the authors, companies that mobilized the seizing capability demonstrated greater supply chain resilience.

4.2 Toward Expanding Beyond the Scope of SMEs' Internal Resources

It can sometimes be difficult for SMEs to access relevant information to mitigate uncertainty. The lack of internal resources within SMEs can hinder the effective deployment of their SI capability. Therefore, the mitigation of these constraints can be achieved through the moderation played by external determinants.

The first of these determinants is the external social capital of SMEs. By facilitating access to interorganizational resources in their supply chain network, external social capital promotes SMEs' adaptation to a changing environment (Aldrich, 2012; Chowdhury, Paul, Kaisar & Moktadir, 2019; Nahapiet & Ghoshal, 1998; Ozanne et al., 2022). This social capital provides shared access to tangible and intangible resources that are crucial for supply chain resilience (Ali & Gölgeci, 2020). These relationships enable SMEs to exchange, acquire, and pool resources that may be lacking when facing highly disruptive events, thereby reducing the time required to react (Jia et al., 2020). External social capital would then be a determinant that strengthens the SI capability of SMEs. This determinant can be understood through three dimensions: structural social capital, which is the configuration of the network and the nature of the relationships between stakeholders (Jia et al., 2020; Nahapiet & Ghoshal, 1998; Ozanne et al., 2022; Preston et al., 2017); cognitive social capital, characterized by the development of common understandings of the environment, reducing the time needed for common decision-making; and relational social capital, based on the strength of relationships, trust, and reciprocity among network actors, facilitating more efficient resource sharing and enhancing responsiveness by reducing the waiting time (Jia et al., 2020; Ozanne et al., 2022; Li et al., 2016).

Another external determinant that moderates the relationship between SI capability and supply chain resilience is government support (Braglia, 2022; Cradock-Henry, 2019; Forbes & Wilson, 2018; Prosser et al., 2021). This form of support is manifested through financial and non-financial initiatives aimed at SMEs (Park, Hong & Roh, 2019; Parker et al., 2009; Nakku, Agbola, Miles & Mahmood, 2019). The measures of support, as documented in the literature, aim to alleviate constraints related to access to relevant business information, the identification of new partners, administrative procedures, and regulations that can sometimes be a burden to these businesses (Tambunan, 2008). In practice, government support can materialize through the creation of sectoral networks or consortia initiated and supported (especially financially) by the state, with the aim of providing SMEs with better access to collective resources. By pooling their knowledge and capital resources, members of these consortia enhance the effectiveness of their SI capability, which is crucial when faced with systemic disruptions.

Furthermore, the leaders of these consortia maintain close ties with government agencies and international actors. This proximity allows for a more rapid reduction of contextual uncertainty, facilitates the determination of resilience strategies, and creates new partnership opportunities between SMEs and other supply chain actors (Ali & Gölgeci, 2020). The closeness to governmental and international spheres helps reduce contextual uncertainty more quickly and allows for tailored solutions during crises. It also promotes the creation of new partnerships between SMEs and other supply chain actors. Thus, government support proves to be an essential element in strengthening the SI capability of SMEs and promoting their resilience to supply chain disruptions. Direct and indirect government initiatives, when well implemented, play a significant role in building SMEs' resilience, which is essential for their survival and success in an ever-evolving business environment.

4.3 Defining a Conceptual Framework and Future Empirical Research Agenda

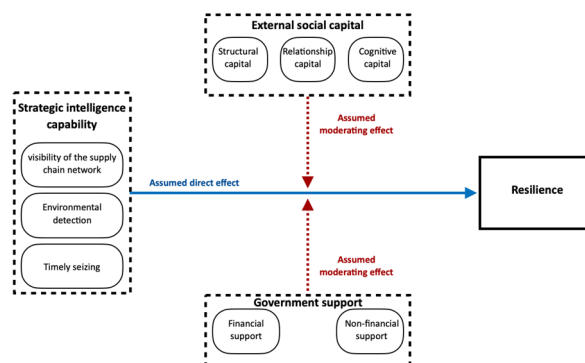


Figure 1. Simplified schematic of the conceptual framework

The framework (Figure 1) simplifies the relationships between the SI capability and the resilience of SMEs' supply chains. By reducing the scope of uncertainty, SI capability acts as a driver for action and shortens the

waiting time for SMEs. They will thus commit tangible resources to find a balance within a new context. The moderating determinants in the relationship between the SI capability and resilience aim to counterbalance the limited resources available to SMEs to effectively deploy their SI capability. Thus, external social capital can enable SMEs to gain better access to information related to their suppliers, current or impending disruptions in the supply chain, or changes in the business environment. Government support, on the other hand, can provide SMEs with additional resources, both financial and non-financial, through the pooling of resources and the encouragement to create cross-sectional synergies involving SMEs, industries, and institutions.

