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Supply Chain Resilience in the face of Uncertainty: how Horizontal and Vertical Collaboration Can help?

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Abstract

Purpose – The COVID-19 outbreak highlights that many supply chains are exposed to unforeseen disruptions, that risks are unavoidable, and that the international nature of supply chains can seriously disrupt normal operations. Therefore, the need for Supply Chain Resilience (SCRES) is more imperative than ever. Furthermore, collaboration in supply chains may have benefitted the response to the COVID-19 outbreak. The aim of this research is to gain a deeper understanding of how collaboration with both types of horizontal and vertical collaboration, in the supply chain affects its resilience.

Design/methodology/approach – A thematic analysis of the literature is used to investigate the concepts of both vertical and horizontal collaboration and supply chain resilience separately, then integrating identified themes to understand the relationship between them through a thematic map.

Findings – The thematic analysis indicates that the more firms collaborate in the supply chain, the more resilient they will be. Furthermore, both horizontal and vertical collaboration between supply chain partners will enhance resilience. This relationship is positively moderated by governance in the partnership and negatively moderated by competition in the partnership.

Originality/value – This is one of the first papers to provide in-depth insights into how collaboration, with both types of horizontal and vertical collaboration, affects supply chain resilience. Neither of previous articles provide an understanding of how both types of collaboration enables supply chain resilience.

Keywords: Horizontal Collaboration, Vertical collaboration, Supply chain resilience, Collaboration

1- Introduction

The Covid-19 pandemic has illustrated the broad and diverse challenges supply chains face in preparation and response to significant disruptions (Azadegan and Doooley 2021). It presents an unprecedented test of resilience (Bryce et al. 2020), in which of course supply chains fail. The increasing vulnerability and greater exposure to risk is caused by different factors such as globalisation, outsourcing, increasing complexity, volatile and turbulent global conditions accompanied by pandemics, natural disasters, and political upheavals (Lotfi and Saghiri 2018; Fiksel *et al.*, 2015).

The empirical and conceptual literature highlights how collaboration is important for building a resilient supply chain (Azadegan and Doooley 2021, Poberschnigg et al., 2020, Scholten and Schilder, 2015). Collaboration in the supply chain is defined as, “a partnership process where two or more autonomous firms work closely to plan and execute supply chain operations toward common goals and mutual benefits.” (Cao and Zhang, 2011 p.166). There are two main types of collaboration: vertical and horizontal. Vertical collaboration is “two or more organisations such as the manufacturer, the distributor, the carrier, and the retailer share their responsibilities, resources and performance information to serve relatively similar end customers”, while horizontal collaboration is “two or more unrelated or competing organisations cooperate to share their private information or resources such as joint distribution centres” (Simatupang and Sridharan, 2002 p.19).

The motivation for investigating the relationship between Supply Chain Resilience (SCRES) and collaboration comes from the need to improve risk management in the supply chain due to increasing vulnerability to risks and the failure of traditional Supply Chain risk Management (SCRM) methods (Azadegan and Doooley 2021, Fiksel *et al.*, 2015). Previous research on SCRES is fragmented and definitions of resilience are contradictory and confusing

(Ponomarov and Holcomb, 2009). Furthermore, there is an inconsistent identification of the capabilities that achieve SCRES (Wieland and Wallenburg, 2013; Tukamuhabwa *et al.*, 2015; Ali *et al.*, 2017). This research uses the definition by Ponomarov and Holcomb as “*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*” (Ponomarov and Holcomb 2009 p.131). At the time of writing, no event demonstrates the need for SCRES more than the COVID-19 global pandemic. Therefore, the need for SCRES is more imperative than ever. Furthermore, collaboration in supply chains may have benefitted the response to the COVID-19 outbreak. For example, collaboration between firms may have helped cope with the shortage of personal protective equipment in the UK (Moglix Business, 2020). Studies identifying collaboration as an enabler of SCRES are not hard to find (Tukamuhabwa *et al.*, 2015; Ali *et al.*, 2017). However, research into exactly how collaboration enables SCRES is lacking and studies specifically focusing on collaboration as an enabler of SCRES are scarce. Scholten and Schilder (2015) argue that while collaboration enables SCRES, exactly how this is achieved is not widely understood. An investigation into the role of collaboration in SCRES by Scholten and Schilder (2015) provides some insight, however this study fails to differentiate between the different types of collaboration (vertical and horizontal). Azadegan and Dooley (2021) discuss micro level resilience as a result of collaboration between buyer and supplier, macro level resilience as a result of collaboration between competitors with government and trade associations and introduce meso level resilience when multiple supply networks collaborate on short to medium supply risks. However, their study doesn’t differentiate between horizontal and vertical collaboration and goes beyond the boundaries we define here in this study as they consider the collaborations with external bodies such as governments. Poberschnigg *et al.* (2020) discuss collaboration as a capability of resilience with no distinction between horizontal

and vertical collaboration. In fact, no known studies differentiate between the types of collaboration when identifying it in relation to SCRES. The motivation is therefore to fill these research gaps and add to the existing literature by providing clarity on how the two concepts are related.

The main objective of this investigation is to gain a deeper understanding of how collaboration enables SCRES, through a thematic analysis of the literature. This will be achieved by bringing together the constructs of collaboration and SCRES, and so a subsequent objective is to identify these constructs. Another objective is to differentiate between vertical and horizontal collaboration as enablers of SCRES and understand how each type affects SCRES. Therefore, the research question we will address, which encompasses these objectives is: *How does collaboration in both forms of horizontal and vertical collaboration in the supply chain affect SCRES?*

Our findings reveal that both types of horizontal and vertical collaboration help supply chain to be more resilient. However, this relationship is moderated positively by the governance in the partnership and negatively by the competition in the partnership.

