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Dealing With the Unpredictable: Supply Chain Resilience

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1. Introduction

It is estimated that almost three quarters of organisations experience a supply chain disruption each year (BCI, 2018), i.e. an event that impacts the flow of goods, materials, and/ or services (Craighead et al., 2007), thereby limiting the ability of an organisation to serve the end consumer (Jüttner, 2005). The disruptions felt by supply chains are wide ranging. For example, while some originate from within the supply chain, such as a production line break down, IT problems, demand fluctuations, sustainability issues or quality problems, others are external and due, amongst other causes, to labour strikes, regulatory changes, weather conditions, financial turbulence, terrorism, and counterfeiting. This breadth of threat also reminds us that disruptions can be man-made and somewhat controllable or a result of the natural environment and consequently more unpredictable. Meanwhile, the performance impact of such events is also dependent on the severity and duration of the disruption as well as on the supply chain's competency and experience in dealing with disruptions and threats.

Some organisations are better able to reduce the severity and duration of disruptions to their supply chains than their competitors; and it is argued that this is because they are more resilient (Christopher and Peck, 2004; Sheffi and Rice, 2005). Supply Chain Resilience (SCRes) can be an important strategic weapon in the current competitive environment and is at the heart of contemporary supply chain management thinking and research (Melnyk et al., 2014; Pettit et al., 2019). SCRes is the capability of supply chains to operate in the face of disturbances and disruptions with or without a limited decrease in their performance (Christopher and Peck, 2004). The review by Tukamuhabwa et al. (2015, p.8) defined SCRes not only in terms of the ability 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" but also in terms of its ability to re-emerge in "ideally, a better state than prior to the disruption" thereby gaining ground on the competition by bouncing back or taking advantage of new opportunities better than other firms that were affected.

The concept of SCRes has received significant attention in recent years from practitioners. For example, a survey by the World Economic Forum (2013) revealed that more than 80% of companies are concerned about the resilience of their supply chains; and the Business Continuity Institute found that disruptions cost 10% of firms more than 1 million Euros per year and as much as 101-250 million Euros (BCI, 2018). Consequently, SCRes has become a topic of significant academic attention (e.g., Sheffi, 2005; Brandon-Jones et al., 2014; Ambulkar et al., 2015; Hohenstein et al., 2015; Scholten and Schilder, 2015; Stevenson and Busby, 2015; Kamalahmadi and Parast, 2016; Purvis et al., 2016; Tukamuhabwa et al., 2017; MacDonald et al., 2018; Scholten et al., 2019). Further, resilience as a theme has become important not only in industries such as insurance, food, automotive, and electronics but also as an area for governmental and inter-governmental attention, as reflected in calls for H2020 projects on, for instance, city resilience. Hence, achieving and increasing SCRes is high on the agenda of researchers, organisations, supply chains, industries, governments, and economic institutions.

