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Supply chain risk management: capabilities and performance

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Supply chain risk management: Capabilities and performance

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The student author and the program of study committee are solely responsible for the content of this dissertation. The Graduate College will ensure this dissertation is globally accessible and will not permit alterations after a degree is conferred.

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DEDICATION

This dissertation is dedicated to my late Grandmother, Elizabeth Schlegelmilch, who was denied the opportunity to pursue her dream of a college education. Her high school principle discarded her college scholarship and acceptance letter because he didn't believe women should go to college. She instilled her passion for college education in all of her children and grandchildren. I want to thank all of my family for their support, encouragement and sacrifices in making my dream come true.

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NOMENCLATURE

CI	Confidence Interval
CV	Credibility Interval
SC	Supply Chain
SCRM	Supply Chain Risk Management

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ABSTRACT

Growing environmental turbulence and increasingly complex supply chain networks have resulted in greater supply chain disruptions. Firm supply chain risk management performance varies due to differences in recognition of the need for and ability to cultivate supply chain risk management capabilities. This study helps to identify which capabilities have the greatest effect in supply chain risk management and firm performance as well as describes how to achieve them. A meta-analysis of empirical supply chain risk management studies reveals the confounding state of the field and points toward future work which can provide consensus and progress. A multiple case study describes organizational learning from supply chain disruption and identifies a new construct of bracketing necessary to deviate from firm risk dominant logic and respond to changes in the environment.

CHAPTER 1 GENERAL INTRODUCTION

A core tenet of supply chain management is maintaining a constant supply of goods and services through their networks. Despite their best efforts, however, supply risk and disruptions are inevitable. A supply chain disruption is an event which interrupts this flow. Managing this supply chain risk of disruption is increasingly challenging and of growing interest to researchers and practitioners.

Supply chain risk management has become increasingly challenging due to two factors. First, the environments in which supply chains operate has become increasingly dynamic and prone to disasters. One study reports that the top three disruptions are IT outages, natural disasters and supplier service issues (Glendon & Bird, 2013). At the same time, organizations are experiencing increasing competitive pressure, and engaging in more outsourcing and offshoring. This makes engaging and monitoring suppliers more difficult. This combination of factors make supply chain networks more vulnerable to disruptions (Blackhurst, Dunn, & Craighead, 2011; Bode, Wagner, Petersen, & Ellram, 2011; Christopher & Holweg, 2011; Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Kim, Chen, & Linderman, 2015). This not only increases exposure to risk but propagation once a disruption occurs (Blackhurst, Craighead, Elkins, & Handfield, 2005; Craighead et al., 2007; Ponomarov & Holcomb, 2009). Propagation refers to the spread of a disruption, impacting dependent parties connected through supply chain networks.

Firms vary in their approach to managing their supply chain risks and experience variation in outcomes as well. They vary in their beliefs about the importance of supply chain risk management. Even firms who are seeking to manage their supply chain risk do not always find they are able. It is difficult to know which capabilities to develop and how

to cultivate them. To make matters worse, due to environmental dynamism, the strategies and capabilities which maintain supply today may not be adequate tomorrow. Firms must remain vigilant and constantly adapt to their changing environment. Contingencies such as these impact the effectiveness of various capabilities.

This study attempts to contribute to the understanding of what capabilities are most important in managing supply chain risk and how to develop them. Chapter 2 is a meta-analytic study of the existing empirical supply chain risk management research. This is a quantitative literature review showing which capabilities are the most effective for supply chain risk management, and which combinations are complementary or tradeoffs. It also identifies which constructs would be fruitful avenues for future research. Chapter 3 is a qualitative study describing how firms can improve their resilience to a disruption through organizational learning. Specifically, we address the questions of how organizations respond to disruptions by learning greater resilience and why some learn more effectively than others.

CHAPTER 2 RELATIONSHIPS BETWEEN SUPPLY CHAIN RISK MANAGEMENT AND PERFORMANCE: A META ANALYTIC INVESTIGATION

Pam Manhart, Dr. James Summers, Dr. Jennifer Blackhurst

2.1 Introduction

Supply chain risk is the susceptibility to a supply chain disruption which is an interruption in the flow of materials (Craighead et al., 2007). The supply chain risk management process has been described with varying numbers of steps but they all have three basic phases in common: 1) prevention and preparation, 2) the disruption occurrence, and 3) response and recovery. Several mitigation capabilities have been identified to prepare for and prevent supply chain disruptions: contingency planning (Christopher & Lee, 2004), information sharing (Brandon-Jones, Squire, Autry, & Petersen, 2014), postponement (Boone, Craighead, & Hanna, 2007), supplier monitoring (Blackhurst et al., 2011), trust (Bode et al., 2011) and redundancies such as dual sourcing (Chopra & Sodhi, 2004), safety stocks (Manuj & Mentzer, 2008a) and excess capacity (Peck, 2005).

Proactive supply chain risk management capabilities are important because of the significant losses incurred. Backorders and lost sales have negative impacts to customer service and market share (Hendricks & Singhal, 2005). Operational losses are due to a mix of idle resources and expedite costs (Hohenstein, Feisel, Hartmann, Giunipero, & Saenz, 2015; Ponomarov & Holcomb, 2009; Sodhi, Son, & Tang, 2012; Wagner & Bode, 2008). This combination of factors quickly deteriorates financial performance due to simultaneously reduced revenues and increased expenses. Negative relational outcomes also occur due to supply chain disruptions (Ponomarov & Holcomb, 2009; Sodhi et al., 2012). Brand damage

occurs in the marketplace and reputations are damaged with suppliers. Internally, employees can lose faith in their supply chain.

Mitigation capabilities have also been identified to respond and recover from a disruption: agility (Christopher & Towill, 2001), bridging linkages (Bode et al., 2011), communication (Manuj & Mentzer, 2008b), coordination (Kleindorfer & Saad, 2005), early detection (Craighead et al., 2007), flexibility (Skipper & Hanna, 2009), and root cause analysis (Elkins, Handfield, Blackhurst, & Craighead, 2005) to name a few.

Reactive supply chain risk management capabilities are important because firm losses have greater impact as disruptions propagate through the network over time. Firms with superior supply chain risk management can experience shorter recoveries with reduced losses. Likewise, when a disruption impacts an industry, it can be a source of competitive advantage for the firm recovering first (Craighead et al., 2007; Fiksel, Polyviou, Croxton, & Pettit, 2015; Greening & Rutherford, 2011; Skipper & Hanna, 2009). Similarly, marketing research has found that some firms can gain stronger relationships by responding well to a breach of trust as opposed to no event occurring (Aaker, Fournier, & Brasel, 2004).

The literature in supply chain risk management reveals a lack of consensus. One sign of lack of consensus is the inconsistent use of definitions. For example, Hohenstein et al. (2015) discovered 46 unique definitions of supply chain resilience. What resilience definitions have in common is the capability to manage flow, either preventing or quickly recovering from a supply chain disruption. Similarly, supply chain resilience has been Brandon-Jones et al. (2014) describe resilience and robustness as a continuum from flexibility to stability while Durach, Wieland, and Machuca (2015) describe resiliency as an

overall supply chain risk management capability balancing proactive and reactive capabilities with robustness as a proactive dimension.

Clearly these factors need more precise and parsimonious meanings. When definitions are inconsistent they vary in operationalizations. Consistency is required to identify significant relationships among variables (O'Leary-Kelly & J. Vokurka, 1998; Schwab, 1980). Likewise, ambiguity results in confusing and contradictory outcomes and lack the capability to advance theory (Flynn & Flynn, 2004; Rosenzweig & Roth, 2004).

We find evidence of contradictory results in relationships between supply chain risk management capabilities and supply chain risk management For example, integration has been considered key to supply chain risk management (Frohlich & Westbrook, 2001; Leuschner, Rogers, & Charvet, 2013; Manuj & Mentzer, 2008b; Ponomarov & Holcomb, 2009) yet contrary evidence was found by Wieland and Wallenburg (2013). They found that only communication and cooperation were necessary. They operationalize integration as distinct from communication and cooperation, however, while other studies operationalize communication and cooperation as dimensions of integration (Flynn, Huo, & Zhao, 2010; Leuschner et al., 2013).

Precise and parsimonious construct definitions are required for accurate measurement of variables and their relationships (O'Leary-Kelly & J. Vokurka, 1998; Schwab, 1980). The inconsistency in definitions and operationalization of supply chain risk management constructs has likely contributed to the contradictory research results. In fact, in their review of supply chain resilience, Hohenstein et al. (2015) found the lack of alignment regarding required capabilities to hinder our understanding.

Similarly, links between supply chain risk management and performance outcomes are not well understood. Traditional manufacturing efforts focus on productivity and efficiency sometimes at a contrast to marketing or business strategy (Skinner, 1969). For instance, Simchi-Levi, Schmidt, and Wei (2014) found that firms often prioritize their supply chain risk management by annual spend, although spend is not correlated with company performance. Firms then remain vulnerable, because low cost commodity suppliers were overlooked. Traditional cost calculations consider proactive capabilities as costly when an incident does not occur. However, when factoring in the avoidance of losses, the lack of any disruption could be considered savings. In fact a recent study found that obtaining top management support for investments is one of the key challenges to supply chain risk management (Glendon & Bird, 2013). Prior disruption experience has been shown to improve supply chain risk management performance suggesting that firms must endure a disruptive event prior to recognizing its value (Bode et al., 2011).

Once a firm recognizes the need for supply chain risk management, they lack understanding in practice of which capabilities have the greatest effect. Elkins et al. (2005) found firms consistently stated the need for processes dealing with disruptions. More recently, a 2011 study found that still only 10% of firms had specific plans for mitigating a supply chain disruption (Black et al.). Firmly establishing empirical links between supply chain risk management capabilities and performance outcomes may help gain the strategic recognition it needs for appropriate top management support.

Contributing further to our lack of consensus is the abundance of conceptual frameworks unsupported by empirical work (Van Der Vegt, Essens, Wahlström, & George, 2015). Many qualitative reviews have been conducted in an attempt to organize them,

(Durach et al., 2015; Ponomarov & Holcomb, 2009; Sodhi et al., 2012) but no systematic quantitative review has yet been conducted.

We argue that the supply chain risk management field needs a quantitative synthesis of empirical studies in order to generate consensus and point future work toward areas which can resolve these issues (Humphrey, 2011; Hunter & Schmidt, 2004). Thus, the purpose of this study is to clarify the lack of consensus regarding which constructs are the most effective to supply chain risk management, the relationships among them, and which combinations are positively related to performance. It is by understanding the interrelationships that will help practitioners and academics transition from conducting risk management activities to improving resiliency (Van Der Vegt et al., 2015). The research questions, therefore, are which capabilities have the greatest effect on supply chain risk management performance? Which combinations lead toward superior firm performance?

We therefore undertake a meta-analysis of empirical supply chain risk management work. It focuses on the direction and magnitude of effects, not the statistical significance. A meta-analysis can help gain consensus, resolve conflicts and increase generalizability by aggregating multiple individual studies (Hunter & Schmidt, 2004). It provides direction for future streams of research by pointing to gaps in the literature and identifying the presence of unknown moderators.

This research makes several contributions. First we study the classification of capabilities of and relationships between proactive and reactive supply chain risk management capabilities. Second, we find antecedents and moderators of supply chain risk management and firm performance. Third, we evaluate the relationship between supply

chain risk management and firm performance. Lastly, future work is identified to help drive future work in those areas of need.

2.2 Hypothesis Development

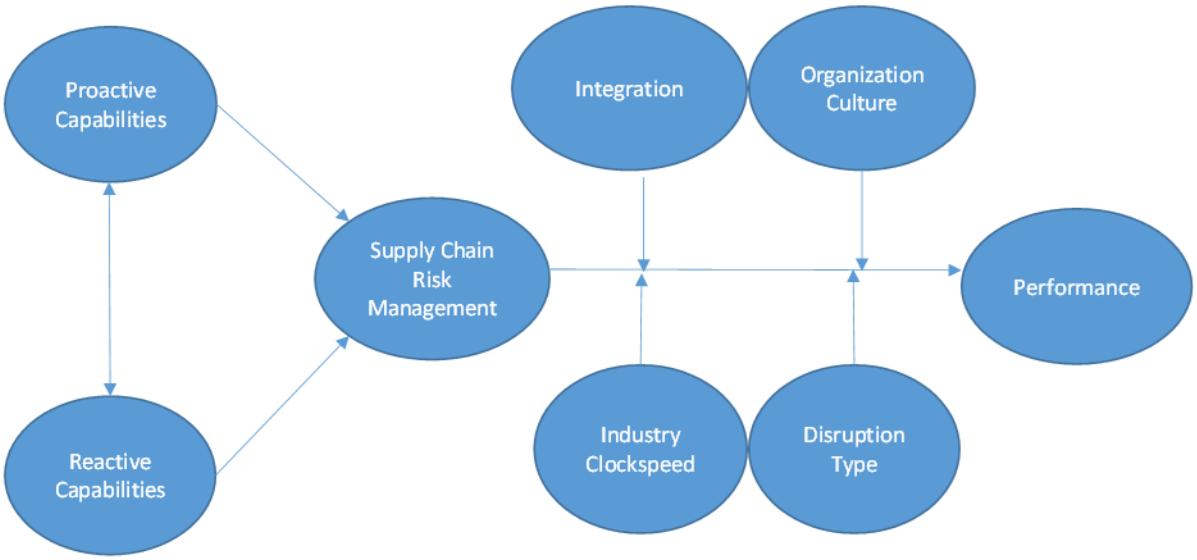


Figure 1: Supply Chain Risk Theoretical Model

2.2.1 Paradox theory

We utilize paradox theory to analyze capabilities and their relations. Figure 1 above illustrates the overall theoretical model. A paradox is an condition based upon two persistent opposing elements which each have merit individually yet seem incompatible taken together (Poole & Van de Ven, 1989). Paradox theory suggests that what first may appear as a tradeoff may not be. Digging further into competing strategies could reveal relationships enabling their integration (Poole & Van de Ven, 1989). As opposed to compromising "some bland halfway point between one extreme or the other", paradox theory suggests that tensions are "two sides of the same coin" (Eisenhardt, 2000; Lewis,

2000). By simultaneously engaging in contradictory strategies, firms may gain synergies between them (March, 1991).

We classify supply chain risk management capabilities according to proactive and reactive capabilities. We hypothesize that capabilities in the preparation and prevention phase of the supply chain risk management process enable greater supply chain risk management. Preparation and prevention of a supply chain disruption will preclude associated losses and improve supply chain risk management performance. Qualitative literature reviews have summarized anticipation and resistance (Kamalahmadi & Parast, 2016) and readiness (Ho, Zheng, Yildiz, & Talluri, 2015) to enable supply chain resilience. More specifically, Tukamuhabwa, Stevenson, Busby, and Zorzini (2015) identifies 17 proactive capabilities for supply chain resilience in their literature review.

H1: Proactive risk management capabilities have a positive relationship to supply chain risk management performance.

We hypothesize that capabilities in the response and recovery phase of the supply chain risk management process enable greater supply chain risk management. Responding to a supply chain disruption will reduce the associated propagation and impact improving supply chain risk management performance. Recovery after a supply chain disruption ends the disruption and any associated propagation or losses, therefore improving supply chain risk management. Literature reviews, have also found recovery and response (Ho et al., 2015; Kamalahmadi & Parast, 2016) to contribute to supply chain resilience. In their literature review, Tukamuhabwa et al. (2015) identifies 11 different reactive capabilities for improving supply chain resilience.

H2: Reactive risk management capabilities have a positive relationship to supply chain risk management performance.

We also hypothesize that supply chain risk management will enable greater firm performance. Successful management of supply chain risks should increase revenues because disruptions to the marketplace are fewer and of less significant impact. Likewise, successful management of supply chain risks should decrease expenses as recovery costs are minimized. Wieland and Wallenburg (2012) examined both proactive (robust) and reactive (agile) capabilities and their relationship with supply chain risk management and business performance found that only proactive (robust) capabilities had a statistically significant relationship. The literature review by Ho et al. (2015) find that significant relationships exist between supply chain risk management processes and call for work incorporating multiple components. Ghadge, Dani, and Kalawsky (2012) also note the need for holistic work including both proactive and reactive strategies.

H3: Supply chain risk management has a positive relationship with firm performance.

Tradeoffs

Although studies acknowledge that some level of both proactive and reactive strategies may need to be employed they are not recognized as potential complementarities and often framed as tradeoffs to be compromised (Chopra & Sodhi, 2004; Norrman & Jansson, 2004; Thun & Hoenig, 2011; Yang & Yang, 2010). In a tradeoff, one is at the expense of the other (Skinner, 1969). Tradeoffs occur when competing priorities exist like risk reduction and efficiency. Preparation for a disruption can be costly

when a disruption does not occur, therefore, some firms rely on responses to actual disruptions (Christopher & Peck, 2004). Inefficiencies or compromises are expected to occur when conducting both (Fiksel, 2003; Pettit, Fiksel, & Croxton, 2010; Wagner & Bode, 2008; Yang & Yang, 2010).

