How different disruptions moderate practices contributing to supply chain resilience

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Abstract

Driven by an increasingly unpredictable operation environment and global supply networks of ever higher complexity, managing supply chain risk has in recent years become a core issue for companies in practice. Supply chain resilience (SCR) is deemed a critical capability to cope with such an environment. Hence, it is important to investigate which factors contribute to SCR and their interactions when faced with different disruptions. Drawing on the dynamic capability view, this study provides preliminary insight about the relationship between resilience elements and overall SCR in regards to different disruptions, contributing to the improvement of final business performance.

Keywords: supply chain resilience, supply chain risk, disruption management.

Introduction

The growing volatility and complexity across supply chain networks indicates the need for innovation in supply chain management (Christopher et al., 2011). Hence, the concept of supply chain resilience (SCR) has garnered interest from academics and practitioners alike because it promises organisations to maintain their competitiveness during times of turbulence (Martin and Helen, 2004, Sheffi and Jr., 2005). Nevertheless, there is little consensus among scholars about which factors contribute to the development of SCR (Ali et al., 2017, Hendry et al., 2019), and the relationship among its constituent factors and resulting performance are not known (Sá et al., 2019, Wong et al., 2019).

This means that two critical issues in the area of SCR research remain unsolved. First, previous studies mainly built on conceptual frameworks or engage in simulation/mathematical modelling, but lack empirical support for their underpinning assumptions about SCR factors (Ali and Gölgeci, 2019). Second, prior studies assume

that possessing SCR has a positive impact on an organisations ability to cope with disruptions. However, there is seldom validation of this assumption, especially when thinking about the differences between disruption types (Wong et al., 2019).

As to the first issue, resilience is created through management practices that help organisations prepare for, respond to, and recover from disruptions, and are aligned to flexibility, collaboration, redundancy, or visibility. These practices could be implemented either by a firm individually or with its supply chain partners collaboratively (Hohenstein et al., 2015, Ali et al., 2017, Stone and Rahimifard, 2018). Despite many studies having explored concepts that contribute to resilience at different disruptions phases, there is little consensus on what practices are required at different phases because current SCR literature is dominated by conceptual and modelling work (Hohenstein et al., 2015, Hendry et al., 2019). Meanwhile, little is known about how the practices at different levels relate to each other, but this issue is crucial for an organisation to find an effective balance (Sá et al., 2019).

Coming to the second issue, most studies in the SCR area build on the resource-based view (RBV) or the dynamic capability view (Ali and Gölgeci, 2019) and take the positive effect of building SCR for granted in that it helps mitigate the adverse impact of disruptions as well as gain competitive advantage in the process. Building SCR usually requires firms to invest, yet there is little empirical evidence proving the strategic and business value of such investments into SCR (Wong et al., 2019).This omission in previous literatures make it hard for practitioners to evaluate the cost-effectiveness of possessing such a capability. Meanwhile, the impact of SCR on firm's performance may also vary because of the different characteristics of disruptions. For example, firms may have clear plans and procedures in place such as small buffer stock to cope with disruptions like IT breakdown and uncertain demand. But for events like a pandemic or a significant policy change impacting international trading relationships, both of which lead to a dramatic change in the business environment, the impact of SCR on business performance would be different and difficult to predict.

This study addresses these gaps by considering the performance outcome of SCR when experiencing different types of disruptions. Meanwhile, interrelationship between resilience practices at different levels are explored. The contribution of this study is therefore two-fold. First, this study aims to empirically validates the influence of different management practices on the overall SCR and the interrelationship between them in different disruption situations. Here, the study makes a distinction between practices that need to be performed collaboratively with supply chain partners as part of concerted SCR efforts, and firm level practices that can be adopted more unilaterally but still be deemed effective. Second, this study empirically explores the influence of building SCR on business performance in different disruption scenarios, as the common recommendations like excess stock may not be beneficial from a business perspective in every situation.

The paper is structured as follows. Section 2 first presents a review of literatures on SCR and the interreference of different disruptions, hence providing the theoretical background and a conceptual framework. Next, the methodology adopted by this research is presented, following with a proposed data collection and analysis process. Section 4 elaborates the findings, followed by discussions and conclusion.