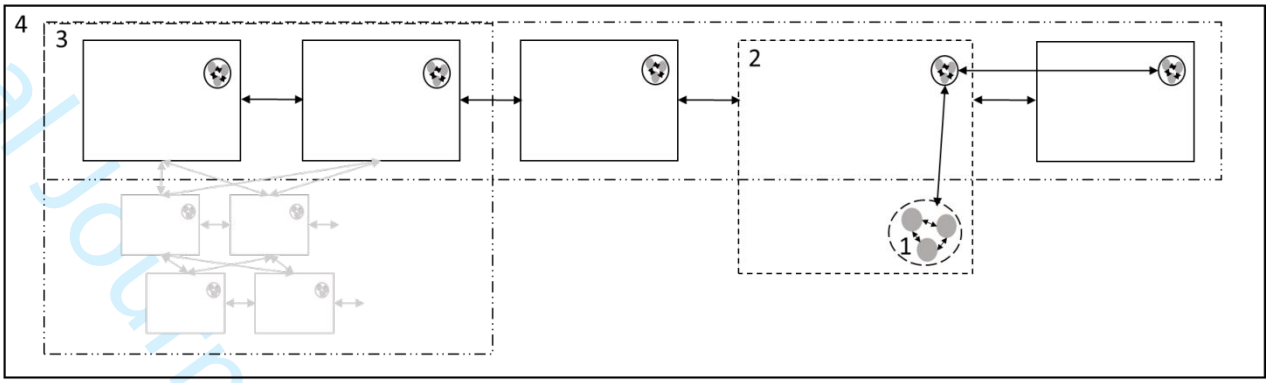
2. Aims of the Special Issue

Despite the attention, growth in publications and the research progress made in SCRes to date, it has been highlighted that the empirical base and exploration of SCRes is limited so far (e.g., Tukamuhabwa et al., 2015) and that a considerable part of the available SCRes literature is conceptual in nature (e.g., Ponomarov and Holcomb, 2009). At the same time, several recent literature reviews on the topic (e.g., Hohenstein et al., 2015; Tukamuhabwa et al., 2015; Kamalahmadi and Parast, 2016; Ali et al., 2017; Kochan and Nowicki, 2018; Stone and Rahimifard, 2018) have shown that SCRes research has established supply chain principles that underpin resilience (Christopher and Peck, 2004; Sheffi, 2005); identified and explored formative elements of resilience (e.g., Jüttner and Maklan, 2011) and their interrelationship (e.g., Brandon-Jones et al., 2014; Scholten and Schilder, 2015; Gligor et al., 2019); studied SCRes in specific contexts, such as disaster relief (e.g., Day, 2014; Scholten et al., 2014) and the agri-food industry (Leat and Revoredo-Giha, 2013); related resilience to sustainability (e.g., Fahimnia and Jabbarzadeh, 2016; Ivanov, 2018); and begun to examine the impact of big data analytics and innovative technologies on resilience (e.g., Papadopoulos et al., 2017; Dubey et al., 2019; Min, 2019).

Notwithstanding the above contributions, there remains much scope for further work. For example, we know relatively little about what constitutes SCRes beyond top-level generic supply chain strategies; how strategies for building SCRes relate to one another; if and how SCRes can be measured *before* the unexpected happens; how SCRes relates to other supply chain concepts that

help to improve performance, including supply chain integration, sustainability, quality management, and lean; and there is limited understanding of behavioural aspects of building resilience. Further, most studies to date have focused on resilience at the organisational level rather than looking more closely at the individuals within firms that make decisions or, importantly, looking truly at the level of the supply chain or beyond. Moreover, the literature has thus far made limited use of existing theory frames to further our understanding of SCRes. The most notable theory frames used to date are the resource based view (e.g., Ponomarov and Holcomb, 2009; Blackhurst et al. 2011), systems theory (e.g., Erol et al., 2010; Blackhurst et al., 2011), contingency theory (e.g., Brandon-Jones et al., 2014), dynamic capabilities (e.g., Brusset and Teller, 2017; Chowdhury and Quaddus, 2017), social capital theory (Gölgeci and Kuivalainen, 2019), and complex adaptive systems theory (e.g., Day, 2014). Using other theory frames may provide additional explanatory power and further our understanding of SCRes. Finally, given the very nature of SCRes, it seems natural to import insights from other disciplines into Operations Management to better understand SCRes (Van der Vegt et al., 2015).