Plants have limited resources so managers attempt to maximize efficiency by choosing to focus on the development of a few selected capabilities (Hayes & Wheelwright, 1984; Norrman & Jansson, 2004). Imagine a potential supplier selection decision. A firm with a proactive strategy may select the most reliable supplier to prevent a disruption. A firm with a reactive strategy, on the other hand, may select the lowest cost supplier so that safety stock inventories can be maintained. Tradeoffs are demonstrated by a recent study on the relationship between collaboration and flexibility (Scholten & Schilder, 2015). Relation specific investments in mutually dependent relationships enable collaboration and increased supply chain resilience. However, this increases costs of the flexibility in utilizing an alternative supplier. We therefore test paradox theory by exploring the alternative potential of tradeoffs between risk management capabilities and outcomes.

H4a: Proactive risk management capabilities have a *negative* relationship to reactive risk management capabilities.

Complementarities

In a meta-analysis on manufacturing tradeoffs, Rosenzweig and Easton (2010) found tradeoffs in priorities and strategies but not capabilities. This suggests that many supply chain risk management capabilities may in fact be paradoxes not tradeoffs. With the proper priorities, strategies and metrics, organizations could enable dynamic decision

making consistent with the alignment of both domains (Smith, 2014). Paradox theory explains complex systems better than contingency theory which focuses on a small number of variables, because paradox theory assumes that tensions exist in complex systems (Smith, 2014). Echoing the call of Matthews, Power, Touboulic, and Marques (2016) for greater use of a paradox lens, supply chain risk management research may develop further by examining the dualities as opposed to attempting to capture all of the contingencies involved in complex systems.

Some research has attempted to combine seemingly opposing supply chain risk management capabilities through a temporal lens based on their application in the supply chain risk management process. Ponomarov and Holcomb (2009) developed the most parsimonious capability model with three phases of readiness, response and recovery. Others have elaborated four (Hohenstein et al., 2015), five (Manuj & Mentzer, 2008b; Sáenz & Revilla, 2014), and eight separate phases (Sheffi & Rice Jr, 2005) to classify and integrate supply chain risk management capabilities. The problem with these, as Tukamuhabwa et al. (2015) points out is that several capabilities may be planned proactively yet enacted reactively making process-based, temporal classifications "gray" or confusing.

Research has considered the potential complementarity of supply chain risk management capabilities. After conducting a literature review, Ghadge et al. (2012) propose taking a holistic risk management approach including both proactive and reactive strategies. They found the approach lacking in the literature, but argue this would result in more relevant models. Congruent to the argument that capabilities are applied at multiple times throughout the risk management process, Ho et al. (2015) argue that supply chain

risk management processes are inter-related and a comprehensive review of strategy selection and joint impact is needed.

Wieland and Wallenburg (2013) found synergies between proactive and reactive strategies from supply chain visibility. In addition to supply chain risk management, Norrman and Jansson (2004) noticed that tools developed for supply chain risk management were being used for other business purposes providing more firm benefits. These initial findings support the argument based in paradox theory. A holistic approach to risk management which embraces paradoxical tensions may reveal the complementarities of constructs resulting in even greater resiliency.

Paradox theory has rarely been applied in supply chain but a well-known example from other domains is ambidexterity. Ambidextrous firms simultaneously engage in exploration and exploitation (Ashforth, Rogers, Pratt, & Pradies, 2014; Tushman & O Reilly, 1996). The most innovative firms view exploitation of existing resources and exploration of new opportunities both as necessary and thus jointly manage (Andriopoulos & Lewis, 2009). We similarly argue that supply chain resiliency requires the joint management of both proactive and reactive risk management capabilities. We therefore test paradox theory by exploring the potential complementarity between proactive and reactive supply chain risk management capabilities and outcomes.

H4b: Proactive risk management capabilities have a *positive* relationship to reactive risk management capabilities.

2.2.2 Contingency theory

Contingency theory proposes that no best practice is universally applicable. Firm differences are due to contextual contingencies in the firm environment. The role of management, according to contingency theory, is that of choosing strategies appropriate for their unique situation (Ketokivi, 2006). Managerial choice in strategy is the means by which a firm can control its environment (Doty, Glick, & Huber, 1993). Superior firm performance is associated with the firm whose strategies enable the best fit with their contextual contingencies (Lawrence & Lorsch, 1967). Insights into firm differences can therefore be gained by looking at the effect of contextual differences on various strategies (Hofer, 1975).

The impact of supply chain risk management on firm performance varies so we use contingency theory to investigate contextual differences affecting that relationship. We explore integration, firm culture, industry clockspeed and disruption types as potential moderators of the relationship between supply chain risk management and firm performance.

Integration

Supply chain integration is the extent of engagement with suppliers (Frohlich & Westbrook, 2001) and therefore includes dimensions of information sharing (Rai, Patnayakuni, & Seth, 2006), collaboration, coordination (Mackelprang, Robinson, Bernardes, & Webb, 2014). Information sharing has been shown to relate positively to supply chain flexibility in both proactive and reactive supply chain risk management (Lee, Padmanabhan, & Whang, 1997; Mohr & Nevin, 1990; Skipper & Hanna, 2009). Wieland and

Wallenburg (2013) found that it is the relational aspect of information sharing that is more important than integration. Alternatively, visibility of information has been cited as the most beneficial. Lack of visibility to supplier information resulted in capacity related disruptions hampering the ability to grow the business (Panchak, 2013).

Network collaboration and coordination could help predict and identify capacity constraints. Collaboration has been defined as a mutual process of shared understanding and vision to integrate resources for accomplishing shared goals (Richey, Adams, & Dalela, 2012). Thus, collaboration and coordination by all network partners is necessary in order to be effective. This requires a match in understanding, needs and capabilities and makes achieving collaboration so challenging (Richey et al., 2012). Collaboration has been found to enable the coexistence of both cooperation and competitive behavior which enabled greater information sharing simultaneously with greater vigilance towards opportunism (Majchrzak, Jarvenpaa, & Bagherzadeh, 2014).

Bridging is a similar term for comprehensive boundary spanning actions which link firms with an exchange partner. Boundary spanning actions attempt to reduce information uncertainty (Bode et al., 2011). These linkages have been shown to improve visibility, agility, supply chain performance, and mediate supply chain risk (Barratt & Oke, 2007; Brandon-Jones et al., 2014; Christopher, 2000; Mabert & Venkataramanan, 1998).

Integration in moderate levels is expected to enable collaborative supplier relations, facilitate information sharing and visibility, thereby reducing uncertainty of supplier risks. We hypothesize, however, an inverted U shaped relationship. Insufficient levels of integration would provide little collaboration, information sharing or visibility and be inadequate in reducing the uncertainty of supplier risks. Low levels of integration are

expected to hamper the ability of supply chain risk management to improve firm performance. Low levels of integration lack the joint coordination necessary for efficient and effective response to disruption (Scholten & Schilder, 2015). Likewise, very high levels of integration may create excessive supplier dependencies and rigidities reducing the flexibility and agility of supply chain risk management. In fact, Villena, Revilla, and Choi (2011) found an inverted U shape in buyer-supplier relationships. Very high levels of integration are expected to hamper the ability of supply chain risk management to improve firm performance.

H5: Integration has a moderating relationship between supply chain risk management and firm performance.

H5a: Moderate levels of integration will have a positive moderating effect on the relationship between supply chain risk management and firm performance.

H5b: High and low levels of integration will have a negative moderating effect on the relationship between supply chain risk management and firm performance.

Organizational culture

Organizational culture partly determines the flexibility, responsiveness and agility which organizations utilize to mitigate and respond to supply chain disruptions (Braunscheidel & Suresh, 2009). For example, firms may focus supply chain risk management on key suppliers as opposed to balancing efforts across more regularly used low cost commodities (Simchi-Levi et al., 2014).

Some companies have created a culture of flexibility emphasizing soft skills such as communication and training which have shown to contribute to supply chain resilience

(Blackhurst et al., 2011; Christopher & Peck, 2004; Sheffi, 2005). This requires commitment from leadership encouraging change capabilities and innovation and has been demonstrated to impact firm performance (Akgün & Keskin, 2014; Ates & Bititci, 2011; Camisón & Villar López, 2010; Demmer, Vickery, & Calantone, 2011; Golgeci & Ponomarov, 2013). Similarly, culture can impact the valuation of tradeoffs between investment in flexible capabilities and their associated costs which is critical in determining the level of commitment toward supply chain risk management (Christopher & Holweg, 2011; Elkins et al., 2005; Kamalahmadi & Parast, 2016).

Other capabilities the organization has committed to develop can also influence supply chain risk management such as the ability to process information, continuously improve and innovativeness (Elkins et al., 2005; Skipper & Hanna, 2009). In fact, Fine (2000) argues that the capabilities a firm chooses to develop is the most important competitive strategy. Senge (1999) argues that unless organizations have the motivation and capacity to change they will not address deeper issues and crises will be repeated. Similarly, organizational culture can impede collaboration (Richey et al., 2012). Motivation and capability to change stem from cultural norms about appropriate levels of risk and spending (Senge, 1999; Zsidisin & Wagner, 2010). Leadership commitment is required for effective implementation (Durach et al., 2015).

In developing contingency plans, Ketokivi (2006) points out that each location will respond uniquely to the volume variation, product mix and technology changes in its own environment more so than at the firm level. In their study, Kim and Tomlin (2013) found that decentralized firms were more likely to focus on responses to actual disruptions, overinvesting in capacity, while centralized firms utilize more preventive strategies.

Decentralized firms with excess capacity experience shorter internal capacity related disruptions and develop fewer prevention capabilities (Kim & Tomlin, 2013) which may make them more vulnerable to supplier related disruptions. In fact, they suggest that decentralized firm cultures are more tolerant of exposure to externally related disruptions as they perceive diffused responsibility and involvement.

In summary, organizational culture has the capacity to affect strategies, capability development, norms, and leadership commitment. The influence of various organizational cultures has the ability to strengthen or weaken the ability of supply chain risk management to effect firm performance.

H6: Organizational culture types a) centralization b) continuous improvement c) flexible d) innovation e) learning and f) supply chain risk management have a positive moderating relationship between supply chain risk management and firm performance.

Industry clockspeed

The industry environment influences the strategies of firms competing in that environment (Fine, 1998). Clockspeed is an environmental characteristic described as the industry rate of product, process, and structural change (Fine, 1998). Industry rate of change includes both internal and network partners. Product change is the pace of new product introductions and technological innovation. Process change includes lean practices, concurrent engineering and design for manufacturing. Structural change is the composition of firms within the industry as well as the vertical or horizontal structure of networks in the market.

Supply chain risk management is impacted by contingencies in environmental characteristics (Kleindorfer & Saad, 2005). The relationship between customers and suppliers increases with higher rates of industry clockspeed and improves performance (Chavez, Gimenez, Fynes, Wiengarten, & Yu, 2013). Inventory buffers are used more frequently in higher clockspeed industries (Meijboom, Voordijk, & Akkermans, 2007). Likewise, lean practices were found to be efficient and have a positive impact on flexibility under conditions of low clockspeed (Meijboom et al., 2007).

Managers often use industry clockspeed to benchmark the acceptable level of firm change (Carrillo, 2005). The planned rate of mitigation, however, may not be appropriate for the rate of change required during a disruption (Greening & Rutherford, 2011). If the industry pace of change outpaces firm adaptation capability, it will be less likely to successfully recover from disruptions.

High industry clockspeed introduces higher rates of change into the supply chain environment. Higher rates of change in a supply chain network corresponds with more turbulence and vulnerability to supply chain disruptions. Turbulence can negatively impact supplier relations, require higher safety stocks and make lean practices inefficient. Higher turbulence requires greater adaptive capabilities of supply chain risk management.

H7: High industry clockspeed has a negative moderating relationship between supply chain risk management and firm performance.

Disruption classification

Turbulence can also be introduced via natural disasters, labor strike, political unrest or pandemic related trade bans (Kleindorfer & Saad, 2005; Sheffi, 2001). However,

catastrophic risks are both less frequent and more severe. Wagner and Bode (2008) found catastrophic events to have an insignificant impact on supply chain performance and suggested focusing on the more frequent "every-day" supply chain disruptions which are more significant to supply chain performance. "Every-day" supply chain disruptions are more commonly associated with issues regarding demand uncertainty (Kleindorfer & Saad, 2005).

High and low impact disruptions have been shown to impact firms differently. While effective resource management may mitigate low impact disruptions, high impact disruptions require the capability to quickly adapt and reconfigure resources (Ambulkar, Blackhurst, & Grawe, 2015). Catastrophic disruptions, therefore, are expected to have a negative effect because most supply chains are designed for efficient "every-day" operation and lack the capabilities to quickly adapt (Christopher & Holweg, 2011; Hendricks & Singhal, 2005; Sáenz & Revilla, 2014). In fact, Greening and Rutherford (2011) operationalize disruption by the development of a post event change in network structure.
H8: Severe (a) and uncontrollable source (b) disruption types have a negative moderating relationship between supply chain risk management and firm performance.

2.3 Method

The random effects meta-analytic procedure followed guidelines suggested by Hunter and Schmidt (2004). This method is broadly used in business because it relies upon correlational data which is usually available in business research due to the common use of surveys. Because meta-analysis corrects for many statistical artifacts in original studies, it has been shown to produce more accurate population estimates with less biased effects (Field, 2001). The meta-analytic process can be summarized by three basic steps: 1) search

for and gather studies 2) extract and code information from studies and 3) apply meta-analysis to the extracted information.

2.3.1 Selection process

The search process gathered studies through a Thomas Reuter's Web of Science all database search. Due to an interest in being comprehensive and inconsistencies in determining quality, all journals were included, not just the upper echelon (Lipsey & Wilson, 2001). No time constraints were imposed. The following search terms were used: "supply chain agility", "supply chain disruption", "supply chain flexibility", "supply chain glitch", "supply chain disruption recovery", "supply chain mitigation", "supply chain resilience", "supply chain resiliency", "supply chain risk", "supply chain robustness", and "supply chain vulnerability". A dissertation search was conducted in ABI Inform. Manual searches were also conducted by reviewing citation lists and related meta-analyses on supply chain integration and flexibility. The compiled search returned an initial sample size of 1,221 studies.

The first step of the selection process was paper availability. Due to the inclusion of all journals, 68 papers were unable to be located with the aid of interlibrary loan library services.

All available studies were reviewed for the content. We removed 1,049 papers which had no empirical data on the constructs and relationships of interest. This eliminated simulations, patents, meta-analysis, multivariate analysis, conceptual frameworks and literature reviews. This included removing studies involving supply chain

risk management antecedents which related directly to firm performance and not supply chain risk management. This resulted in 104 plausible studies.

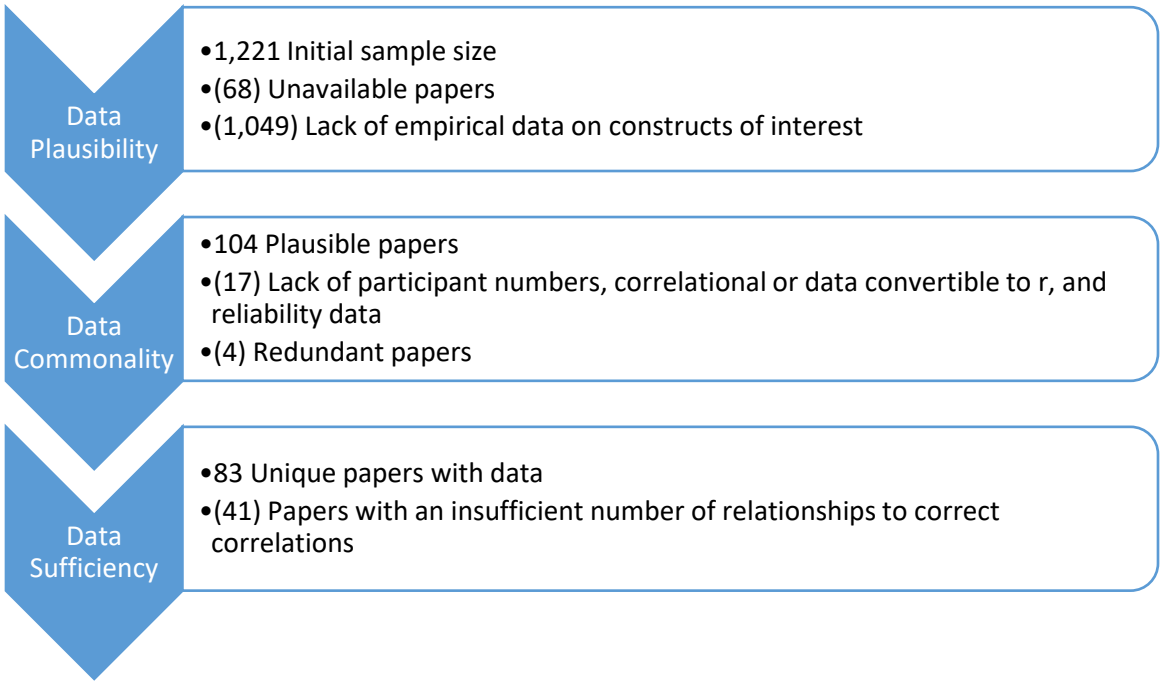
It is the standardization from using a common effect size statistic which allows for the meta-analysis because they are interpretable in a consistent fashion. The pooled estimate provides greater statistical power than the individual studies. Therefore data were scrutinized closer for common data. Only correlational data or data convertible to r were considered. Studies were required to contain the number of participants so that effect sizes could be weighted. Reliability data is needed to correct for sampling and measurement error. Common data requirements eliminated 17 studies.

