

# Analysing supply chain resilience: integrating the constructs in a concept mapping framework via a systematic literature review

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## Abstract

**Purpose** – The purpose of this paper is to analyse the concept of supply chain resilience (SCRES) within a concept mapping framework to seek conceptual clarity, with an emphasis on SCRES definitions, essential elements and managerial practices.

**Design/methodology/approach** – A systematic literature review was conducted of 103 peer-reviewed journal articles from the year 2000 to 2015, with the aim of answering a focus review question.

**Findings** – Through analysis and synthesis of the literature, the study revealed three major constructs used to define SCRES: phases of resilience, resilience strategies and the capabilities needed to be resilient. Emerging from the capabilities construct are five core SCRES capabilities: the ability to anticipate, to adapt, to respond, to recover and to learn. Also, given the need to consolidate the various constructs of SCRES, the study identified 13 essential elements and 84 managerial practices that support firms to achieve the five capabilities, which are then linked to SCRES strategies and phases to establish the connections that provide an integrated view of the concept.

**Research limitations/implications** – The explorative nature of this study and the role of the concept mapping framework, which does not empirically test the relationships in the model, are considered as limitations, to be addressed by the authors in future research.

**Originality/value** – The originality of this paper lies in the classification of different features of SCRES through a comprehensive concept mapping framework that establishes relationships and interactions between them. This study, therefore, lays a foundation for testing these connections in future empirical studies. The paper brings together fragmented literature from multiple studies to create a solid body of knowledge that addresses the need for conceptual clarity in SCRES literature.

**Keywords** Resilience, Supply-chain management, Systematic literature review

**Paper type** Literature review

## 1. Introduction

Research on supply chain resilience (SCRES) has increased substantially over the years, and researchers and practitioners are showing strong interest in it due to its potential impact on business continuity and competitiveness (Christopher and Peck, 2004; Sheffi, 2015). This interest represents a shift in businesses away from traditional risk management thinking, which is insufficient in addressing the increased vulnerabilities, uncertainties and unforeseen disruptions faced by complex global supply chains (Pettit *et al.*, 2013; Fiksel *et al.*, 2015). As supply chain networks enter an era of turbulence, new approaches and thinking are needed to design, build and manage supply chains to insulate them from disturbances (Christopher and Holweg, 2011). Building resilience is deemed an essential strategic capability (Sheffi and Rice 2005; Seville *et al.*, 2015) that enables the supply

chain to anticipate, adapt, respond and recover promptly from unpredictable events (Rice and Caniato, 2003; Ponomarov and Holcomb, 2009; Blackhurst *et al.*, 2011; Jüttner and Maklan, 2011). A resilient supply chain is perceived to absorb disturbances, restore its function and “bounce back” from adversity while maintaining a competitive advantage (Sheffi, 2007; Wieland and Wallenburg, 2013; Chopra and Sodhi, 2014). The concept of SCRES can, therefore, be promising when cultivated and implemented effectively in the field of supply chain management (SCM).

Current research on SCRES indicates that, to achieve resilience, it is vital for firms to build certain operational capabilities that must be aligned with supply chain partners to manage both expected and unexpected changes (Christopher and Peck, 2004; Sheffi and Rice, 2005; Ponomarov and Holcomb, 2009; Pettit *et al.*, 2010). However, the published research on SCRES remains fragmented, with too much disparity in the definitions of the concept, inconsistent identification of its constructs and

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a lack of clarity on the relationships between them. Further theoretical explanation is needed to improve the conceptual clarity. Indeed, many researchers have highlighted these limitations in recent years (Ponomarov and Holcomb, 2009; Bhamra *et al.*, 2011; Blackhurst *et al.*, 2011; Jüttner and Maklan, 2011; Melnyk *et al.*, 2014). Despite the growing body of literature on SCRES, few attempts have been made to address these issues.

Recent studies have addressed certain aspects of the gaps outlined above through a systematic review of the literature. For example, Hohenstein *et al.* (2015) suggest an appropriate definition and essential elements of SCRES; Pereira *et al.* (2014) focus on enablers and barriers of SCRES elements and Tukamuhabwa *et al.* (2015) propose a suitable theoretical lens to examine SCRES. Few studies, however, have sought to improve the conceptual clarity by consolidating the various SCRES constructs in an integrated and systematic way, to enhance the understanding of the concept.

In addressing these gaps, the aim of this study is to analyse the concept of SCRES to seek conceptual clarity, with an emphasis on SCRES definitions, essential elements and managerial practices, within a holistic model. A holistic model of SCRES is presented through a concept mapping framework guided by a systematic review of the literature. A concept map provides a useful framework to organise and represent knowledge on a topic (Novak and Cañas, 2008), and to identify key constructs so as to understand the theory, concepts and relationships between them (Rowley and Slack, 2004). This paper synthesises the accumulated findings, using integrative synthesis, and draws on a range of methodological approaches in the extant literature to address the review question: *How can the concept of supply chain resilience be analysed to inform research and practice?*

A key contribution of this framework is that it enables analysis of the potential of SCRES through the relationships of its constructs by evaluating and synthesising the current body of knowledge. Moreover, the framework lays the foundations for future research to explore the underlying theory and practice involved, with a view to creating resilient supply chains. The paper contributes to better understanding of SCRES and has both theoretical and practical implications. It adds value to the body of SCRES knowledge and bridges the research gap by using concept mapping to understand the complex relationships and dynamic interplays between SCRES constructs. Also, it increases managerial awareness of the interlinks between the constructs in building SCRES capabilities, which leads to better practices in terms of creating more resilient supply chain functions.

The rest of this paper is structured as follows. First, a systematic literature review (SLR) process is outlined. Then, a descriptive analysis of the reviewed literature is presented, and the findings related to the sub-questions are summarised. Next, a holistic model of SCRES is illustrated through a concept mapping framework, followed by a discussion of the implications for research and practice. Finally, directions for further research, arising from the study limitations, are proposed, and conclusions are drawn based on the findings.

## 2. Research methodology: systematic review of supply chain resilience literature

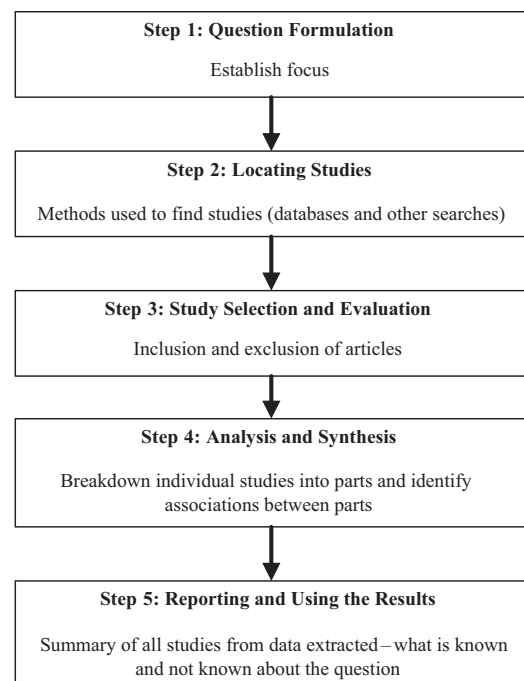
An SLR is an explicit and methodical way to gain deep knowledge about a given topic to inform researchers and practitioners (Briner and Denyer, 2012). Unlike traditional narrative reviews, an SLR follows a strict set of guidelines and adopts a replicable, scientific and transparent process (Tranfield *et al.*, 2003). It improves the clarity of scholarly communication, increases internal validity (against selection and publication bias) and creates transparency through the auditable process (Booth *et al.*, 2012).

SLRs synthesise results based on their robust, evidence-informed approach; their power to combine evidence from existing studies can create new knowledge through rigour in the criteria for selection, the analyses and the reporting (Tranfield *et al.*, 2003; Denyer and Tranfield, 2009). Hence, to improve methodological rigour, replicability and scholarly communication about the inconsistent body of literature on SCRES, the SLR approach was taken. This study follows the five-step guidelines on conducting systematic reviews of Denyer and Tranfield (2009) (Figure 1).

### 2.1 Question formulation

The first step of a systematic review is to define the scope of the study (Booth *et al.*, 2012) and to avoid ambiguity by defining and formulating the review question (Rousseau *et al.*, 2008), as identified in the Section 1. Specifically, SCRES conceptual clarity is sought by analysing the extant literature to provide a comprehensive framework through a concept

**Figure 1** Steps for conducting an SLR



**Source:** Adapted from Denyer and Tranfield (2009)

map. Hence, this study aims to answer the following review question: *How can the concept of SCRES be analysed to inform research and practice?* To provide more insights into the review question, three sub-questions were formulated:

- 1 What are the constructs used to define SCRES?
- 2 What are the essential elements and managerial practices needed to support SCRES capabilities?
- 3 How can SCRES constructs be linked to improve conceptual clarity?

## 2.2 Locating studies

The purpose of this phase was to search through relevant journal articles to locate, select and assess contributions pertinent to the review question (Denyer and Tranfield, 2009). Several online databases were searched to minimise bias and cover a broad range of sources. The database search included EBSCO (Academic Search Complete and Business Source Complete), Emerald, Science Direct, ABI/Inform Global, Web of Knowledge and Wiley Online. These databases are considered extensive, are available at academic institutions and have been used in similar studies (Mandal, 2014; Tukamuhabwa *et al.*, 2015).

In line with other systematic reviews on SCRES (Pereira *et al.*, 2014; Hohenstein *et al.*, 2015), several defined keywords were used as search criteria. The keywords consisted of the phrase “supply chain” combined with the following keywords: “resilience”, “resilient”, “resiliency”, “resilien\*”, “risk”, “mitigation”, “security” or “business continuity”. The selected keywords were then used to construct search strings with Boolean connectors (e.g. AND, OR) using a combination of the search fields. For example, the phrase “supply chain” in the abstract and keyword “resilien\*” OR “business continuity” in a full-text search (Table I). The time horizon for locating studies was from 2000 to 2015 (June). The year 2000 was selected as a starting point due to the emergence of studies on supply chain risks and vulnerability around that time (Svensson, 2000). The search was first carried out in February 2015 and repeated in June 2015.

## 2.3 Study selection and evaluation

The transparency of the process was maintained through explicit selection criteria to evaluate the relevance of studies for answering the review question (Denyer and Tranfield, 2009; Booth *et al.*, 2012). A list of inclusion criteria (Table II)

was used for the first screening, involving the reading of titles and abstracts of each paper. In total, 785 documents were screened at this stage. Articles that did not meet the inclusion criteria were not relevant to the topic or were duplicates were excluded. The remaining 130 articles were identified as potential candidates for inclusion in the review process. The second screening evaluated the preliminary list through the reading of the introduction and conclusion of each paper to further assess their relevance. From this screening, 33 articles were excluded either due to them not being relevant to the topic or because the full article was unobtainable due to access restrictions. Through the abstracts reading, it was concluded that the contribution of the unobtainable articles was not significant. Hence, the authors of the missing paper were not contacted.

The two screenings resulted in a total of 97 articles for undergoing full document screening. A further eight articles were identified through hand-searching and cross-referencing citations. Hand-searching was carried out on known journals that contribute to SCRES studies, but that had been missed by the databases search. In total, 105 articles were included in the full document screening process. Each article was fully read and analysed to address the review question. Further, quality criteria were applied to check the alignment of the paper’s rationale regarding the topic, methods and execution, methodological rigour and contribution to knowledge (Miles and Huberman, 1994). Two articles were excluded as a result of the quality screening, leaving 103 articles for the final review process. The sample of 103 articles is denoted with an asterisk (\*) in the reference list. A graphical illustration of the selection and evaluation process is provided in Figure 2.