In the light of the above, we called for papers seeking contributions that extended the literature and expanded the knowledge base in order to further develop our understanding and strengthen the theoretical underpinning of SCRes. Our ambition was to gain insights into, for example, how SCRes impacts performance; if and how SCRes links to other concepts, such as sustainability or SC integration; how specific or one-off disruptions, such as an economic crises, Brexit or flooding, influence supply chains and what strategies companies and supply chains use to mitigate these disruptions or their inherent risks; SCRes in under-represented contexts, including developing countries and Small and Medium sized Enterprises (SMEs) to improve understanding of SCRes, its antecedents, and impact; and SCRes in the overall supply chain through chain-wide research. Ultimately, this special issue is comprised of four papers that fit the call and satisfied the publication standards required by IJOPM – although the initial number of submissions would have been enough to fill a whole volume of IJOPM (around 70 formal submissions from 18 different countries). Reflecting upon these papers and their content as well as on a number of interesting recent papers and the subject of some of the rejected papers, we recognise that SCRes as a supply chain construct needs to be considered at different levels of aggregation and analysis, as depicted in Figure 1 – a four-level framework for SCRes. The four levels depicted in Figure 1 are unpacked in the following section, which also introduces and positions the four special issue papers in terms of their contributions to one or more levels of the framework.



Level 1: Individuals and teams, Level 2: Organisational, Level 3: Supply chain and network, Level 4: Sector, national, and supranational

Figure 1: A Four- Level Framework for Supply Chain Resilience

3. Four Levels of SCRes and the Contributions of the Special Issue Papers

3.1 SCRes Level 1: Individuals and Teams

Supply chain management is human-centric and almost all studied contexts contain and revolve around people. Indeed, the success of tools and techniques, and the accuracy of theories, relies heavily on the individuals and teams making decisions or improving processes (Bendoly et al., 2006; Croson et al., 2013). This also holds true in the specific area of SCRes. The origins of the concept of resilience lie in the field of psychology where the individual and their resistance to adversarial events is a central point of concern and attention (van der Vegt et al., 2015). Yet, while there is some acknowledgement of the role of individuals and teams in the SCRes literature (e.g., Fahimnia et al., 2019), SCRes is mainly seen as a system characteristic rooted in concepts of engineering and ecological science (van der Vegt et al., 2015). In contrast, this special issue includes three papers that begin to contribute novel insights to the individual/ team level of building SCRes.

The paper by Vanpoucke et al. (2019) provides a behavioural perspective on the development of supply-side resilience, focusing on the decisions made by managers. It is thus focused on the individual and his/ her influence on decisions relating to the resilience of the supply chain. Primary data is collected from 113 buyers using two experimental scenarios featuring supply-side disruptions of low and high probability. The paper shows that risk propensity affects the type of risk mitigation strategy employed by buyers, providing an insight into how risk propensity influences the risk mitigation decision-making process. The work expands the literature by offering an insight into how buyers actually make decisions to build resilience. In addition, it provides a new methodological approach within the SCRes literature: while experimental approaches are widely used in the risk literature, to date they are scarce in the field of SCRes. The paper may provide a springboard for further experimental research considering other characteristics of supply chain disruptions, other

strategies for building resilience and their deployment, and work that goes beyond the supply-side decisions of the buyer towards a more supply chain view.

Moving from the individual to a team-based perspective, the paper by Rubbio et al. (2019) in this special issue draws on dynamic capabilities theory to explore how surgery wards in two Italian hospitals employ resilient behaviour to solve operational failures and improve patient safety. As such, it studies the effect of team decisions – a ward's nurses and physicians – within a larger organisation. Employing an in-depth case study approach, the authors identify five dynamic capabilities related to individual and team behaviour, knowledge, and experience. The findings show that resilience practices are not necessarily linked to an organisational routine or a managerial process, and thus the work emphasizes the importance of individual and team level contributions to SCRes. While contributing new insights at this lowest SCRes level, the paper also provides a rare insight into how digital technologies can support such behavioural capabilities.

Finally, the paper from Polyviou et al. (2019) includes some new insights on this first level of analysis. The authors explore how resources or capabilities enhance SCRes and find that particularly internal social capital, comprised of interpersonal relationships, commitment, respect and employee tenure, matters. As such, it provides an insight into resilience-enhancing resources that are not rooted in a firm's supply chain operations but in its human resources.