Four redundant studies were also rejected. When dissertations or conference proceedings were later published in a peer reviewed journal, the journal paper was retained and the earlier work eliminated. A sample size of 83 were coded.

Correction for artifacts cannot be conducted on single papers. Therefore, if a relationship was expressed in only one study, those relationships and corresponding studies were excluded. This final selection step disqualified another 41 studies. The final sample size was reduced to 42. The sample selection results are displayed in table 1. Great care was taken to capture all relevant studies and any omission is unintentional.

Library services and emails to authors were utilized to find English versions of all papers. Those remaining papers were translated with google translate for appropriateness of fit. Five papers appeared to have potentially relevant relationships which were then reviewed and translated by a Ph.D. student in statistics whose native language matched that used in the paper. This ensured accurate understanding of the operationalization of constructs and the data presented.

Table 1: Sample Selection



2.3.2 Coding of variables

The second meta-analysis step was to extract coded variables from the remaining studies which pertain to the research question and possessed the necessary data. These descriptive statistics can then be combined to reveal essential relationships of accumulated data. A total of 395 item level variable codes were initially created. Two categorical variables were created for industry and country.

Individual items were aggregated represent broader, related constructs. These broader constructs enable greater generalization than the context specific individual studies. The coding protocol was performed jointly by two authors with subject matter expertise. In the occasion when an items name and operationalization resulted in two different categorizations, the actual measurement was used for coding. This reduced the constructs to 106 unique aggregate variables. Supply chain risk management performance

was conceptualized as supply chain risk, resilience, robustness and disruption management performance. Disruption management was operationalized as frequency of disruption and negative impact. Since disruption management was operationalized as a negative relationship it was reverse coded to aggregate with the other positive relationships. Firm performance was conceptualized as firm, market and profit performance. Table 2 lists the papers used and which aggregations were created.

Table 2. Papers Used In Meta-Analysis

Author	Proactive	Reactive	Integration	SCRM	Culture
(Ambulkar et al., 2015)	X	X			X
(Brandon-Jones et al., 2014)	X	X			
(Cai, Liu, Huang, Liang, & Shen, 2014)			X		
(Cantor, Blackhurst, Pan, & Crum, 2014)			X		
(Cantor, Blackhurst, & Cortes, 2014)		X			
(Cho, 2013)	X				
(Ellinger, Chen, Tian, & Armstrong, 2015)	X		X		X
(Golgeci & Ponomarov, 2013)	X	X			X
(Gölgeci & Ponomarov, 2015)	X				
(Graeml & Peinado, 2014)					X
(Ha & Park, 2013)	X	X			
(Kern, Moser, Hartmann, & Moder, 2012)	X	X			X
(Kim, 2014)	X	X	X	X	
(Kim, 2010)				X	X
(Kim, 2004)	X	X	X		
(Kim & Kwon, 2013)	X	X	X	X	X
(Kim & Kwon, 2012)	X				
(Kim & Kwon, 2011)	X	X	X	X	X
(Kim, Park, & Jo, 2015)	X	X		X	X
(Kim, Yang, & Seok, 2012)	X	X	X	X	
(Koçoğlu, İmamoğlu, İnce, & Keskin, 2011)			X		
(Lee, 2010)	X		X		
(Lee & Rha, 2016)	X	X	X	X	
(Lehnert, Zentes, & Schramm-Klein, 2013)	X	X		X	
(Li, Fan, Lee, & Cheng, 2015)			X		

Table 2 continued

(Merschmann & Thonemann, 2011)	X	X			
(Park, 2011)	X	X	X		
(Riley, 2013)	X	X	X	X	X
(Rosenzweig, Roth, & Dean, 2003)			X		
(Sanchez Torres, 2012)	X	X	X		
(Shao, 2013)	X	X	X		
(Su, 2011)	X				
(Sylla et al., 2014)		X			
(Viswanathan, 2011)	X	X			
(Voss & Williams, 2013)	X			X	
(Wagner & Bode, 2008)				X	
(Wieland & Wallenburg, 2012)	X	X		X	
(Wieland & Wallenburg, 2013)			X		
(Yang, 2014)			X		
(Yang, Wu, & Li, 2009)	X	X	X		
(Zhao, Huo, Sun, & Zhao, 2013)			X		
(Zsidisin & Wagner, 2010)	X	X			

2.3.3 Meta-analytic procedure

The third step applied the meta-analytic procedure to the extracted and coded information. The Hunter and Schmidt method progressively makes corrections for individual study variances (Hunter & Schmidt, 2004). The correlation statistic, r, was used due to its wide availability. Sample weighted averages were made to each individual study. Then random variation due to sample size was corrected. Next, variances in independent and dependent variables were corrected for measurement error by multiplying by an attenuation factor calculated from the construct reliabilities. Missing reliability data were imputed with average reliability (Lipsey & Wilson, 2001). Variances were corrected by subtracting artifact errors. Consistency was thereby gained by correcting for measurement and sampling errors. The combined and corrected results are more generalizable to the "true" population.

The Hunter and Schmidt method utilize these measures over significance testing which does not describe if the variance is large enough to worry about or distinguish between variance due to uncorrected artifacts or moderators. Moderator variables were analyzed by a Chi-Square test for systemic variation and the 75% rule of thumb. Error variances explained by artifact correction < 75% are considered to indicate missing moderators (Hunter & Schmidt, 2004). Formulas are displayed in table 3.

Data were first manually analyzed with Excel to become familiar with the detailed data. Then, established scripts (Field & Gillett, 2010) of the Hunter and Schmidt method were run through SPSS for effect size estimates and magnitude of differences for moderator analysis. Study output results in a population estimate and both credibility and confidence intervals.

Analysis was conducted in three stages. The first stage analyzed items relating to supply chain risk management performance. The second stage analyzed supply chain risk management performance to broader firm performance outcomes. The third stage conducted subgroup analysis with a random effects regression analysis and chi square test for potential moderators.

Table 3. Meta-Analysis Formulas

Correction for Sampling Error:

Weighted Mean Effect Size ($\bar{r}_w$)	$\bar{r} = \frac{\sum_{i=1}^{k} n_i r_i}{\sum_{i=1}^{k} n_i}.$
Total Observed Variance	$\hat{\sigma}_r^2 = \frac{\sum_{i=1}^{k} n_i (r_i - \bar{r})^2}{\sum_{i=1}^{k} n_i}$
Sampling Error Variance	$\hat{\sigma}_e^2 = \frac{(1 - \bar{r}^2)^2}{\bar{N} - 1}$

Table 3 continued

Residual Population Variance	$\hat{\sigma}_\rho^2 = \hat{\sigma}_r^2 - \hat{\sigma}_e^2$
Upper and Lower Credibility Intervals	$\bar{r} + 1.28\sqrt{\hat{\sigma}_\rho^2}$ $\bar{r} - 1.28\sqrt{\hat{\sigma}_\rho^2}$

Correction for Measurement Error:

Attenuation Factor	$A = \sqrt{rel_A}\sqrt{rel_B}$
Corrected Estimated Population Mean ($\bar{r}_c$)	$\rho = \frac{r}{\sqrt{rel_A}\sqrt{rel_B}}$
Corrected Standard Deviation of Population Correlation	$s_r^2 = \frac{\sum [N_i (r_i - \bar{r})^2]}{\sum N_i}$
Upper and Lower Confidence Intervals	$95\%\, CI = \bar{r} \pm 1.96\sqrt{\frac{s_r^2}{k}}$
Measurement Error Variance	$S^2_2 = Var(\bar{r}_c * A)$

Moderator Identification:

Explained Variance	$((\sigma^2_e + S^2_2)/S^2_{\bar{r}}) * 100\%$
Chi-Square Homogeneity	$\chi^2 = \sum_{i=1}^{k} \frac{(n_i - 1)(r_i - \bar{r})^2}{(1 - \bar{r}^2)^2}$

2.4 Results

For each meta-analysis we present the following results: the number of independent samples (k), uncorrected sample-weighted mean effect size (r), the combined total sample size (n), corrected effect size (ρ), credibility intervals using standard deviation (CV), confidence intervals using standard error (CI), and the % of variance explained by artifacts (%ARTV) for the effect of hypothesized relationships (Hunter & Schmidt, 2004). Positive effect sizes indicate positive relationships The rule of thumb is that effect sizes of 0.1 are considered small, effect sizes at least 0.25 are of medium significance and those greater

than 0.4 are largely significant (Cohen, 1977, 1988). Credibility intervals express magnitude of the population variance and indicate there is an 80% chance the mean lies within the interval. Wider CVs are less reliable. Confidence intervals reflect precision of the mean and indicate the range of the mean true score. Intervals containing zero are considered to potentially have a true mean effect of zero and are therefore not supported. Explained variances above 75% are generally considered free from large moderator effects (Hunter & Schmidt, 2004). Those less than 75% indicate that other variables contributing to outcomes are missing. Most of the relationships in this study have %ARTV less than 75% suggesting that more complex relationships should be studied in the future.

2.4.1 Paradox or tradeoff

The division of capabilities to proactive or reactive strategies was made according to previous work utilizing that classification. These studies are summarized in table 8 (Braunscheidel & Suresh, 2009; Chang, Ellinger, & Blackhurst, 2015; Chopra & Sodhi, 2004; Ghadge et al., 2012; Gunasekaran & Yusuf, 2002; Hohenstein et al., 2015; Knemeyer, Zinn, & Eroglu, 2009; Thun & Hoenig, 2011; Tukamuhabwa et al., 2015; Wieland & Wallenburg, 2013; Zsidisin, Ellram, Carter, & Cavinato, 2004). A summary of proactive and reactive meta-analytic results are presented in table 4 below. Both hypothesis 1 and 2 are supported. Proactive capabilities had a large effect ($\rho = .461$) and the intervals did not contain zero (CV = .26 - .51; CI = .18 - .75). Reactive capabilities also had a large effect ($\rho = .413$) and the intervals did not contain zero (CV = .24 - .49; CI = .09 - .75).

Table 4. Proactive and Reactive Effects on Performance

	Direct Effects on Supply Chain Risk Management								
Bivariate Antecedent Relationships with SCRM Performance	k	N	r	ρ	Lower 80% CV	Upper 80% CV	Lower 95% CI	Upper 95% CI	% ARTV
Proactive strategies with SCRM performance	105	18,124	0.383	0.461	0.26	0.51	0.18	0.75	10.7
Reactive strategies with SCRM performance	55	10,266	0.361	0.413	0.24	0.49	0.09	0.75	7.5

Proactive (ρ = .461) and reactive (ρ = .413) correlations have about the same effect on supply chain risk management performance. This would indicate that neither is preferable to the other but both can have a positive effect on supply chain risk management performance. Additionally, a regression analysis (β= .416) indicates that the relationship between proactive and reactive strategies are positive (table 5). This indicates they are not tradeoffs, but together both contribute to supply chain risk management performance. Therefore, hypothesis 4a is not supported. Consistent with paradox theory, hypothesis 4b is supported.

Table 5. Proactive and Reactive Regression Analysis

			Random Effects Regression Model Fit								
			Categorical Predictors						Model with Predictors		
Paradox Versus Tradeoff	β Beta Coefficient	Model w/out Predictors p	Proactive χ^2	df	p	Reactive χ^2	df	p	Residual Variance χ^2	df	Full Model p
Proactive and Reactive	0.416	0	1.207	1	0.272	1.963	1	0.161	102.751	108	0.625

The credibility intervals are also very similar and nearly overlap (CV = .26-.51 & .24-.49) indicating a lack of distinction between the two groups. Lack of discriminant validity is further supported by the poor model fit of the regression analysis, in table 5 (p = .272, p = .161, p = .625). P values of .00 - .01 are generally considered desirable (Griffeth, Hom, & Gaertner, 2000; Kong, Dirks, & Ferrin, 2014). One reason for the striking similarity between proactive and reactive is that many capabilities have been operationalized as proactive by some authors and reactive by others. Capabilities classified as both: agility, collaboration, communication, flexibility, redundancies, supplier development and visibility. This can be

observed from the summary of past classifications (table 8.) Proactive strategies have been considered to be both capabilities to prevent supply chain disruption but also capabilities to reduce the impact of a disruption (Grötsch, Blome, & Schleper, 2013). Likewise, reactive strategies can be implemented before a disruption (Grötsch et al., 2013). Analysis revealed that capabilities classified as dual had a stronger effect size than either exclusively proactive or exclusively reactive capabilities (ρ= .475>). Firms may benefit most by focusing on dual capabilities.

Table 6. Dual Capabilities Based Upon SCRM Process

	Direct Effects on Supply Chain Risk Management								
Bivariate Antecedent Relationships with SCRM Performance	k	N	r	ρ	Lower 80% CV	Upper 80% CV	Lower 95% CI	Upper 95% CI	% ARTV
Dual proactive and reactive	46	8,067	0.404	0.475	0.28	0.53	0.22	0.73	12.27
Exclusively proactive	57	9,679	0.356	0.438	0.22	0.49	0.13	0.75	10.02
Exclusively reactive	8	1,652	0.284	0.325	0.16	0.41	-0.25	0.90	2.62

We argue that although the proactive and reactive classification has been a popular description of supply chain risk management capabilities (Grötsch et al., 2013), it may hamper progression of the field due to its lack of clarity and distinction. The fact that many variables overlap probably contributes to the synergistic nature of supply chain risk management. For example, supplier communication is likely to enable many firm capabilities such as cost and lead time reductions, and new product manufacturability. Although effect sizes are similar, we have studied proactive capabilities significantly more than reactive. Therefore, more research in responses to disruption would be important. The variance explained by most of the artifacts is less than 25% which indicates low heterogeneity and a large degree of unidentified potential moderators.

Results in table 7 indicate that supply chain risk management strategies have a large and positive effect on business performance (ρ=.393) providing support for hypothesis 3.

Surprisingly, however, the association with overall business performance (ρ= .393) was stronger than the association with supply chain performance (ρ = .243). These results suggest that supply chain risk management enables the avoidance of firm losses resulting in greater overall business performance. Firms cannot operate when the flow of products or services is interrupted. This positions supply chain risk management as a strategic core competency providing more value to the firm than to supply chain performance alone. This further supports the paradox theory of cumulative benefits of supply chain risk management capabilities. The almost perfect degree of variation attributed to the artifact (98.9% ARTV) likely indicates that supply chain performance is consistently operationalized across studies such as on time delivery. The fact that the effect size was moderate (ρ= .243) may indicate that on time delivery is an insufficient metric for explaining supply chain performance. For example many inefficiencies can be accrued in perfecting on time delivery.