The dynamic capability view and supply chain resilience

Resilience is a wide-ranging concept, commonly used in engineering and ecology (Stone and Rahimifard, 2018). Engineering resilience emphasises the resistance of systems to disturbances, as well as the speed with which it can return to a state of optimal operation. In ecology the definition of resilience is measured similarly, but with a focus on

equilibrium instead of optimal operation. This ecological resilience includes the possibility of moving to a new equilibrium while maintaining core functions. However, definitions from these two areas imply a closed system, which is not applicable to the current business environment. Hence, the third definition of resilience has been proposed as "adaptive" resilience which implies a cyclical system that changes iteratively to external pressures through a learning and adaptation process.

SCR has therefore shown a shift to the adaptive resilience understanding (Stone and Rahimifard, 2018) after having first been defined as he ability of a system return to its original state after disruptions (Christopher and Peck, 2004, Sheffi and Jr., 2005). A stage of "anticipation" has been added to this understanding, referring to the importance of actions taken by firms before disruptions occur (Ponomarov and Holcomb, 2009). Lastly, Hohenstein et al. (2015) supplemented this with a "grow" twist which denotes the ability of a system to learn and thrive in a post-disruption environment.

The evolution of SCR definitions and understandings are in line with the basic premise of the dynamic capabilities view (DCV). The DCV was first introducted by Teece et al. (1997) as an extension to the resource based view (RBV). The RBV proposes that orgniazations develop and utilise resources and abilities to gain competitive advantages, but without taking the uncertainty of environment into consideration. DCV, on the other hand, fills this gap by stressing firms' organisational and strategic processes to integerate, allocate and reconfigure their resources and abilities to survive and adapt to environmental changes and foster competitiveness (Teece et al., 1997, Eisenhardt and Martin, 2000). As the votality of the business environment is increasing, resilience is becoming a necessity for long-term competitiveness.

Therefore, the adaptive resilience of supply chain can also seen as a dynamic capability to cope with disruptions caused by a changing environment and source of competitiveness, because it enables supply chains to prepare for and respond to disturbances, and even thrive post-recovery (Golgeci and Y. Ponomarov, 2013, Chowdhury and Quaddus, 2017). In order to examine the outcome of possessing SCR in the face of different disturbances, the development of measures of SCR follows the concept of adaptive resilience in line with capability view.

The performance impact of supply chain resilience

A large number of studies have investigated the performance impact of possessing SCR (Ponomarov and Holcomb, 2009, Jüttner and Maklan, 2011). Pettit et al. (2010) argued that SCR is able to enhance manufacturing companies' competitiveness and their financial performance. Wieland et al. (2013) has proven that enhancing SCR by developing relational competencies can help firms maintain visibility and responsiveness during disruptions and therefore achieve customer value. Further, more there has been evidence that during the global financial crisis, firms that lacked resilience capability had to shut down their operations (Jüttner and Maklan, 2011).

There are two major measures of performance deployed by prior studies, namely financial and operational, or non-financial performances. The measurements of financial performance usually includes common indicators such as ROA, ROE and profit. Meanwhile, prior studies have also assessed the influence of SCR on operational performance such as customer value, operating efficiency and service quality by reducing contingencies and maintaining operations (Wong et al., 2019, Chowdhury et al., 2019). As customers are key for surviving in a competitive market environment, the final goal of operational management is to provide better customer service. Therefore, customer service and business performance are linked and three commonly used items are adopted

from prior studies to measure firms' business performance. The associated hypothesis is developed as following:

> H1. Supply chain resilience (SCR) has a positive impact on business performance (BP).