Exploring the relationship between collaboration and supply chain resilience has both practical and academic relevance. In terms of academic contribution, a better understanding of how collaboration in its both types of vertical and horizontal affects supply chain resilience can help clarify the existing literature which is often contradictory. Practically, this research provides details on the collaborative activities and practices link to both vertical and horizontal collaboration that can enable supply chain resilience, which could help managers in the supply chain recognise how they can achieve supply chain resilience through horizontal and vertical collaboration with partners.

The study is structured as follows: Section 2 details the research methodology. Section 3 reports the findings and ends by integrating the individual themes to develop a thematic map. Section 4 discusses the findings in relation to existing research and finally Section 5 summarises the conclusions of this research as well as limitations and future avenues for research.

2- RESEARCH METHODOLOGY

This research uses the thematic analysis of literature method to determine the research themes by conducting a thematic analysis of the relevant article samples. Thematic analysis is a method for identifying, organizing and reporting patterns (themes) within some data. The reason for using the thematic analysis is that because of its characteristics for data accessibility and flexibility. As Sodhi and Tang (2014) introduced 4 steps in any research stream maturity as (1) awareness (2) framing (3) modelling and (4) validation. Thematic analysis as employed in this research can help framing and modelling on the horizontal and vertical collaboration and SCRES. Furthermore, thematic analysis is becoming increasingly a qualitative research methodology in its own right (sodhi and Tang 2018).

Because of these characteristics, the data collected in this study is more in line with the focus and description of the thematic analysis. The qualitative data can be systematically coded and analysed, and then linked to a wide range of theories or concepts (Braun and Clarke ,2012). The thematic analysis was performed following the steps Hasting and Sodhi (2020) and Sodhi and Tang (2018) followed in their thematic literature review research which was divided into six steps: The most important step in this research is to select 'data corpus' in step 1, which means being familiar with a representative sample of relevant literature and provides the basis for subsequent analysis. Step 2 is to systematically encode all the data and identify as many potential codes or semantic topics as possible. Step 3 is to organize and integrate the initial data

encoding to determine the entire data set. Different encodings are sorted to extract, and form identified themes. The fourth step is to review and refine the early two steps to re-examine the coding level. At the same time, whether the designed themes and coding are appropriate and coherent to gradually improve the entire map should be into consideration. In step 5, the themes and subthemes are named, and detailed analysis is performed to integrate the overall framework. A map is eventually proposed that could be applied to SCRES and horizontal and vertical collaboration. Step 6 is to produce the above steps into this research (Hastig and Sodhi 2020, Sodhi and Tang 2018).

The challenge was selecting a relevant sample that could be replicated without any perceived bias (Sodhi and Tang, 2018). Therefore, our data set included a broad range of secondary data sources, including many different journals. Our data set was defined using sources that were commonly referenced in the literature. These were found through a Google Scholar search combining terminology relevant to this research.

The first search combined “‘collaboration’ and ‘supply chain resilience’”, followed by “‘horizontal collaboration’ and ‘supply chain resilience’” and “‘vertical collaboration’ and ‘supply chain resilience’”. Articles are considered included in the sample in the order in which Google presents (i.e., the relevance ranking). In the initial period of filtration, the selection standard of including or deleting the article is based on the relevance of the abstract and/or full-text research topics (collaboration and supply chain resilience). In further selection, we determined the comprehensive selection of literature by three factors: high frequency of relevant keywords; recent publication period; and more citations. Some of the literature reserved in view of their uniqueness, including the contribution of theories in the field or the representativeness of cases (Behl and Dutta, 2018). In the selection process, once we found that ten consecutive articles had no relevant content, we stopped filtering the articles in rank order. Then, another similar phrase will substitute before continuing the search.

The term “supply chain resilience” was substituted with “supply chain” and “logistics” in additional searches. This produced the bulk of sources selected for the data set. When more information was required for the constructs of collaboration, we searched for “constructs of ‘horizontal collaboration’”, and then, ‘constructs of "vertical collaboration"’. Additionally, the term collaboration was substituted with “co-operation” as these terms are often interchanged. Following Sodhi and Tang (2018), articles and sources were considered for inclusion in the data set in the order Google presented them, this is in order of decreasing relevance and the search for literature from a set of keywords was concluded when 10 sources in sequence were found to be irrelevant. This was repeated for the various combinations of the key words. The search was done in the period of July 2020- September 2020 after the first wave of the pandemic Covid-19 motivated us for this research.

Our final data set had a total of 79 sources. We made a judgement of when a threshold of relevant literature to build a report had been reached. This would mean that if a relevant article was excluded, omissions would not be detrimental. As we are seeking a greater understanding of the relationship between collaboration and SCRES by identifying and connecting different research themes, as long as the data set is broad enough to span different themes, it should be suitable (Sodhi and Tang, 2018). The selected sources will be widely cited as Google Scholar ranks sources based on how frequently they have been cited. However, this may exclude recent sources that have not been referenced often (Sodhi and Tang, 2018). As we have a number of recent sources (post 2015) in our data set we are confident that we have a broad view of the literature including recent studies. We followed the checklist of criteria for good thematic analysis outlined by Braun and Clarke (2006). However, this kind of search has certain limitations, and it is impossible to determine whether all related articles are covered, or some similar resources are also excluded. Some articles may be excluded when we end the list search. We believe the themes and content contained have reached saturation, and there will be no

further critical themes. We took the initial subthemes from literature for resilience and collaboration as our main themes. Next, in order to create more meaning and details (Ferraris et al. 2019), second order codes were extracted through literature related to each main subtheme. Both authors investigated the main themes and subthemes in different meetings, however the second round of coding related to each subtheme was conducted by the second author first and reviewed by the first author. In case there were different viewpoints, in different meetings both authors discussed the sub themes and codes and come to the conclusion for the right Theme-Subtheme and codes.

3- FINDINGS

After reviewing the relevant literature, we identified relevant themes and sub themes from codes highlighted in the thematic analysis. We use the identified themes to build a thematic map and make proposals regarding the relationship between horizontal collaboration, vertical collaboration and SCRES.