Table 7: Supply Chain Risk Management With Performance

	Direct Effects on Supply Chain Risk Management								
Bivariate Antecedent Relationships with SCRM Performance	k	N	r	ρ	Lower 80% CV	Upper 80% CV	Lower 95% CI	Upper 95% CI	% ARTV
SCRM performance with Business performance	9	2,175	0.354	0.393	0.24	0.46	0.17	0.61	11.6
SCRM performance with SC performance	5	1,440	0.201	0.243	0.09	0.31	0.23	0.25	98.9

Table 8. Proactive and Reactive Classification

Supply Chain Risk Management Capabilities	**Papers Labeling Constructs Proactive**	**Papers Labeling Constructs Reactive**	**Supply Chain Risk Management Capabilities**	**Papers Labeling Constructs Proactive**	**Papers Labeling Constructs Reactive**
Agility (visibility) (comm + info= visibility, quick redesign, velocity) (flex, responsive, cost, qual)	Gun02	Tuk15 Hoh15 Wie13	IT backup system		Thu11
Aggregate (pool) demand for stability	Cho04		Joint decision making	Hoh15	Hoh15

Table 8 continued

Collaboration (cooperation) (coord, joint dec, knowledge sharing, supplier cert, supplier dev)	Tuk15 Hoh15 Gha12	Tuk15 Hoh15	Joint planning		
Communication	Zsi04 Gun02	Hoh15	Knowledge management (gather & share)	Tuk15 Hoh15	Hoh15
Contingency planning	Hoh15 Kne09 Zsi04	Tuk15 Gha12	Logistics capabilities	Tuk15	Tuk15
Contractual agreements	Tuk15 Gha12		Low inventory levels		
Coordination (collaboration)	Gha12	Hoh15	Monitoring	Hoh15 Gun02	
Coopetition	Tuk15		Postponement	Gha12 Gun02	
Cross functional teams	Hoh15 Gun02	Hoh15	Previous disruption experience	Hoh15	Hoh15
Culture - learning orientation	Gun02		Product design	Gha12	
Culture - relational supplier management	Gha12 Thu11		Public-private partnerships	Tuk15	
Culture - risk management	Tuk15 Hoh15		Quality (high)	Gun02	
Culture - top mgmt involvement	Gun02		Redesign of network	Hoh15	Gha12
Customer responsiveness			Redundancy		Tuk15 Hoh15 Thu11
Delivery management	Gha12		Resource shifting		Gha12
Demand management (rerouting, pricing)		Tuk15 Gha12	Responsiveness strategy (over cost)	Cho04	
Demand planning (forecasting to identify supplier capacity constraints)	Zsi04		Risk sharing	Gha12	
Detection of existing threats	Hoh15		Robustness	Wie 12	
Dual/Multi source	Hoh15 Gha12 Cho04	Hoh15 Thu11	Safety stocks	Hoh15 Gha12 Cho04	Thu11
Efficiency (facilities, equipment & design)	Gun02		Security	Tuk15	
Excess capacity	Hoh15 Cho04	Hoh15	Social capital	Tuk15	Tuk15
Flexibility	Cho04	Tuk15 Hoh15 Thu11	Strategic concentration on stable products (diversity bad), secure markets or areas	Thu11	

Table 8 continued

Flexible labor	Gun02	Hoh15	Supplier certification	Hoh15 Thu11 Zsi04	Hoh15
Flexible multipurpose machinery			Supplier development	Tuk15 Hoh15 Gha12 Thu11 Zsi04	Hoh15
Flexible order fulfillment			Supplier dispersion (multiple locations)		Hoh15
Flexible manufacturing	Gun02	Hoh15	Supplier evaluations	Zsi04	
Flexible mix			Supplier selection	Tuk15 Thu 11	
Flexible supply base (switching)		Hoh15	Supply chain network design	Tuk15	
Flexible logistics		Hoh15	Sustainability compliance	Tuk15	
Flexible volumes		Hoh15	Temporary alliances	Gun02	
Identify & assess vulnerabilities	Kne09		Training & education	Hoh15 Gun02	Hoh15
Information sharing (quality, relevance) interpretation?		Hoh15	Transparency (RFID)	Thu11	
Innovativeness	Tuk15		Velocity (speed)		Hoh15
Integration	Gun02		Visibility (demand & inv) (comm & info sharing)	Tuk15	Hoh15
Inventory management	Tuk15		VMI	Gha12	
IT use	Tuk15 Gun02	Tuk15	What if analysis scenarios	Zsi04	Gha12

2.4.2 Potential moderators

Integration

Data was insufficient for testing hypothesis 5, i.e., integration levels as a moderator between supply chain risk management and firm performance. Available relationships were analyzed for effect size of the various dimensions of integration. Previous research has reported mixed results regarding the value of integration. Ambiguity exists because communication and collaboration are both capabilities for achieving integration (Flynn et al., 2010; Leuschner et al., 2013). Integration was coded as linkages enabling real time

exchange of data including databases and aligned goals. Combined integration was coded as integration, communication, collaboration and information sharing. None of the relations explained more than 75% of the variation, indicating that there are potential moderators excluded. Table 9 provides detail for aspects of integration as potential moderators. The greatest effect was found between integration and both supply chain risk management (ρ= .687) and supply chain performance (ρ = .546). This is consistent with findings from Flynn et al. (2010) that all of the dimensions of integration must be considered together because they each impact performance in a different way. Significant positive relationships were also found between overall factors such as combined integration and combined performance (ρ= .487) as well as more detailed factors of collaboration and supply chain risk management (ρ= .53). Collaboration was commonly defined as developing and executing plans and by relational variables such as teamwork, confidence, and trust. Collaboration had the greatest effect on supply chain risk management, supply chain and business combined performance (ρ= .572). This is likely due to the ability of collaboration to impact other aspects of the business besides supply chain risk management. Information sharing had smaller effects than either collaboration, integration or the combination of factors. The operationalization for information sharing included communication but emphasized a constant flow of data. There was insufficient data to test communication. Despite the difficulty in distinguishing collaboration and integration, they provide value to the firm above and beyond their relationship with supply chain risk management. This provides further support for firm synergies of risk management strategies and helps to resolve prior contradictory findings.

Table 9. Integration

	Direct Effects on Supply Chain Risk Management								
Bivariate Relations with Integration and Performance	k	N	r	ρ	Lower 80% CV	Upper 80% CV	Lower 95% CI	Upper 95% CI	% ARTV
Integration with SCRM Performance	8	1,637	0.564	0.687	0.47	0.66	0.55	0.83	22.2
Integration with SC Performance	7	1,690	0.43	0.546	0.33	0.55	0.35	0.74	17.0
Combined integration with SCRM Performance	19	3,619	0.451	0.540	0.34	0.56	0.32	0.76	13.8
Collaboration with SCRM Performance	4	538	0.455	0.530	0.32	0.59	0.47	0.59	72.0
Combined integration with SC Performance	11	2,176	0.402	0.505	0.28	0.52	0.21	0.80	9.9
Combined integration with Firm Performance	13	2,883	0.377	0.432	0.26	0.49	0.09	0.77	5.9
Information Sharing with SCRM Performance	7	1,444	0.322	0.385	0.20	0.44	0.24	0.53	29.3
Information Sharing with Firm Performance	4	944	0.254	0.066	0.13	0.37	-0.03	0.60	7.6

Organizational culture

Data was insufficient to test hypothesis 6 as a moderator, however, data was available to test direct effects. Not surprisingly, a culture of supply chain risk management is the strongest relationship to supply chain risk management performance (ρ = .651). Combining supply chain and innovation cultures had an effect second only to supply chain risk management (ρ = .481) with no interval containing zero (CV = .33 - .53; CI = .29 - .67). This suggests that a culture of supply chain innovation may be an enabler of supply chain risk management. This is consistent with findings by Akgün and Keskin (2014) that innovativeness moderates the relationship between resilience and firm performance. Cultures associated with lean (learning, innovation and supplier relations) (Bortolotti, Boscari, & Danese, 2015; Dodgson, 1993) also had a strong effect on supply chain risk management (ρ = .439). This is interesting given that the low redundancies associated with lean have often been framed as a tradeoff with supply chain risk management (Ghadge et al., 2012; Tukamuhabwa et al., 2015; Wagner & Neshat, 2010). These findings indicate that other firm cultures to enable supply chain risk management. Consistent with paradox theory, this could be due to cumulative properties.

Firm culture is a moderator of supply chain risk management and should be explored further in future work. Future research in this area could help identify more synergies and moderators of supply chain capabilities. In addition to the limited number of cultural variables noted here, there may be other cultural variables moderating the relationship of supply chain risk management and performance such as continuous improvement, decentralization, empowerment, flexibility, leadership involvement or risk tolerance.

Table 10. Organizational Culture

	Direct Effects of Supply Chain Risk Management								
Bivariate Relations with Culture and Performance	k	N	r	ρ	Lower 80% CV	Upper 80% CV	Lower 95% CI	Upper 95% CI	% ARTV
SCRM Culture with SCRM Performance	4	810	0.565	0.651	0.47	0.66	0.35	0.96	5.1
Innovation and SC Culture with SCRM Performance	4	1,012	0.431	0.480	0.33	0.53	0.29	0.67	13.6
Learning, Innovation and Supplier Relations	9	1,265	0.36	0.439	0.22	0.50	0.24	0.63	25.4
Market and SC Culture with SCRM Performance	3	686	0.359	0.396	0.25	0.47	0.29	0.50	36.6
Innovation and Market Culture with SCRM Performance	7	746	0.28	0.349	0.10	0.46	0.26	0.44	72.2

Industry clockspeed

Although no relevant studies specific to industry clockspeed were found to test hypothesis 7, we have coded categorical industry control variables. Ten different dummy variables were created to represent various industries and an eleventh to represent mixed results from pooled industries. A random effects regression analysis was performed on the Fisher transformed means. Contrary to expectations, none of the models were improved by including the categorical variable industry. None of the p values for industry were in the desired range less than or equal to .05. One possible explanation is that many of the studies reported pooled results from all industries diluting the detail. Another possible explanation is that many disruptions could equally impact multiple industries. Examples include natural disasters, port labor strikes, carrier bankruptcies or changes is trade regulations.

Table 11. Industry and Country

	Random Effects Regression Model Fit With Country and Industry Potential Moderators									
		Categorical Predictors						Model with Predictors		
Chi Square Test for Homogeneity with Potential Moderators	Model w/out Predictors p	Country χ2	df	p	Industry χ2	df	p	Residual Variance χ2	df	Full Model p
SCRM performance with Business Performance	0.000	1.3	3	0.718	0.2	1	0.694	7366.0	8	0.498
Proactive strategies with SCRM Performance	0.000	19.0	6	0.004	1.9	3	0.589	94.8	95	0.487
Reactive strategies with SCRM Performance	0.000	10.7	6	0.099	2.3	3	0.505	45.3	45	0.46
Flexible strategies with SCRM Performance	0.000	11.4	5	0.044	1.4	3	0.713	35.5	34	0.397
Combined integration with Combined Performance	0.000	6.9	6	0.332	4.9	3	0.178	37.4	35	0.358
Aggregate Practices with SCRM Performance	0.000	15.7	6	0.016	4.0	3	0.262	102.7	102	0.461

Country additional analysis

Although not hypothesized we analyzed the available categorical information on country and found significant data (table 11). Similar to the industry data many studies ported results from pooled country data. Fourteen dummy variables were created to represent the 13 specific countries and mixed data. Country codes with sufficient data to be analyzed individually are presented in table 12. Similar to industry data, we might expect insignificance due to dilution of aggregated data, however, Wowak, Craighead, Ketchen, and Hult (2013) found the relationship between supply chain knowledge and performance with data collected in multiple countries stronger than with data collected from a single country. Contrary to the meta-analysis conducted by Wowak et al. (2013), we found insignificant effects in the mixed country data.

A significant difference (table 11 ρ= .004) was found for country effects of proactive strategies effect on supply chain risk management performance. Interestingly given the similarities between proactive and reactive capabilities, there was no significance in reactive capabilities by country moderators (table 11 $p = 0.078 > 0.05$). This may indicate that there are very strong country differences in a firm's ability to implement proactive risk management strategies. All capabilities were then combined and the effect of country

remained significant ($p < 0.016$). This indicates that dual capabilities not exclusive to one classification are significantly moderated by country.

Upon finding significance by country we analyzed country specific data. Results are shown in table 12. We isolated each country individually and compared aggregate practices to the rest of the countries. Although none of the models were a good fit with industry predictors, they had significant group differences between each individual country. The greatest significant effects were from Korea ($\rho = .003$), Germany ($\rho = .005$), the US and UK ($\rho = .013$) and China ($\rho = .038$). We also assess each individual country in one model. Similarly, the model was a poor fit, but the country differences were the most significant ($p = 0.000$).

Country differences could potentially be due to economic development, legal/regulatory, geographical or accessibility differences. Country differences were demonstrated in purchasing due to short/long term and individualist/collectivist orientations (Cannon, Doney, Mullen, & Petersen, 2010). Country cultural differences have been shown to affect negotiation ability (Ribbink & Grimm, 2014) and require cultural adaptation to mitigate supply chain relational risk (Jia & Rutherford, 2010). In summary, the effect of supply chain risk management on firm performance appears to be consistent regardless of country. However, consistent with contingency theory, global firms should not universally apply supply chain risk management but should vary and specify across countries.

Table 12. Additional Country Analysis

Random Effects Regression Model Fit With Country Potential Moderators							
		Categorical Predictors			Model with Predictors		
Chi Square Test for Homogeneity with Potential Moderators	Model w/out Predictors p	χ^2	df	p	Residual Variance χ^2	df	Full Model p
Aggregate Practices with SCRM Performance All Countries	0.000	35.7	5	0.000	125.5	126	0.496
Aggregate Practices with SCRM Performance & S Korea	0.000	8.6	1	0.003	131.9	130	0.437
Aggregate Practices with SCRM Performance & Germany	0.000	8.4	1	0.004	132.0	130	0.435
Aggregate Practices with SCRM Performance & US	0.000	6.2	1	0.013	136.0	130	0.341
Aggregate Practices with SCRM Performance & UK	0.000	6.2	1	0.013	140.1	130	0.257
Aggregate Practices with SCRM Performance & S Korea	0.000	4.5	1	0.035	137.3	130	0.313
Aggregate Practices with SCRM Performance & China	0.000	4.3	1	0.038	137.7	130	0.305
Aggregate Practices with SCRM Performance & Mix	0.000	3.7	1	0.056	136.8	130	0.324
SCRM with Business Performance	0.000	1.5	3	0.678	8.1	9	0.52

Disruption types

Disruption type data was insufficient for moderation testing of both hypothesis 8a and 8b. Risk source disruption data were available for direct effects and results are summarized in table 13. They are classified according to a framework of controllable, partially controllable and uncontrollable sources for each internal and external risks (Wu, Blackhurst, & Chidambaram, 2006). Controllable sources of risk had a small effect, however it is unreliable as the confidence interval includes 0. Partially and uncontrollable sources had even weaker effect sizes and zero in both their credibility and confidence intervals.

When intervals contain zero it indicates that sometimes the relationship is positive and sometimes it is negative. Given the severity of differences in outcomes, it would be an important avenue of research to identify the moderator which determines the direction of effects. Future research should investigate potential contingencies which may result in differing direction of effects. For example, Brandon-Jones, Squire, and Van Rossenberg (2015) investigated the different placement of buffers to find that safety stock held at the supplier had positive effects on plant performance and disruptions while safety stock held at the plant had the opposite effects.

It is interesting that controllable and partially controllable sources of risk had a negative relationship with performance while uncontrollable sources had a positive relationship with performance. Although the results are unreliable and should be interpreted with caution, one explanation could be that firms successfully utilize buffers when they recognize uncontrollable risk more than they do for sources they feel they have some control over. Properly identifying risk is therefore likely a strong antecedent to successful supply chain risk management.

Table 13. Sources of Disruption

	Moderator Effects of Supply Chain Risk Management								
Bivariate Relations with Integration and Performance	k	N	r	ρ	Lower 80% CV	Upper 80% CV	Lower 95% CI	Upper 95% CI	% ARTV
Controllable sources with SCRM SC performance	2	913	-0	-0.216	-0.30	-0.08	-0.48	0.05	9.4
Partially controllable sources with SCRM & SC perform	2	1,520	-0.02	-0.027	-0.09	0.05	-0.14	0.09	20.8
Uncontrollable sources with SCRM & SC performance	4	3,040	0.043	0.051	-0.03	0.05	-0.05	0.15	24.0

2.5 Discussion

2.5.1 Theoretical contributions

This study provides support for use of Paradox Theory in the domain of supply chain risk management. The paradox lens highlights the lack of distinctiveness in the common classification of proactive and reactive capabilities. An adequate classification is needed to develop new insight and progress the field of supply chain risk management.

We find dual capabilities of agility, collaboration, communication, flexibility, redundancy and visibility, to have the most significant effect on supply chain risk management. We also find the construct of integration to provide the largest effect on supply chain risk management of any single capability. This helps to resolve the conflict

effect of integration on supply chain risk and firm performance. This also points to the most significant variables to clearly operationalize and develop discriminant validity.

Contingency Theory provides the framework for applying contextual differences to broader theories. This study demonstrates that capabilities leading to supply chain risk management and firm performance vary by firm culture, country and many other unidentified moderators. This study supports the contention of Contingency Theory that a blanket application of supply chain risk management capabilities cannot be prescribed for supply chain risk management performance, especially in a global context. While these contributions are significant, it is important to note the extent of unexplained moderators in the analysis. For example, relationships which contain zero in the intervals are sometimes positive and sometimes negative. The contingencies which determine the direction of effect should be investigated as the outcome differences are significant.

Results also show the synergy created for overall firm performance by supply chain risk management, especially dual capabilities. The effect of supply chain risk management is stronger for firm performance than supply chain performance. The avoidance of corresponding losses should be considered cost savings. Supply chain risk management should be given higher strategic priority.

2.5.2 Managerial implications

In agreement with Van Der Vegt et al. (2015) we advocate that a focus on vulnerabilities results in a view of risk mitigation as a cost to be justified. For example, while the ability to withstand a disruption has been argued to be a tradeoff with efficiency (Yang & Yang, 2010), we find that supply chain risk management contributes to overall firm performance. Likewise, Fiksel et al. (2015) find that cost reduction practices actually

increase vulnerability. Reorienting firm culture to a resilience approach based on the joint management of tensions may result in firm competitive advantage. This is supported by the strong effect of a supply chain risk management to firm performance.

Based upon the correlations of integration with performance it would appear that the linkages between firms and suppliers may be as important as supply chain risk management to performance. Global firms must select supply chain capabilities specific to each country. The benefits of supply chain risk management to firm performance will be more universal.

Firms may also find benefit in re-analyzing risk which they feel they have control or partial control over. Evidence suggests that firms may be overconfident in their ability to control supply chain risk. Additional strategic benefits may be found by incorporating a lean culture and supply chain innovation. Managers should not focus on actions to be taken in each step of the risk management process. We suggest a shifting perspective from action processes to decision making processes.

2.6 Limitations

This study is limited by the availability of primary studies. There are potential moderators which have not been captured which could explain relationships more precisely. It is also possible there are other papers which may be relevant but were not found due to our selection of keyword search terms. Other researchers could have utilized different selection criteria and perhaps obtained different results. For example, due to the use of correlational data, many other methods were excluded. In addition, correlation does not equal causation, hence, causal relations should not be inferred.