## 2.4 Analysis and synthesis

The objective of this phase was to analyse and synthesise the selected 103 articles so as to develop new knowledge and insights about the topic that were not visible through reading every article in isolation (Denyer and Tranfield, 2009). An analysis was conducted by entering a summary of each of the 103 articles into a Microsoft Excel spreadsheet, while each study was broken down into the different features of SCRES. The extracted data provided a tabulation of all the studies included and a comprehensive summary of SCRES, which aided in the classification of

Table I Keywords and search strings

| Construct                    | Keywords                | Search strings  | Databases  |
|------------------------------|-------------------------|---|--|
| Supply chain resilience      | Supply chain resilience | AB supply chain AND TX (resilien* OR security OR mitigation OR business continuity) | EBSCO (Academic Search Complete and Business Source Complete)<br>Emerald<br>Science Direct<br>Web of Knowledge<br>ABI/Inform<br>Wiley Online |
|                              | Supply chain resiliency |   |  |
|                              | Resilient supply chain  | AB supply chain AND TX (resilien* OR risk OR risk management)                       |  |
|                              | Supply chain security   |   |  |
|                              | Risk mitigation in      |   |  |
|                              | supply chain Business   |   |  |
|                              | continuity of supply    |   |  |
|                              | chain                   |   |  |
| Supply chain risk            |                         |   |  |
| Supply chain risk management |                         |   |  |

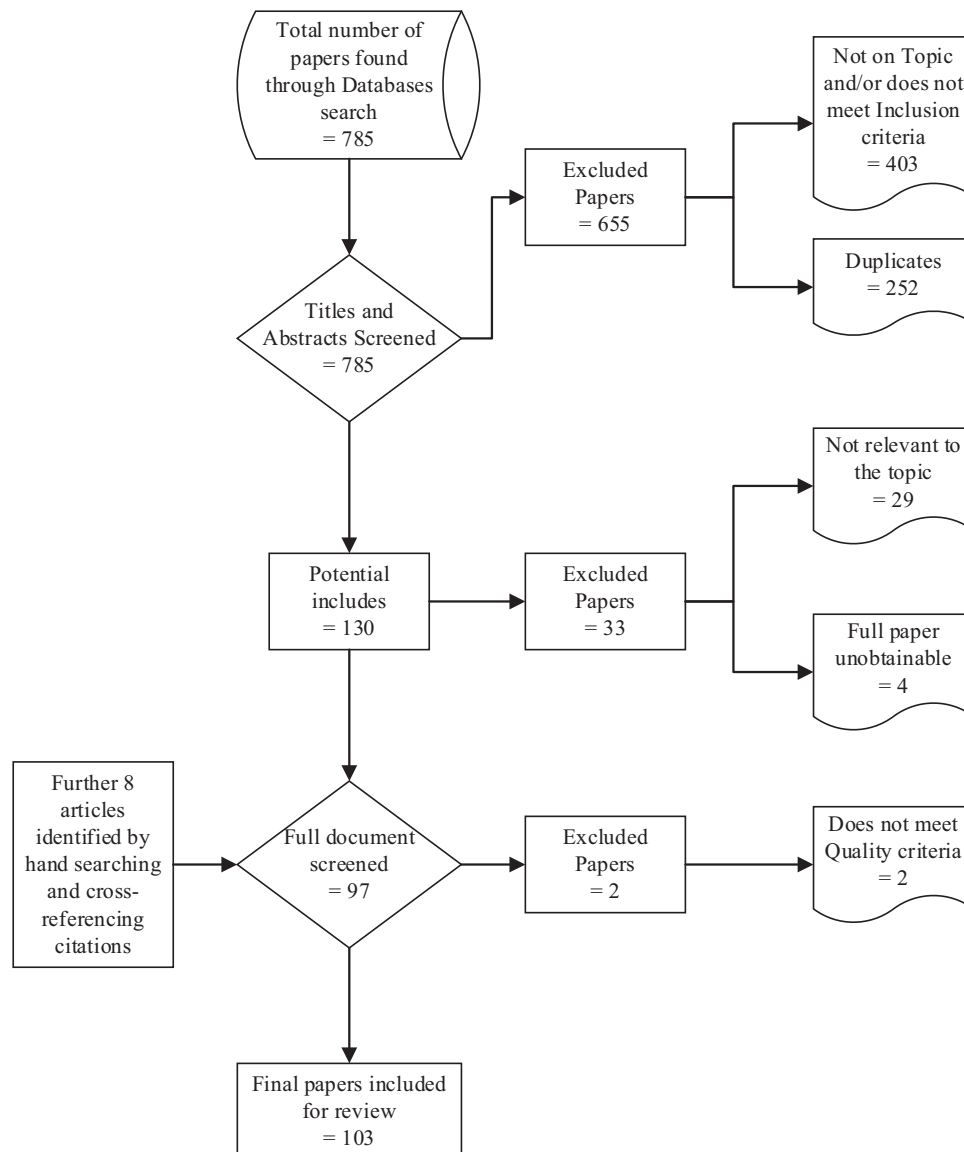
Note: AB = abstract and TX = all text

Table II Inclusion criteria for SCRES systematic review

| Inclusion criteria   | Rationale  |
|--|--|
| Published in peer-reviewed journals  | Peer-reviewed journals are considered to be of higher quality than non-peer-reviewed articles  |
| Selection of papers published 2000-2015*   | The year 2000 was selected as a starting point due to the emergence of studies on supply chain vulnerability around this time (Svensson, 2000) |
| Resilience addressed within the context of SCM or logistics, and is, at least, one of the focus of the paper | The aim of the review is to analyse and map the different features of SCRES to improve conceptual clarity and understanding                    |
| Published in the English language  | English is the dominant language in the field of SCM research  |
| Different types of article considered (e.g. empirical, literature review, conceptual)                        | The focus of the study is to evaluate and synthesise the various approaches to the concept of SCRES  |

Note: \*Up to the end of June 2015

Figure 2 Study selection and evaluation



Source: Based on PRISMA flow diagram (Moher *et al.*, 2009)



themes and the synthesis. The synthesis was carried out by making associations between the themes identified in each study. There are different approaches to synthesis in SLR such as aggregation, integration, interpretation and explanation (Rousseau *et al.*, 2008). The integration approach was used because of the heterogeneous nature of the articles in this review, and as the goal was to synthesise across multiple studies and methods to answer the review question (Rousseau *et al.*, 2008).

### 2.5 Reporting and using the results

This step provides the findings from all the selected studies, their relation to each other and what is known and not known about the review question (Denyer and Tranfield, 2009). The subsequent synthesis is an informed interpretation of the scientific evidence relating to the research question and the gaps found in the review process (Rousseau *et al.*, 2008). The following section outlines these findings on the current state of SCRES studies and the results relating to the three sub-questions.

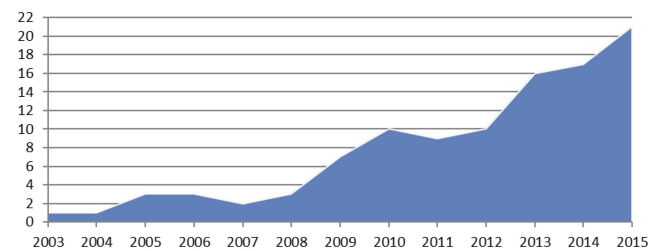
## 3. Findings

The SLR findings are reported in four sections, each of which will advance the understanding of the concept of SCRES. First, to understand the developments in SCRES literature, a descriptive analysis of the 103 articles is presented below, detailing the publication year, the relevant academic journals and the methodological approach. Second, SCRES definitions are analysed to evaluate SCRES phases, strategies and capabilities to answer the first sub-question. Third, to address the second sub-question, essential elements and managerial practices that support SCRES capabilities are examined. Finally, a holistic model is proposed to improve conceptual clarity by integrating SCRES constructs emerging from the SLR. The model is presented through a concept mapping framework that visually illustrates the relationships between the concept's constructs and highlights the best practices for achieving a resilient supply chain.

### 3.1 Descriptive analysis

Even though the time horizon for the selection of papers for this study started in 2000, the first article found to address the concept of SCRES was by Rice and Caniato, in 2003. Although other reviews on SCRES have reported papers from 2000 (Pereira *et al.*, 2014), none of these (Christopher, 2000; Sheffi, 2001) mentioned the term SCRES explicitly before the year 2003. Instead, research on the concept of SCRES started as a follow-up to two significant report findings on supply chain responses to terrorism (MIT Center for Transportation and Logistics, 2003); and Cranfield University: School of Management (2003) on creating resilient supply chains. In fact, the work of Rice and Caniato (2003), Christopher and Peck (2004) and Sheffi and Rice (2005), which forms the foundation of the SCRES literature, is based on the findings from these reports. Their research has influenced and motivated other studies on SCRES, leading to a steady growth of articles in the SCM domain. Figure 3 shows that most SCRES articles were published between 2009 and 2015, providing evidence for the growing body of literature and the importance of SCRES in

**Figure 3** Number of studies on SCRES 2003–2015\*



**Note:** \*Based on the final results of the SLR in this study

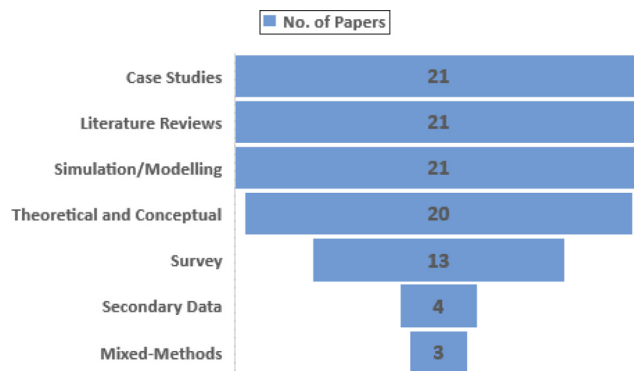
maintaining business continuity and competitiveness. This observation is also emphasised by Pereira *et al.* (2014), Mandal (2014) and Hohenstein *et al.* (2015).

The 103 articles were published in 43 interdisciplinary academic journals. More than half of the articles (53) were published in eight leading journals in the field of SCM (Table III). The highest share of studies in these leading journals was published in the *International Journal of Production Research* and *Supply Chain Management: An International Journal*. The diversity of the journals' research themes (i.e. production research, business logistics, operations management and SCM) is evidence of the multidisciplinary nature of the topic and the increasing attention it is attracting from various research communities.

In the literature, various research methodologies have been used to address the topic of SCRES. Based on Figure 4, five methodologies are common across the 103 reviewed articles: theoretical and conceptual papers (20), case studies (21), simulation/modelling papers (21), literature reviews (21) and surveys (13). The remainder used mixed-methods (3) and secondary data (4) methodologies. Although the use of multiple methods was applied in some studies (Craighead *et al.*, 2007; Azevedo *et al.*, 2013), each article in this instance was classified under the primary methodology. For example, Craighead *et al.* (2007) applied

**Table III** Number of articles published in academic journals

| Academic journal   | No. of papers | (%)   |
|--|---------------|-------|
| <i>International Journal of Production Research</i>                              | 12            | 11.65 |
| <i>Supply Chain Management: An International Journal</i>                         | 11            | 10.68 |
| <i>International Journal of Physical Distribution &amp; Logistics Management</i> | 6             | 5.83  |
| <i>Journal of Business Logistics</i>   | 6             | 5.83  |
| <i>International Journal of Logistics: Research &amp; Applications</i>           | 5             | 4.85  |
| <i>International Journal of Production Economics</i>                             | 5             | 4.85  |
| <i>MIT Sloan Management Review</i>   | 5             | 4.85  |
| <i>Journal of Operations Management</i>  | 3             | 2.91  |
| Others   | 50            | 48.54 |

**Figure 4** Classification of SCRES methodologies

multiple methods – involving a case study, semi-structured telephone interviews and a focus group in their study, but this article was classified under “case study” because this was the primary method used. The analysis indicates that few articles used mixed-method research, despite its rigorous approach to in-depth and wider analysis of a concept such as SCRES. As SCRES is a complex and multidimensional research subject, a mix of empirical and analytical research methods is needed to develop the theory and evaluate its implementation.

### 3.2 Analysis of supply chain resilience definitions

Resilience is considered one of the fundamental attributes that supply chains need to embrace to efficiently cope with disruptive events (Rice and Caniato, 2003; Christopher and Peck, 2004). The concept of SCRES appears to offer a way to avoid the limitations of traditional approaches to risk prevention and protection strategies and to deal with the complexities of global supply chains (Pettit *et al.*, 2013; Sheffi, 2015). The idea of resilience, however, according to Walker and Salt (2012), is wide-ranging and has its origin in the fields of engineering (Hollnagel *et al.*, 2006), psychology (Luthar *et al.*, 2000), ecology (Holling, 1973) and disaster relief (Manyena, 2006). Indeed, several resilience aspects from these domains have been borrowed by the SCM field to define SCRES (Sheffi and Rice, 2005; Ponomarov and Holcomb, 2009).