Theme 1: Supply Chain Resilience (SCRES)

Ali *et al.* (2017) identify five core capabilities of achieving SCRES; the ability to anticipate, to adapt, to respond, to recover and to learn. We identify five sub-themes of SCRES; the ability to anticipate, adapt, respond, recover and learn, in line with Ali *et al.* (2017).

Many authors investigate the elements required to build SCRES and the relationships between them (Fiksel *et al.*, 2015; Scholten and Schilder, 2015; Ali *et al.*, 2017). There are inconsistent terminologies used to refer to these elements, such as: capabilities (Pettit *et al.*, 2010; Jüttner and Maklan, 2011), antecedents (Ponomarov and Holcomb, 2009), or enablers (Soni *et al.*, 2014). In line with Ali *et al.* (2017) and Christopher and Peck (2004) we refer to these attributes as elements of SCRES. We use the categorisation of the elements of SCRES within the capabilities of anticipating, adapting, responding, recovering, and learning, provided

by Ali *et al.* (2017). For a detailed understanding of the elements required for SCRES and their constructs (Ali *et al.* 2017).

The ability to anticipate

The ability to anticipate is “necessary to identify and monitor potential events, changing environments, and performance before the ability of the supply chain to function is affected,” (Ali *et al.*, 2017 p.23). The elements of robustness, situation awareness, increasing visibility, building security and knowledge management (pre-disruption) are required to enhance the ability to anticipate when building SCRES (Ali *et al.*, 2017). Robustness is the ability of the supply chain to resist change (Wieland and Wallenburg, 2013). Building robustness involves designing a supply chain which can withstand a disruption and operate during and after a disruptive event (Tang, 2006, cited in Ali *et al.*, 2017 p.25). Visibility is defined as “knowledge of the status of operating assets and the environment in which the supply chain operates in,” (Fiksel *et al.*, 2015 p.84). Increasing visibility within a supply chain can reveal where resources are located, where risk is present, provide an upstream and downstream view of inventories and demand and supply conditions (Christopher and Peck, 2004; Blackhurst *et al.*, 2011). Security is the supply chain’s defence against deliberate intrusion or attack such theft and terrorism (Pettit *et al.*, 2010 p.12, Fiksel *et al.*, 2015 p.84). Knowledge management in the supply chain involves developing an understanding of supply chain structures, as well as educating other entities (Pettit *et al.*, 2010; Tukamuhabwa *et al.*, 2015; Ali *et al.*, 2017). Improving knowledge management before a disruption can develop SCRES through practices such as education and training and creating a SCRM/SCRES culture (Rice and Caniato, 2003; Jüttner and Maklan, 2011). Situation awareness requires an understanding of supply chain vulnerabilities and planning for risk events and has the potential to identify a risk event by sensing and interpreting indicators and early warning (Pettit *et al.*, 2010 p.12; Ali *et al.*, 2017).

The ability to adapt

The ability to adapt is “required to manage and adjust critical supply chain resources continually during disruptions and/or normal business activities,” (Ali *et al.*, 2017 p.23). Flexibility and redundancy are essential elements in the ability to adapt and are concurrent elements required to assess the level of responsiveness to adapt to disruption (Ali *et al.*, 2017; Mackay *et al.*, 2020). Flexibility is “the ability of an organisation to adapt with minimum time and effort,” (Stone and Rahimifard, 2018 p.220). Redundancy is “the strategic and selective use of spare capacity and inventory that can be used to cope with disruptions” (Tukamuhabwa *et al.*, 2015 p.5602), which can reduce the severity and improve the ability to adapt to disruption (Christopher and Peck, 2004; Sheffi and Rice, 2005).

The ability to respond

The ability to respond is required “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,” (Ali *et al.*, 2017 p.23). The elements of collaboration and agility are essential in developing SCRES, these are concurrent elements (Lotfi and Saghiri 2018, Ali *et al.*, 2017). Agility is the ability to respond rapidly to unpredictable changes (Christopher and Peck, 2004). Agile supply chains possess velocity to adapt to unexpected changes such as fluctuations in demand or supply (Christopher and Peck, 2004; Jüttner and Maklan, 2011). Agility requires visibility from communication an information sharing and velocity for responsiveness and quick supply chain redesign to reduce the impact of disruptions (Wieland and Wallenburg, 2013; Hohenstein *et al.*, 2015). Velocity refers to the time of response or recovery (Christopher and Peck, 2004) and is essential in the ability of the supply chain to respond. Collaboration is the ability to work effectively with others for mutual benefit (Pettit *et al.*, 2010; Fiksel *et al.*, 2015).

The ability to recover

The ability to recover is “essential in the aftershock of a supply chain event, so as to restore or return to normal operations,” (Ali *et al.*, 2017 p.23). The elements of contingency planning and market position are required in the ability to recover from disruption. These are reactive strategies used to aid recovery (Tukamuhabwa *et al.*, 2015; Ali *et al.*, 2017). Developing contingency plans (Lotfi 2019) of a disruption helps enable SCRES after a disruption, as it enhances the ability to recover by enacting ready made plans. Contingency plans aid restoration of the supply chain to normal or better operating conditions by decreasing the response time following a disruption (Hohenstein *et al.*, 2015; Ali *et al.*, 2017). Having a strong market position increases a firm’s ability to recover from supply chain disruptions (Ali *et al.*, 2017). This is the “status of a company or its products in specific markets” (Pettit *et al.*, 2010 p.12). A strong market position is associated with increased market share, customer loyalty/retention, and improved customer communications and relationships (Pettit *et al.*, 2010 p.12; Fiksel *et al.*, 2015 p.84). Therefore, a strong market position aids recovery due to benefits that it can bring.