2.7 Future Research

Rather than organizing supply chain risk management strategies by classifications which present confounding overlaps, a classification with greater discriminant validity needs to be developed. Clearly defined categories would enable consensus allowing future research to progress to more complex relationships incorporating potential moderators.

Almost all of the tested relationships revealed significant moderators unaccounted for. Previous work has combined country results in a 'melting pot', however, reporting results by country from the same study may identify what factors need to be customized in each unique context. Research could be conducted to address the hypotheses which had insufficient data for testing, such as dimensions of integration and industry dimensions such as clockspeed. Additionally, while we have substantial supply chain risk management work in manufacturing or mixed settings, we know far less about process and service type settings. More empirical methods of research may reveal moderators not identified through those means. For example, utilization of more archival data sets could contribute new insights to supply chain risk management.

This study also highlights numerous opportunities for future work to test variables already identified. For example, while postponement is theorized as way to respond to changes in demand and create opportunities for reconfiguration in the face of disruption (Yang & Yang, 2010) we found insufficient empirical data.

Given that supply chain risk management strategies have synergistic benefits and impact on overall firm performance, future work should which interactions provide those benefits.

2.8 Summary

This study introduces paradox theory to the field of supply chain risk management research. This theory offers explanatory power to complementary relationships which impact multiple performance measures. We find capabilities with significant positive impact on supply chain risk management. We point to the inadequacies of the classification system based on supply chain risk management processes and suggest it may contribute to lack of consensus in the field.

We contribute to the debate over the importance of integration demonstrating its very strong effects to not only supply chain risk management but overall firm performance as well. Strong linkages between supply chain risk management and overall firm performance were also established. Supply chain risk management has a more significant effect on firm performance than supply chain performance establishing its strategic importance.

CHAPTER 3 SUPPLY CHAIN RESILIENCE: ORGANIZATIONAL LEARNING FROM DISRUPTION

Pam Manhart

Dr. Jennifer Blackhurst and Dr. Frank Montabon

3.1 Introduction

The firms' environment is becoming more turbulent faster than the firm is becoming more resilient (Hamel & Valikangas, 2003). Resilience is defined as the ability to recover after a supply chain disruption (Christopher & Peck, 2004) which is an interruption to the flow of goods or services (Craighead et al., 2007). The firm which can make sense of its environment develops more supply chain knowledge, which a recent meta-analysis has shown to be increasingly important to performance (Wowak et al., 2013). One way in which supply chain knowledge improves performance is through responses to disruption (Craighead, Hult, & Ketchen, 2009). Each disruption is an opportunity to learn and update supply chain knowledge by better understanding the environment and consequent supply chain risk (Fiksel et al., 2015). In order for the firm to learn from disruption, organizational learning mechanisms are required to capture, interpret and disseminate knowledge. In agreement with Huber (1991), we define organizational learning as an increase in the range of potential behaviors and not require their enactment. In fact, in the context of supply chain resilience, firms would hope to not encounter a disruption and enact learning.

Disruptions, however, are difficult to learn from. First, no two disruptive events are identical. They have different sources, severity and duration (Craighead et al., 2007). This makes patterns difficult to identify and learning more challenging. Second, social processes and dynamics inhibit organizational learning (Crossan, Lane, & White, 1999). Supply chain

personnel managing a disruption are often simultaneously being affected by it (Hardy & Maguire, 2016). This can create a chaotic environment in which reflection and learning is secondary to recovery efforts. People will then choose to endure existing practices even when facing novelty (Carlile, 2004) resulting in oversimplified or misleading lessons (Desai, 2015).

It is important to understand how firms learn and develop resilience because firms suffer financial, operational and relational losses from disruptions (Hendricks & Singhal, 2005; Ponomarov & Holcomb, 2009; Sodhi et al., 2012; Wagner & Bode, 2008). The number of firms suffering significant losses are increasing (Aon Risk Solutions, 2013). In addition to the external causes of more turbulent environments and increasingly complex supply chain networks, there are internal reasons for this trend. A recent study found that 75% of companies acknowledge they don't fully understand their true losses from disruptions or the actual causes (Glendon & Bird, 2013). This makes identifying the appropriate resilience capabilities very difficult.

Although understanding supply chain risk and management is critical to firm performance, little research has investigated the organizational response once a disruptive event has occurred (Greening & Rutherford, 2011). Answering the calls of Desai (2015), Hardy and Maguire (2016) and (Van Der Vegt et al., 2015) we address the questions of how organizations respond to disruptions by learning greater resilience and why some learn more effectively than others. Due to the exploratory nature of our research questions, we complete case studies to empirically discover evidence. Evolutionary theory is utilized to frame our study which draws on and extends existing literature.

This research makes several contributions. We identify four distinct organizational learning mechanisms in the context of supply chain disruptions: fragmented, immediate, expert, and collective. Our study provides a framework for illustrating why some organizational learning mechanisms are more effective in learning from supply chain disruptions than others. We show that organizational learning is dependent upon the ability to update a firm specific risk dominant logic. We also reveal a new construct necessary to update the firm risk dominant logic, bracketing, defined as the practice of noticing environmental cues, interpreting underlying events, and assigning a differentiating category which produces an appropriate response.

3.2 Organizational Learning And Supply Chain Resilience

3.2.1 Organizational learning and evolutionary theory

The basis of evolutionary theory (Nelson & Winter, 2009) is that environments change and organizations must change or respond accordingly to fit the new context. It follows a prescribed process of variation, selection and retention. In learning from supply chain disruption, the supply chain disruption serves as the variation. Firms must then select what information to attend to and act upon. Learning is retained through organizational learning mechanisms and routines.

According to evolutionary theory, selection after variation is critical to determining the future form of the organization. For example, for individuals conducting postmortems after an event, Whiteman and Cooper (2011) find four patterns of sensemaking in their ethnographic study: ecological embedded uses site specific information, expert driven draws on skills from other sites, fragmented focuses on expectations and therefore misses cues, and disembedded, which focuses on social relations. Although these are individual

level patterns for making sense of material landscapes and ecological conditions, they conclude that experience relates to noticing subtle signs of vulnerability prior to the situation escalating into a crises.

Postmortems in organizational learning, however, are different because individual and organizational learning are different (Weick, 1991). Although not all members of an organization are required to learn, by definition, organizational learning implies shared understandings among multiple actors. Among the multiple actors involved, several researchers have suggested that boundary spanners such as middle management (Beck & Plowman, 2009) and centrally located units or hubs (Nerkar & Paruchuri, 2005; Schilling & Fang, 2014; Tsai, 2001) share, transfer and retain more information. Shared understanding is hard to develop because people often form different interpretations of the same event (March, Sproull, & Tamuz, 1991). Groups with information do not share it when they don't recognize its usefulness elsewhere (Huber, 1991). Likewise, groups won't access or utilize the stored knowledge of others unless they recognize its value to them. Recognizing the value is more difficult when it is not applied to the exact same criterion (Kane, 2010).

Huber (1991) lists several types of organizational learning which may occur after a disruptive event: experiential, in which feedback and appraisal follow; vicarious, in which second hand knowledge is gained through observing another organization's event; grafting, in which external hires bring new knowledge to the firm; and searching, in which the environment is scanned or monitored in response to a problem. In their seminal study, Levinthal and March (1993) describe two organizational learning mechanisms, simplification and specialization and three learning myopias which limit improved organizational performance from those mechanisms. Organizations tend to focus on the

short term, events near to the learner and success rather than failures. Rather than continuously learning new capabilities, firms tend to repeat activities in which they possess competency. This can inhibit learning until an environmental trigger exposes a capability gap. In fact, Leonard-Barton (1992) found that the longer a competency has been in place, the more difficult it is to change.

Lampel, Shamsie, and Shapira (2009) summarize their special issue by identify four learning processes specifically triggered from rare events: learning about rare events concentrates on management of rare events; learning through rare events is self-learning of capabilities; deliberate learning pursues codification of best practices; and emergent learning generates unanticipated insights. They suggest that in contrast to views that rare events are interpreted systematically by probability estimates, they actually become salient due to their categorization and sensemaking (Beck & Plowman, 2009; Christianson, Farkas, Sutcliffe, & Weick, 2009). The danger of rare events or patterns based upon scarce history is superstitious learning may occur, which is making an incorrect attribution of causation. Beck and Plowman (2009) theorize that culmination and synthesis of interpretations across different levels of the organization results in more reliable learning.

Consistent with evolutionary theory, random change is highly unlikely to result in positive outcomes (Nelson & Winter, 2009). Likewise, organizational learning doesn't happen automatically or by chance, but requires deliberate organizational learning mechanisms (Madsen & Desai, 2010; Nembhard & Tucker, 2011; Pisano, Bohmer, & Edmondson, 2001; Srivastava & Gnyawali, 2011). Organizational learning mechanisms are critical to filtering what knowledge will be retained and disregarded (Hult, 2003). When they aggregate and synthesize varying perceptions, higher level learning occurs which

reassess norms, values and logic (Huber, 1991; Ocasio, Mauskapf, & Steele, 2016). Higher level learning involves understanding causation, long term effects and an opportunity to adjust beliefs. It affects the entire organization as opposed to more common low level learning, which is more functional, conforming to beliefs and short term oriented (Fiol & Lyles, 1985).

3.2.2 Supply chain resilience

Bode et al. (2011) classify supply chain response to disruption into two broad categories: bridging and buffering. Bridging responses are due to supplier dependencies and focus on reducing uncertainty. They include information exchange, scanning and collaboration. Buffering responses, on the other hand, are independent of supplier dependencies. They protect the firm from a disruption by utilizing safety stocks, redundant suppliers and flexible production processes and product designs. The authors find that disruption impact, supplier dependence, and firm orientation inform the selection of response to supply chain disruption.

Although firms conduct both bridging and buffering, supply chain disruptions continue. One reason is that many risk sources are difficult to predict even in stable networks, for example natural disasters. Predicted risks are often analyzed by traditional supply chain priorities such as annual spend and suppliers of key components which are not correlated with supply chain risk performance (Simchi-Levi et al., 2014). This leaves them vulnerable to risks stemming from non-key, low-cost, commodity suppliers Complicating matters, supply chain networks frequently change, if not immediate tiers, then subsequent tiers, i.e., a supplier's supplier making risk identification more challenging. Network dependencies propagate disruptions (Craighead et al., 2007) which make it

difficult to unravel and identify the initial source. Therefore, our first premise is that while firms are mitigating supply chain risk from key sources, they remain vulnerable to many, evolving sources of risk.

Kaufmann, Carter, and Rauer (2016) investigated the transition from firm centric to network centric risk management strategies and found they co-evolve with the relationship dominant logic of the purchasing department. This was defined as the mindset for managing supplier relationships. After purchasing received negative feedback, firms then engaged in joint ventures and interfirm collaboration. This evolution of relationships helps us understand how supply chain risk management strategies evolve and how they can be a catalyst for other strategic initiatives. Our second premise is that the supply chain response to a supply chain disruption has the ability to trigger organizational learning impacting the evolution of supply chain risk management.

Bode et al. (2011) suggest that what happens after a disruption has received scant attention in the literature. This is important because the disruption serves as the motivation to act. This source of variation is the first step in the evolutionary process. It is followed by a selection of whether the event warrants attention. Learning from disruptions are then retained through organizational learning mechanisms and routines.

3.3 Method

3.3.1 Data collection and coding

We design our descriptive case study in accordance with the positivist position of multiple case strategies to ensure maximum validity, reliability and theory development (Eisenhardt, 1989; Yin, 2014). This results in deeper understanding (Miles, Huberman, &

Saldana, 2013) and avoids the potential of biased results based on the conditions of a single case (Yin, 2011).

Due to our interest in the organizational level of learning, our unit of analysis is the firm. Since supply chain risk stems from the wider supply chain network (Christopher & Peck, 2004), screening of cases began with firms representing a variety of industries. Industries differ by product life cycles (Chopra & Sodhi, 2004), density and complexity of networks, (Craighead et al., 2007) and network interdependencies (Bode & Wagner, 2015) which impact their supply chain resiliency.

We utilized a replication strategy, by having multiple firms from each of four industry categories (Yin, 2014). We purposefully selected firms from a variety of industries including traditional manufacturing, services, healthcare and process based industries. Traditional manufacturing is the most common industry in supply chain research. Services and a focus on healthcare, are growing in their application of supply chain research. Process based industries were added for the unique variety they provided. Firms of interest within each industry were targeted based on their reputations as leaders within their industries and the potential for developing a contact.

Contact individuals were identified and approached within targeted firms. Some contacts were found through personal networks and others were cold called. We enlisted participation by first asking the contact for the highest level person in their organization that would be responsible for supply chain risk management. That person became our key source who was then asked to participate and refer us to other senior leaders within the firm who participated in supply chain disruption recoveries similar to a snowball technique.

We confirmed a minimum of four subsequent participants per firm. This eliminates any individual bias in attempting to explore firm level phenomenon (Eisenhardt & Graebner, 2007). We eliminated one firm who could not meet the minimum requirement of senior leaders engaged with supply chain disruptions. A second firm declined to participate and was replaced by another firm within the same industry. After the inclusion of nine total cases we reached theoretical saturation (Eisenhardt, 1989). This is within the recommended range for detail and manageability (Miles et al., 2013; Yin, 2014).

Government agencies in this study represent different divisions of a large corporation where interagency cooperation and learning may occur during a disruption. We received support for this logic from a participant in Surgical Instruments who shared their observation: "Government agencies work more together now, sharing information." Beginning with the Director of Public Health as our key source, other government agencies were identified as jointly participating in supply chain disruptions. See table 14 for a participant summary of all firms.

This study was exempted from the requirements of the Institutional Review Board of human subject protection regulations. This document is found in appendix B. It is included to fulfill the body of manuscript formatting requirements of the Graduate College.

Table 14: Participant Summary

Firm	# of Participants	Revenue	Employee Size	SIC Code		Industry Replication	Firm Age in Years	Title List	Participant Experience
Furniture	6	1-10b	10,000-25,000	2522	Public	Manufacturing	50-100	Dir of Flow Improvement, Director of Strategic Materials, Director of Supply Chain (2), Supply Chain Manager, VP of Operations	7-30 years
Biodiesel	4	1-10b	1-1,000	2911	Public	Process	1-25	Director of Transportation, Manager of Rail Fleet, Transportation Manager, Senior Supply Chain Manager	3-29 years
Automotive	6	10-25b	100,000-500,000	3714	Public	Manufacturing	1-25	Production Control & Logistics Business Process Manager, Plant Manager, Plant PC&L, Program Director of Contract Manufacturing, Quality Manager, VP of Integrated Supply Chain	12-33 years
Consumer Durables	8	10-25b	50,000-100,000	3633	Public	Manufacturing	100-150	Dir Trade Customer Support, Dir Risk Management, Regional Distribution Mgr, Sr Finance Dir, Sr Mgr Global Information Systems, Sr Mgr of Order Fulfillment, Sr Mgr Reverse Logistics, Transportation Supply Chain Manager	8-32 years
Agribusiness	5	10-25b	10,000-25,000	5143	Private	Process	50-100	Dir of Transportation, Dir of Warehousing & Distribution, Sr Packaging Manager, Sr Warehouse Manager, Sr Transportation Manager	5-30 years
Retail	4	<50b	100,000-500,000	5331	Public	Sevice	50-100	Dir Risk & Security, Dir International Logisitcs, Dir Global Logistics Planning, Store Manager	13-34 years
Surgical Instruments	8	1-10b	10,000-25,000	3841	Private	Healthcare	50-100	Dir Business Solutions, Dir Supply Chain APAC, Dir Supply Chain Europe, Dir Supply Chain Programs, Global Supply Chain Project Mgr, Mgr Sustained Supplier Engineering, North American Distribution Center Mgr, VP Supply Chain	10-36 years
Pharmaceutical	7	10-25b	25,000-50,000	2834	Public	Healthcare	100-150	Dir Global Supply Chain, Dir Supply Chain Projects, Global Supply Chain Business Process Mgr, Global Supply Chain Risk Mgmt Consultant, Sr Dir Corporate Risk, Sr Dir Global Manufacturing & Procurement, Sr Dir Global Supply Chain	16-33 years
Government Services	4	N/A	1,000-10,000	9431	Public	Service	100-150	Dir Department of Transportation, Dir Public Works, Executive Officer Public Health; State Veterinarian	10-22 years

The interview protocol was designed for consistency across a large number of interviews. Open ended, semi-structured interviews were conducted according to recommendations by Arksey and Knight (1999). They were conducted from March through November 2016. At least one onsite visit of one to two days was made to each firm by the first author. Interviews from cases within a day's drive were all conducted face to face, although in some cases multiple visits were required. More distant cases were visited only once although in some cases for two days. Any participant unavailable during the onsite visit to more distant locations was interviewed over the phone including international participants. A total of 52 usable interviews were conducted. Each interview followed a prescribed protocol and lasted approximately one hour. They were audio recorded and professionally transcribed.