Table IV (abridged) shows the diversity of SCRES definitions in the selected studies of the reviewed literature based on their contributions to advancing SCRES knowledge (for the remainder, see Table AI, Appendix 1). These definitions address the concept on three different levels: from a firm, network and system-wide perspective. Overall, the definitions either were adapted from previous studies or aspects of resilience from other disciplines (such as psychology, ecology and engineering) were borrowed to form part of the definition of SCRES. The analysis of the definitions (Table IV; Table AI) identified three constructs in most definitions: the phases of resilience, resilience strategies and the capabilities needed for resilience. The following sections analyse, synthesise and interpret each of these constructs.

#### 3.2.1 Phases of supply chain resilience

The first construct relates to the three phases of SCRES, which cover the moments of pre-disruptions,

during-disruption and post-disruptions (Sheffi and Rice, 2005). To examine these phases, the themes that characterised them in each definition were highlighted. Themes such as *prepare*, *resist*, *avoid* and *alert* are used to describe the pre-disruption phase (Table IV), while themes such as *respond*, *cope* and *adapt* refer to the during-disruption phase, and themes such as *recover*, *survive*, *restore* and *return* describe the post-disruption phase. A chronological order of SCRES definitions shows that the initial focus on the concept was response (during-disruption phase) and recovery (post-disruption phase) in adversity. For example, Rice and Caniato's (2003) definition centres on the ability to react and restore normal operations; Christopher and Peck's (2004) on the system's ability to return or move to a new state through adaptability, whereas that of Sheffi and Rice (2005) focuses on the notion of “bouncing back” from disruption. Peck (2006) highlights the ability to absorb or mitigate disturbances, whereas Datta *et al.* (2007) put the stress not only on maintaining control but also on adaptation and response.

Over time, the emphasis in defining SCRES shifted from supply chain ability to respond and recover to include elements of resilience-preparation and growth, as shown in Figure 5. The first definition to highlight preparation (pre-disruption phase) for unexpected events was developed by Ponomarov and Holcomb (2009) and was followed by the similar theme of anticipation (Ponis and Koronis, 2012; Day, 2014). Similarly, the idea of seeking growth through opportunities that may emerge in the post-disruption phase was reflected in themes such as *grow/growth* and *thrive* that formed part of certain definitions (Pettit *et al.*, 2010; Johnson *et al.*, 2013; Hohenstein *et al.*, 2015), thus encompassing all three phases of resilience. However, only 10 of the 59 reviewed definitions incorporated all three phases, which indicates that further theoretical development of the concept is needed to consolidate the major phases.

#### 3.2.2 Supply chain resilience strategies

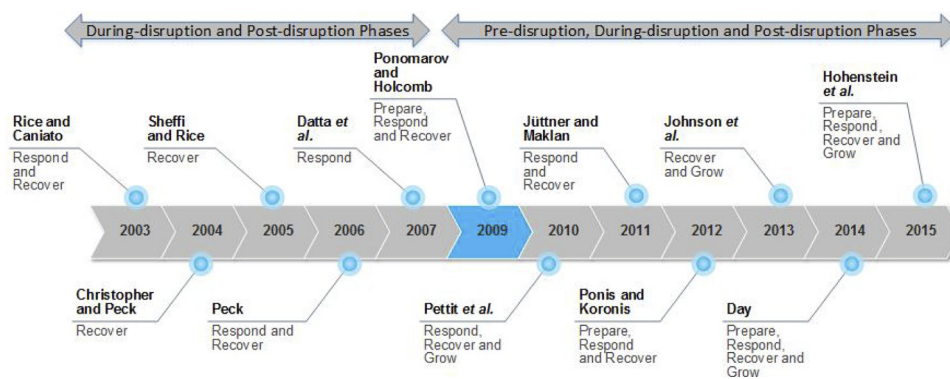
The second construct addressed in most of the definitions is the strategy used to prepare for, respond to and recover from supply chain disruptions. These strategies can be classified into three main categories: proactive, concurrent and reactive (Hollnagel, 2011). Proactive strategies refer to competencies needed in the pre-disruption phase; key themes in the definitions are *plan*, *anticipate alert* and *prepare* (Ponomarov and Holcomb, 2009; Day, 2014; Ambulkar *et al.*, 2015). Concurrent strategies, on the other hand, relate to quick reactive thinking and first-response abilities to cope with disturbances in the during-disruptions phase (Sheffi and Rice, 2005; Hollnagel, 2011). Themes such as *cope with change*, *adapt* and *respond* to unexpected events (Knemeyer *et al.*, 2009; Carvalho *et al.*, 2011; Wu *et al.*, 2013) imply a concurrent strategy. Finally, reactive strategies refer to what is required in the post-disruption phase so as to recover; the recurring themes in the definitions are *bounce back* from disruption and *return* to the original or desired state (Schmitt and Singh, 2012; Brandon-Jones *et al.*, 2014; Urciuoli, 2015).

Although proactive and reactive strategies are explicitly discussed in the SCRES literature, concurrent strategies are implicitly referred to. For example, Sheffi and Rice (2005)

Table IV SCRES definitions

| Authors                               | SCRES definitions   |
|---------------------------------------|---|
| Rice and Caniato (2003, p. 25)        | Resilience is widely used to characterize an organization's ability to react to an unexpected disruption, such as one caused by a terrorist attack or a natural disaster, and restore normal operations   |
| Christopher and Peck (2004, p. 2)     | The ability of a system to return to its original state or move to a new, more desirable state after being disturbed  |
| Sheffi and Rice (2005, p. 41)         | The ability to bounce back from a disruption  |
| Datta et al. (2007, p. 189)           | Supply chain resilience is defined as not only the ability to maintain control over performance variability in the face of disturbance but also a property of being adaptive and capable of sustained response to sudden and significant shifts in the environment in the form of uncertain demands   |
| Ponomarov and Holcomb (2009, p. 131)  | The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function  |
| Klibi et al. (2010, p. 287)           | "... resilience is the capability of a SCN to avoid disruptions or quickly recover from failures"   |
| Pettit et al. (2010, p. 1)            | The capacity for an enterprise to survive, adapt and grow in the face of turbulent change   |
| Jüttner and Maklan (2011, p. 247)     | Supply chain resilience addresses the supply chain's ability to cope with the consequences of unavoidable risk events in order to return to its original operations or move to a new, more desirable state after being disturbed  |
| Blackhurst et al. (2011, p. 374)      | We specifically define supply chain resilience as a firm's ability to recover from disruptive events  |
| Ponis and Koronis (2012, pp. 925-926) | The ability to proactively plan and design the Supply Chain network for anticipating unexpected disruptive (negative) events, respond adaptively to disruptions while maintaining control over structure and function and transcending to a post-event robust state of operations, if possible, more favourable than the one prior to the event, thus gaining competitive advantage |
| Wieland and Wallenburg (2013, p. 301) | In this research, resilience is understood as the ability of a supply chain to cope with change   |
| Melnyk et al. (2014, p. 36)           | The ability of a supply chain to both resist disruptions and recover operational capability after disruptions occur   |
| Day (2014, p. 3)                      | Resilience is "the capability to anticipate risk, limit impact, and bounce back rapidly through survival, adaptability, evolution, and growth in the face of turbulent change"  |
| Hohenstein et al. (2015, p. 108)      | Supply chain's ability to be prepared for unexpected risk events, responding and recovering quickly to potential disruptions to return to its original situation or grow by moving to a new, more desirable state in order to increase customer service, market share and financial performance   |
| Ambulkar et al. (2015, p. 112)        | Firm's resilience to supply chain disruptions is defined as the capability of the firm to be alert to, adapt to and quickly respond to changes brought by a supply chain disruption   |

Figure 5 SCRES phases timeline in definitions



referred to the concurrent strategies as a first response, while Scholten et al. (2014) discussed them under immediate response. One plausible explanation could be that, in most SCRES literature, concurrent strategies are classified under, and sometimes considered part of, reactive strategy. In practice, however, these strategies are different; concurrent strategies consist of rapid adjustments of the system during disruption, whereas reactive strategies take place in the aftermath of an event (Hollnagel, 2011).

### 3.2.3 Supply chain resilience capabilities

The third construct used to define SCRES relates to the capability required to be resilient. Despite the diversity in SCRES definitions, the reviewed literature shares common capabilities through which firms can effectively manage disruptions and/or a changing environment. Based on SCRES definitions in Table IV and Table AI, various themes that convey common terms of resilience capabilities were coded and grouped. Four main groups were identified based on

Hollnagel's (2011) taxonomy for safety science resilience capabilities: the ability to anticipate, to monitor, to respond and to learn. Three of the four capabilities (ability to anticipate, respond and learn) were actively supported by common themes in the definitions. Surprisingly, despite it being important for firms to monitor supply chain performance before, during and after disruption, only the Ambulkar *et al.* (2015) definition referred to monitoring capability. One explanation for this could be that most authors adapt previous definitions, and thus SCRES definitions change slightly over time (Hohenstein *et al.*, 2015). Another explanation may be that monitoring capabilities are seen as part of the ability to anticipate and are thus tacitly referred to by other similar terms such as preparing and planning. In this study, the capacity to monitor is considered as an integral part of the ability to anticipate. Building on Hollnagel's classification of resilience capabilities, the reviewed definitions reveal two more significant SCRES capabilities that can support a firm in developing a resilient supply chain: the ability to adapt and to recover.

Table V summarises the five SCRES capabilities derived from the reviewed definitions. It indicates that the emphasis in the current literature is on the ability to recover and adapt, while scant attention is paid to the capacity to learn from experience. The results support the suggestion that SCRES research needs to address the broader role of proactive capabilities (Knemeyer *et al.*, 2009; Wieland and Wallenburg, 2013) and learning capabilities in building SCRES (Blackhurst *et al.*, 2011; Jüttner and Maklan, 2011).

In summary, the three constructs described above can help map definitions of SCRES through their phases, strategies and capabilities, as illustrated in Figure 6. Narrow definitions of SCRES in the literature can pertain to aspects of one or two phases and strategies of resilience, whereas a broad definition encompasses all three phases and strategies. Furthermore, the analysis of SCRES definitions indicates that more refined constructs are warranted, as the alignment among SCRES capabilities, resilient phases and strategies lacks clarity. As

such, the aim here is to highlight such ambiguities to enhance future clarity on definitions, and not to adapt or provide a new SCRES definition. The examination of SCRES definitions has helped to bridge this gap by mapping the relations between SCRES capabilities and its strategies and phases, as outlined in Figure 6.