The ability to learn

The ability to learn is “required after a supply chain event to understand what has happened and improve future performance based on the experience,” (Ali *et al.*, 2017 p.23). This requires the elements of knowledge management (post-disruption) and building social capital, these are reactive strategies (Ali *et al.*, 2017). The ability to learn after a disruption and develop better solutions for future disturbances is a fundamental part of SCRES (Ponomarov and Holcomb, 2009). Post-disruption knowledge management involves education and training (Rice and Caniato, 2003), post-disruption feedback and understanding the total cost of supply chain management to provide employees with the necessary skills and understanding to recognise an event and act (Blackhurst *et al.*, 2011; Ali *et al.*, 2017). Therefore, knowledge management about previous disruptions can facilitate the ability to learn. Building social capital and

relational competences among supply chain partners strengthens the ability to learn from each other. It requires communication, cooperation, trust, reciprocity (Blackhurst et al., 2011; Tukamuhabwa et al., 2015). Furthermore, appropriate selection of suppliers can help develop the ability to learn (Soni et al., 2014). In Table 1, the themes, sub-themes, and codes for SCRES are presented.

Table 1: Sub-themes, underlying codes, and sample references for SCRES

Theme: SCRES		
Sub-theme	Codes	Ref.
Ability to anticipate	Proactive strategies, readiness, sensing and interpreting, monitoring, supply chain design, decentralisation, visibility, ICT, detection systems, connectivity, information sharing, transparency, security, knowledge management, risk management culture, supply chain understanding, sustainability, robustness, situation awareness.	Christopher and Peck, 2004; Ponomarov and Holcomb, 2009; Pettit et al., 2010, Blackhurst et al., 2011; Jüttner and Maklan, 2011; Pettit et al., 2013; Scholten et al., 2014; Tukamuhabwa et al., 2015; Hohenstein et al., 2015; Fiksel et al., 2015; Kamalahmadi and Parast, 2016; Ali et al., 2017, Lotfi 2019
Ability to adapt	Concurrent strategies, absorb, flexibility, multiple sourcing, flexible transport, holding buffer stocks, flexible supply base, postponement, redundancy, excess capacity, multiple sites for production, business continuity plans, alternative routes, cross functional workforce.	Sheffi and Rice, 2005; Pettit et al., 2010; Pettit et al., 2013; Fiksel et al., 2015; Hohenstein et al., 2015; Kamalahmadi and Parast, 2016; Ali et al., 2017
Ability to respond	Concurrent strategies, control, contingency planning, horizontal and vertical collaboration, information sharing, collaborative activities, agility, velocity,	Christopher and Peck, 2004; Ponomarov and Holcomb, 2009; Pettit et al., 2010; Jüttner and Maklan, 2011; Pettit et al., 2013; Scholten et al., 2014; Fiksel et al.,

	responsiveness, alternative routes, time, communication, information sharing	2015; Scholten and Schilder, 2015; Ali et al., 2017, Naghshineh and Lotfi 2018
Ability to recover	Reactive strategies, survive, continuity, return to original/normal state, move to new/desirable state, quick response, recovery time, contingency planning, supply chain reconfiguration, market position, financial strength, market share, efficiency, customer commitment and relationships	Sheffi and Rice, 2005; Ponomarov and Holcomb, 2009; Pettit et al., 2010; Pettit et al., 2013; Fiksel et al., 2015; Tukamuhabwa et al., 2015; Ali et al., 2017, Lotfi and Saghiri 2018
Ability to learn	Reactive strategies, growth, competitive advantage, knowledge management, education and understanding, performance outcomes, innovation, building social capital, trust, communication, cooperation, leadership, sustainability	Ponomarov and Holcomb, 2009; Blackhurst et al., 2011; Tukamuhabwa et al., 2015; Kamalahmadi and Parast, 2016; Ali et al., 2017

**Adapted from Ali et al. 2017*

Theme 2: Collaboration

Vertical collaboration is inter-organisational within a supply chain and can be collaboration with upstream or downstream organisations in the supply chain (Barratt, 2004, Mason *et al.*, 2007). Horizontal collaboration occurs between organisations operating at the same level of the supply chain, that are often in competition with each other (Cruijssen, 2006; Pomponi *et al.*, 2015). Following the thematic analysis, we identified 4 key themes in the collaboration literature which we will now explore in more detail.

Mutual Objectives and Incentives

Partners in both horizontal and vertical collaboration must have mutual objectives for the partnership to succeed (Simatupang and Sridharan, 2002; Cao and Zhang, 2011). Furthermore, goal congruence is a key component of successful collaboration. Another key component of

successful collaboration is incentive alignment (Cao *et al.*, 2009; Cao and Zhang, 2011). This is the process of sharing costs, risks, and benefits among supply chain partners (Simatupang and Sridharan, 2005a, 2005b) and requires that each participant share gains and losses equally. Cruijssen (2006, p.35) states that for collaboration to succeed, partners must act harmoniously to achieve joint goals, sharing costs, risks and benefits. Therefore, it is important to have mutual objectives and incentives when undertaking both types of collaboration.

Mutual Objectives and Incentives in Vertical Collaboration

The main objectives of vertical collaboration are improvements in effectiveness and efficiency in the supply chain (Min *et al.*, 2005; Cao and Zhang, 2011). Subsequently, firms seek to reduce costs and eliminate “waste” from the system (Cruijssen, 200; Cao and Zhang, 2011). Cao and Zhang (2011) identify collaborative advantage which includes process efficiency, offering flexibility, quality and innovation, as key objectives of vertical collaboration. Another objective of vertical collaboration is risk management (Sheffi, 2001; Cao *et al.*, 2009), where companies should work with partners to develop security practices and share growing expertise on risk events (Sheffi, 2001). Other objectives of vertical collaboration include: reduction of stock levels and inventory, improved sales and profits, increased market share, more efficient flows of materials, improved asset utilisation, quick response to changing demands and operating conditions, improved customer satisfaction, competitive advantage and acquiring new skills and knowledge (Min *et al.*, 2005; Cao *et al.*, 2009; Cao and Zhang, 2011).