How supply chain and firm practices contribute to supply chain resilience

Different management and operational practices can build resilience capability (Hohenstein et al., 2015, Tukamuhabwa et al., 2015, Ali et al., 2017, Chowdhury and Quaddus, 2017). Prior studies have presented a list of concepts that relate to building SCR, yet not only without consensus but also without distinguishing their individual levels. For example, Scholten et al. (2014) proposed an integrative framwork and included five concepts for building SCR from the perspective of disaster management. Chowdhury and Quaddus (2017) developed a SCR construct with 12 elements via a qualitative field study and equation modelling and Ali et al. (2017) identified 13 elements and proposed a conceptual framework through a systematic literature review. Stone and Rahimifard (2018) conceptualised a framework for building agriculture SCR using 23 elements at organisational and supply chain level, which they then divided into 'core' and 'supporting' elements with some exploration of their differing relationships among each other.

As suggested by Scholten et al. (2019), SCR should be considered at different levels and how the elements relate to one and another remains underexplored. They provided a four-level framework of SCR, which includes individual level, orgnisational level, network level and sector/national level. Based on the nature of this research, only the organisational and supply chain level are considered to remain within the sphere of influence of an individual firm to strengthen practical value of the study.

Resilience at organisational level refers to the ability of an organisation to manage their internal resources to cope with disturbances. Resilience at network or supply chain level, in turn, can refer to activities among supply chain stakeholders to control the disturbances from damaging their core ability to supply products to end consumers (Ali et al., 2017, Sá et al., 2019).

At organisational level, practices most cited in the literature include a culture of sitautional awareness, flexibility, redundancy, and adaptability. These reflect the ability of an organisation to anticipate, respond and adapt before-, during- and after-disruptions. Situational awareness specifically refers to pre-emptive procedures or plans an organisation have in place to reduce its susceptibility of disruptions and it reflects the ability of an organisation to recognise and aniticipate the potential risks and prepare themselves before the adverse consequence happens. This could involve practices such as continuity forcasting, contingency planning and training program (Gölgeci and Ponomarov, 2015, Ali et al., 2017, Chowdhury and Quaddus, 2016). Flexibility concerns the ability of an organisation to adapt with minium effort or time during disruptions, which, based on the range of options, can include alternative sourcing, production or transportation options (Stone and Rahimifard, 2018, Chowdhury and Quaddus, 2017, Tukamuhabwa et al., 2015). Redundancy refers to the excess capability an organisation possesses, which could be used as buffer to mitigate the influence of disruptions, and can be achieved through practices such as saftey stock or back-up storage (Tukamuhabwa et al., 2015, Kochan and Nowicki, 2018, Stone and Rahimifard, 2018). Adaptability is a measure of an organistion's ability to adapt or change in responding to the changing enviroment (Tukamuhabwa et al., 2015) and it depends on concepts such as self-organisation, post-disruption learning process, and new investment in infrastructures

according to the new operating environment (Pettit et al., 2013, Stone and Rahimifard, 2018).

At supply chain level, resilience elements in the literature are commonly visibility and collaboration. Visibility relates to the ability to see the processes, products and structures from one end of supply chain to another (Pettit et al., 2013), which mainly depends on the effective and efficient of information flow within the network. Collaboration refers to activities among two or more supply chain actors to generate advantages that they cannot achieve individually. This is reflected sharing information and decisions among supply chain partners (Christopher and Peck, 2004, Scholten and Schilder, 2015).

Elements mentioned above, either achieved by firms indivually or collaboratively with their supply chain partners, help nodes within the supply chain to plan for, respond to, or recover from disruptions, and subsequently adapt to the new operating environment. By building such capabilityies, organisations and their supply chains will become less vulnerable to disruptions (Ponomarov and Holcomb, 2009, Ambulkar et al., 2015, Sá et al., 2019). The above arguments lead to the development of the following hypothesis:

> H2. Supply chain (SC) level practices have a positive impact on supply chain resilience (SCR).
> H3. Firm level practices have a postiive impact on supply chain resilience (SCR).

The moderating effect of disruption types

SCR serves as a stabalising mechanism in the face of supply chain disruptions but such disruptions may take different forms. The literature has discussed them from two perspectives based on the sources they arise from, namely catastrophic disruptions and infrastructure disruptions (Wong et al., 2019, Kochan and Nowicki, 2018).