Analysis began with interview notes of emergent concepts. Participants also provided supporting documents and files. Examples include risk analysis, reports, contingency plans and manuals. Additional information was obtained from the internet such as SIC codes, size and revenue. In sum data were triangulated with multiple informants per firm, on site visits and observations and corroborating materials (Jick, 1979).

Transcription were loaded into NVivo and coding conducted according to recommendations by Miles et al. (2013). Initial coding was conducted line by line and provided descriptive summaries of participant views. Interview notes and the literature of emerging concepts were reviewed resulting in second level coding of patterns and categories. Some codes were divided or combined as coding progressed. Firm specific history, product, market and cultural information were provisionally coded by firm to enable the within case analysis. Features pertaining to organizational learning mechanisms such as timing and participation were coded separately to facilitate pattern recognition. Further review of the literature on patterns and categories as well as cross case analysis resulted in third level coding of themes. See table 19 in the appendix A: additional material for a coding summary.

3.3.2 Within case analysis

Cases describe the products and market the industry is involved in and include any industry drivers of change. Firm culture is depicted by training practices, learning attitudes, acceptable risks and responses, and how disruption results are measured. Finally, the organizational mechanisms used are listed with an explanation of how they may have evolved over time.

Case 1: Furniture

Our first case manufactures both stock and custom furniture. Production occurs across multiple sites worldwide and deliveries must be coordinated for the concurrent installation of entire suites of furniture. Market pressures have led to a greater variety of product offerings as well as lead time reductions. This squeezes the organization to do more with less.

They haven't had the resources for much organizational learning. "I don't know that we've ever given them the right education to … successfully put out a fire and then document and improve processes." "We don't do any training around this kind of stuff. We just figure that you're going to figure it out, you know? "Materials are an afterthought. People don't realize the impact of not having a good … and robust supply chain. It's more about push it out the door." Their culture is highly influenced by cost control and a lean philosophy of continuous improvement.

This informs their concept of acceptable risk. In reference to using inventory to buffer against variation they shared: "We're a just in time organization, we don't do that. That's scary. That's risky." Product differentiation and an aptitude for change resulted in complexity for their suppliers who were selected by cheapest cost. "Transitions as a whole caused significant disruption in the organization and it felt like every time we did one it was the first time." "Consistency across the facilities and departments isn't the best, which means we have best practices here and best practices there, and not so good practices here and there, and how do we bring that all together and make one consistent methodology that we follow and we know so that when there is an issue we can better solve it?" They have suffered many supplier related disruptions and address a lot of root causes – "and

that's part of the problem. We're too tolerant of change". They acknowledged that "I think we helped them [suppliers] get there [fail us]". "Product differentiation … resulted in supply chain disruptions, not always the supplier's fault".

The mechanisms Furniture uses to learn from disruption revolve around a team dedicated to monitoring and controlling risk, called the "control tower". They now meet daily to jointly evaluate and escalate disruptive events. "Before it would be somebody emails somebody and waits for a response, and then emails another group and waits for a response." "The trail is fresh for us to get at the root cause." After action reviews are then conducted to report the consensus derived from the situation. "There is a root cause analysis done pretty thorough, and that's shared across all of the manufacturing plants and distribution centers, so that we can all learn." However, a recent pilot towards greater risk reduction was explained, "We can't risk supply chain execution or disruption with a growing product line. We actually went with a higher part cost supplier who's more stable, who has better capabilities." They are developing more standard work and consistent processes to reduce what they see as growing risk. "We had too many failures. And it was just, "guys, what can we do differently"?"

Case 2: Biodiesel

This case is a producer of biodiesel refined for custom markets. It is a relatively new and growing industry which is heavily regulated. They have had to build and acquire many refinement facilities in order to keep up with demand and expansion. Many of the markets have seasonal demand. Seasonality also impacts the appropriateness and availability of various inputs as well.

The young age of the company impacts the organization in many ways. They do not yet have many robust routines or training processes. “A new organization is not as focused on following procedures, [it] is more focused on determining where the variability is, learning how to adapt and perform, whatever the circumstances and the environment requires.” Lack of formality provides: empowerment “we like people to report or solve or take charge and that's the environment we're trying to inculcate”; flexibility “there's no solution that is not available to us. If we were a mature organization we would be locked into whatever the protocol required”, and responsiveness “we can do things in a matter of weeks”. Instead, they have an open floor plan they feel is key to information sharing and collaboration. “Being able to communicate small things constantly throughout the day. Sitting in a cluster… that's crucial.” The culture is influenced by the regulatory nature of the environment and many of the executives are lawyers. “The CEO likes attorneys working in non-attorney roles”. They rely on contractual mechanisms for control and capturing lessons learned. “We're putting legal terms in our contracts to avoid issues and things in the past, customers not calling, customers requesting different what nots, to where we're now taking to the contract basis, to where we try to close any loop holes that might still be out there.” “Hopefully [protection from risk] is all up front and it's already in contract.” The prevailing wisdom is cost control “more than any company I've worked for, which is interesting. Just really being cost-conscious”. This may stem from the age of the firm and a need to pay for initial investments like the refineries. They accept risk to serve financial purposes with the expectation they can execute their way out of any negative consequences. “[Employees] can run their … inventories low when they want to put more

pressure on the market, or they want to increase inventories because they can buy something cheap."

Reliance upon good execution, however, can't eliminate costs when they are simply deferred. "We stored [rail cars] where it wouldn't cost us any money. Now we have cars that are still in storage that aren't readily available to us. That costs us because it limits our capacity." Individual discretion is key to organizational learning. "It's basically manager, team leader, and director-driven. How important is it to get to the root cause … taken in the totality of everything else that you're doing at the time."

The primary mechanism for organizational learning is an individual seeking expertise from more experienced personnel. "We need to get some help." "You learn or share just by observing." "A lot of it is just osmosis and learning and just listening to the other folks in the department." "People in the discussion learn something because we're a close-knit team and verbal policies are usually arrived at." Another mechanism is benchmarking similar industries. "We try to use the big oil platform … and ethanol." Rapid industry growth has helped them recognize learning opportunities from disruptions. "We're doing a little bit better on some things where we've learned from the past." "Now we have an integration team [for new refineries] to get others involved." This way, they can consistently apply lessons learned from past experience and update the knowledge of team experts with each new experience.

Case 3: Agribusiness

Agribusiness processes food and feed products many of which have low margins and very short shelf lives. They deal with a lot of seasonality in both supply and demand which are at opposing times of the year. They are heavily reliant upon trucking which ebbs

and flows between who has the greater power. Demand and distribution are very susceptible to weather conditions.

Industry pressures afford little room for error, therefore, training is highly valued in the Agribusiness culture. “We're trying to have a centralized, standardized focus of training to put people on the same knowledge platform. We'll bring people from all the production facilities, and even overseas here to go through training.”

Agribusiness is privately held and they feel that makes the culture less risk averse than a publicly held company. “I think there's a little more tolerance for risk [management] here. The quarter focus is king at a public company versus a private.” “We have a lot of latitude.” They monitor the environment closely for threats and opportunities. “We saw what [suppliers] went through with [competitor] and said, "let's go for it [proactive supplier fee schedule], what have we got to lose? If we screw it up we can reverse course, but we believe this is the right angle." And it turned out it was.” Risk to them is the unknown “where we don't have a lot of institutional knowledge …the international space.” It depends on the maturity of the business unit, however. “Especially where the processes were mature, more refined, people are expected to follow them. They deviate from them far less. We’re less agile in terms of quickly understanding, "OK, this is what I've got to do." Agribusiness conducts grafting, bringing in outside talent to fill capability gaps. Risks are taken to prevent disruptions. “We tend to err on the side to avoid the disruption.” “We definitely can plan heavy … because the thing that we did not want, couldn't afford to have, was an outage.” “I probably drive my team nuts with the what-ifs. But, if we haven't thought that far ahead in terms of potential risk, then shame on us.” “We're very much tied to

getting the customer what they want. And getting them what they want on a consistent basis."

The focus on risk management capabilities has paid off for Agribusiness who has been able to use it as a competitive advantage. "The folks on our team did a great job, not just for our parts, but for our customers' [other] parts. The reason it was really a success was not so much what we did for ourselves, but we became a value added for our customer." They have highly structured mechanisms to ensure not only that learning gets captured but that members who were not involved can review the data and contribute to the conclusions drawn. "If somebody is not coordinating and driving it from an overall perspective you lose sight of those small things." "In terms of how it's shared… it would be actively done through a function at corporate center." "We basically put a case study up to the national group." Here's the situation." How would you manage this? What are the challenges?" During the delay before the annual meeting, each person has time to reflect upon the situation. The larger audience will likely not come up with the same solution as the original group did initially. This simultaneously allows for input and learning generalization from a greater diversity of people as well as dissemination to the entire organization. Each unit's solutions or lessons could be tailored to their specific context rather than just accepting or rejecting the initial generalization of those originally involved. The group originally involved might not possess enough knowledge of other business unit contexts to accurately generalize learning for them. The broader, collective involvement affords more accurate lessons and application of learning. "It kind of gives everyone a buy in." "Once you get it embedded in the culture then you don't have to baby-sit it, it becomes natural. You become quicker to respond to changing conditions. You recognize risks and

gaps a lot quicker." The reason Agribusiness have evolved this way is because "we've got our hands dirty and looked stupid." "You're going to make mistakes, that's ok. But, you can't make the same ones."

Case 4: Consumer durables

The combination of expensive consumer durables and a highly competitive market result in low margins. SKU proliferation has occurred in an attempt to provide greater competitive differentiation. This contributes to greater cost-compliance pressure. They have expanded globally to capitalize on cheap labor and growing markets. "What gives us a competitive advantage over many people is that we have a very large, very diverse global operating platform. With the commonality of platforms, it's not that difficult to be able to retool for a production run of the same product that's made in Poland to be made in Mexico or someplace else." However, "with the purchase of [European acquisition]… and [Chinese acquisition] and a large presence in Russia and the Ukraine, think of the complexity that was just added. Now we're dealing with geopolitical risks…and there's not necessarily an eloquent or simple solution to that."

Knowledge is gained through experience and connections. "I'm going to be conditioned, due to that dramatic experience to do something and ask questions. But, I wouldn't have the network to be able to rely on, to ask that necessarily, if I were brand new." Training is strategically conducted with the expectation that individual expertise will be redirected and shared as necessary. Due to strong pressure to maintain margins, a short term stockout is preferable to cutting deep into margins to ensure availability. Repeated risks are perceived to be known and accounted for but new, uncertain threats don't have the historical data to warrant investment in prevention. "You've got to be pretty confident

that an event is going to happen where you're going to spend money ahead of time, kind of just in case. We don't do that here, unless it's a very painful event from in the past, or the probability of an outage is high."

Spending more than required is unacceptable. This results in reacting to disruptions which allows for higher reoccurrence. "I've seen that same problem for twenty years." "Well, why? What are we doing? Why aren't we solving that?" Higher reoccurrence has led to automatic responses of informal plans "the ones that we frequently kind of deal with… those just kind of come and we just kind of go through the motions."

Most of the organizational learning mechanisms are informal and cultural. "I've seen people who solve everything. You ask them what they did and they're like, "Oh, I don't know." Individuals share the tales of grand failures with newer employees to demonstrate what not to do. "There is definitely a kind of inside joke. You never want to be like [previous failure] was in 2010." However, permanent change is not usually achieved. "Next year, or five years from now, nobody will be doing anything, because the pain of that is gone. Leaders change and people move around, and, it just kind of becomes forgotten, until it happens again and everybody is like, "Oh, wow…" That recognition has led toward some more embedded mechanisms such as the enterprise risk management department. "That really taught us a lesson that it was not fully transparent. It took us way too long to be able to respond to that issue. So, we put together a lot of efforts to understand, not only our supply chain, but we geo-mapped that and superimposed our distribution and manufacturing sites so that we could take a look digitally at where things were happening."

Case 5: Retail

Retailer sells products from a wide variety of industries including cleaning products, electronics, groceries, clothing, office supplies, pharmaceuticals, and toys. Therefore, they purchase from quite a few very large and powerful suppliers. Customers expect that Retailer will offer top brands which equalizes the buyer supplier power of Retailer and their suppliers. This cultivates a win-win culture in which long term relationships are highly valued. “It's a lot harder to be successful if you're not trying to make everybody successful.” “It’s not just being good at their jobs, it’s their connections within the industry, because then you get the advanced notice.” Limited time offers and varying shelf lives of products add criticality and complexity to processes and availability.

Certified trainers conduct employee training and job rotation is highly encouraged to gain experience in different areas. “Retail is a generalist culture. They don't want specialists.” Generalists solve problems by working together. “It's just a matter of finding the right people, finding the right information, getting that in the hands of the right people.” Priorities are established from the top. “Our CEO says, "Here's a category of items I guarantee we will not be out of stock on". This drives alignment in managing supply chain risk. “It's irresponsible not to have some sort of back-up plan, or a back-up plan to that back-up plan.”

They invest proactively in relationships that can be leveraged later. “The only way we were able to get through that was leveraging our relationships with either the steamship lines or the terminals and to have us already have invested in those relationships prior to that event happening. We were able to pull levers that other retailers were not. And, that's what it came down to.” External relationships are also considered a

major source of risk identification." "We scan the environment for risk. A lot of that intelligence is gathered through relationships that you have with individuals."

Mechanisms used for organizational learning from supply chain disruption are pushed independently by individuals who have the autonomy to meet expectations in multiple ways. The right internal relationships enable special accommodations. "How do you really know what your lost sales are, unless you actually have enough and you don't run out? Now I've got some partnerships at headquarters, so it's not a big deal. But, that first battle was hard because I was going against what everybody else did, but not everybody else is space-constrained and busy that time of year. The following year, our forecasts were way better because it was based on better numbers." Retailer is starting to capture lessons learned through creation of expert roles who can then share with others. "It worked so well that we actually took that and made it into a chain line program for all of the [similar demand pattern] stores." Metrics include disruption duration, inventory speed, reliability and network uptime.

Retail has experienced pressure from online competitors and advancements in technology. Their desire to be customer focused has caused them to strive for greater supply chain resiliency. As managers override routines to be successful, the organization has evaluated and updated processes. They simulate disruptions, make contingency plans and have strategically developed more specialized roles, sometimes grafting expertise externally. "We brought in a chief risk and compliance officer. So when you have somebody that reports directly to your CEO focused on risk that forces you to ask those tougher questions and make sure you have the resiliency and controls in place to manage those risks."

Case 6: Automotive

This tier one automotive supplier produces parts for six different OEMs. The market is noted by high volumes and rigid schedules. Each OEM, additionally, has unique requirements, processes and demand. For example, some provide six weeks of electronic data information while others provide 40. Consistent across the organization, however, is the expectation that they must never be disrupted and steep penalties ensure total compliance. “Delaying the program for as little as a day can cost millions.” This causes Automotive to take drastic steps to satisfy their customers. “I've called up my logistics group and said 'I need a plane,' and they said you can have one as soon as one lands. You've got the rest of them up in the air." I said, "You mean I've got them all." He said, "Yep, you've got every plane I could get that's flying between here and Mexico to get you parts". Network exposure to risk is very high due to the high number of parts in an automobile. A supplier can suddenly lose demand because another supplier shut down the OEM.

Employees change jobs between departments as well as international locations and learn primarily by practice. Production planning processes are highly valued and mature. “The key thing is the production planning process, the follow up checks and balances that we have in place to ensure that we have alarm systems throughout the process that signals that we're going to be short a part from a supplier, and then we can work it in advance.” Supplier issues are viewed as the cause of disruptions. “If something happens at one of our suppliers we don't have control over that except determining how much inventory we want to maintain. There's no way you can afford to house that much inventory.” “We have 210 suppliers that supply this site. And the majority of them ship from Asia Pacific. The majority of our larger components are brought in on ocean freight and the smaller ones air.

So then you're at risk of multiple delivery issues." Disruption response has developed into a core capability. "There's a recovery procedure for everything."

Recovery costs are not considered risky because they are passed on to the delinquent supplier. "The amount of money is not the issue, its complete customer satisfaction." "We're chartering planes. We're stopping a truck because it can't get there fast enough and having the helicopter pick it up." The accepted risk is the probability that the supplier won't reimburse Automotive for all recovery efforts. Likewise, since issues are not considered internal, there is not a lot of learning from disruptions about prevention. "We didn't change anything due to [disruption] because I really think our process is robust. And you can't predict [disruption]." Response related knowledge however, is documented and updated during or immediately following a disruption. They are so good at recovery that responsiveness has become a competency trap (Levitt & March, 1988). Leadership just assumes that supply chain can alleviate any disruption. "This is just something that happens, make it go away. You guys do this all the time." "They think because you get so good at firefighting sometimes it becomes not such a good thing." The measure of success is customer impact. "If you're aware of it and can react first, as long as you're not the slowest person, you don't get eaten by the lion.

Learning is primarily local with input from experts. Mechanisms include templates for what to do, SharePoint sites for dispersing information, process maps to define procedures, and a known issues database. A central role coordinates activities during a disruption affecting multiple plants. Their focus is allocating the constrained material across multiple sites. "The recovery actions, the lessons learned, all of that, any potential continuous improvement, it lives in the site that had the problem." "The roof collapsed, and

that business unit happens to comprise probably 70 percent of our global footprint for manufacturing. I can guarantee you that the people from the other divisions had no idea that it even occurred, let alone any sort of learning from it."