Mutual Objectives and Incentives in Horizontal Collaboration

Common objectives of horizontal collaboration also include improving efficiency and effectiveness through reduced costs and improved service (Cruijssen, 2006; Pomponi *et al.*, 2015; Zhu, 2017). Other common objectives of horizontal collaboration include; growth, innovation, increased profitability, improved market position, increased responsiveness, increased capacity utilisation, improved predictability and flexibility, improved customer

service, and reduced CO₂ emissions (Crujssen, 2006; Pomponi *et al.*, 2015; Zhu, 2017). Cost reduction is achieved by using joint facilities or reducing transport costs (Crujssen, 2006; Crujssen *et al.*, 2007). Horizontal collaboration allows growth by optimising truck capacity utilisation and reducing empty mileage (Crujssen, 2006; Crujssen *et al.*, 2007). Quick response seeks to reduce response times through horizontal collaboration which can enable partners to successfully enter new markets, develop a competitive advantage and provide better customer service (Crujssen, 2006; Schulz and Blecken, 2010). The social objectives of horizontal collaboration include reducing congestion, noise and air pollution in areas (Crujssen, 2006). Switching to more environmentally friendly transport modes such as rail transport can mitigate this problem and horizontal collaboration enables companies to combine freight loads to meet the threshold of use for these alternative modes (Crujssen, 2006).

Joint Activities

Although the constructs and objectives of vertical and horizontal collaboration are similar, organisations operationalise the constructs differently within the two types of collaboration. This comes from differing joint activities between horizontal and vertical collaboration.

Joint Activities in Vertical Collaboration

Examples of vertical collaborative activities include; joint planning, decision synchronisation, joint problem solving, joint performance measurement, leveraging and sharing resources and skills, collaborative communication, and joint knowledge creation (Min *et al.*, 2005; Cao *et al.*, 2009; Cao and Zhang, 2011). Joint planning involves activities such as setting joint performance targets, joint manufacturing and planning, joint budgeting, collaborative demand planning, and collaborative design (Barratt, 2004; Min *et al.*, 2005; Matopoulos *et al.*, 2007). Decision synchronisation is the process by which supply chain partners make decisions in supply chain planning and operations to maximise benefits for the supply chain (Simatupang and Sridharan, 2002). For example, decisions to determine the most effective use of resources

(Min *et al.*, 2005). Joint problem solving can result in process improvements such as improving distribution, inventory management and procurement (Min *et al.*, 2005; Matopoulos *et al.*, 2007). Leveraging resources and skills involves activities such as using a partner's distribution networks, knowledge and skills, sharing transportation/distribution and sharing IT capabilities (Barratt, 2004; Min *et al.*, 2005; Matopoulos *et al.*, 2007). Vendor Managed Inventory (VMI) and Collaborative, Planning, Forecasting, and Replenishment (CPFR) are commonly identified activities in vertical collaboration (Sheffi, 2001; Simatupang and Sridharan, 2002; Barratt, 2004; Cruijssen, 2006; Zhu, 2017).

Joint Activities in Horizontal Collaboration

The activities involved in horizontal collaboration are very different from those in vertical collaboration. Collaborative distribution is the most implemented activity (Zhu, 2017). Cruijssen (2006) identifies this as freight sharing, where organisations share transport to better utilise assets and capacity. Higher fill-rates, fewer transportation trips, lower CO2 emissions and better management of demand are some advantages to implementing collaborative distribution (Zhu, 2017). Sharing logistics assets and facilities such as trucks and warehouses reduces costs, improves efficiency, increases utilisation, reduces issues of low volumes and helps manage uncertain demand or seasonal operational fluctuations (Cruijssen, 2006; Zhu, 2017). Freight modal shift is a horizontal collaborative activity where organisations switch from trucks and lorry transport modes to more cost-efficient modes of transport such as rail and waterways. Horizontal collaboration allows shippers to consolidate freight loads to acquire the high volumes required for these transport modes (Zhu, 2017; Cruijssen, 2006). Freight consolidation is an activity that decreases the number of miles driven, reduces associated fuel costs, congestion and emissions and improves delivery times (Cruijssen, 2006; Mason *et al.*, 2007). Schulz and Blecken (2010) investigate collaboration from a disaster relief perspective

and state that horizontal collaboration includes activities such as during contingency planning and last-mile distribution.

Information sharing

Information sharing is the extent to which relevant, accurate and complete information is shared in a timely manner between partners (Simatupang and Sridharan, 2002, Zacharia *et al.*, 2009; Cao and Zhang, 2011). Many authors identify information sharing as a key component of both horizontal and vertical collaboration in the supply chain and much of the same information is shared in both types of collaboration (Cruijssen, 2006; Cao and Zhang, 2011; Sheffi *et al.*, 2019). Increased visibility in the supply chain is recognised as an important benefit of sharing information (Simatupang and Sridharan, 2002; Mason *et al.*, 2007) as it enhances the ability to make better decisions and can result in immediate, corrective actions being employed to avoid disruption (Min *et al.*, 2005).

Information shared between supply chain partners in a vertical collaboration can include point-of-sales data, availability of resources, inventory levels, capacity, inventory policies, market trends, customer preferences, competitor activities, production schedules, delivery plans, supply disruptions, the status of performance, the status of processes such as ordering, delivery and replenishment and demand and sales forecasting data (Simatupang and Sridharan, 2002, 2005a, 2005b; Min *et al.*, 2005).

In horizontal collaboration sharing information about route optimisation, truck sharing and lead times can be shared (Pan *et al.*, 2019). Sharing client information and vehicle capacities in horizontal collaboration allows joint routing planning between partners to occur. By sharing customer information, storage facilities, vehicle capacities and route planning can be improved through a more efficient customer-to-depot allocation in horizontal collaboration (Quintero-Araujo *et al.*, 2017).