3.2 SCRes Level 2: Organisational

Resilience to supply chain disruptions can be built at an organisational level by, for example, keeping redundancies in the form of spare capacity or additional inventory, or by creating visibility in processes and routines (e.g., Jüttner and Maklan, 2011). To date, much of the SCRes research has focused on this level of analysis, i.e. on how a focal company can or should deal with disruptions in their supply chain for its own gain, either by developing specific capabilities and/or by restructuring their supply chain, and in terms of how it can deal with suppliers (e.g., Ambulkar et al., 2015). The insights that have been provided to date are largely generic and while these are valuable there has been limited attention to date on specific organisational factors such as the size, culture or nature of an organisation or how these factors affect resilience.

The paper by Polyviou et al. (2019) in this special issue provides an organisational level study of SCRes based on four case studies of manufacturing organisations. The paper is novel in its focus on medium sized firms, highlighting the particular challenges they face in applying existing generic SCRes insights. For example, on the one hand, such firms do not have the resources, scale, or influence to develop multiple resilience-enhancing capabilities in the same way as large firms while,

on the other hand, they are too large to obtain the support offered to small firms. As described above, the paper draws attention to internal social capital and the role of a firm's human resources (Level 1) for building organisational level SCRes (Level 2). As such, it also provides valuable insights into the interactions between different levels of our framework for building SCRes.

3.3 SCRes Level 3: Supply Chain and Network

Similar to the fields of supply chain integration (Frohlich and Westbrook, 2001; Flynn et al., 2010) and sustainability, where a multi-tier approach has been advocated (e.g., Hartmann and Moeller, 2014; Tachizawa and Wong, 2014), it is argued that resilience is not something to be pursued at the organisational level only. Ultimately, the resilience of the supply chain as a whole depends on the capability of the individual chain partners and on the broader network, even including competitors (Scholten and Schilder, 2015). To date, most contributions to Level 3 of the SCRes framework have been limited to a dyadic focus, i.e. on a buyer organisation and its immediate tier one suppliers. This is perhaps understandable given that first-tier suppliers are the predominant source of supply chain disruptions (BCI, 2018). Yet, this narrow focus might neglect opportunities and threats beyond the dyadic relationship (see also literature on the bullwhip effect, e.g., Lee et al., 1997). A broader focus could, for example, identify the transformation or migration of a risk from one point in the network to another, as has been shown by Tukamuhabwa et al. (2017). As such, supply chains that are disrupted and aim to be resilient could rethink where redundancy can be located in their chain, specifically if it relates to additional inventory. Such a question can be compared to the location of inventories for normal functioning chains where concepts such as vendor managed inventory (VMI) help to reduce stocks and improve chain performance.

The paper by Martins de Sá et al. (2019) in this special issue studies two supply chains over three tiers and how these supply chains were prepared for, responded to and recovered from a supply chain disruption. The authors provide a rare study of how each node contributes to the overall process of building resilience; and they note that investigating SCRes from the perspective of the focal firm only may omit consequences for the overall supply chain. In the context of supply chains with low interdependence between actors, the authors find that resilience is mainly built at the organisational level (Level 2), where firms implement isolated solutions rather than strategies for building SCRes in the overall chain/network. At the same time, the authors also find that despite no evidence of resilience at the most upstream node, both of the supply chains they studied were resilient. This suggests that SCRes is not dependent on the overall chain but rather on specific nodes. More specifically, the authors conclude that resilience is more dependent on the capacity of

downstream actors who are responsible for delivery to the end consumer than on upstream nodes. This may seem somewhat counter-intuitive when considering previous literature suggestions and would not have been identified if a supply chain level approach had not been taken. There is potential to build on the contribution of this paper in future studies and to conduct similar investigations in supply chains with greater levels of interdependence between actors.