### 3.3 Elements and managerial practices of supply chain resilience capabilities

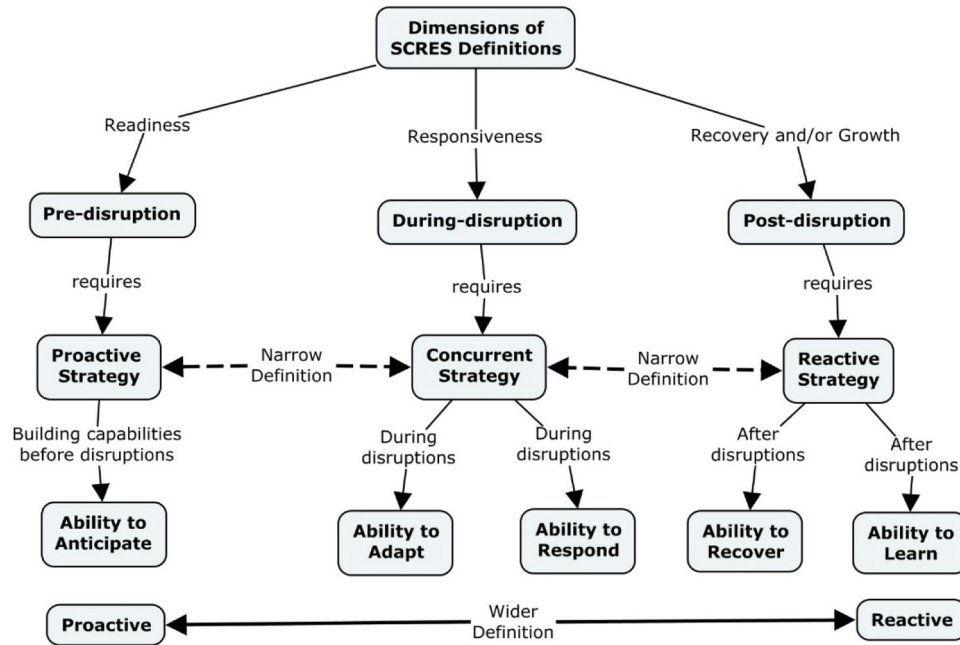
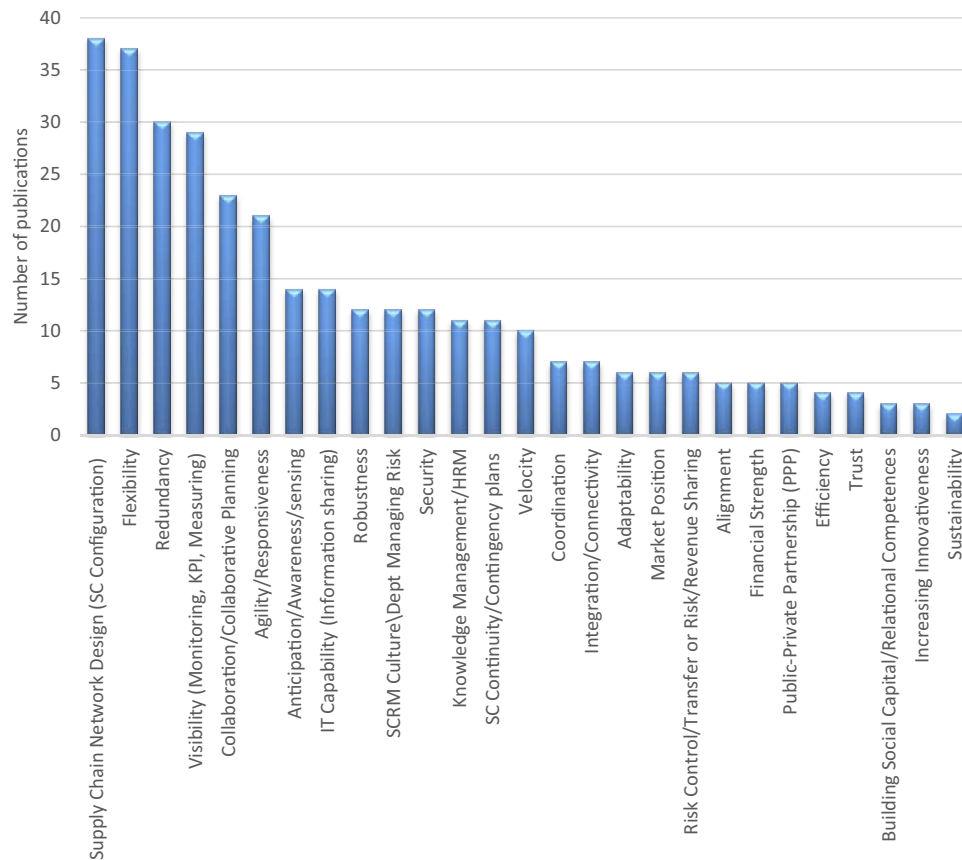
In evaluating the elements that build SCRES capabilities, an array of terms is found in the literature that describes this attribute. These include terminologies such as dimensions (Aigbogun *et al.*, 2014), capabilities (Pettit *et al.*, 2013), enhancers (Blackhurst *et al.*, 2011), enablers (Pereira *et al.*, 2014) and elements (Christopher and Peck, 2004). Antecedents (Scholten and Schilder, 2015), principles (Seville *et al.*, 2015) and competencies (Wieland and Wallenburg, 2013) have been used to describe features of SCRES. These differences explain the divergence in how resilience is understood, investigated and applied in the SCM context. Indeed, many researchers have argued that the body of knowledge on SCRES is fragmented, lacks conceptual clarity and is in need of better theory-building to advance the topic (Ponomarev and Holcomb, 2009; Bhamra *et al.*, 2011). Despite the growing body of literature on SCRES (Figure 3), these issues are not consistently addressed.

Hence, to bring consistency to the terminology, this study, consistently with the Christopher and Peck (2004) and Hohenstein *et al.* (2015) analysis of SCRES attributes, refers to them as elements. The systematic review of the SCRES literature identified 27 elements (Figure 7). The largest number of studies addressed supply chain network design through configuration (38) and building flexibility (37). Other essential elements such as redundancy (30), visibility (29), collaboration (23) and agility (21) were also discussed in the literature. For the complete list of 27

Table V SCRES capabilities

| SCRES capabilities    | Description  | Themes in SCRES definitions  | No. of papers |
|-----------------------|--|--|---------------|
| Ability to anticipate | Proactive capabilities necessary to identify and monitor potential events, changing environments, and performance before the ability of the supply chain to function is affected | Proactively plan, anticipate risk, prepare, resist, avoid and be alert   | 14            |
| Ability to adapt      | Concurrent capabilities required to manage and adjust critical supply chain resources continually during disruptions and/or normal business activities                           | Cope with unexpected disturbance or change, absorb/withstand/reduce impact, tolerate, adapt  | 29            |
| Ability to respond    | Concurrent capabilities needed to react to supply chain events on time and efficiently, to lessen the impact of disruptions or change the effects to ensure a desirable outcome  | Maintain control, retain structure and function, react, change rapidly and respond   | 19            |
| Ability to recover    | Reactive capabilities essential in the aftershock of a supply chain event, so as to restore or return to normal operations   | Survive, maintain continuity, bounce back, return to original/normal state, move to new/desirable state, recover, restore quickly, in timely fashion, and cost-effectively and resume operations | 48            |
| Ability to learn      | Reactive capabilities required after a supply chain event to understand what has happened and improve future performance based on the experience                                 | Sustain, growth, thrive, evolve, future adjustments and profitability  | 10            |



**Figure 6** Three constructs of SCRES definitions**Figure 7** Elements supporting SCRES capabilities

elements and their corresponding authors, see Table AII, Appendix 2.

The analysis of elements that support SCRES capabilities reveals the disparity in the way these elements are grouped in the literature. For example, some authors regard velocity and visibility as an antecedent of achieving agility (Christopher and Peck, 2004; Jüttner and Maklan, 2011). In contrast, the study by Pettit *et al.* (2013) found visibility to be an important element in enhancing SCRES capabilities through information exchange and business intelligence. Similarly, previous reviews on SCRES studies have grouped and classified elements into their corresponding sub-elements and/or strategies (Hohenstein *et al.*, 2015; Tukamuhabwa *et al.*, 2015). In this study, the term managerial practice is used to indicate sub-elements that operate at the operational level of the concept's abstract to build SCRES capabilities.

To seek clarity and improve understanding of SCRES elements, the need to consolidate the various elements and their practices and link them to the three SCRES constructs analysed in previous sections (i.e. phases, strategies, capabilities) is necessary. Based on the 27 elements (Table AII), 13 essential elements and their matching practices are selected to support the five SCRES capabilities (Table V). The 13 elements are selected based on rigorous previous studies (Blackhurst *et al.*, 2011; Pettit *et al.*, 2013) and reviews grounded in theory (Ponomarev and Holcomb, 2009; Pereira *et al.*, 2014). Further, these elements and practices are then linked with their related SCRES capabilities and strategies, as shown in Table VI. This establishes the connections that provide an integrated view of SCRES, allowing the concept to develop and progress and promoting further advances in the field.

### 3.3.1 Integrated approach: establishing relationships and interactions in managerial practices

In the context of the pre-disruption phase, five essential proactive elements and their related practices were identified, which can gauge the level of SCRES readiness to anticipate the potential impact of disruption:

- 1 Situation awareness involves an understanding of supply chain vulnerabilities and planning for such events, and requires the ability to discern a possible disruption by sensing and interpreting events (Datta *et al.*, 2007) through early warning strategies (Sáenz and Revilla, 2014) and continuity planning (Pettit *et al.*, 2010). These practices will help in the mapping of supply chain vulnerabilities (Melnyk *et al.*, 2010) so as to avoid, contain or control risk (Manuj and Mentzer, 2008; Stecke and Kumar, 2009). However, these practices require coordination, information sharing and pre-existing knowledge (Salas *et al.*, 1995) among supply chain partners to proactively develop and improve the level of situation awareness (Vargo and Seville, 2011) in anticipating disruptions.
- 2 Robustness is the ability of the supply chain to resist change and entails proactive anticipation of change before it occurs (Wieland and Wallenburg, 2012, 2013). Building robustness involves strategic decisions on the design of the supply chain network (Klibi *et al.*,

2010). That is, designing a value-creating supply chain network structure, which sustains the operation during and after a disruptive event (Tang, 2006). A robust supply chain can function despite some disturbances, as it withstands and copes with shocks by retaining its stability when changes occur (Meepetchdee and Shah, 2007; Wallace and Choi, 2011; Wieland, 2013; Durach *et al.*, 2015). It achieves this by proactively configuring the supply chain network density and complexity (Craighead *et al.*, 2007), critical location (Knemeyer *et al.*, 2009), product design (Khan *et al.*, 2012), supply base strategy (Christopher and Peck, 2004) and segmenting the supply chain over a broad range of possible scenarios (Chopra and Sodhi, 2014).

- 3 Visibility serves as a warning strategy that provides valuable time for firms to align their capabilities to minimise disruptive impact (Stecke and Kumar, 2009). It also generates awareness on the current status of supply chain operating assets and the environment (Fiksel *et al.*, 2015) by using key performance indicator metrics to monitor performance (Melnyk *et al.*, 2014; Ambulkar *et al.*, 2015). Increased visibility in the supply chain is enhanced by investing in IT capabilities that enable transparency through integrated information-sharing and connectivity (Melnyk *et al.*, 2010; Jüttner and Maklan, 2011; Brandon-Jones *et al.*, 2014).
- 4 Security is an essential part of SCRES that should be designed in advance rather than sought after an incident (Rice and Caniato, 2003; Sarathy, 2006). Building security protects the supply chain against deliberate attacks such as counterfeiting and helps to ensure cyber-security and freight security (Manuj and Mentzer, 2008; Stevenson and Busby, 2015). Moreover, security can be improved by creating synergies with supply chain partners and public-private partnerships (Bakshi and Kleindorfer, 2009; Stewart *et al.*, 2009; Voss and Williams, 2013).
- 5 Knowledge management and understanding of supply chain and human resource structures are the building blocks for creating a resilient supply chain (Blackhurst *et al.*, 2011; Pettit *et al.*, 2013; Scholten *et al.*, 2014). Hence, SCRES is improved by cultivating knowledge management in the pre-disruption phase through practices such as education and training (Jüttner and Maklan, 2011), creating an SCRM/SCRES culture (Christopher and Peck, 2004) and supply chain drills, simulations and exercises (Rice and Caniato, 2003).