Based on this conceptual framework, we propose a research avenue. Indeed, various studies have already operationalized robust and empirically tested constructs to measure supply chain resilience to disruptions (Goaill et Al-Hakimi, 2011), but none has yet sought to measure these three dimensions of SI in an integrative framework. New empirical studies will provide an opportunity to measure the significance of the effect of each SI sub-capability on SMEs' supply chain resilience to determine which dimension of SI should be prioritized by SMEs. Furthermore, testing the moderating effect of external determinants will allow us to move beyond a simple view of resource-constrained companies. Moreover, most dimensions of SI (and more generally DCs) have been empirically tested as a driver of firm performance (Battisti & Deakins, 2017; Kahkonen et al., 2021; Mikalef & Pateli, 2017; Nedzinskas, Pundzienė, Buožiūtė-Rafanavičienė & Pilkienė, 2013). Thus, in the context of highly disruptive supply chain events, the seizing capability can enable firms to react swiftly and accurately to detected threats and opportunities. Kahkonen et al. (2021) have used this capability as a measure of firm performance in strategic decision-making during a systemic crisis. We propose an adaptation of literature items to transpose the use of SI as a resilience capability. Although the corpus presented in this article is not exhaustive, Table 2 identifies authors whose empirical work can contribute to the proposed model in Figure 1:

Table 2. Framework dimensions & literature anchoring

| Framework dimensions | Authors |
|-------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SI sub-dimension 1: Visibility of the supply network | Juttner & Maklan (2011); Mubarik et al. (2021) |
| SI sub-dimension 2: Environmental sensing capability | Lee & Rha (2016); Mikalef & Pateli (2017); Pavlou & El Sawy (2011); Wilden et al. (2013) |
| SI sub-dimension 3: Timely seizing capability | Akpan et al. (2021); Kahkonen et al. (2021); Lee & Rha (2016); Li & Liu (2014); Swafford et al. (2008) |
| Supply chain resilience | Goaill & Al-Hakimi (2011) |
| Inter-organizational & Institutional Resources | Pal et al. (2014); Paul et al. (2021); Polyviou et al. (2021); Jia et al. (2020); Ozanne et al. (2022); Parker et al. (2009); Songling et al. (2018); Park et al. (2019); Nakku et al. (2019); Otache & Usang (2022) |

To test this model, future empirical research can employ Partial Least Squares Structural Equation Modeling (PLS-SEM) as it allows the estimation of multiple relationships, considers both latent and observed variables simultaneously, and takes into account the effects of random measurement error in latent variables (Nakku et al., 2019). This method has proven to be effective and has been used by Akpan et al. (2021) to determine the relationship between DCs and organizational resilience in manufacturing firms. It has also been employed by Nakku et al. (2019) to test the moderating effect of government support in the relationship between firms' entrepreneurial orientation and performance. This method can thus allow us to test the moderating effect of inter-organizational and institutional external factors. Such empirical research will help fill a gap by focusing on the resilience of SMEs' supply chains, which is often overlooked, compared to large enterprises. It will extend the theory of DCs, with a focus on SI, to create new concepts. Methodologically, it will introduce latent variables to incorporate external determinants, thereby strengthening the DCs of SMEs in the face of major disruptions. In practical terms, the study will guide managers toward resilient strategic choices. It will underscore the importance of inter-organizational resource sharing and provide insights into the impact of government support for SMEs in times of crisis, leading to more effective resource allocation.

5. Recommendations and Limitations

5.1 Managerial Recommendations

In general, it has already been demonstrated that certain dimensions of SI capability can enhance the identification of opportunities associated with managing systemic crises (Belhadi et al., 2020; Kahkonen et al., 2021). Managers should therefore focus on strengthening the visibility of their supply network, notably by investing in effective information systems to monitor stocks, demand, and supply, thus mitigating the impact of volatility induced by crises (Caridi et al., 2010; Christopher & Peck, 2004). Additionally, they should develop their environmental detection capability by proactively paying attention to signals from suppliers, competitors, and the business environment in general (Lee & Rha, 2016). The primary objective of these strategies is to increase access to information (whether from the supply network structure or the environment) and its processing to reallocate resources and strategies in the right direction. Companies could also develop specific action plans to manage identified risks in their supply chain, based on extreme disruption scenarios, past highly disruptive events, or by implementing genuine benchmarking of best practices within the industry (Martinelli et al., 2018). External social capital (empirically tested by Ozanne et al., 2022) emerges as a key factor in acquiring resources for the company, particularly through information and knowledge sharing. It not only maintains strong ties with partners in disruptive contexts but also indirectly contributes to supply chain resilience by mediating the visibility of the supply network and environmental detection effects (Nikookar & Yanadori, 2022). Social capital, gauged by the focal company's ties with partners like suppliers, customers, and stakeholders, connects the company to its external environment, ensuring reliable access to valuable external information (Ozanne et al., 2022). Therefore, managers should seek to strengthen ties with their key suppliers or customers and go beyond a simple transactional relationship. Developing proximity can be achieved through regular contacts, site visits, participation in common business events, joint product development, or shared learning through experience sharing after a disruption (Ozanne et al., 2022; Scholten & Schilder, 2015).