Catastrophic disruptions typically come from external sources, including natural disasters (e.g. earthquakes, floods and pandemics) and man-made disruptions (e.g. policy changes, social unrest or terrorism, financial crises, labour strikes). Such disruptions tend to cause high and widespread cost and damages. As they are often highly unpredictable, firms can rarely prepare for them in advance, and will need large number of resources to for mitigation and recovery. Park et al. (2013) noted that by possessing critical capability such as supply chain information design, portability, and dispersion, which enable the robustness and responsiveness of supply chain, firms may respond to natural disasters ebetter. Matsuo (2015) also suggested that working collaboratively with supply chain stakeholders based on coordination mechanisms is important for firms coping with natural disasters. Ambulkar et al. (2015) suggested that in the context of high supply chain disruptions (such as political issues, natural disasters or plant disruptions), resource reconfiguration can mediate the realtionship between supply chain resilience orientation and firm resilience–firms' ability to leverage resources and reconfigure them is therefore critical to effective response to disruptions. Wong et al. (2019) has proven that, in the situation of catastrophic disruption, the relationship between SCR and firms' market performance is strengthed.

Based on the prior studies' results regarding the influence of catastrophic disruptions, it is argued that the presence of catastrophic disruptions strengthens the relationship between supply chain and firm level practices and resulting SCR because such disruptions may be better combatted via associated practices.

> H4a. Catastrophic disruptions have a positive impact on the relationship between supply chain (SC) level practices and SCR.

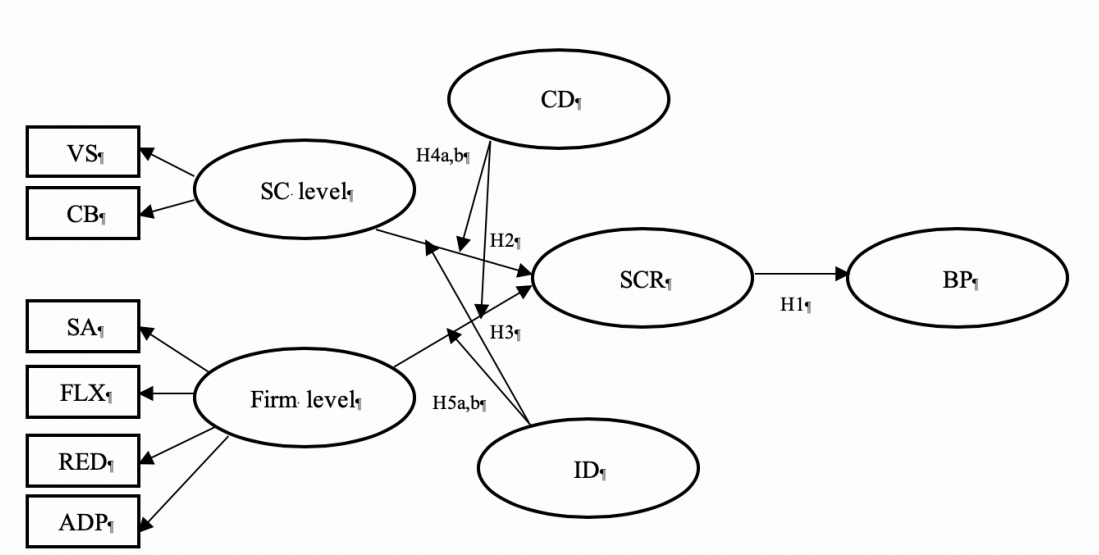
H4b. Catastrophic disruptions have a positive impact on the relationship between firm level (practices and SCR.

Infrastructure disruptions stem from inside of the system and may be caused by the failure or breakdown of IT systems, production lines or supply routes. As current supply chains are often international or global, coordination and throughput requirements for goods, information and finances are high. Disrupting such coordination and flow then severely impacts the supply chain and reduces its ability to deliver goods and services (Wagner and Neshat, 2010, Wong et al., 2019). SCR acts as buffer in this situation as it equips firms with excessive capacity and resources and this ability enables firms to be flexible in making changes to products or processes, as well as maintaining their services and delivering products to customers.

It is therefore proposed that the presence of infrastructure disruptions improves the SCR firms gain from SC and firm level practices.