3.4 SCRes Level 4: Sectors, National and Supranational

It is important that management practice and research takes account of the wider context; this is also important to research on SCRes (Leat and Revoredo-Giha, 2013), which should consider the broader context in which individuals, firms, and supply chains are embedded and how they can contribute to resilience at a higher level of aggregation. Indeed, building SCRes can require organisations and supply chains to contribute to resilience at an industry, national, or supranational level. The paper by Rubbio et al. (2019) contained in this special issue is a starting point for such research. To the best of our knowledge, it is the first to extend SCRes to the healthcare sector. The authors find that healthcare knowledge in relation to experience, clinical knowledge and organisational dynamics are antecedents of readiness, flexibility, and collaboration, which are dynamic capabilities required for exhibiting resilient behaviour. Resilience at the firm level becomes an antecedent for building the resilience of the sector.

There is also a need to consider how organisations and supply chains can be resilient to threats that have consequences for entire industries, countries, or more. Here, research has begun to examine the resilience of supply chains to constitutional changes that affect an entire sector or are nationwide, including the effects of Brexit on agri-food supply chains in the UK (Hendry et al., 2019) and how energy supply chains build resilience with implications for the support mechanisms that should be introduced or improved by the European Union (Urciuoli et al., 2014). At the same time, research has called for the impact of transnational phenomena such as the belt and road initiative on supply chain resilience to be examined (Thürer et al., 2019). The paper by Martins de Sá et al. (2019) in this special issue adds further insight to agricultural supply chain resilience, as previously explored by Leat and Revoredo-Giha (2013) and synthesised by Stone and Rahimifard (2018), by studying a sugarcane and an orange supply chain.

Other existing literature at this fourth level of analysis takes a more extreme point of view. It focuses on humanitarian logistics and disaster management (Kovács and Spens, 2007; Kunz et al., 20), often studying a specific disaster and its effect on managing a supply chain that delivers services to affected populations (e.g., Perry, 2007; Holguín-Veras et al., 2014; Dufour et al., 2018). The paper

by Martins de Sá et al. (2019) also focuses on a particular natural disaster – an extreme drought in 2014/2015 – and how it affected the resilience of two supply chains. As such, it departs from the regular disaster management literature in studying the effect of a slow onset disaster on ongoing commercial supply chains rather than those of humanitarian organisations. The authors' findings highlight the importance of information sharing about Level 4 aspects such as climate across Level 3, i.e. the supply chain, to increase risk awareness and willingness to adapt. At the same time, the broader network (Level 3) is found to be important as associations, cooperatives, and government organisations are relevant to fostering knowledge and training across the supply chain.

4. Supply Chain Resilience: Where to Next?

The papers included in this special issue are testament to the novel, interesting and high quality SCRes research being undertaken at different levels of aggregation and analysis. The intersection of these different levels is depicted in the framework contained in Figure 1. We hope that, together with this framework, the contributions of the papers in this special issue spark further ideas and research in the future. There remains much scope for expanding our understanding of SCRes, as also recently identified in a review by Pettit et al. (2019), especially in the more underrepresented areas of the framework described in this introductory essay.

We conclude by providing a few examples of areas that would be interesting to study further in the coming years in the context of SCRes:

- Level 1: the role of individual managers, including their risk perceptions and approaches to decision making, and their effect in order to identify personality characteristics and behaviours that help in enhancing resilience; and the composition and effective decision making structure of teams, including both regular management teams for responding to 'everyday' disruptions and emergency teams for responding to crises and unpredictable threats;
- Level 2: interactions between teams within an organisation in building resilience; the role of cross-functional teams and their effect on resilience; the nature of an organisation (e.g., for-profit *vs.* not-for-profit) and how this affects the threats a firm faces and how it approaches resilience using its resource base; different organisational cultures; and other organisational theories;
- Level 3: the value of relationships between buyers and suppliers not only at an organisational level but also at an interpersonal level (individual/ team) in building resilience; the role of the broader network, including competitors, in responding to disruptions that have a broad resonance; supply chain structural components, such as upstream and downstream tiers or the

length of a supply chain and their effect on resilience; and different levels of interdependencies between actors across the chain or network;

- Level 4: the study of different contexts and industry regulations and their effect on SCRes using relevant theories, including of institutional theory and embeddedness; and the role of policy in supporting the enhancement of SCRes.

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