5.2 Recommendations for Policymakers

Observing business censuses conducted worldwide reveals that SMEs constitute the economic and social backbone of economies. Support for SMEs through targeted policies aimed at enhancing SI capability can be achieved through financial support in the form of grants, preferential loans, and consulting services (Pergelova & Angelo-Ruiz, 2014; Park et al., 2019), enabling companies to invest in tangible resources (equipment, computer hardware) or intangibles (human capital) to better deploy this capability in the face of systemic crises. Government support for SMEs should also be provided non-financially through simplifying access to public and regulatory information or by creating industrial ecosystems bringing together SMEs, large companies, and research organizations focused on exchanging information, knowledge, practices, and carrying out joint projects. Previous studies focused on Australia have thus shown improved resilience to natural disasters among companies integrated into consortia (Ali & Gölgeci, 2020). Finally, it is imperative to regularly evaluate the effectiveness of government support programs to adjust strategies based on observed needs and outcomes. Studies such as those conducted by Nakku et al. (2019) or Park et al. (2019) offer valuable insights into the impact of government support on SMEs, which could guide the development of more effective policies in this area.

5.3 Limitations

While our conceptual study proposes a novel framework for understanding the role of SI in enhancing the resilience of SMEs' supply chains, several limitations should be acknowledged. The conceptual framework developed in this study is based on existing literature and theoretical constructs. However, its applicability across diverse industries, geographical regions, and organizational contexts remains to be empirically tested. Therefore, future research should aim to validate the framework through empirical studies conducted in various settings to ensure its generalizability. Moreover, conducting empirical research to validate the proposed conceptual model requires access to comprehensive and reliable data on SMEs' supply chain operations, SI capabilities, and external determinants such as government support and social capital. However, gathering such data can be challenging, especially for small businesses with limited resources and proprietary information. Establishing causal relationships between SI, external determinants, and supply chain resilience poses methodological challenges. While our conceptual model suggests that SI positively influences resilience, it is possible that other factors not accounted for in the model also influence these constructs. While SI has some potential as a capability to enhance SMEs' resilience, its effective implementation may, in practice, be hindered by resource constraints and organizational barriers. SMEs often operate with limited financial, human, and technological resources, which may impede their ability to invest in sophisticated information systems, training programs, and strategic planning initiatives. Moreover, organizational culture, leadership dynamics, and resistance to change

within SMEs may present additional challenges to the adoption and integration of SI practices. The conceptual framework presented in this study assumes a static relationship between SI and supply chain resilience. However, systemic risks and disruptions are dynamic and evolving phenomena that require continuous adaptation and response from organizations. Therefore, the effectiveness of SI in enhancing resilience may vary over time and in response to changing environmental conditions. Future research should explore the dynamic nature of these relationships and develop strategies for ongoing monitoring and adjustment.

6. Conclusion

In the face of a new reality characterized by an increase in systemic risks, SMEs integrated into global supply chains appear particularly vulnerable. These companies have often been overlooked in studies on supply chain resilience due to their limited resources. This conceptual research has highlighted the need to address this gap by exploring the role of SI in strengthening the resilience of SMEs. It has proposed a conceptual model showing how SI can reduce uncertainty, expedite the shift from waiting to action, and enhance supply chain resilience in the face of major disruptions. Furthermore, this conceptual study underscores the potential importance of external factors, such as external social capital and government support, in moderating the relationship between SI and supply chain resilience. Future empirical research based on this conceptual model could contribute to a better understanding of SMEs' supply chain resilience. By examining the significance of sub-capabilities of SI and testing the moderating effect of external factors, these studies would help prioritize key aspects of SI and bolster the DCs of SMEs. Methodologically, using Partial Least Squares Structural Equation Modeling would allow for a more in-depth analysis of these complex relationships. Ultimately, this research contributes to filling a knowledge gap about the resilience of SMEs' supply chains while offering practical insights for managers and policymakers. It highlights the importance of SI, inter-organizational resource sharing, and government support in promoting SMEs' resilience in the face of systemic disruptions, which, in turn, can strengthen the robustness of our economies in an increasingly complex and uncertain world.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Canadian Center of Science and Education.

The journal and publisher adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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