In the context of the during-disruption phase, four vital concurrent elements and their practices were acknowledged that can help to assess the level of SCRES responsiveness to adapt and respond to an event during a disruption:

- 1 Flexibility is the second-most discussed element of SCRES due to its various benefits in SCM functions (Figure 7). For example, authors have highlighted many ways to develop flexibility in SCM to enhance SCRES by having flexible supply and/or demand management (Tang and Tomlin, 2008; Zsidisin and Wagner, 2010) and processes (Azevedo *et al.*, 2013), as well as by maintaining flexible order fulfilment (Pettit *et al.*, 2013) and transportation (Ishfaq, 2012). Increasing flexibility provides the ability to adapt to changes quickly and

Table VI Integrated view of SCRES constructs

| Strategy   | Capability            | Elements                               | Practices  | Authors  |
|------------|-----------------------|--|--|--|
| Proactive  | Ability to anticipate | Situation awareness                    | Sensing and interpreting events, continuity planning, mapping of supply chain vulnerabilities, warning strategies, risk avoidance and containment, risk control/transfer/share   | Christopher and Peck (2004), Craighead <i>et al.</i> (2007), Datta <i>et al.</i> (2007), Manuj and Mentzer (2008), Ponomarov and Holcomb (2009), Stecké and Kumar (2009), Melnyk <i>et al.</i> (2010), Pettit <i>et al.</i> (2010, 2013), Kumar and Sosnoski (2011), Sawik (2013), S&acute;enz and Revilla (2014), Ambulkar <i>et al.</i> (2015), Seville <i>et al.</i> (2015)               |
|            |                       | Robustness                             | Supply chain network design: supply chain/infrastructure configuration, segmentation, decentralisation, density, complexity, node/location criticality, product flow, product design, supply base strategy, anticipation/preparedness to changes | Blackhurst <i>et al.</i> (2005), Tang (2006), Craighead <i>et al.</i> (2007), Datta <i>et al.</i> (2007), Ratick <i>et al.</i> (2008), Knemeyer <i>et al.</i> (2009), Klibi <i>et al.</i> (2010), Blackhurst <i>et al.</i> (2011), Khan <i>et al.</i> (2012), Wieland and Wallenburg (2013), Chopra and Sodhi (2014), Day (2014), Scholten <i>et al.</i> (2014), Durach <i>et al.</i> (2015) |
|            |                       | Increasing visibility                  | Monitoring performance (KPI metric and measurement), IT capabilities, information sharing, transparency through integrated systems, connectivity   | Christopher and Peck (2004), Pereira (2009), Ponomarov and Holcomb (2009), Stecké and Kumar (2009), Blackhurst <i>et al.</i> (2011), Jüttner and Maklan (2011), Brandon-Jones <i>et al.</i> (2014), Day (2014), Melnyk <i>et al.</i> (2014), Ambulkar <i>et al.</i> (2015), Fiksel <i>et al.</i> (2015)  |
|            |                       | Building security                      | Freight/physical security, security culture, countermeasures for counterfeiting threat, cyber-security, layered defences, creating public-private partnerships (PPP), cooperative strategies with supply chain partners                          | Rice and Caniato (2003), Sarathy (2006), Manuj and Mentzer (2008), Bakshi and Kleindorfer (2009), Stewart <i>et al.</i> (2009), Williams <i>et al.</i> (2009), Pettit <i>et al.</i> (2010, 2013), Voss and Williams (2013), Melnyk <i>et al.</i> (2014), Stevenson and Busby (2015)  |
|            |                       | Knowledge management (pre-disruption)  | Supply chain understanding, education and training, supply chain drills, simulations and exercises, SCRM/SCRES culture, board-level leadership, risk-management department, risk awareness, inter-organisational learning                        | Rice and Caniato (2003), Christopher and Peck (2004), Manuj and Mentzer (2008), Pettit <i>et al.</i> (2010, 2013), Blackhurst <i>et al.</i> (2011), Jüttner and Maklan (2011), S&acute;enz and Revilla (2014), Scholten <i>et al.</i> (2014), Seville <i>et al.</i> (2015), Stevenson and Busby (2015)   |
| Concurrent | Ability to adapt      | Increasing flexibility                 | Flexible supply via multiple suppliers, flexible manufacturing processes or resources, flexible product via postponement, flexible pricing via responsive pricing, flexible transportation mode, flexible order fulfilment                       | Rice and Caniato (2003), Sheffi and Rice (2005), Tang and Tomlin (2008), Pettit <i>et al.</i> (2010, 2013), Yang and Yang (2010), Zsidisin and Wagner (2010), Ishfaq (2012), Azevedo <i>et al.</i> (2013), Melnyk <i>et al.</i> (2014), Fiksel <i>et al.</i> (2015)  |
|            |                       | Building redundancy                    | Excess capacity in production or transportation or resources, multiple suppliers, safety stock, strategic inventory, emergency backup/storage facilities, low capacity utilisation   | Rice and Caniato (2003), Sheffi and Rice (2005), Datta <i>et al.</i> (2007), Ratick <i>et al.</i> (2008), Stecké and Kumar (2009), Zsidisin and Wagner (2010), Carvalho <i>et al.</i> (2011), Klibi and Martel (2012), Wu <i>et al.</i> (2013), Azadeh <i>et al.</i> (2014), Ambulkar <i>et al.</i> (2015)   |
|            | Ability to respond    | Collaboration                          | Collaborative planning, supply chain intelligence, information-sharing, coordination, cooptation with competitors  | Christopher and Peck (2004), Bakshi and Kleindorfer (2009), Pettit <i>et al.</i> (2010, 2013), Jüttner and Maklan (2011), Leat and Revoredo-Giha (2013), Scholten <i>et al.</i> (2014), Fiksel <i>et al.</i> (2015), Scholten and Schilder (2015)  |
|            |                       | Agility                                | Velocity and acceleration, responsiveness, speed   | Christopher and Peck (2004), Tang and Tomlin (2008), Ponomarov and Holcomb (2009), Ismail <i>et al.</i> (2011), Jüttner and Maklan (2011), Cabral <i>et al.</i> (2012), Wieland and Wallenburg (2013), Ivanov <i>et al.</i> (2014), Scholten and Schilder (2015)   |
| Reactive   | Ability to recover    | Contingency planning                   | Supply chain reconfiguration, resource reconfiguration, recovery plans, restoration plans, time to market, scenario analysis   | Blackhurst <i>et al.</i> (2005), Craighead <i>et al.</i> (2007), Ponomarov and Holcomb (2009), Blos <i>et al.</i> (2010), Colicchia <i>et al.</i> (2010), Melnyk <i>et al.</i> (2010), Gong <i>et al.</i> (2014), Ambulkar <i>et al.</i> (2015), Rajesh and Ravi (2015)  |
|            |                       | Market position                        | Financial strength, market share, efficiency, strategic alignment, adaptability, customer relationships, customer communications   | Sheffi and Rice (2005), Pettit <i>et al.</i> (2010, 2013), Boone <i>et al.</i> (2013), Wu <i>et al.</i> (2013), Day (2014), Melnyk <i>et al.</i> (2014), Fiksel <i>et al.</i> (2015), Seville <i>et al.</i> (2015)   |
|            | Ability to learn      | Knowledge management (post-disruption) | Education and training, post-disruption feedback, cost/benefits knowledge, becoming a learning organisation, looking beyond risks to see opportunities, increasing innovativeness in contingency planning and continuity management              | Rice and Caniato (2003), Ponomarov and Holcomb (2009), Stecké and Kumar (2009), Blackhurst <i>et al.</i> (2011), Golgeci and Ponomarov (2013), G&ouml;lgeci and Ponomarov (2015), Seville <i>et al.</i> (2015)   |
|            |                       | Building social capital                | Trust, inter-organisational relationships, relational competence, leverage co-creation processes   | Johnson <i>et al.</i> (2013), Wieland and Wallenburg (2013), Day (2014), Seville <i>et al.</i> (2015)  |

readily in the case of disruption and to facilitate operational efficiencies in normal conditions (Sheffi and Rice, 2005). Flexible decisions help firms to adjust to rather than withstand disruptions (Wallace and Choi,

2011) by redeploying dedicated capacity (Rice and Caniato, 2003).

- 2 Redundancy entails maintaining excess capacity to respond to disruptions in the supply chain through

capital investments (Rice and Caniato, 2003). Building redundancy improves the ability to adapt to sudden changes through the strategic use of excess capacity in production (Sheffi and Rice, 2005), transportation (Stecke and Kumar, 2009), inventory (Wu *et al.*, 2013) and storage facilities (Ratick *et al.*, 2008).

- 3 Collaboration is the ability to respond to supply chain disruptions with partners through collaborative planning (Christopher and Peck, 2004) and information- and intelligence-sharing (Jüttner and Maklan, 2011; Pettit *et al.*, 2013) to coordinate the immediate response (Scholten *et al.*, 2014). Vertical collaboration and horizontal collaboration between supply chain partners are shown to increase SCRES (Leat and Revoredo-Giha, 2013).
- 4 Agility refers to the ability to respond rapidly to changes; in this phase, it improves the time of response to variations in both risk mitigation and market response (Braunscheidel and Suresh, 2009). An agile supply chain possesses qualities such as increased velocity to quickly adapt to unexpected changes in demand or supply (Christopher and Peck, 2004; Jüttner and Maklan, 2011), acceleration to speed up the reaction time (Wieland and Wallenburg, 2013) and responsiveness to react to changes (Cabral *et al.*, 2012; Ivanov *et al.*, 2014). These practices enable firms to reduce the impact of the disturbances, which enhances the ability to respond.

In the post-disruption phase, four crucial reactive elements and their practices were identified that can characterise and help in evaluating the level of SCRES recovery and learning in the aftermath of the event:

- 1 Evaluating supply chain contingency plans in the post-disruption phase enhances a firm's ability to recover by assessing the plans that can be activated in this phase. In particular, processes such as supply chain reconfiguration (Blackhurst *et al.*, 2005; Craighead *et al.*, 2007), resource reconfiguration (Ambulkar *et al.*, 2015), resource mobilisation (Pettit *et al.*, 2010) and scenario analysis (Colicchia *et al.*, 2010; Melnyk *et al.*, 2010) are essential for developing effective contingency plans. Measuring these processes will assist in improving supply chain restoration plans, for example, in transportation and communications (Gong *et al.*, 2014), and reducing time to market on new product introduction to normal operational state (Blos *et al.*, 2010).
- 2 Having a strong market position increases a firm's ability to recover from supply chain disruptions due to financial strength (Fiksel *et al.*, 2015), organisational efficiency (Ponomarov and Holcomb, 2009) and product market share (Wu *et al.*, 2013). A strong market position is associated with increased market share (Pettit *et al.*, 2010) and results in high margins that allow investments in SCRES (Sheffi and Rice, 2005), which helps to maintain healthy customer relationships (Melnik *et al.*, 2014) in the aftermath of an event.
- 3 Post-disruption knowledge management enhances the ability of a supply chain to learn from events. Resilient supply chains cultivate their ability to learn in the aftermath of an event through education and training (Rice and Caniato, 2003), post-disruption feedback and cost/benefit knowledge (Blackhurst *et al.*, 2011). They

also look beyond risks to see opportunities (Seville *et al.*, 2015) and are innovative in their contingency planning and continuity management (Gölgeci and Ponomarov, 2015). The ability to learn after a disruption and develop better solutions for future disturbances is a fundamental element of SCRES (Ponomarov and Holcomb, 2009).

- 4 Building social capital among supply chain partners and across other entities such as community stakeholders strengthens the ability to learn from each other. Social capital may be nurtured and emerge in the post-disruption period as a result of inter-organisational relationships (Johnson *et al.*, 2013) and relational competence (Wieland and Wallenburg, 2013). Such practices can be further fostered by building trust and leveraging co-creation processes (Seville *et al.*, 2015).