H5a. Infrastructure disruptions have a positive impact on the relationship between supply chain (SC) level practices and SCR.
H5b. Infrastructure disruptions have a positive impact on the relationship between firm level (practices and SCR.

The resulting Figure 1 is the emergent research framework based on the previously developed hypotheses.



Note: VS=Visibility; CB=Collaboration; SA=Situational awareness; FLX=Flexibility; RED=Redundancy; ADP=Adaptability; SC level=Supply chain level; SCR= Supply chain resilience; CD=Catastrophic disruptions; ID=Infrastructure disruptions; BP=business performance.

Figure 1 – Research framework

Discussion and conclusion

SCR has been posited as a dynamic capability of firms to help them plan for, respond to and recover from disruptions effectively, in turn improving firms' performance in the long run (Golgeci and Y. Ponomarov, 2013, Chowdhury and Quaddus, 2016, Wong et al.,

2019). Yet, a number of previous studies have focused on the SCR construct in isolation, neglecting to contextualise it holistically in the variety of practices a company pursues at supply chain and firm level. Meanwhile, the impact of different types of disruptions has been overlooked in the literature despite their fundamentally dissimilar nature. This preliminary study provides a conceptual framework, in which resilience elements synthesised from previous studies are divided into two levels and supplemente with hypothesised impacts of two disruption types.

The contribution of this work is two-fold. First, the separation of resilience elements into a supply chain and firm level benefits research by providing an intuitive schema in which the various practices of organisations slot in. This brings some clarity to the area of SCR which has struggled to formalise its relationships with its constituent parts like buffer stocks, etc. Second, this study makes progress on comparing different types of disruptions based on their sources and will serve to identify how well generically adopted practices may better or worse result in SCR depending on the disruption type. Clarifying the strength of these moderators will then assist in proving whether practices at the supply chain or firm level are best for dealing with the respective disruption types in practice.

References

ALI, A., MAHFOUZ, A. & ARISHA, A. 2017. Analysing supply chain resilience: integrating the constructs in a concept mapping framework via a systematic literature review. *Supply Chain Management: An International Journal,* 22**,** 16-39.

ALI, I. & GÖLGECI, I. 2019. Where is supply chain resilience research heading? A systematic and co-occurrence analysis. *International Journal of Physical Distribution & Logistics Management,* 49**,** 793-815.

AMBULKAR, S., BLACKHURST, J. & GRAWE, S. 2015. Firm's resilience to supply chain disruptions: Scale development and empirical examination. *Journal of Operations Management,* 33-34**,** 111-122.

CHOWDHURY, M. M. H. & QUADDUS, M. 2016. Supply chain readiness, response and recovery for resilience. *Supply Chain Management: An International Journal,* 21**,** 709-731.

CHOWDHURY, M. M. H. & QUADDUS, M. 2017. Supply chain resilience: Conceptualization and scale development using dynamic capability theory. *International Journal of Production Economics,* 188**,** 185-204.

CHOWDHURY, M. M. H., QUADDUS, M. & AGARWAL, R. 2019. Supply chain resilience for performance: role of relational practices and network complexities. *Supply Chain Management: An International Journal,* 24**,** 659-676.

CHRISTOPHER, M., MENA, C., KHAN, O. & YURT, O. 2011. Approaches to managing global sourcing risk. *Supply Chain Management: An International Journal,* 16**,** 67-81.

CHRISTOPHER, M. & PECK, H. 2004. BUILDING THE RESILIENT SUPPLY CHAIN.

EISENHARDT, K. M. & MARTIN, J. A. 2000. Dynamic capabilities: What are they? *Strategic Management Journal*.

GÖLGECI, I. & PONOMAROV, S. Y. 2015. How does firm innovativeness enable supply chain resilience?.pdf.

GOLGECI, I. & Y. PONOMAROV, S. 2013. Does firm innovativeness enable effective responses to supply chain disruptions? An empirical study. *Supply Chain Management: An International Journal,* 18**,** 604-617.

HENDRY, L. C., STEVENSON, M., MACBRYDE, J., BALL, P., SAYED, M. & LIU, L. 2019. Local food supply chain resilience to constitutional change: the Brexit effect. *International Journal of Operations & Production Management,* 39**,** 429-453.