Case 7: Government services

Some of the services included in government services include pharmaceutical inventory and allocation, quarantine and depopulation of infected food supplies, maintenance and availability of incident free transportation systems, and flood control. Interrelated government agencies coordinate during disruptions because of their interdependencies. Disease can move from human to animal and vice versa. Floods can disrupt local and interstate logistics, employee work routes, and also spread pathogens and impact illness. Their focus is on new threats. "Our big things right now… we're always on the outlook for a novel virus, 'novel' meaning the first time that it's been seen because the chances of you having immunity to it are going to be very, very slim." "We rapidly hit them with something that might not totally eradicate [it] but may slow it down, help contain it long enough for us to identify what it is and then combat it with the most appropriate item."

Plans must be well defined and communicable because help during a crises is external to the agency. They don't have the luxury of proactively training employees in every situation. "In order to operate … during a time of crisis [requires] anywhere from 80-100 public health workers. I've got 17 people. It doesn't work." For example, "we had veterinary students from [local university] helping on the surveillance testing, going farm to farm, wherever there were birds to collect samples for testing." Disruption effects can quickly propagate. "Even though there were no positives in that county, the whole state can

be impacted. There's some foreign countries that will say, "If you have one case in the US we're not going to take anything from any state." "The potential for life or death impact drives risk management decisions. "We take that maximum response until proven otherwise." "Having a response plan set up is an acceptable risk, it's expending resources and training time and staff time for something that we -- I hope we never need. That would be the best case scenario, that I wasted money on being prepared for a tornado." Some metrics track the speed of recovery. "Important is getting freedom from disease and getting back to business. Clearly to maintain continuity of business during that type of disease event is extremely important." Like manufacturing, they acknowledge the more accurate metric would be to capture the disruption averted. "How do you measure the effectiveness of emergency medical services? The only way you could do that is you'd have to shut them all off for a two week time period. I'm not sure that in the business of human life that we want to take that gamble and that risk."

During disruptions, interrelated agencies convene in a 'war room' to facilitate information sharing and communication. Due to the gravity of scenarios as well as restrictive budgets, government services places great importance in coordination to gain public feedback, capture lessons learned, share best practices and document potential process guidelines. In addition to reviewing disruptions with those agencies they coordinated with during the disruption, they also network with counterparts in other states. They go to association conventions, schedule regular conference calls. "I'm very happy to learn from the lessons of others." Scenario role playing helps agencies prepare as well as educates decision makers. "We took, to national disaster response training, a crew of 70 that included elected officials, city managers, county administrators, highway people,

fire chiefs, sheriff, and deputies, and medical leaders, and even business members and community leaders to run through a scenario that was, "Imagine the Joplin tornado dropped in your footprint." It was a command post computer simulation exercise." The robustness is relatively new. "Our approach to things is vastly different today than it was… most of our stuff came about because of September 11th, 2001. Public health had not been part of the primary response group of the traditional fire, police and EMS. The federal government has put a lot of money into the effort of ensuring that public health as well as hospitals, that the entire healthcare system is able to respond in a unified process."

Case 8: Surgical and medical instruments

Patient lives are at stake if the required surgical and medical instruments aren't available when needed. Products requested by even a single doctor are stocked. Quality products drive reputations and sales. Decades of growth and an entrepreneurial spirit led to autonomous agents empowered to do whatever it takes to keep up, including products, processes and technology systems. Patient driven healthcare and increased government oversight have created a reverse swing in strategy towards caution and cost control. The company's historical value of quality overlaps with this new pressure resulting in efforts to standardize. "There's what I call an awakening that efficiency, effectiveness and waste reduction does not equal bad healthcare."

Most training is not formalized. Efforts are made to cross train within departments. Significant resources have been re-allocated towards regulatory compliance, constraining activities to improve costs "from want to need." The common practice of reacting to a disruption through substitution of alternate components or suppliers, is not an option because regulatory approval for such changes takes years. Therefore, the predominant

strategy has been to carry significant inventories in preparation for a supply chain disruption. “A disruption would have to be really massive to create a big problem for us.” They understand how this holds them back from being responsive and cost effective but find change requires a “transformation”. In fact, to find the mindset and skills necessary for the new direction they often hire externally from other industries.

Supply chain now finds “a seat at the table”. Supplier evaluations were based on annual spend but now look at the impact on the overall business. Network relationships are seen as a valuable source of risk identification. “They want to jump through hoops for you. We were able to continue running [although] it took almost a year and a half for them to come back up.” Metrics gauge the impact to manufacturing, distribution and the patient. “There’s not really an accountability factor in reaction, you take it as it comes and get rewarded for solving problems rapidly.”

Efforts are underway to transfer “tribal knowledge”, to the broader organization. Although historically voluntary, some documentation of local best practices and relationship histories is underway. Specialist roles have emerged which attempt to capture and share knowledge more broadly. The challenge is to develop the appropriate strategy and align it across the organization because “if everyone is autonomous you can be super busy but not move in any particular direction.”

Case 9: Pharmaceuticals

Each drug is unique and Pharmaceuticals is the sole source until the patent expires. The focus is on patented drugs because they impact patient lives. Patients have alternatives for disruptions in generic drugs. If a patient had to switch drugs due to a disruption they are not likely to switch back again after recovery. Supply chains get heavily involved during

the trial phase to help speed time to market. There are first mover advantages for drugs with similar efficacy.

Annual risk reviews are conducted on each product line to three tiers. Employees across units in similar roles meet in monthly forums to share best practices. Training has become highly valued because of a painful experience not capturing organizational knowledge. They received an FDA warning a second time because the employees were inexperienced. Those employees involved the first time were no longer in their roles. Job rotation was occurring too fast. “We want deep expertise… to develop knowledge and wisdom such that when you see an incident and then you see something else five years from now, it's not you're learning it for the first time… I know exactly what to do to respond to that.” Succession plans are in place for management and key contributor roles. Government regulation has a strong influence on priorities. “We make life-saving medicines… we guarantee the government that we will maintain at least a year's stockpile of active ingredient.” Regulatory documents bind them to specific suppliers. They strive to select suppliers who have multiple locations to reduce site related risks. They don’t manufacture anything in India or China to reduce the risk of counterfeits.

Market and regulatory driven priorities, however, provide alignment. “There's a couple of reasons now to implement something that's going to help out with risk.” For example, two dimensional bar codes required to enable conducting a recall, also provide supply chain visibility. Customer service and inventory levels are used to measure success. “Despite the fact that consultants consistently come in and say, "You have too much inventory," we've chosen to say no.” Although they have experienced catastrophic disruptions, they’ve not impacted the patient in over ten years.

Pharmaceutical has extensive mechanisms to learn from disruption. Mitigation plans and checklists are updated on collaboration websites. After action reviews and root cause are conducted. Key employees in each department are certified as "go to" specialists. A couple times a year they conduct simulations of scenarios which would trigger a disruption. These enable cross functional teams to engage in learning without the pain of experiencing a disruption. They test new processes instituted after the most recent disruption or newly identified sources of disruption. The risk management process owner gets ideas by vicariously researching cases of others' disruptions. These are used not only to identify vulnerabilities but also justify new initiatives. However, sometimes requests for new initiatives are denied until the vulnerability creates a problem.

Within case results are summarized in table 15.

Table 15: Firm Summary

	Market Impact	Training Attitudes	Risk Attitudes	Metric	Driver of Evolution to Greater Embeddedness	Highest Level Mechanism Commonly Used
Furniture	Product proliferation and cost reduction	No best practices, figure it out on your own	Not being 'lean' is unacceptable, constant change is tolerated	Customer impact	Firm generated turbulence makes them more vulnerable	Expert: "control tower"
Biodiesel	New, high growth product	Standard protocols are restrictive	Contractual protection from anticipated risk	Profit	Minimal priority, trying to keep up with growth	Voluntary: employee discretion
Agribusiness	Low margins and high seasonality	Highly structured, no room for error	Long term view, reduce uncertainty, avoid outages	Customer value	Past problems, don't repeat mistakes	Collective: case studies

Table 15 continued

Consumer Durables	Highly competitive, high cost, low margins	Experience and connections	Short term stockouts are tolerated over financial losses, proactive for only known risk	Customer promise date	Painful past, avoid being the latest example	Immediate: after action reviews
Retail	Online competition and technology requirements	Dedicated functional trainers and job rotation	Leverage relationships for detection and service	Service level	Competitive pressure for greater resiliency	Voluntary: connections
Automotive	High volume, rigid schedules	Experience and job rotation	Recovery competencies, pass costs to disruptive supplier	Customer impact	Lack of evolution is considered evidence of competence	Immediate: templates of recovery procedures
Government Services	Distinct agencies with high levels of coordination, life and death consequences	Personal networks	Triage priorities, disruptions are uncontrollable and unavoidable, 'wasted' preparation is valuable	Service level	Painful past, exposed capability gaps and the need for volunteer resources	Collective: simulations
Surgical Instruments	Industry shift from doctor driven healthcare to patient driven healthcare and increased regulatory enforcement	Experience of highly tenured employees, personal networks	Regulation is considered restrictive to adaptation, inventory buffers are considered the only option	Customer impact	Poor performance due to lack of transformation, handmade quality must be more cost efficient	Voluntary: connections
Pharmaceuticals	Although drugs are unique, competition offers drugs with similar efficacy	Functional and cross functional training	Vulnerability to counterfeits is unacceptable, inventory buffers are heavily used	Service level	Patent expiration requires service levels to maintain sales	Collective: simulations

3.3.3 Cross case analysis

Synthesizing the individual cases reveals varying performance in organizational learning from supply chain disruption. Patterns exist among the firms regarding shared

and unique phenomenon. We present tabular evidence and theoretical explanations for observed patterns of results.

Risk dominant logic

Each firm possessed a risk dominant logic. This pervasive logic dominated perceptions and actions leading toward convergence of the mitigation of risk established by these norms (Bettis & Prahalad, 1995; Prahalad & Bettis, 1986). Contrary to realist perspectives of risk as measurable and assessable, our findings indicate that firms make supply chain risk decisions according to their dominant logic of risk, beliefs about acceptable and unacceptable sources and consequences we call normed risk. Each firm possessed strong capabilities in practices mitigating normed risk but struggled to gain commitment or apply resources towards risk outside of the dominant logic we refer to as non-normed risk. It is an overemphasis on the reliability of shared knowledge. Such strong capabilities can influence the perception of outcomes a priori based upon expectations, not actual observations (Levinthal & March, 1993).

People act according to what they know and unknowingly have blind spots. Employees don't ignore non-normed risk in a self-serving sense, nor is it an attempt by leadership to control divergent views. Either they don't see it or it is considered irrelevant. By nature, there is inherently plenty of normed risk to work on – and people are good at it. Anticipations based upon normed risk are often confirmed which then reinforces itself.

The risk dominant logic can be driven top down by management. "There's a mentality that has changed in the company, and [leadership is] heading that up. It's pretty much burned in everybody's memories, minds. It helps people make decisions about what's important and what's not" (Medical Devices). "We don't do a great job at thinking about a

risk score, risk value, on each one of our plants and then determining how we protect it. You've got to think about it in terms of revenue." (Automotive). "That's not something that's on the mind of one person, it's engrained into the work flows of the entire organization" (Government Services). "It's a dominant mindset" (Furniture).

It can also grow bottom up based upon history. "It's impossible not to over rely your past experiences" (Biodiesel). "The only thing you can do is order heavy" (Agribusiness). The risk dominant logic locks behavior into past patterns of success and failure, preventing identification of new risks and solutions. "We tried that once and it ended in disaster" (Medical Devices). This is consistent with findings from Zsidisin and Ellram (2003) that firms unilaterally utilize buffers regardless of the actual level of supply risk. The superstitious learning is that alternatives can't be successful. Superstitious learning is an incorrect conclusion of an event.

Changing the risk dominant logic as conditions change is challenging and requires organizational learning mechanisms. "For it to be successful it has to be cultural, because you can't get people to change that thought process, you can't force it, it goes back to what is acceptable to you as a business" (Agribusiness). "You've got to fight through your own predetermined ideas and get down to the facts" (Biodiesel).

Organizational learning mechanisms

Across the nine cases we observed four distinct patterns of organizational learning mechanisms used after a supply chain disruptions: fragmented, immediate, expert and collective. Each is described below and compared in table 16.

(1) Fragmented. Fragmented organizational learning mechanisms are disembedded, voluntary and therefore, sporadic and inconsistent. Individuals may

voluntarily share knowledge surrounding an event. Teams may also have task specific group discussions with local input and sharing. Learning is highly contextual and confined within the bounds of the dominant logic. Dissemination of learning to others outside the group is informal and limited to personal networks. This mechanism is susceptible to all three learning myopias. It focuses on the immediate disruption event being impacted by the learner and is likely to produce learning which reinforces the risk dominant logic.

(2) Immediate. Immediate organizational learning mechanisms are embedded processes which occur immediately after the disruptive event. Formal review processes such as after action reviews and root cause analysis generally address what went right and wrong. Discussing what went wrong has the opportunity to overcome the myopia of failure. Learning is often limited to gaining consensus of the event by those who experienced it. Because of proximity to the event, participants don't generally know the long term consequences of the mitigation efforts beyond resuming normal operational flow. Knowledge may be dispersed to a close group of stakeholders, however, generalizations are limited to the understanding of participants' knowledge of other business groups.

Individuals also update templates in documents, websites and systems which are publicly stored for others to access later. The endurance of these documents may overcome the myopia of time. Typically normed risk is addressed and the group impacted quickly transitions to catching up on their normal roles and responsibilities. Should learning contrary to the dominant logic happen to occur, the group may struggle to obtain the necessary resources to mitigate non-normed risk.

(3) Expert. Specialist employees or teams of experts are embedded within the structure of the organization. They are called upon to assist during disruptions and provide

expertise gained by their experience over diverse events. This diversity can help counter the myopia of nearness. Continuation of the role over time affords the opportunity to reflect, leading to greater knowledge and the opportunity to develop stronger supply chain resilience. This can also help solve the myopia of time. Their credibility and visibility usually command an abundance of resources to deploy during a disruption. Participants are provided strong support for their current situation but don't necessarily gain vast knowledge apart from access to the expert. Contextual learning usually disseminates from the expert to employees engaged in the disruption. The experts have credibility and may have success in dealing with the myopia of failure and perhaps changing the dominant logic. However, the success which makes them credible may also limit the perceived need for change. Perceived competency in recovery due to the expert may in fact be part of the dominant logic thwarting the firm's development of improved resilience capabilities. This mechanism is empirical support for the argument by Hardy and Maguire (2016) that retrospective reviews often emphasize expert knowledge while anecdotal evidence from lay people are ignored.

(4) Collective. Collective engagement from a broader audience results in the highest form of learning. Case studies were conducted at senior leadership meetings. Narratives of actual events were presented to a group representing all of the major business groups. It's not a judgement of what occurred in the heat of the moment, but an opportunity to pause and reflect and look at the bigger picture in a less tense environment. Initially after a disruption, employees are dealing with the aftermath of the disruption. Work that was postponed during the event must now be addressed. Reflection and learning are not priorities.

First, without knowledge of the outcome, collective discussion ensues about various mitigation ideas. Then the actual responses are shared and further discussion takes place. Other groups can ask questions relevant to them. The input stimulates innovative thinking by each presenting group who now has the benefit of hindsight, but also allows other groups to provide input and determine what is generalizable to them.

This is a critical distinction because when knowledge is disseminated across a boundary it can't just be transferred, it must be transformed to another context to be understood (Bechky, 2003). This has the highest chance of updating the risk dominant logic and mitigating non-normed risk because of the simultaneous higher order learning by the broad audience of authority figures. "Once you've been through an exercise… it makes you more in-tune to think about, "what if this happens…" It starts getting you thinking that not everything is smooth sailing" "A good recovery is really just having thought about those things ahead of time" (Pharmaceuticals).

Another collective method is cross functional simulations. Scenarios are created and players react as mock events unfold. Capabilities are tested, and new sources of risk and process gaps are identified as events propagate.

While the other mechanisms are based upon experiential learning, collective cases and simulations build knowledge on narratives which can identify non-normed risk (Garud, Dunbar, & Bartel, 2011). Identification of non-normed risk can help organizations break competency traps of the risk dominant logic and successfully transform to another life cycle phase or prosper after failing to meet goals.

Firms can progress from voluntary to immediate and expert to collective mechanisms. Firms in the growth stage had less effective organizational learning

mechanisms. Managerial attention may be focused on growth or perhaps during growth, the environment is just too unstable to notice any particular variation. Some firms in the maturity phase were firmly entrenched in their risk dominant logic and efforts to change went unheeded. Others had identified variation but not yet selected a new strategy. Firms who recognized pressure from changing environments often enacted new strategies. Responses to supply chain disruption justified more effective mechanisms, which in turn helped firms identify variation and select new strategies. Table 16 summarizes the mechanisms for organizational learning from disruption. Table 17 depicts an organizational learning from disruption framework of breadth of learning and impact by supply chain resilience capability development.