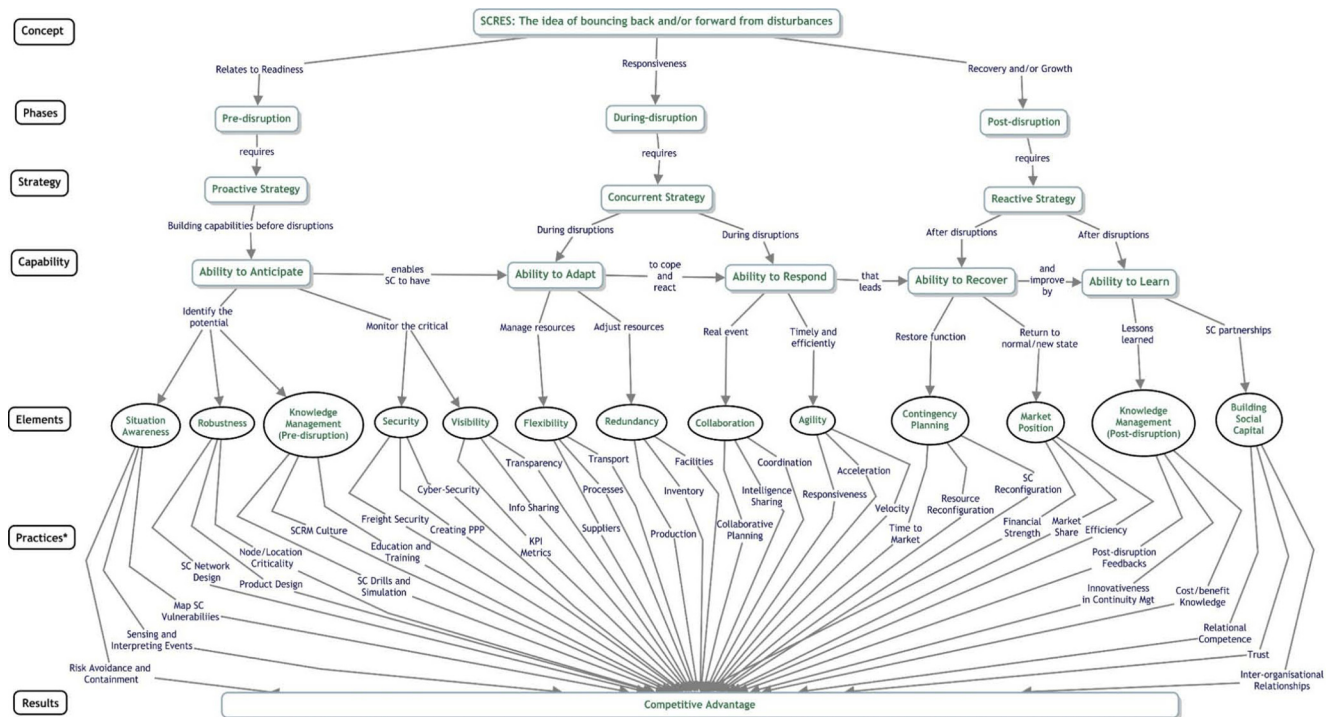
### 3.4 Supply chain resilience conceptual clarity: linking the constructs in a concept mapping framework

Answering the first two sub-questions in this review has helped to provide insights into the central question: *How can the concept of SCRES be analysed to inform research and practice?* The systematic SCRES literature review established a number of key features of a resilient supply chain, which were discussed at different levels of the constructs such as phases, strategies, capabilities, elements and their practices. As discussed in the previous section, the promise of SCRES cannot be achieved within the supply chain by focusing on the individual concepts without understanding their interactions (Ponomarov and Holcomb, 2009; Bhamra *et al.*, 2011). Similarly, resilience does not just happen; it is an ability that is cultivated and maintained (Seville *et al.*, 2015) by understanding the relationships that exist. Furthermore, these complex relationships and dynamic interactions among SCRES constructs should be linked to improve conceptual clarity. Hence, the premise of sub-question three: *How can SCRES constructs be linked to improve conceptual clarity?* That is, to synthesise the current body of knowledge to understand the potential of SCRES by identifying the relationships and interactions of the constructs.

In taking a holistic view, different constructs of SCRES are integrated to understand their relationships through a concept map. Concept maps are graphical tools used to organise and represent knowledge in a particular field, to seek answers to a focus question in a hierarchical structure (Novak and Cañas, 2008). Their value, when applied to SCRES, is in identifying key ideas so as to understand the theory, concepts and relationships between them (Rowley and Slack, 2004). Mapping the field helps to provide sufficient knowledge to develop crucial understanding and highlights the distribution of interests in the topic (Hart, 1998). A concept map is, therefore, a useful tool to evaluate and synthesise the SCRES concept by representing the different components for building and improving the body of knowledge in the field.

Using the IHMC CmapTools (<http://cmap.ihmc.us>) computer software program, Figure 8 shows the mapping of the SCRES concept based on the SLR. The reviewed literature supports the integration of the various constructs of SCRES and provides an adequate theoretical basis for framing the concept and examining the relationships between the



**Figure 8** SCRES concept mapping framework

**Note:** \*For a full list of practices, see (Table VI)

phases, strategies, capabilities, elements and their practices. Identifying these relationships is necessary so that researchers and practitioners can improve the knowledge and practice of SCRES.

#### 4. Implications for research and practice

Supply chains are exposed to various disruptive events and shocks, and often operate in volatile markets (Craighead *et al.*, 2007; Christopher and Holweg, 2011). How can they anticipate, respond, recover and grow from such disturbances (Sheffi and Rice, 2005; Pettit *et al.*, 2013)? In essence, this is the central question behind the concept of SCRES. In addressing these issues, various SCRES attributes are proposed in the literature, resulting in differing ways in which the concept is defined, examined and applied in the field of SCM. To date, however, no research has integrated the various SCRES constructs into the holistic model of a concept mapping framework to establish connections and relationships between them. This review attempts to fill this gap by conceptualising SCRES and exploring the relationships among its related constructs, to further develop the understanding and its application. This study, therefore, has both managerial and research implications.

##### 4.1 Managerial implications

Recent events such as the floods in Thailand in 2011, earthquake and tsunami in Japan in 2011 and the massive Tianjin explosions in China in 2015 are a reminder that disruptive events are inevitable and will continue to affect

supply chains. These events have affected suppliers in industries such as aerospace, electronics and automotive, to name a few, and the effects have resonated across the supply chains. Many organisations, however, suffer from a lack of guidance on effective resilience capabilities (Blackhurst *et al.*, 2011). This study has identified five core SCRES capabilities to build a resilient supply chain. For managers, the advantages of cultivating these five capabilities are as follows.

First, the five SCRES capabilities encompass the full range of supply chain risk management (SCRM) strategies (proactive, concurrent and reactive) and thus provide a mechanism to cope with risks and changes from varied sources. For example, Sáenz and Revilla (2014) provide insights into how Cisco Systems was able to evaluate the disruption impact of the 2011 tsunami in Japan on more than 300 suppliers within 12 h, due to the effectiveness of its proactive and reactive capabilities.

Second, supply chain disruptive events have increased over the years, and SCRES is considered as a fundamental way of coping with such disturbances (Christopher and Peck, 2004; Sheffi and Rice, 2005). The concept mapping framework provides managerial guidance on cultivating and building SCRES. The framework links SCRES phases and strategies, and the required capabilities, elements and practices needed to maintain a competitive advantage. For example, firms can implement effective capabilities in the pre-disruption phase by understanding their capacity to identify and monitor a potential problem. In nurturing such behaviours, firms provide a platform for their managers not only to build their

SCRES capabilities but also to leverage these capabilities to increase their competitive advantage.

Third, by refining these five capabilities, managers are in a position to assess their resilience weaknesses and strength, and the effectiveness of the elements and practices that support these capabilities. Thus, managers can use these capabilities as an evaluative tool to assess their overall resilience and thereby improve and manage their SCRES. For example, studies have shown that building flexibility is cost-efficient and generates competitive advantage in the marketplace compared to building redundancy, which is costly due to keeping resources in reserve (Sheffi and Rice, 2005; Zsidisin and Wagner, 2010). Such decisions should prompt debate among managers when developing these elements to support their SCRES capabilities.

#### 4.2 Research implications

The main research contribution of this study is the analysis of the SCRES concept through a concept mapping framework, guided by an SLR approach, to improve its conceptual clarity. The evaluation and synthesis of the current body of knowledge have enhanced the understanding of SCRES and have several implications in terms of developing the current literature.

First, the SLR synthesis found three constructs used to define SCRES: phases, strategies and capabilities. This finding supports the argument that SCRES is an abstract concept, and its utility in the SCM domain still lacks clarity. Tighter construct definitions are needed to enhance the usefulness of the concept. Second, the concept mapping approach provides a foundation for future empirical studies of SCRES to analyse the relationships between SCRES constructs and address the current gap in the literature. This review presented an opportunity to operationalise SCRES constructs and to test the interactions and relationships between them. Third, the elements and practices identified to support SCRES capabilities can be used to understand their application and value in different industry perspectives. Although previous studies have empirically analysed elements such as collaboration (Scholten and Schilder, 2015), visibility (Brandon-Jones *et al.*, 2014) and flexibility (Zsidisin and Wagner, 2010), more studies are needed to examine the value of these elements in practice. This study provides a source for exploring the applicability and effectiveness of the elements and their practices in different industry settings.

#### 5. Limitations and recommendations for further research

Despite the scientific approach of SLR, and the findings and implications highlighted in the previous section, this study has certain limitations. First, it is exploratory and based on the relevant literature over the past 13 years that is available in six databases. Second, the articles selected in the review process were limited to peer-reviewed journal articles, and thus the review was not exhaustive. Although peer-review journals are of higher quality, other sources such as conference papers, books and trade journals are also vital sources of knowledge on this topic. Third, the focus of this study was to analyse the

concept of SCRES from a holistic perspective, rather than a particular function in SCM.

Despite these limitations, the value of this study lies in the accumulation of findings and the synthesis of the body of knowledge on SCRES “that is not apparent from reading the individual studies in isolation” (Denyer and Tranfield, 2009, p. 685). Consequently, the findings from the SCRES concept analysis have highlighted several paths for further research to advance this topic.

First, the concept mapping framework provides insights into the relationship and dynamic interplay of different SCRES constructs. This study, however, due to its exploratory nature, did not address any moderating, mediating or contingent factors (e.g. trust, uncertainty, complexity) for these attributes. Further research could investigate the supporting role of such factors in building SCRES; specifically, the interactions that affect resilience behaviour and performance. Such studies will complement and build upon previous work concerning supply chain disruptions (Bode *et al.*, 2011).

Second, despite the blossoming literature on the topic, there is a need to apply well-established theoretical lenses to ground the usefulness of the concept in the SCM domain – in particular, theories that consider the dynamic and non-linear relationships of supply chain functions. Indeed, previous studies have suggested theories that can address the complexities of the SCRES phenomenon – for example, complex adaptive systems (Day, 2014; Tukamuhabwa *et al.*, 2015), contingency theory (Brandon-Jones *et al.*, 2014), social capital (Johnson *et al.*, 2013) and strategic choice (Pereira *et al.*, 2014). Also, the applicability of theories such as high-reliability organisations (La Porte, 1996) and normal accident theory (Perrow, 1999) that address organisational safety should be considered to test their usefulness in SCRES studies.

Third, the review findings reveal that less empirical research exists compared to non-empirical studies (Figure 2). While this can be attributed to the infancy of the topic in the SCM domain (Blackhurst *et al.*, 2011), more rigorous empirical research is needed to test the potential and ascertain the value of SCRES. Consistent with other researchers, suggestions for rigorous methodologies such as longitudinal studies are needed to identify the progress of SCRES strategies over time (Blackhurst *et al.*, 2011; Jüttner and Maklan, 2011). Also, recommended are mixed-methods studies for robust analysis to capture both in-depth views and a broader understanding of SCRES practices (Pettit *et al.*, 2013; Pereira *et al.*, 2014).

Fourth, the next logical step in the development of the topic is to operationalise SCRES capabilities to assess its merits. Although previous research has attempted to measure SCRES capabilities (Azevedo *et al.*, 2013; Pettit *et al.*, 2013), only few studies have focused on the multi-dimensional nature of SCRES (Vugrin *et al.*, 2011). As shown in the concept mapping framework (Figure 8), the interactions of the constructs are crucial; any proposed metrics should take a holistic view of SCRES by extending its application in practice beyond the boundaries of a single firm (Ambulkar *et al.*, 2015). Such measures pose challenges for organisations with complex global supply chains; nevertheless, identifying suitable indicators and

metrics of SCRES capabilities would represent a significant advance in research and practice.

Finally, the idea of “bouncing back” from adversity while sustaining operations and thriving in the process is promising; however, building SCRES capabilities is not cheap. Trade-off decisions between SCRES investment and cost need to be further investigated (Jüttner and Maklan, 2011; Pereira *et al.*, 2014). These decisions can involve the question of when to invest in spare capacities to reduce vulnerabilities, and where to minimise such investments to cultivate adaptive capabilities. A balance between capability and vulnerability is desirable to achieve balanced resilience (Pettit *et al.*, 2013). Future research could investigate the five SCRES capabilities proposed in this study and examine the trade-offs between them that building a resilient supply chain involves.