HOHENSTEIN, N.-O., MARIA JESUS SAENZ, P., XENOPHON KOUFTEROS, D., FEISEL, E., HARTMANN, E. & GIUNIPERO, L. 2015. Research on the phenomenon of supply chain resilience. *International Journal of Physical Distribution & Logistics Management,* 45**,** 90-117.

JÜTTNER, U. & MAKLAN, S. 2011. Supply chain resilience in the global financial crisis: an empirical study. *Supply Chain Management: An International Journal,* 16**,** 246-259.

KOCHAN, C. G. & NOWICKI, D. R. 2018. Supply chain resilience: a systematic literature review and typological framework. *International Journal of Physical Distribution & Logistics Management,* 48**,** 842-865.

MARTIN, C. & HELEN, P. 2004. BUILDING THE RESILIENT SUPPLY CHAIN.

MATSUO, H. 2015. Implications of the Tohoku earthquake for Toyota′s coordination mechanism: Supply chain disruption of automotive semiconductors. *International Journal of Production Economics,* 161**,** 217-227.

PARK, Y., HONG, P. & ROH, J. J. 2013. Supply chain lessons from the catastrophic natural disaster in Japan. *Business Horizons,* 56**,** 75-85.

PETTIT, T. J., CROXTON, K. L. & FIKSEL, J. 2013. Ensuring supply chain resilience: development and implementation of an assessment tool.pdf.

PETTIT, T. J., FIKSEL, J. & CROXTON, K. L. 2010. Ensuring supply chain resilience: development of a conceptual framework. *Journal of business logistics,* 31**,** 1-21.

PONOMAROV, S. Y. & HOLCOMB, M. C. 2009. Understanding the concept of supply chain resilience. *The International Journal of Logistics Management,* 20**,** 124-143.

SÁ, M. M. D., MIGUEL, P. L. D. S., BRITO, R. P. D. & PEREIRA, S. C. F. 2019. Supply chain resilience: the whole is not the sum of the parts. *International Journal of Operations & Production Management,* 40**,** 92-115.

SCHOLTEN, K. & SCHILDER, S. 2015. The role of collaboration in supply chain resilience. *Supply Chain Management: An International Journal,* 20**,** 471-484.

SCHOLTEN, K., SHARKEY SCOTT, P. & FYNES, B. 2014. Mitigation processes – antecedents for building supply chain resilience. *Supply Chain Management: An International Journal,* 19**,** 211-228.

SCHOLTEN, K., STEVENSON, M. & VAN DONK, D. P. 2019. Dealing with the unpredictable: supply chain resilience. *International Journal of Operations & Production Management,* 40**,** 1-10.

SHEFFI, Y. & JR., J. B. R. 2005. A Supply Chain View of the Resilient Enterprise.

STONE, J. & RAHIMIFARD, S. 2018. Resilience in agri-food supply chains: a critical analysis of the literature and synthesis of a novel framework. *Supply Chain Management: An International Journal,* 23**,** 207-238.

TEECE, D., PISANO, G. & AMY, S. 1997. Dynamic capabilities and strategic management.

TUKAMUHABWA, B. R., STEVENSON, M., BUSBY, J. & ZORZINI, M. 2015. Supply chain resilience: definition, review and theoretical foundations for further study. *International Journal of Production Research,* 53**,** 5592-5623.

WAGNER, S. M. & NESHAT, N. 2010. Assessing the vulnerability of supply chains using graph theory. *International Journal of Production Economics,* 126**,** 121-129.

WIELAND, A., TÖYLI, H. L., LAURI OJA, J. & MARCUS WALLENBURG, C. 2013. The influence of relational competencies on supply chain resilience: a relational view. *International Journal of Physical Distribution & Logistics Management,* 43**,** 300-320.

WONG, C. W. Y., LIRN, T.-C., YANG, C.-C. & SHANG, K.-C. 2019. Supply chain and external conditions under which supply chain resilience pays: An organizational information processing theorization. *International Journal of Production Economics*.