Research on the Capabilities and the Performance Metrics of Supply Chain Resilience: a systematic literature review

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Abstract:

The purpose of this paper is to analyse the concept of capabilities and performance metrics of the supply chain resilience (SCRE) and to explore the relationship between them. We find that much of the literature is conceptual and normative, but there are no integrated or cross analysed of the two concepts that can improve the understanding of SCRE. To achieve this, a systematic literature review is applied to review 96 journal articles from 2003 to 2017 aiming to provide a comprehensive and systematic literature review on a contemporary area of supply chain management (SCM). This review brings together the fragmented literature of capabilities and performance metrics to provide a solid knowledge of the two areas and explains the connections between them. Thus, in this study, we build on the two important concepts and integrate them to bring wider benefit in the literature for future research development.

Keywords:

Supply chain resilience, Capabilities, Performance metrics, Systematic literature review

1. Introduction

Supply chain resilience (SCRE) has attracted strong interest from researchers and practitioners due to the multiplicity of disruptive events and its potential impact on business competitiveness and continuity (e.g. Christopher and Peck, 2004; Sheffi, 2015; Jüttner and Maklan, 2011). Supply chain managers are forced to adopt more intense resilient approaches to insulate the supply chain from disturbances (e.g. Christopher and Lee, 2004; Christopher and Holweg, 2011).

Though the number of research papers of SCRE is increasing rapidly, the performance metrics

of the supply chain resilience remain sketchy, there are very limited studies that discussed the supply chain resilience measurement or attempted to measure the SCRE (e.g. Chowdhury and Quaddus, 2016; Kamlahmadi and Parast, 2016; Spiegler et al., 2012). Furthermore, it is noticed that the number of literature review studies about the performance metrics of the SCRE is even less. Based on the search results in the key academic databases, there is only one systematic literature review study contains a section discussing about performance metrics (Hohenstein et al., 2015). Therefore, it is worth of conducting a literature review study to further analyse the performance metrics of SCRE that covers latest literature.

Compared with performance metrics, SCRE capabilities are researched widely by scholars and are mainly studied using conceptual research method (e.g. Jüttner and Maklan, 2011; Petti et al., 2010). However, the number of literature review studies that systematically summarise the capabilities discussed by scholars is still limited. Although research on capabilities in SCRE has obtained vast attentions (e.g. Jüttner and Maklan, 2011; Petti et al., 2011), the study of relationship between capabilities and SCRE are still ambiguous and lack of understanding. In particular, a critical literature assessment on both capabilities and performance metrics of SCRE is currently lacking. To our best knowledge, no such work has been done before.

The key contribution of this study is that it enables the establishment of a framework for the capabilities and performance metrics of the SCRE through the analysing and synthesising of current studies. This study has both academic and practical implications. Academically, it contributes to the current literature of the evaluation of the SCRE and bridges the gap of lacking literature review studies that discuss about the capabilities and performance metrics of the SCRE. Moreover, the study encourages the future research on the measurements on SCRE. Practically, it increases the managerial understanding and awareness of the capabilities and performance metrics that applied in the evaluation of the SCRE, which could lead to a better practice by providing the knowledge of the issues that call for special attention in the SCRE.

The rest of the paper is structured as follows: The following section is the explanation of the research methodology. Then, the results of the systematic review are presented. This study concludes with the discussion of key findings, implications, limitations and the recommendation for future research.

2. Methodology

A Systematic Literature Reviews (SLR) aims at acquiring all evidence to address a specific research questions for a given topic and involve a reproducible and thorough search of the literature and critical evaluation of eligible studies (Rousseau et al., 2008). SLR is useful in synthesising the results and evidence from existing studies to create new knowledge (e.g. Light and Pillermer, 1984; Tranfield et al., 2003). It is considered that 2000 is the year of the emergence of studies about supply chain risks and vulnerabilities (Ali et al., 2017). In 2003, important study about the capabilities of the SCRE is published (Rice and Caniato, 2003), and in 2007, the study that quantitatively researched the performance metrics of the SCRE appeared

(Datta et al., 2007; Hohenstein etal., 2015). Therefore, this study intends to conduct a systematic review on both capabilities and performance metrics of the SCRE with a time range of 2003 to 2017.