## 6. Conclusion

The concept of SCRES offers a way for supply chains to harness capabilities that enable them to bounce back and/or forward from adversity to achieve business continuity. Likewise, building SCRES is seen as an essential strategic capability to improve a firm's competitiveness by turning disruptive events, and changes in the market and the environment into opportunities (Sheffi and Rice, 2005; Seville *et al.*, 2015). However, when one examines the literature underpinning the review question “*How can the concept of supply chain resilience be analysed to inform research and practice?*” inconsistencies emerge surrounding the various aspects of the idea, suggesting that further theoretical explanations on the topic are warranted. The exploratory approach and development of a holistic model have allowed us to integrate fragments from the current body of knowledge. This study synthesised the results of analysing 103 peer-reviewed academic articles to address the central question via three sub-questions.

The first sub-question was: *What are the constructs used to define SCRES?* Three constructs emerged from the evaluation of the various definitions. The first construct relates to the three phases of resilience that cover the moments of pre-disruption, during-disruption and post-disruption. The second refers to the three strategies used to prepare for, respond to and recover from disruptions: proactive, concurrent and reactive. The third relates to the capabilities needed for supply chains to be resilient. One of the significant findings to emerge from the reviewed definitions is the common terms and themes implied to describe these capabilities, despite the diversity of definitions. The five core SCRES capabilities identified are the ability to anticipate, adapt, respond, recover and learn.

The second sub-question was: *What are the essential elements and managerial practices needed to support SCRES capabilities?* This study has revealed the array of expressions used to describe this feature, and this is a source of inconsistencies in the SCRES literature. To maintain consistency and align with other researchers (Christopher and Peck, 2004; Hohenstein *et al.*, 2015), these were referred to as elements. The reviewed literature revealed 27 elements, but the need to consolidate to improve clarity and relevance is warranted. Based on this premise, 13 essential elements and related practices were

identified to support the five SCRES capabilities, which were connected back to the resilience strategies and phases to present an integrated approach to the concept in managerial practices.

Finally, the third sub-question was: *How can SCRES constructs be linked to improve conceptual clarity?* In an attempt to consolidate and link the features of SCRES to improve clarity, this study provides a holistic model of SCRES through a concept mapping approach. The concept mapping classifies the different features of SCRES and establishes the complex relationships and dynamic interactions between them. The study, therefore, has both theoretical and practical implications. It contributes to increasing managerial awareness of the links between the constructs, thus enabling better practices. It also lays the foundation for future research to investigate the underlying theory and practice involved, and hence promote the creation of resilient supply chains.

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### Further reading

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## Appendix 1

Table AI SCRES definitions

| Authors                                | SCRES definitions   |
|--|---|
| Peck (2005, p. 211)                    | Resilience is defined as “the ability of a system to return to its original [or desired] state after being disturbed”. The definition is rooted in ecology (the study of the relationships between living organisms and their environment) and was adopted because it sits comfortably with the view of supply chains as interacting networks               |
| Peck (2006, p. 132)                    | The ability of the system to return to its original or desired state after being disturbed, i.e. its ability to absorb or mitigate the impact of the disturbance  |
| Sarathy (2006, p. 40)                  | A resilient supply chain is one that can bounce back quickly from a disruption  |
| Williams <i>et al.</i> (2009, p. 253)  | Resiliency is defined as the “ability to react to unexpected disruption and restore normal supply network operations”   |
| Stewart <i>et al.</i> (2009, p. 349)   | A process linking a set of adaptive capabilities to a positive trajectory of functioning and adaptation after a disturbance   |
| Pereira (2009, p. 374)                 | A resilient supply chain with the ability to maintain, resume, and restore its original (or desired) state after being disrupted should also be considered. (. . .) resilience should mean the ability to change smoothly and rapidly, by either creating redundancy or increasing flexibility  |
| Colicchia <i>et al.</i> (2010, p. 681) | Supply chain resilience is defined as the “ability of a system to return to its original (or desired) state or move to a new, more desirable state after being disturbed”   |
| Melnyk <i>et al.</i> (2010, p. 34)     | Resilience ensures that the supply chain can recover quickly and cost-effectively from disruptions caused by natural disasters (such as earthquakes), social factors (employee strikes), medical emergencies (epidemics such as H1N1 flu), economic setbacks (the bankruptcy of a critical link in the chain) or technological failures (a software crisis) |
| Higgins <i>et al.</i> (2010, p. 964)   | Resilience is the capacity of a system to recover from disturbance and maintain its structure, function and controls  |
| Yang and Yang (2010, p. 1903)          | “ . . . an organisation’s capability to recover to the original operating status before a disruption”   |
| Kumar <i>et al.</i> (2010, p. 3721)    | “ . . . resilient supply chain networks need to be built having the ability to maintain, resume and restore operations after any disruption”  |
| Klibi <i>et al.</i> (2010, p. 287)     | “ . . . resilience is the capability of a SCN to avoid disruptions or quickly recover from failures”  |
| Zsidisin and Wagner (2010, p. 3)       | Supply chain resiliency consists of the ability to return to normal performance levels following a supply chain disruption  |
| Kumar and Sosnoski, (2011, p. 5432)    | Resilient companies have the ability to withstand the unexpected  |
| Carvalho <i>et al.</i> (2011, p. 154)  | Resilience refers to the ability of the supply chain to cope with unexpected disturbances   |
| Ishfaq (2012, p. 216)                  | A resilient supply chain has the ability to maintain continuity in operations under disruptions   |
| Spiegler <i>et al.</i> (2012, p. 6182) | “the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at desired levels of connectedness and control over structure and function”  |
| Cabral <i>et al.</i> (2012, p. 4831)   | Resilience refers to the ability of the SC to cope with unexpected disturbances, and is concerned with the system’s ability to return to its original state or to a new, more desirable, one following a disruptive shock   |
| Carvalho <i>et al.</i> (2012, p. 49)   | Resilience is referred to as the ability of supply chains to cope with unexpected disturbances  |
| Pettit <i>et al.</i> (2013, p. 46)     | “ . . . resilience—the ability to survive, adapt, and grow in the face of turbulent change”   |
| Schmitt and Singh (2012, p. 23)        | “ . . . resilience refers to the ability of a system or component to bounce back from a setback (. . .). Resilience . . . focuses on the ability of the firm to sustain operation and recovery quickly in the face of a disruption”   |
| Johnson <i>et al.</i> (2013, p. 325)   | “ . . . resilience is considered to develop over time, enabling an organisation, or network, to survive and thrive in the face of adversity and, to further strengthen its capability to make future adjustments”   |
| Sawik (2013, p. 260)                   | Resiliency refers to a firm’s capacity to survive, adapt and grow in the face of change and uncertainty   |
| Wu <i>et al.</i> (2013, p. 676)        | “ . . . the ability to respond and recover from a stockout disruption”  |
| Hearnshaw and Wilson (2013, p. 458)    | For supply chain systems, resilience is critical as the success of firms is often determined by the ability of the system as a whole to continue to provide flows despite disturbances  |
| Wieland (2013, p. 655)                 | A supply chain can thus be resilient if its original stable situation is sustained or if a new stable situation is achieved as long as the supply chain is able to “bounce back from a disruption”. A supply chain is resilient if it uses resources that enable it to cope with change   |

(continued)

Table AI

| Authors                                    | SCRES definitions  |
|--|--|
| Azevedo <i>et al.</i> (2013, p. 134)       | "... resilience is referred to as the SC ability to cope with unexpected disturbances"   |
| Golgeci and Ponomarov (2013, p. 604)       | "... supply chains that have an adaptive capability to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations"   |
| Voss and Williams (2013, p. 324)           | Resilience is the "ability to react to unexpected disruptions and restore normal supply network operations"  |
| Pereira <i>et al.</i> (2014, p. 627)       | Supply chain resilience is defined here as the capability of supply chains to respond quickly to unexpected events so as to restore operations to the previous performance level or even to a new and better one   |
| Brandon-Jones <i>et al.</i> (2014, p. 58)  | Supply chain resilience is defined as the ability of a system to return to its original state, within an acceptable period, after being disturbed  |
| Mandal (2014, p. 431)                      | "... supply chain resilience is the ability of a supply chain to sustain operations profitably when faced with disruptive events"  |
| Scholten <i>et al.</i> (2014, p. 212)      | "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruption and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structures and function"                               |
| Kristianto <i>et al.</i> (2014, p. 39)     | Resilience is the ability of a system to return to its original state or move to a new, more desirable state after being disturbed   |
| Gong <i>et al.</i> (2014, p. 104)          | A resilient supply chain is a system that has the ability to recover quickly from disruptions and ensure customers are minimally affected  |
| Urciuoli (2015, p. 14)                     | "... resilience of supply chains, that is, the capability of supply chains to bounce back to stable conditions after a disruption"   |
| Heckmann <i>et al.</i> (2015, pp. 125-126) | Supply chain resilience is defined as a supply chain's ability to return to its original or move to a new, more desirable state after being disturbed  |
| Rajesh and Ravi (2015, p. 343)             | "... resilience that stands for the adaptive capability to respond to disruptions and recovering from it needs to be considered in supplier selection"   |
| Sprecher <i>et al.</i> (2015, p. 6741)     | Resilience can be defined as the capacity of a system to tolerate disruptions while retaining its structure and function   |
| Tukamuhabwa <i>et al.</i> (2015, p. 5599)  | The adaptive capability of a supply chain to prepare for and/or respond to disruptions, to make a timely and cost-effective recovery, and therefore progress to a post-disruption state of operations—ideally, a better state than prior to the disruption                       |
| Kim <i>et al.</i> (2015, p. 50)            | "... define supply network resilience as a network-level attribute to withstand disruptions that may be triggered at the node or arc level. Consequently, supply network resilience is an emergent structural property of a supply network"                                      |
| Golgeci and Ponomarov (2015, p. 269)       | "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function"                              |
| Fiksel <i>et al.</i> (2015, p. 82)         | We define resilience as "the capacity of an enterprise to survive, adapt and grow in the face of turbulent change"   |
| Scholten and Schilder (2015, p. 472)       | Resilience enables a supply chain to be prepared for events and reduce the impact of a disruption and strengthens the ability to recover quickly from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function |