Bridging and Bonding strategies

Bridging and bonding strategies have been used to investigate organisational resilience (Jung and Song, 2014; Andrew *et al.*, 2015). The bonding hypothesis suggests that a community with a strong sense of togetherness is more resilient to disasters than a community with a lower sense of social cohesion (Andrew *et al.*, 2015). While the bridging hypothesis suggests that a firm in the central position of a network has the capacity to undertake the responsibility of allocating the flow of resources (Andrew *et al.*, 2015). Jung and Song (2014) suggested that the bonding or bridging effect can differ based on the type of collaborative network, they investigated the strategies separately in hierarchical and horizontal collaborative networks to determine their impact on organisational resilience. Jung and Song (2014) investigated bonding strategies in horizontal collaboration as commitment is a key problem in this relationship and the purpose of bonding strategies is overcoming commitment problems. A bonding relationship between partners represents tight social cohesion and a strong sense of belonging. Jung and Song (2014, p.1471) propose that “a bonding strategy is more likely to increase the level of organizational resilience in horizontal collaboration”.

They also investigate bridging strategies in hierarchical (vertical) collaboration, as information and coordination are the key problems in this relationship. The bridging hypotheses means a firm holds a central position and links other firms that would otherwise not be connected to the network, creating a “spider-web “ type network for emergency management which can help enhance resilience (Jung and Song, 2014). They propose that a bridging strategy is more likely to increase the level of organizational resilience in hierarchical collaboration (Jung and Song, 2014 p.1472). They found that bridging strategies in hierarchical emergency management networks have a positive effect on the level of organizational resilience. In addition, the coordinating efforts of upper-level firms in a partnership are

important for enabling resilience from collaboration. In Table 2, the sub-themes and codes for collaboration are presented.

Table 2: Sub-themes, underlying codes and sample references for collaboration

Theme: Collaboration		
Sub-theme	Codes	Ref.
Mutual Objectives	Goal congruence, incentive alignment, gainsharing, efficiency, sales and profits, market share, quick response/ responsiveness, customer satisfaction, competitive advantage, capacity utilisation, accurate forecasting, risk management, enhanced flexibility, growth, innovation, social relevance	Sheffi, 2001; Simatupang and Sridharan, 2002; Min et al., 2005; Simatupang and Sridharan, 2005a, 2005b; Cruijssen, 2006; Cruijssen et al., 2007; Matopoulos et al., 2007; Cao et al., 2009; Cao and Zhang, 2011; Pomponi et al., 2015; Zhu, 2017; Pan et al., 2019
Joint Activities	Joint planning/ manufacturing/ budgeting, collaborative design, decision synchronisation, joint problem solving, inventory management, procurement, leveraging and sharing resources, sharing transportation/distribution, sharing IT capabilities, collaborative communication, joint knowledge creation, freight sharing, asset/ capacity utilisation, sharing logistics assets and facilities, sharing trucks and warehouses, asset pooling, freight modal shift, joint route planning, collaborative purchasing, collaborative service	Sheffi, 2001; Simatupang and Sridharan, 2002; Barratt, 2004; Min et al., 2005; Simatupang and Sridharan, 2005a, 2005b; Matopoulos et al., 2007; Cao et al., 2009; Schulz and Blecken, 2010; Cao and Zhang, 2011; Zhu, 2017; Pan et al., 2019

Information Sharing	Visibility, communication, information technology, transparency, trust, supply and demand data, point-of-sales data, promotion plans, availability of resources, inventory levels, capacity, inventory policies, market trends, customer preferences, production schedules, delivery plans, the status of performance, the status of processes, forecasting data	Simatupang and Sridharan, 2002; Barratt, 2004; Min et al., 2005; Simatupang and Sridharan, 2005a, 2005b; Cruijssen, 2006; Cao et al., 2009; Zacharia et al., 2009; Zhu, 2017; Sheffi et al., 2019
Bridging and Bonding Strategies	Organisational resilience, commitment problems, social cohesion, trust, information and coordination problems, governance	Jung and Song, 2014; Andrew et al., 2015

Thematic Map: Integrating the themes

After reviewing the literature, we have identified the appropriate themes for collaboration and SCRES and the subthemes and codes within these. We now integrate the themes to establish a greater understanding of how collaboration affects SCRES and develop several propositions relating to this relationship. The thematic analysis indicated that collaboration, both horizontal and vertical, enhances SCRES by improving the capabilities of anticipating, adapting, responding, recovering, and learning in the supply chain.

The ability to anticipate is greatly improved by information sharing in the supply chain, this is a key component of both horizontal and vertical collaboration. Information sharing supports the elements of situation awareness by sharing indicators of events and knowledge management by educating partners about risk events (Tukamuhabwa et al., 2015). Most

importantly information sharing improves visibility in the supply chain, which is vitally important in its ability to anticipate (Mason *et al.*, 2007).

The key elements of the ability to adapt are creating flexibility and redundancy in the supply chain, both horizontal and vertical collaboration can develop these elements in the supply chain through joint activities. The ability to adapt requires activities such as multiple sourcing, flexible transport, buffer stocks, excess capacity and alternative routes (Pettit *et al.*, 2010, 2013; Ali *et al.*, 2017). These activities can be achieved through collaboration (Matopoulos *et al.*, 2007). Flexibility and redundancy from vertical collaboration can come from joint planning, manufacturing, forecasting and inventory management and leveraging resources and skills (Barratt, 2004; Min *et al.*, 2005; Matopoulos *et al.*, 2007). Similarly, in horizontal collaboration flexibility and redundancy can come from collaborative distribution, joint route planning and using alternative distribution modes (Crujssen, 2006; Zhu, 2017).

The ability to respond is enabled through collaboration and agility (Ali *et al.*, 2017). Responsiveness is identified as a component of agility, which is an important element in the ability to respond (Ali *et al.*, 2017). Incentive alignment is a component of the mutual objectives theme and decision synchronisation is a component of the joint activities theme. This indicates that mutual objectives, joint activities and information sharing in both horizontal and vertical collaboration are important in the ability to respond.