This research adapts the five-step guidelines (Figure 1) by Denyer and Tranfield (2009). This method is also applied by other literature review studies that also focusing on SCRE, such as Ali et al., (2017) and Hohenstein et al., (2015).

Step 1: Question Formulation
The first step of a SLR is to define the scope to develop a clear focus for the study (Rousseau et al., 2008; Hohenstein et al., 2015). As explained, this study intends to review the related studies of capabilities and performance metrics of SCRE, and to discuss the connection between studies researching on the two areas. Therefore, this study proposes and attempts to answer following questions:
Q1: What are the capabilities that are normally discussed in building SCRE?
Q2: What are the performance metrics of the SCRE?
Q3: How does the studies about SCRE capabilities and performance metrics related?

Step 2: Locating Studies
To minimise the bias and to cover a wide range of sources and information, this study searched key online academic database. These databases are selected due to the availability at academic institution and they are considered in other similar studies.
Consistent with other systematic reviews in management, especially SCRE (e.g. Hohenstein et al., 2015; Colicchia and Strozzi, 2012), several key words were defined as search criteria. The keywords consisted of the phrase "supply chain" combined with at least one of the following keywords: "resilience", "resiliency", "resilient", "measurement", "performance", "assess", "indices" and "capabilities". The time horizon of this study is from 2003 to 2017.

Step 3: Study selection and evaluation
In line with some other systematic literature review of the SCRE (e.g. Ali et al., 2017; Hohenstein et al., 2015, explicit selection criteria (Table 1) were applied for the inclusion and exclusion of the relevant studies to maintain the transparency of the process. The process of selection is presented in Figure 1, finally 96 articles are selected in total for the analysis. Among the 96 articles, 25 of them discuss about performance metrics of supply chain resilience, either discussed along with capabilities or only about performance metrics; while the other 71 papers are merely about capabilities.
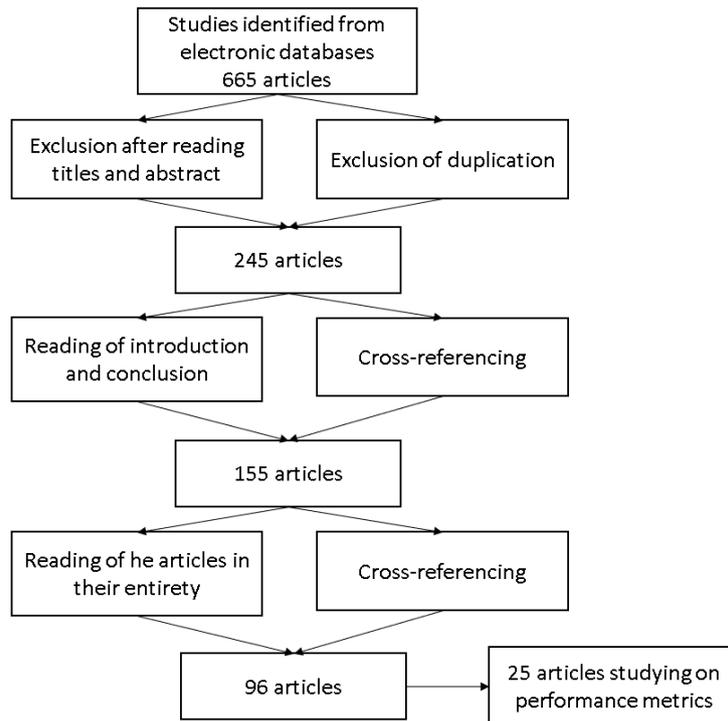
Fig 1. Review process for study selection. Adapted from Moher et al., 2009

Inclusion Criteria	Rationale
Papers that discuss about the performance metrics of resilience	This study aims to review the papers that include the discussion on performance metrics of the SCRE
Papers that discuss about the capabilities of resilience	This study aims to review the papers that include the discussion on capabilities of the SCRE
Published in English language	The dominant language in the field of supply chain management
Different article types (e.g. empirical, conceptual, literature review)	To evaluate and synthesise the various research approaches

Table 1 Inclusion Criteria

3. Analysis

3.1 Capabilities of the SCRE

Table 2 presents the capabilities of SCRE summarised from the selected literature. 11 capabilities are identified and are categorised into 3 dimensions. The reason of selecting these dimensions is explained under Table 2.