Table 16: Organizational Learning Mechanisms

Mechanism	Fragmented	Immediate	Expert	Collective
Who	Individuals, co-workers or departments	Individuals, local teams	Ad hoc experts and local members	Cross functional teams and leadership
Boundary Object	Exploitative sharing of event specific knowledge	Templates, repositories and after action review	Structured role, team or department	Case study, simulation
When	During an event	Immediately following an event	During an event	Time lapsed
Dissemination	Fragmented	Broad	Narrow	Broad
Learning Outcomes	Task specific	Context specific	Context specific	High level
Overcomes Myopia	N/A	Time, failure	Time, nearness	Time, nearness and failure
Learning Approach	Experiential	Experiential	Experiential	Narrative

Table 17: Model of Organizational Learning Through Disruption

	Weak Capabilities	Strong Capabilities
Broad Learning	Immediate	Collective
Narrow Learning	Fragmented	Expert

Bracketing

The analysis reveals differentiation in responses to disruption. Supply chain risk is a social construction which privileges the risk dominant logic unless special attention is paid to non-normed risk. How a situation is initially approached influences the interpretation and response. Combining these insights with the literature revealed a distinguishing factor, bracketing, summarized in table 18. The term bracketing has been used to describe coding in qualitative analysis and sensemaking in individual learning. Bracketing in this context is how we interpret and classify risk knowledge. Bracketing expands the interpretation of events so that organizational learning can occur. We define bracketing of supply chain risk knowledge as the practice of noticing environmental cues, interpreting underlying events and assigning a differentiating category that produces an appropriate response. When less uncertainty is perceived, less data is collected and analyzed. How risk knowledge is bracketed impacts the subsequent learning and supply chain resilience strategies developed.

Bridging collects data, but bracketing determines the attention it gets. Without bracketing, precursors such as weak cues and unusual events may be overlooked because they are not part of the risk dominant logic. Overlooked signals can propagate into bigger disruptions. Once a disruption has become complex it can be difficult to unravel the underlying causes. The symptoms may be more familiar and support continuation of the

risk dominant logic. This is similar to Wildavsky's (1988) theory of searching for safety which asserts that buffering based upon expected surprises creates a false sense of security. Resilience must be searched for through methods of probing the unexpected. While bridging and buffering seek to reduce stress, bracketing is stress seeking.

It requires a mindset that doesn't accept a situation at face value or as inexplicable. It is an ability to recognize patterns to see a hazard early before it propagates and becomes so complex it is hard to get at the root cause. "This is different, why am I seeing all of these patients here?" (Government Services). Pattern recognition comes from experience which is why firms utilizing collective mechanisms have come to avoid frequent job rotation. "The more experience… education you get, you'll learn to identify the precursors to emergencies. You're not quite sure what might go wrong, but you do know that this is something you've got to pay attention to before it does go wrong" (Biodiesel). Understanding can help pinpoint mitigation rather than relying on more broad sweeping and costly methods.

Bracketing activities, such as the narrative in collective organizational learning mechanisms, facilitate the aggregation of multiple, diverse narrative accounts that have the potential to alter perceptions (Hardy & Maguire, 2016). Patterns can be recognized from seemingly isolated cues in different parts of the organization. By hearing diverse narratives and asking questions, they overcome filtering by the risk dominant logic and bring non-normed risk to light. Only when new risks become part of the dialogue can they result in new resilience capabilities. When current risks are better understood, outdated risks can become less prominent. This is known as higher level or double loop learning (Fiol & Lyles, 1985). It is feedback, not foresight, which drives evolution (Jacobides & Winter, 2012). This also distinguishes bracketing from bridging and buffering which requires some foresight.

Thus, in addition to bridging and buffering responses to disruption, we propose bracketing as a necessary response to supply chain disruption.

Rerup (2009) describes three types of attention: stability, vividness and coherence. . He suggests all three dimensions are necessary to identify weak cues and unusual events, however, it requires discipline and coordination. *Stable* attention comes through routines. Attentional *vividness* focuses on many concurrent events and results in pattern matching. Attentional *coherence* is the dispersion across groups of attention focused on specific events. Bracketing can help magnify and draw attention to weak cues and unusual events to prevent a supply or market disruption from impacting the firm. Collective organizational learning mechanisms provide this triangulation of attention by crossing group boundaries (coherence); digging deeper into events beyond symptoms to uncover causes (vividness); and updating routines and the risk dominant logic (stability). Bracketing helps to balance the reliability of shared knowledge and the validity of exploring novel ideas (March et al., 1991). In this way, bracketing activities highlight areas of needed attention which can evolve firm supply chain resilience capabilities.

Table 18: Bracketing Theoretical Framework

Definition	The practice of noticing environmental cues, interpreting underlying events and assigning a differentiating category that produces an appropriate response.
Theoretical Foundation	Resilience must be searched for. Avoidance of risk hinders development of resilience capabilities. Learning resilience is strength from stress which is distinct from stress reducing methods such as redundancy/buffering (Wildavsky, 1988).
Origins	Sensemaking: an incipient state of sensemaking guided by mental models (Weick, Sutcliffe, & Obstfeld, 2005). Qualitative analysis: looking beyond preconceptions to more clearly and accurately construct participants' perspectives and phenomena (Tufford & Newman, 2012).
When	In response to supply chain risk, disruption or precursor.

Table 18 continued

Who	Individual contributors, management and teams within the firm or supply chain network.
Examples	• Furniture: “Sometimes it just feels like there's more… something systematic going on that we need to go after and fix.” “We've always pulled the levers through production, never the material side of it, being, "How do I have strategic inventory in place to make myself successful? And so now I think we've finally opened our eyes to that.” • Agribusiness: “Things weren't going well. We stepped back and realized, "You know what? We own pretty much all of this [responsibility]”.” • Automotive: “There is some level of cookie-cutterness to [disruptions], but each one of them are still very unique and there's generally some spin off that we didn't think about.” • Pharmaceutical: “We found out after the fact that their tooling is bad. They wanted us to buy new tools. Well, nobody ever talked about what's the issue? It was just "I need material.” "Well, we can only get you so much this week." Nobody ever asked, "Why are you only getting so much this week?" And then when we finally did ask that question, we were so far in the hole…” • Surgical instruments: “Those winds of change are changing. As that moves, I think we'll have disruptors come into the industry and actually… if we don't do it fast enough, they'll disrupt us and show us.” “We're seeing that we each have individual data that needs to be shared and trying to get places to share that.”

3.4 Discussion

3.4.1 Theoretical contributions

First, this study contributes to the evolutionary theory of firm change. We describe how firms evolve their supply chain resilience capabilities by experiencing variation through a supply chain disruption, selection of what events to attend to and retain organizational learning through routines such as organizational learning mechanisms. This study also ties organizational learning from disruption to the literature on rare and unusual events, as well as learning from failure and safety.

This study also extends the dominant logic perspective to supply chain risk and

introduces the constructs of risk dominant logic and bracketing. A risk dominant logic pervades each firm which shapes the perception of risk sources and available management strategies. Each firm recognizes and mitigates normed risk for their firm, however, disruptions continue. Bracketing is required to deviate from the firm dominant logic, address non-normed risk, and update supply chain resilience capabilities.

We extend organizational learning and sensemaking to the supply chain resilience literature by looking at how disruptive events are interpreted and classified. This adds a distinctive factor to the previously identified bridging and bracketing responses to supply chain disruption. Bracketing helps explain why some firms have superior supply chain resilience capabilities.

We identified four organizational learning mechanisms used to learn from supply chain disruption. Mechanisms are classified into four categories of fragmented, immediate, expert and collective with varying degrees of dissemination and supply chain resilience capability development. Fragmented organizational learning has very little selection and retention compared to variation. Learning is limited to task and context specific knowledge and not widely shared. Immediate organizational learning has higher retention, however, knowledge selection can be limited to the risk dominant logic of the firm. Experts select responses from vast experience to new disruptions but knowledge is less broadly shared. Collective learning has both broad dissemination and also results in strong resilience capability development. It has high selection due to the temporal distance from the event and high retention due to the expanded number of participants.

3.4.2 Managerial implications

This study provides insight for supply chain risk strategy. Much of supply chain risk and resilience has focused on identifying sources, network characteristics, position in the network and supply base strategies. We find, however, that internal practices such as bracketing and collective organizational learning mechanisms may be as important as those practices managing external factors. Although we agree that every supply chain disruption cannot be avoided, we argue that supply chain resilience can be accelerated. Introduction of stress seeking bracketing can accelerate the acknowledgement of non-normed risk and updated supply chain resilience.

Firms with generalist roles who encourage job rotation may want to discontinue that practice and promote more prolonged job experience in order to facilitate pattern recognition of non-normed risk. However, caution must be exercised in creating roving expert roles because over-reliance upon experts can create core competence rigidities. This is important because if firms can adapt to environmental changes sooner than their competition they can gain a competitive advantage.

3.5 Limitations

The primary limitation of any case study is generalizability due to the small number of cases. Although we include a variety of industries, caution must be exercised in extrapolating the results. Certainly this is not an exhaustive list of practices used for organizational learning from disruption but after experiencing diminishing returns we feel confident that the categories in our framework for organizational learning are theoretically saturated.

3.6 Future Research

Future work could develop a survey instrument for the organizational learning from disruption mechanisms, risk dominant logic and bracketing. This could identify the contribution of mechanisms to various outcomes such as supply chain and firm performance. Likewise, the operationalization of risk dominant logic and bracketing within the context of supply chain risk would be informative as to its significance in determining performance differences.

Another useful measure would be a practitioner metric for more comprehensively assessing supply chain resilience i.e. time without incident. A comprehensive metric would help firms know when to address risk and more accurately track performance outcomes. In addition to obvious practitioner benefits, standardization by industry would provide eventual data sources for supply chain risk researchers. For example, extending bracketing to data analytics could help in understanding a lack of clarity from data.

Results could be viewed from other unit of analysis. Organizational behavior studies of individual differences and personality could explore supply chain employees to determine the antecedents and enablers of the ability to detect patterns and identify precursors to disruption. Can they be preselected or trained? For example, are intrinsically motivated people more likely to be adept at bracketing? Additionally, how can supply chain teams successfully negotiate outside the established norm of the firms risk dominant logic? How many team members or participants need to have bracketing skills?

From a network perspective, the importance of narratives from collective mechanisms could indicate that supply chain integration capabilities complement

bracketing. It would be interesting to test the relationships between firms with capabilities in both integration and bracketing.

3.7 Summary

Firms develop a risk dominant logic to develop and facilitate appropriate responses to supply chain risk. Over time, firms become competent at supply chain resilience capabilities consistent with normed risk of the risk dominant logic. As environments and institutions change, however, those competencies can become a trap blinding the supply chain to needed changes. Bracketing and collective organizational learning mechanisms can help firms break competency traps to identify and address non-normed risk. We identify a taxonomy of four organizational learning mechanisms for development of stronger supply chain resilience capabilities: fragmented, immediate, expert and collective. A model of retention frames mechanisms by knowledge retention and resilience strength.

We introduce the concept of bracketing to the framework of bridging and buffering. Nonstandard disruptions require reflection and deeper analysis than standard cases so that connections may be found between seemingly heterogeneous events. (Haunschild & Sullivan, 2002; Stan & Vermeulen, 2013). These distinctive patterns can help explain how a disruption may unfold (Lampel et al., 2009). Bracketing can identify distinctive patterns of risk to enable appropriate bridging and buffering resilience capabilities.

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APPENDIX A: ADDITIONAL MATERIAL

Table 19: Coding Detail

3rd Level	2nd Level	1st Level	Example
OL Mechanisms	Fresh	Fragmented	"We didn't take what we learned and pass it on to another set of the organization." Furniture
		Immediate	"An after action review pretty simply put it's, "What did we do well?" "What did we expect to happen?" and "How well did we deal with it?" Agribusiness
	Delayed	Expert	"From the different learnings that they've been getting from different plants, they come here to tell us what is it that we need to be doing different. And we provide feedback and then he takes that to the other plants." Automotive
		Collective	"We go out in the district and do an exercise where we get everybody together, both the law enforcement, the cities, the communities, ourselves, and say, "Here's a scenario, 23" of snow on the system, exit 234… these are the impacts, what do you guys do?" And you try to break down some of those walls. Government Services
Risk Dominant Logic	Risk	Mitigation Creates More Risk	"We've taken action and the supplier just is unable to hit our spec or perform at the level we needed to. So then we need to go find a different supplier which creates another disruption, because now you're in a transition mode." Furniture
		Don't Let Mitigation Create More Risk	"That market had three players in it, and when you have one player or two, you are much better enhanced by adding a third competitor to the market. So my interest was to keep all three companies in business [by letting prices fluctuate today] so that I would be able to take advantage of their competition for better prices for indefinite future." Government Services
		Vulnerabilities	We don't want to tell our customers who our suppliers are, for fear they'll go around us. And our suppliers don't tell us who their suppliers are. There's not that level of collaboration. " Automotive
		Tolerance	"We're going to have more variability. So there's an acceptance of a great level of risk. It's just accepting that it's the normal." Biodiesel

		Overconfidence	"When people think that the risk is something is under their experience, they don't escalate or reach for consensus, because it would be harder for them to explain all the background to the rest of the group." Automotive
	Market	Criticality	"Not having a hamburger at McDonald's means you get chicken. For us it's not that interchangeable. I mean no one else has our medicines on the shelves, right? And, we generally have a lot of inventory." Pharmaceuticals
		Regulation	"The regulatory environment is very complex. So, if we said we'd like to dual-source let's say everything. OK, it would take an enormous amount of work." Surgical Instruments
		Industry Specifics	"We've done a pretty good job of aggressively securing capacity and pre-deploying before Black Friday." Retail
	Evolution of Mechanisms	Life Cycle Progression	"Our product line was much more narrow, not as many choices now, consumer-market. Everybody wants lots of options. So, as our products have grown, our supply base has grown, the complexity has grown." Furniture
		Not Hitting Goals	"Historically we've been a very cost-focused organization, and we've seen a shift to where people are actually genuinely focused on service. Some of it was customer feedback." Consumer Durables
		Response Becomes Permanent	"The people who fought the fires did go back to their day jobs, but a new organization was created, recognizing that need that we have a role to play with onboarding our suppliers." Agribusiness
Bracketing	Risk Searching	Inquire	"We found out after the fact that their tooling is bad. They wanted us to buy new tools. Well, nobody ever talked about what's the issue? It was just "I need material." "Well, we can only get you so much this week." Nobody ever asked, "Why are you only getting so much this week?" And then when we finally did ask that question, we were so far in the hole…" Pharmaceutical
		Communication	"I actually don't believe it's the disruption itself. It's the communication about the disruption that typically can be the biggest constraint. If you don't have good communication, you don't know what, really, the disruption is. You're not understanding the timing and you may not likely understand its impact." Government Services

		Probe	"We all get caught in the day-to-day activities that we all have to do. And, if you don't spend time taking people out of that and look at the horizon, you're actually adding more risk that likely you're going to experience disruption and it's going to be pretty awful." Government Services
		Persistence	"Getting that ability to negotiate, push back, and ask questions that would get you the answers you want. Manipulative questions like getting what you want out of that line of questioning. That line of conversation is a very valuable skill in the heat of the moment, in a post event type of scenario. Pharmaceutical
	Initial Response	Importance of Identifying Newness	"We only have the wherewithal to monitor certain things. We have to rely on other people to identify an abnormality in there. And a lot of times we don't receive that information until late in the game, which then creates an issue." Government Services
		Pattern Recognition	"In the past we would have said, "Oh, there's this big mis-scan bucket that's going on." "Now we said "That's not good enough. You've got to finish the rest of the trouble ticket on this one, so we can really understand what's going on." And what they found out going all the way back is we have a very systematic issue that not only happened on this one, but it can happen again, multiple times over. So, we better fix it." Furniture
		Data Analytics	"How well we produce ten years from now is how well we do on our clinical trials today. That's something that popped out, we needed more expertise around understanding our clinical trial supply chain inventory processes." Pharmaceuticals
	Managerial Attention	Who: Broader Audience	"We did have a diverse representation of leaders and levels, so you had people who knew the process extremely well, and you also had SVPs all together helping, making sure they had the right support and the roadblocks removed." Retail
		When: Proactive vs Reactive	"If you're going to prevent it's going to be a bit more strategic. If you're going to react it's purely tactical. There's no shortage of tactical operations people who know how to react to a problem. I could trip over them. But, I can find you many fewer who understand how to prevent the problem in the first place." Automotive

APPENDIX B: IRB APPROVAL

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 9/29/2014

To: Pam Manhart
2200 Gerdin

CC: Dr. Jennifer Blackhurst
3131 Gerdin Business Bldg

From: Office for Responsible Research

Title: Supply Chain Resilience: Learning from Prior Events to Build Resilience Capability

IRB ID: 14-471

Study Review Date: 9/25/2014

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**

- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

Please be aware that **approval from other entities may also be needed.** For example, access to data from private records (e.g. student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **An IRB determination of exemption in no way implies or guarantees that *permission from* these other entities will be granted.**

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.