The ability to recover in the supply chain is facilitated by developing contingency plans and developing a strong market position (Tukamuhabwa *et al.*, 2015; Ali *et al.*, 2017). In both vertical and horizontal collaboration, key mutual objectives include increased market share, improved customer satisfaction, and improving efficiency (Min *et al.*, 2005; Crujssen, 2006; Pomponi *et al.*, 2015; Zhu, 2017). Efficiency is identified as a subcomponent of the element of market position (Ali *et al.*, 2017). Furthermore, customer satisfaction is related to market

position as customer relationships are a key component of market position (Ali *et al.*, 2017). Therefore, the mutual objectives of improving market position in vertical and horizontal collaboration enhances the ability to recover in the supply chain.

Subcomponents of the ability to learn include growth, profitability and improvements in performance. These are important mutual objectives of both horizontal and vertical collaboration. For both vertical and horizontal collaboration, common objectives include improving efficiency, reducing costs and increasing profitability which should facilitate growth (Cruijssen, 2006; Cao and Zhang, 2011). As cost benefits are a subcomponent of the element of knowledge management, then mutual objectives enable knowledge management (Ali *et al.*, 2017). Therefore, mutual objectives enhance the ability of the supply chain to learn through growth and knowledge management. The mutual objective in vertical collaboration of risk management (Sheffi, 2001; Cao *et al.*, 2009) can facilitate the ability of the supply chain to learn, through knowledge management as partners share expertise on risk events and management (Sheffi, 2001).

Therefore, there is evidence that collaboration can enhance the five core constructs of SCRES leading us to propose the following proposal:

P1. The more that firms in the supply chain collaborate, the more resilient they will be.

Additionally, we have differentiated between different types of collaboration. Therefore, we propose:

P1.1. Horizontal collaboration between partners in a supply chain will enhance its resilience.

P1.2. Vertical collaboration between partners in a supply chain will enhance its resilience.

Entering horizontal and vertical collaboration can be risky if the partnership is not managed correctly. Many authors identify the need for governance when undertaking

horizontal and vertical collaboration in the supply chain (Cruijssen, 2006; Schmolzi and Wallenburg, 2012; Pan *et al.*, 2019; Sheffi *et al.*, 2019). Governance is a requirement for successful vertical and horizontal collaboration (Pomponi *et al.*, 2015). Contracts are an effective means of relationship governance, and a lack of written agreement can lead to problems in the case of growth, conflict or when the collaboration comes to an end (Cruijssen, 2006; Sheffi *et al.*, 2019). Informal governance hinges on enablers such as trust and communication, while formal governance relies on contracts to establish clear rules and procedure (Sheffi *et al.*, 2019). Successful collaboration requires formalised agreements and written documents that outline rules and objectives of the partnership (Min *et al.*, 2005). Sheffi *et al.* (2019) state that the legal aspects of horizontal collaborative relationships are particularly important because coordination failure and risks are higher in horizontal collaboration than in vertical collaboration. Implementing the appropriate governance mechanisms will help to manage conflict, reduce issues of commitment, and improve the success of horizontal collaboration in the supply chain (Zhu, 2017). Schmolzi and Wallenburg (2012) found that in horizontal collaboration, formalized operational governance is more effective for counteracting the threat of opportunism than it is in vertical collaboration. Furthermore, it is more important in horizontal collaboration to clearly define the responsibilities of the partners. Therefore, governance is important in the success of both horizontal and vertical collaboration. Consequently, we propose the following proposition:

P1.3. The relationship between collaboration and SCRES is positively moderated by governance in the partnership.

Horizontal collaboration involves combining the opposing forces of collaboration and competition. This can result in a high risk of opportunism and conflict that can jeopardise the partnership (Schmolzi and Wallenburg, 2012). Competition in horizontal collaboration increases the threat of opportunism and reduces the level of trust, because one participant may

use information gathered in the partnership to improve its own market position at the expense of others (Cruijssen, 2006). Schmolzi and Wallenburg (2012, p.57) concur that the threat of opportunism is high in horizontal collaboration because industry know-how allows for a competitive advantage which can be easily replicated by partners once they have access to these capabilities through collaboration. The difference between vertical and horizontal collaboration is since horizontal collaboration is characterised by both collaboration and competition. In horizontal collaboration, formalised operational governance is more effective for counteracting the threat of opportunism than it is in vertical collaboration (Schmolzi and Wallenburg, 2012). Therefore, as competition can negatively impact the development of collaboration, we propose that:

P.1.4. The relationship between collaboration and SCRES is negatively moderated by competition in the partnership.

Following the suggestion of these proposals, we illustrate the thematic map in Figure 1. This Figure represents the integration of themes and subthemes of SCRES and collaboration and the relationships between them.