Dimensions	Capability	Business practices related to the capability
Readiness	Situation awareness	Sensing the events, forecast, continuity planning, warning strategies
	visibility	Track and monitor, information technology capabilities, information

		exchange, transportation visibility, information transparency, perceive potential opportunities
	Security	Access restriction, cyber-security, personnel security, layered defence, security partnership, public-private partnership, physical security
	Redundancy	Safety stock, multiple supplier, multiple sourcing, multiple production locations, backup site, capacity, transportation capacity
Response	Agility	Velocity, channel to detect change, execution of supply chain activities, fast reaction to perceived change
	Collaboration	Information sharing, collaborative forecasting, communication, risk sharing, joint knowledge creation, joint relationship effort, Employee engagement, trust, business relationship, joint decision making
	Flexibility	Auditing supplier process, monitor, flexibility in sourcing, flexibility in order fulfilment, flexible product
	leadership	Top management support, sound decision making, execution of decision made, staff engagement
Recovery	Knowledge management	Learning, innovation, education and training
	Contingency planning	Having supply contingency plans, supply chain reconfiguration, scenario analysis
	Profitability	Financial strength, market share, efficiency, loss absorption, market position

Table 2 capabilities and related practices of the SCRE

SCRE capabilities are the abilities of the supply chain to anticipate, to monitor, to respond to and to learn from changes and disruptions (e.g. Chowdhury and Quaddus, 2016; Ali et al., 2017). Resilience is a multidimensional and multidisciplinary concept (Chowdhury and Quaddus, 2016) and is defined as the capability to prepare for unexpected events, respond to disruptions, and recover from them (e.g. Rice and Caniato 2003; Sheffi and Rice 2005; Ponomarov and Holcomb, 2009; Jütter and Maklan, 2011). Ponomarov and Holcomb (2009) identified that the readiness, response and recovery dimension are directly related to the SCRE in regard to disruptions. Referring to this study and in line with several other literature review studies (e.g. Ali et al., 2017; Chowdhury and Quaddus, 2016) in the capabilities of the SCRE, this study reviews and analyses capabilities through 3 dimensions of SCRE including readiness, response and recovery (presented in Table 2).

3.2 Performance Metrics of SCRE
The 25 papers studied the performance metrics of the supply resilience applied different research methods and perspectives. Most of them conducted the analysis of the performance metrics by having an analytical model of indicators to evaluate the resilience. For example, Cabral et al. (2012) developed an analytic network process model to measure four capabilities of a supply chain with respect to agility, lean, resilience, and green principles based on practices including capacity surplus, replenishment frequency, integration level, information frequency, inventory level, production lead time, transportation lead time.

Given that most of the studies have their own models and have identified specific performance metrics for the SCRE; no common agreement has achieved. To categorise all the performance metrics, 10 academic terminologies are identified according to the underlying definitions of the performance metrics, which are presented in Table 3.

Academic Terminology	Performance metrics from the 25 papers
Customer	Customer service level, customer satisfaction, customer complaints, customer accessibility
Lead Time	Lead time, lead time ratio
Recovery time	days to recovery
Inventory	Stock, capacity, reserve capacity, back-up utility
Collaboration	Connection, interaction, communication, share of information, supply chain relationship, connectivity, cohesion
Financial perspective	Cost, benefit, environment cost, the total transportation cast post-disaster
Forecast	Accuracy, order accuracy, quality of forecast
Impact	Impact of the disruptive events, disruption impact
Responsiveness	Ability to provide appropriate resource quickly, how quickly is the reaction (flexibility, adaptability, efficiency and learning)
Process	Redesign, reconfiguration, restructure, resource reconfiguration scale