## Appendix 2

Table AII Elements of SCRES based on SLR

|  |    |   |
|--|----|---|
| Supply chain network design (SC configuration) | 38 | Christopher and Peck (2004), Blackhurst <i>et al.</i> (2005), Craighead <i>et al.</i> (2007), Manuj and Mentzer (2008), Ratick <i>et al.</i> (2008), Knemeyer <i>et al.</i> (2009), Stecke and Kumar (2009), Higgins <i>et al.</i> (2010), Klibi <i>et al.</i> (2010), Blackhurst <i>et al.</i> (2011), Carvalho <i>et al.</i> (2011), Christopher <i>et al.</i> (2011), Vugrin <i>et al.</i> (2011), Khan <i>et al.</i> (2012), Klibi and Martel (2012), Mandal (2012), Ponis and Koronis (2012), Schmitt and Singh (2012), Bhattacharya <i>et al.</i> (2013), Harrison <i>et al.</i> (2013), Hearnshaw and Wilson (2013), Abe (2014), Chopra and Sodhi (2014), Day (2014), Gong <i>et al.</i> (2014), Kristianto <i>et al.</i> (2014), Pereira <i>et al.</i> (2014), S&acute;enz and Revilla (2014), Scholten <i>et al.</i> (2014), Soni <i>et al.</i> (2014), Melnyk <i>et al.</i> (2014), Boyes <i>et al.</i> (2015), Davis (2015), Kim <i>et al.</i> (2015), Mari <i>et al.</i> (2015), Matsuo (2015), Seville <i>et al.</i> (2015), Thomas <i>et al.</i> (2015)           |
| Flexibility                                    | 37 | Rice and Caniato (2003), Blackhurst <i>et al.</i> (2005), Sheffi and Rice (2005), Datta <i>et al.</i> (2007), Manuj and Mentzer (2008), Tang and Tomlin (2008), Ponomarov and Holcomb (2009), Stecke and Kumar (2009), Blos <i>et al.</i> (2010), Pettit <i>et al.</i> (2010), Yang and Yang (2010), Zsidisin and Wagner (2010), Blackhurst <i>et al.</i> (2011), Carvalho <i>et al.</i> (2011), Jüttner and Maklan (2011), Cabral <i>et al.</i> (2012), Carvalho <i>et al.</i> (2012), Ishfaq (2012), Azevedo <i>et al.</i> (2013), Harrison <i>et al.</i> (2013), Johnson <i>et al.</i> (2013), Pettit <i>et al.</i> (2013), Aigbogun <i>et al.</i> (2014), Azadeh <i>et al.</i> (2014), Carvalho <i>et al.</i> (2014), Kristianto <i>et al.</i> (2014), Scholten <i>et al.</i> (2014), Melnyk <i>et al.</i> (2014), Urciuoli <i>et al.</i> (2014), Ambulkar <i>et al.</i> (2015), Fiksel <i>et al.</i> (2015), Mari <i>et al.</i> (2015), Rajesh and Ravi (2015), Scholten and Schilder (2015), Sprecher <i>et al.</i> (2015), Todo <i>et al.</i> (2015), Yang and Xu (2015) |
| Redundancy                                     | 30 | Rice and Caniato (2003), Peck (2005), Sheffi and Rice (2005), Craighead <i>et al.</i> (2007), Datta <i>et al.</i> (2007), Ratick <i>et al.</i> (2008), Ponomarov and Holcomb (2009), Stecke and Kumar (2009), Melnyk <i>et al.</i> (2010), Pettit <i>et al.</i> (2010), Yang and Yang (2010), Zsidisin and Wagner (2010), Blackhurst <i>et al.</i> (2011), Carvalho <i>et al.</i> (2011), Carvalho <i>et al.</i> (2012), Klibi and Martel (2012), Ponis and Koronis (2012), Pereira <i>et al.</i> (2014), Schmitt and Singh (2012), Pettit <i>et al.</i> (2013), Wu <i>et al.</i> (2013), Aigbogun <i>et al.</i> (2014), Azadeh <i>et al.</i> (2014), Carvalho <i>et al.</i> (2014), Ivanov <i>et al.</i> (2014), Melnyk <i>et al.</i> (2014), Urciuoli <i>et al.</i> (2014), Ambulkar <i>et al.</i> (2015), Fiksel <i>et al.</i> (2015), Hohenstein <i>et al.</i> (2015)   |
| Visibility (Monitoring, KPI, Measuring)        | 29 | Christopher and Peck (2004), Blackhurst <i>et al.</i> (2005), Stecke and Kumar (2009), Blos <i>et al.</i> (2010), Melnyk <i>et al.</i> (2010), Pettit <i>et al.</i> (2010), Blackhurst <i>et al.</i> (2011), Carvalho <i>et al.</i> (2011), Jüttner and Maklan (2011), Ponis and Koronis (2012), Azevedo <i>et al.</i> (2013), Glendon (2013), Johnson <i>et al.</i> (2013), Pettit <i>et al.</i> (2013), Wieland and Wallenburg (2013), Aigbogun <i>et al.</i> (2014), Azadeh <i>et al.</i> (2014), Brandon-Jones <i>et al.</i> (2014), Carvalho <i>et al.</i> (2014), Pereira <i>et al.</i> (2014), S&acute;enz and Revilla (2014), Soni <i>et al.</i> (2014), Ambulkar <i>et al.</i> (2015), Davis (2015), Durach <i>et al.</i> (2015), Fiksel <i>et al.</i> (2015), Hohenstein <i>et al.</i> (2015), Rajesh and Ravi (2015), Scholten and Schilder (2015)   |
| Collaboration/collaborative planning           | 23 | Christopher and Peck (2004), Bakshi and Kleindorfer (2009), Pettit <i>et al.</i> (2010), Jüttner and Maklan (2011), Christopher <i>et al.</i> (2011), VanVactor (2011), Mandal (2012), Ponis and Koronis (2012), Glendon (2013), Johnson <i>et al.</i> (2013), Leat and Revoredo-Giha (2013), Pettit <i>et al.</i> (2013), Wieland and Wallenburg (2013), Aigbogun <i>et al.</i> (2014), Carvalho <i>et al.</i> (2014), Pereira <i>et al.</i> (2014), Scholten <i>et al.</i> (2014), Soni <i>et al.</i> (2014), Fiksel <i>et al.</i> (2015), Hohenstein <i>et al.</i> (2015), Rajesh and Ravi (2015), Scholten and Schilder (2015), Todo <i>et al.</i> (2015)   |
| Agility/responsiveness                         | 21 | Christopher and Peck (2004), Tang and Tomlin (2008), Ponomarov and Holcomb (2009), Klibi <i>et al.</i> (2010), Kumar <i>et al.</i> (2010), Carvalho <i>et al.</i> (2011), Ismail <i>et al.</i> (2011), Christopher <i>et al.</i> (2011), Cabral <i>et al.</i> (2012), Mandal (2012), Ponis and Koronis (2012), Wieland (2013), Wieland and Wallenburg (2013), Carvalho <i>et al.</i> (2014), Ivanov <i>et al.</i> (2014), Pereira <i>et al.</i> (2014), Scholten <i>et al.</i> (2014), Soni <i>et al.</i> (2014), Hohenstein <i>et al.</i> (2015), Mari <i>et al.</i> (2015), Rajesh and Ravi (2015)  |
| Anticipation/awareness/sensing                 | 14 | Christopher and Peck (2004), Peck (2005), Craighead <i>et al.</i> (2007), Datta <i>et al.</i> (2007), Pettit <i>et al.</i> (2010), Pettit <i>et al.</i> (2013), Wieland and Wallenburg (2013), S&acute;enz and Revilla (2014), Melnyk <i>et al.</i> (2014), Ambulkar <i>et al.</i> (2015), Fiksel <i>et al.</i> (2015), Rajesh and Ravi (2015), Seville <i>et al.</i> (2015), Stevenson and Busby (2015)  |
| IT capability (information sharing)            | 14 | Pereira (2009), Ponomarov and Holcomb (2009), Melnyk <i>et al.</i> (2010), Day (2014), Pereira <i>et al.</i> (2014), Scholten <i>et al.</i> (2014), Soni <i>et al.</i> (2014), Melnyk <i>et al.</i> (2014), Ambulkar <i>et al.</i> (2015), Boyes <i>et al.</i> (2015), Davis (2015), Rajesh and Ravi (2015), Stevenson and Busby (2015), Urciuoli (2015)  |
| Robustness                                     | 12 | Blackhurst <i>et al.</i> (2005), Tang (2006), Stecke and Kumar (2009), Klibi <i>et al.</i> (2010), Klibi and Martel (2012), Spiegler <i>et al.</i> (2012), Berle <i>et al.</i> (2013), Wieland (2013), Wieland and Wallenburg (2013), Durach <i>et al.</i> (2015), Mari <i>et al.</i> (2015), Sprecher <i>et al.</i> (2015)   |
| SCRM culture/department managing risk          | 12 | Rice and Caniato (2003), Christopher and Peck (2004), Sheffi and Rice (2005), Williams <i>et al.</i> (2009), Dowty and Wallace (2010), Christopher <i>et al.</i> (2011), Mandal (2012), Soni <i>et al.</i> (2014), Ambulkar <i>et al.</i> (2015), Durach <i>et al.</i> (2015), Seville <i>et al.</i> (2015), Stevenson and Busby (2015)   |
| Security                                       | 12 | Rice and Caniato (2003), Sarathy (2006), Manuj and Mentzer (2008), Bakshi and Kleindorfer (2009), Williams <i>et al.</i> (2009), Pettit <i>et al.</i> (2010), Blackhurst <i>et al.</i> (2011), Pettit <i>et al.</i> (2013), Voss and Williams (2013), Melnyk <i>et al.</i> (2014), Fiksel <i>et al.</i> (2015), Stevenson and Busby (2015)  |
| Knowledge management/HRM                       | 11 | Rice and Caniato (2003), Ponomarov and Holcomb (2009), Stecke and Kumar (2009), Blackhurst <i>et al.</i> (2011), Jüttner and Maklan (2011), Pereira <i>et al.</i> (2014), Scholten <i>et al.</i> (2014), Ambulkar <i>et al.</i> (2015), Hohenstein <i>et al.</i> (2015), Seville <i>et al.</i> (2015), Stevenson and Busby (2015)   |
| SC continuity/contingency plans                | 11 | Blackhurst <i>et al.</i> (2005), Craighead <i>et al.</i> (2007), Ponomarov and Holcomb (2009), Blos <i>et al.</i> (2010), Colicchia <i>et al.</i> (2010), Melnyk <i>et al.</i> (2010), Levesque (2012), Gong <i>et al.</i> (2014), Hohenstein <i>et al.</i> (2015), Rajesh and Ravi (2015), Seville <i>et al.</i> (2015)  |
| Velocity                                       | 10 | Christopher and Peck (2004), Jüttner and Maklan (2011), Ponis and Koronis (2012), Johnson <i>et al.</i> (2013), Azadeh <i>et al.</i> (2014), Carvalho <i>et al.</i> (2014), Pereira <i>et al.</i> (2014), Rajesh and Ravi (2015), Scholten and Schilder (2015), Sprecher <i>et al.</i> (2015)   |
| Coordination                                   | 7  | Craighead <i>et al.</i> (2007), Datta <i>et al.</i> (2007), Knemeyer <i>et al.</i> (2009), Stecke and Kumar (2009), Pereira <i>et al.</i> (2014), Seville <i>et al.</i> (2015), Todo <i>et al.</i> (2015)   |
| Integration/connectivity                       | 7  | Ponomarov and Holcomb (2009), Melnyk <i>et al.</i> (2010), Carvalho <i>et al.</i> (2011), Brandon-Jones <i>et al.</i> (2014), Pereira <i>et al.</i> (2014), Davis (2015), Seville <i>et al.</i> (2015)  |
| Adaptability                                   | 6  | Pettit <i>et al.</i> (2010), Pettit <i>et al.</i> (2013), Aigbogun <i>et al.</i> (2014), Soni <i>et al.</i> (2014), Fiksel <i>et al.</i> (2015), Seville <i>et al.</i> (2015)   |

(continued)

Table AII

|  |   |   |
|--|---|---|
| Market position                                    | 6 | Sheffi and Rice (2005), Pettit <i>et al.</i> (2010), Pettit <i>et al.</i> (2013), Wu <i>et al.</i> (2013), Melnyk <i>et al.</i> (2014), Fiksel <i>et al.</i> (2015) |
| Risk control/transfer or risk/revenue sharing      | 6 | Manuj and Mentzer (2008), Ponomarov and Holcomb (2009), Carvalho <i>et al.</i> (2011), Kumar and Sosnoski (2011), Sawik (2013), Soni <i>et al.</i> (2014)           |
| Alignment  | 5 | Ismail <i>et al.</i> (2011), Khan <i>et al.</i> (2012), Boone <i>et al.</i> (2013), Pereira <i>et al.</i> (2014), Seville <i>et al.</i> (2015)                      |
| Financial strength                                 | 5 | Pettit <i>et al.</i> (2010), Pettit <i>et al.</i> (2013), Day (2014), Melnyk <i>et al.</i> (2014), Fiksel <i>et al.</i> (2015)                                      |
| Public–private partnership (PPP)                   | 5 | Stewart <i>et al.</i> (2009), Voss and Williams (2013), Stevenson and Busby (2015), Urciuoli (2015), Yang and Xu (2015)   |
| Efficiency   | 4 | Ponomarov and Holcomb (2009), Pettit <i>et al.</i> (2010), Pettit <i>et al.</i> (2013), Fiksel <i>et al.</i> (2015)   |
| Trust  | 4 | Day (2014), Pereira <i>et al.</i> (2014), Soni <i>et al.</i> (2014), Seville <i>et al.</i> (2015)   |
| Building social capital and relational competences | 3 | Johnson <i>et al.</i> (2013), Wieland and Wallenburg (2013), Seville <i>et al.</i> (2015)   |
| Increasing innovativeness                          | 3 | Golgeci and Ponomarov (2013), Melnyk <i>et al.</i> (2014), Gölgeci and Ponomarov (2015)   |
| Sustainability                                     | 2 | Soni <i>et al.</i> (2014), Rajesh and Ravi (2015)   |

## About the authors

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