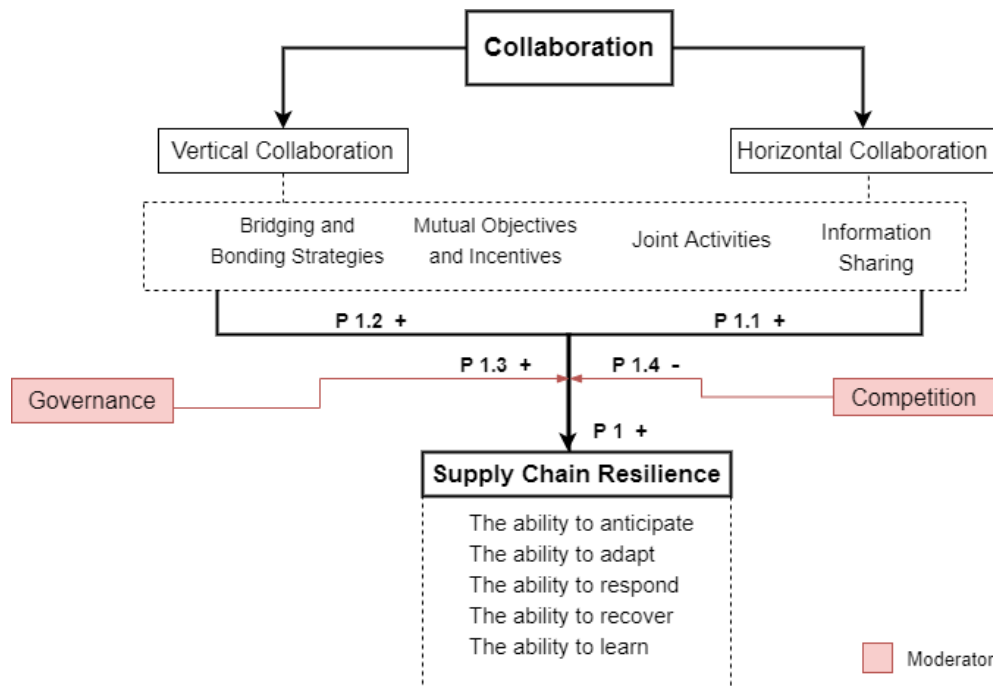


Figure 1: An illustration of the thematic map

4- Discussion

There are many articles that investigate the elements required in building SCRES (Tukamuhabwa *et al.*, 2015; Ali *et al.*, 2017). These articles investigate a broad range of elements, but do not investigate individual elements in depth. Consequently, there is a lack of information into exactly how these elements enable SCRES. This was the case for collaboration. We investigated the relationship between collaboration and SCRES by linking the activities and elements of collaboration to the capabilities of SCRES. Few papers link the activities and elements of collaboration to SCRES. The closest research was provided by Scholten and Schilder (2015) who investigated the role of collaboration in SCRES. They investigate how the collaborative activities of information-sharing, collaborative communication, mutually created knowledge and joint relationship efforts affect SCRES and the relationship between these concepts. Similarly, we investigate how collaborative activities

impact SCRES and the relationship between these concepts. However, Scholten and Schilder's (2015) focus was on how these activities impact SCRES with relation to the elements of visibility, velocity, and flexibility. Our focus was on linking the activities to the elements of SCRES, but more importantly linking the elements to the capabilities of anticipating, adapting, responding, recovering, and learning in the supply chain. Therefore, we add to the literature on SCRES by providing suggestions of how collaboration enables SCRES through various activities and also by illustrating clear links between the activities of collaboration and the capabilities of SCRES. Furthermore, we provide clear suggestions of moderators of the relationship between SCRES and collaboration. This is lacking in other papers investigating collaboration and SCRES. In more recent Publications Azadegan and Dooley (2020) investigated different resilience strategies linked to different types of collaboration within and between supply networks, however they extended their scopes to collaboration with external bodies such as government while in this research we keep the focus on the supply chain actors who collaborate vertically or horizontally. Poberschnigg et al. (2020) discuss collaboration as a capability of resilience with no distinction between horizontal and vertical collaboration. We differentiated between vertical and horizontal collaboration, when investigating how collaboration enables SCRES. No known studies investigate the relationship between the different types of collaboration and SCRES in detail, nor do they provide explanation into how the different types affect SCRES. Differentiation between the types of collaboration is noticeably absent in the investigation into the role of collaboration in SCRES by Scholten and Schilder (2015), which is one of the most detailed investigations into SCRES and collaboration to date. Some papers do identify the need for both vertical and horizontal collaboration for SCRES, however they do not provide an understanding of how they enable SCRES. For example, Hendry *et al.* (2019) identify horizontal and vertical collaboration between supply chain members as important proactive strategies for building SCRES during periods of

constitutional change. Furthermore, Leat and Revoredo-Giha (2013) identify both horizontal and vertical collaboration as important in risk management to enable SCRES. However, neither of these articles provide an understanding of how both types of collaboration enable SCRES. Following the thematic analysis, we found that the constructs of horizontal and vertical collaboration are the same, but they are operationalised differently between the two types. Thus, we found that they enable SCRES through the same constructs, but the constructs are implemented in different ways. For example, both types of collaboration enable SCRES through joint activities and mutual objectives, but the types of activities and objectives used to enable SCRES differ depending on the type collaboration. Therefore, we have provided a deeper understanding of how the different types of collaboration affect SCRES.

5- Conclusion

The results of the thematic analysis led to contributions to the literature through clear identification of the constructs of collaboration and SCRES, linking these constructs to gain a deeper understanding of how collaboration affects SCRES while considering both horizontal and vertical collaboration. The map of the research domain as a whole can be useful for researchers extending or positioning their research as collaboration and its contribution to the SCRES is a vast area. The themes and subthemes developed provide us with concepts that can help with case study research leading to conceptual development.

Although many industries and supply chains are facing huge uncertainty as we witness in Covid-19 pandemic, managers are concerned about how they can make their supply chain more resilient. Collaboration in both its models i.e. horizontal collaboration and vertical collaboration can help manager to achieve the level of desired resilience. Therefore, suppliers might not only collaborate with buyers and other actors vertically, but they can collaborate with

other suppliers even their competitors. However, as this research concludes the issues of governance and competition should be managed carefully.

In terms of limitations, following the thematic analysis we have only suggested proposals for the relationship, a more in-depth survey research or case study analysis would be required in order to empirically test these proposals. We did not have access to third-party data through case studies due to the COVID-19 outbreak and global pandemic. This meant that we were restricted to using secondary data and resulted in a lack of examples to evidence our findings. Theory from different disciplines should be considered, an organisational perspective could be particularly informative. We have proposed that bonding and bridging strategies would enable SCRES in the same way that it enables organisational resilience, but this relationship requires further investigation. Furthermore, while this research is offering the thematic map on relations between resilience which is needed in times of uncertainty, and horizontal and vertical collaboration, the direct effects of challenging scenarios such as Covid-19 can be a future avenue for research. So further empirical investigation on the suggested map and proposed positions is suggested.

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