Table 3 category of performance metrics

3.3 Connection between studies about resilience capabilities and performance metrics

According to the explanation above about different capabilities and performance metrics, situation awareness is a capability to forecast a possible disruption (e.g. Rajesh and Ravi, 2015; Birkie, 2016; Eltantawy, 2016); while the performance metrics allocated under the keyword 'Forecast' are the assessment of the accuracy and quality in forecasting the disruptive events (Rajesh, 2016, Li et al., 2017, Chen et al., 2017). Similarly, redundancy is a resilience capability of having excess inventory, multiple suppliers, backup site and capacity (e.g. Manning and Soon, 2016; Hasani and Khosrojerdi, 2016; Dabhilkar et al., 2016). There are also performance metrics that used to measure the excess stock level and capacity to rapidly respond the disruption (Cabral et al. 2011). Applying the same logic, collaboration as a capability to integrate the complete supply chain network involving the exchange of information to maintain the relationship among the supply chain partners (Sheffi, 2011; Scholten et al., 2014); could also be related to the performance metrics under keyword 'collaboration' which is the evaluation on the quality of the interaction and relationship among supply chain network (Smith et al., 2016). Profitability is the capability refers to the financial perspective including such as financial strength, market share and loss absorption (Wu et al. 2013; Day, 2014; Fiksel et al. 2015); while 'financial perspective' includes the performance metrics to measure the cost, financial benefits, financial strength, fines, and penalties occurred during the disruptions (e.g. Loh and Thai, 2016; Cabral et al. 2012). Contingency planning is the capability to recover by assessing processes such as supply chain reconfiguration, scenario analysis, and resource reconfiguration (e.g. Ponomarov and Holcomb, 2009; Boone et al. 2013; Zsidisin and Wagner,

2010; Birkie, 2016); 'process perspective' also includes the performance metrics involving resource reconfiguration (Ambulkar et al. 2015, Loh and Thai, 2016). Flexibility refers to the ability to adapt and adjust to a disruption rapidly rather than withstand the damage of the disruption (e.g. Jüttner and Maklan, 2011; Ponis et al. 2012; Ishfaq, 2012; Wieland, 2013). 'Responsiveness' is related to performance metrics assessing the adaptability to external influence and unforeseen problems (Day, 2014; Long and Wood 1995; Pettit and Beresford 2005). Smith et al. (2016) applied flexibility in measuring responsiveness.

Capabilities	Performance metrics
Situation awareness	forecast (accuracy)
Collaboration	collaboration (interaction, share of information, communication)
Redundancy	inventory (stock, capacity)
Profitability	financial perspective (cost, benefit)
Contingency planning	process perspective (restructure, reconfiguration, etc.)
Flexibility	responsiveness (flexibility, adaptability etc.)

Table 4 similarities among the frequently discussed capabilities and performance metrics

Table 4 summarises above analysis that allocated capabilities and performance metrics correspondingly. From the analysis, it could be summarised that the performance metrics are actually measuring corresponding capabilities of SCRE. There are studies directly used the academic terminologies of resilience capabilities as performance metrics; although the number of such papers are limited. For example, Rajesh (2016) analysed the measurement of the SCRE from 5 perspectives of resilience represented by flexibility, responsiveness, quality, productivity and accessibility. It could be seen that flexibility and responsiveness are included in the review of resilience capabilities in previous section. To measure flexibility, Rajesh (2016) related it to a system, product or process, and adopted stock out rate, inventory rate, number of small disruptions managed through flexibility, and percentage increase in sales from design flexibility to evaluate flexibility. As for responsiveness, Rajesh (2016) applied on-time delivery ratio, contract issue time, contract approval time and put-away time ratio to measure it. Similarly, some resilience capabilities can be found in several other studies about resilience performance metrics. Lam and Bai (2016) discussed about contingency planning. Day (2014) and Smith et al. (2016) mentioned responsiveness.

It is worth noting that in the 25 selected papers, there is one paper covered a wider range of resilience capabilities as performance metrics and it is analysed through 3 resilience dimensions including readiness, response and recovery; which are also discussed in the previous section of our study. Chowdhury and Quaddus (2016) indicated that the resilience of the supply chain should be measured through the 3 dimensions and affirmed that the readiness dimension has the highest absolute importance. They suggest that the readiness dimension should be constructed by flexibility, redundancy, visibility, collaboration and disaster preparation; flexibility and disaster preparation are considered to the most important in this dimension. From the findings of the study conducted by Chowdhury and Quaddus (2016), it is suggested that more efforts should be put in the readiness dimension and relevant capabilities should be developed to enhance the performance of the SCRE; the significance of flexibility and disaster

preparation are emphasised. Such study established a clear framework of performance metrics of the SCRE based on resilience capabilities. This could provide the companies a clear view on the capabilities that require special attention.

It is therefore suggested that more similar studies could be conducted by adopting resilience capabilities as performance metrics to offer a more straightforward approach that can show how is the performance of the SCRE measured and guide the companies to focus on capabilities with high priority to improve the performance. A systematic framework of performance metrics involving the measurement of capabilities from all 3 dimensions of supply chain is expected.

4. Conclusion

The findings of the review show that there are 11 capabilities normally discussed in the establishment of the SCRE, including Situation awareness, visibility, Security, Redundancy, Agility, Collaboration, Flexibility, leadership, Knowledge management, Contingency planning and Profitability. In addition, this study reviewed 25 papers about performance metrics during 2003-2017. Most of studies have their own model and framework of the resilience evaluation. However, the indicators from different papers have some common characteristics, this study summarised the performance metrics given several academic terminologies including 'customer, 'Lead Time', 'Recovery time', 'Inventory', 'Collaboration', 'Financial perspective', 'Forecast', 'Impact', 'Responsiveness', and 'Process'.

Capabilities and performance metrics of the SCRE are integrated analysed based on their definitions. It is found that many performance metrics for the measurement of the performance of the SCRE is measuring actually the performance of different capabilities of the SCRE. Some studies have attempted to directly measure the performance of certain resilience capabilities; especially the work conducted by Chowdhury and Quaddus in 2016. However, the number of such studies is limited. It is therefore suggested that future studies could pay attention on this direction to establish a completed and systematic framework that involve the measurement all the important resilience capabilities from the readiness, response and recovery dimension of the supply chain.

4.1 Implication

Academically, building on previous research, this study contributes to the analysis of supply chain capabilities and performance metrics guided by the SLR. First, this study reviewed the literature of the capabilities of the SCRE. 11 capabilities of the SCRE and the business practices related to them are summarised based on the three phases of a resilient supply chain when responding a disruption, involving readiness, response and recovery. This contributes to the current literature by providing a systematic review of the capabilities for 14 years (2003-2017), and thus offers clear structure of the capabilities of the SCRE. In addition, a review of the performance metrics of the SCRE for the selected 14 years are reviewed systematically. This study covers variety of papers of performance metrics for SCRE from 2003 to 2017. Thus, this can provide the future researches a clear map about the findings and achievements from previous studies. The study further related the studies researching on capabilities with the performance metrics of the SCRE to find the connection between them. This conducted a close

relationship between the capabilities and the performance metrics, and with a strong basis that contains a considerable amount of literature, the study proved that the SCRE can be measured through the evaluation of the performance of capabilities. This could provide future researches the foundation for conducting relevant studies.

Practically, this review of the capabilities, and the performance metrics could help the managers to have a better understanding about the requirement of a resilient supply chain. The supply chain is becoming more complex and vulnerable due to the continually changes in the business environment (e.g., Elliot et al. 2010; Aitken et al. 2016). Therefore, it is important for the companies to know their own capabilities, to understand their strengths and weaknesses, and further, to have a clear view of where they should invest in to improve the performance of the SCRE. There are 11 capabilities of the SCRE that encompass a full range of a supply chain to manage a disruption (readiness, response and recovery). Therefore, this can offer the companies a framework on cultivating and building their capabilities based on the real company situation. Besides this could serve as a suitable guidance for those who are not familiar with this are enough; to help them in the understanding of capabilities and performance metrics of the SCRE. This literature review could provide such audience a clear picture about the focus of current scholars in supply chain area.

4.2 Recommendation for future research

This study highlighted several paths for future researches. First, the result of this review proved the statement that there are limited papers about the performance metrics (e.g. Chowdhury and Quaddus, 2016; Kamlahmadi and Parast, 2016) given there are only 25 papers identified from the selected literature during the 14 years. Therefore, future studies could focus more on the performance as this topic is important and valuable to help the companies in assessing the strategies and further improvement. Second, the review findings reveal that more conceptual research exists compared to non-conceptual research. More rigorous empirical research is needed to test the capabilities and performance metrics in reality. Case study could be extremely useful to discover the topic in real companies. Third, empirical research can apply the results of this literature review. For example, an empirical study can attempt to research on the SCRE covering different industries to demonstrate the performance metrics applied in the real world. In addition, as explained in the integrated analysis, studies about the performance metrics of the SCRE could develop frameworks that directly measure the performance of the resilience capabilities. Chowdhury and Quaddus (2009) cold be a good example.

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