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Building Supply Chain Resilience through Logistics Capabilities

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Introduction

The nature of a supply chain makes it vulnerable to unexpected disruptions. The global geography of sourcing, manufacturing and markets, combined with shorter product life cycles and increasing customer requirements have created inherent risks for supply chain operations. What happens when a supply chain is not resilient? Key suppliers may not be able to deliver critical parts on time which could result in lost deals and ultimately cause significant lost revenue for both the company the supplier. In addition to lost revenue, supply chain disruptions can lead to loss of market share when critical supplies for a new product are late, delaying the introduction thus enabling the competition to take advantage of this circumstance. According to Singhal and Hendricks (2002), the most cited sources of supply chain disruptions are:

- Changes by customers;
- Production problems;
- Ramp-up, roll-out problems;
- Parts shortages;
- Quality problems; and
- Development problems.

Singhal and Hendricks’s research indicates that these types of disruptions can have a significant impact on stock prices with the damage being as high as an eighteen percent decline.

To reduce this risk, a supply chain must be designed to incorporate event readiness, provide an efficient and effective response, and control the recovery process. This is the fundamental core of supply chain resilience. The concept of resilience has been a subject of scientific research for many years in disciplines such as ecology and developmental psychology. It is only recently that
this topic has gained attention in the emerging disciplines of risk management and supply chain management.

It is a premise of this research that as supply chain risks increase, the need also increases for companies to develop logistics processes and capabilities that can enable them to be ready (capable) of providing the necessary efficient and effective response, and continuing with business as planned. Gaining a better understanding of resiliency and vulnerabilities in a supply chain is not possible, therefore, without the consideration of logistics capabilities. In addition to examining the links between risks and the implications for supply chain management, this research explores the role that logistics capabilities play in enabling the firm to develop supply chain resilience that allows it mitigate risk.

This paper is organized into four major sections. First, the relevant literature on the concept of resilience is examined. This review is important in that it helps establish the characteristics and elements of the concept itself. In addition to the research in the area of resilience, the relevant research on supply chain risk management and logistics capabilities is also reviewed. In the second major section of the paper, a conceptual model of supply chain resilience is presented. This is followed by a discussion of the results of the analysis on establishing a link between logistics capabilities and supply chain resilience. The fourth and last part of this paper addresses the implications of the findings from this research, and discusses the opportunities for future research.

**Background**

**Defining Resilience and its Scope**
Resilience has its origins in the development theory of social psychology and it is an emerging theory in its own right. The concept of resilience is also directly related to important issues such as ecological and social vulnerability, the politics and psychology of disaster recovery, and risk management under increasing threats. Each of these areas has commonly used definitions of resilience. The problem is that they are discipline-specific, and in many cases the domain covered by the resilience construct lacks clarity. While this is the case, in order to understand the phenomena of resilience, the different perspectives and approaches from the various streams of literature need to be examined. The areas of ecology, psychology, economics and emergency management were identified as the most related and appropriate for the literature review.

_Resilience from an Ecological perspective_

The Canadian ecologist C. S. Holling (1973) was one of the first researchers to note that systems have two distinct properties: resilience and stability. Holing defined resilience as a system’s ability to absorb changes, and stability as the capacity of a system to return to an equilibrium state after a temporary disturbance. The definition of resilience was expanded to include other elements such as the degree, manner, and pace of restoration of the initial ecosystem structure and function after a disturbance (Clapham, 1971; Westman, 1978). Various research articles have identified several important dimensions of resilience that are important to this research including elasticity, malleability, and damping.

The speed at which a system restores itself to a stable state following a disturbance is a measure of its elasticity (Orians, 1975; Westman, 1978). The degree to which the steady (or stable) state after a disturbance differs from the original steady state was noted by Westman
as the property of malleability. Clapham (1971) recognized that damping occurs after a disturbance when a system begins the process of restoration. Forces are present that alter and the degree and manner of restoration.

Throughout the ecological research there is an implicit assumption of stability in the system. Without stability there would be no presumed return to the pre-disturbance state, but rather an adjustment to some new equilibrium level that could be better or worse than the previous state (Clapham, 1971). Carpenter et al. (2001) examined the magnitude of disturbance that a system could tolerate before it fundamentally changes into a different region with a different set of controls. They expanded the concept of resilience through the introduction of the notion of the adaptive cycle. According to adaptive cycle theory dynamic systems do not tend towards a stable or equilibrium state. Instead they evolve through four states – rapid growth and exploitation, conservation, creative destruction, and renewal or reorganization – adapting to the disturbance(s).

Psychological perspective

The psychological perspective on resilience is well researched and widely represented in the literature. It has its roots in developmental theory that deals with the examination of people’s behavior across the life span (Conrad, 1999). Reich (2006) examined three psychological principles of resilience that occur as a result of natural or human-made disasters: (1) control (direction, regulation and coordination of activities); (2) coherence (enhancing meaning, direction and understanding during the worst times; processes and procedures needed to reduce uncertainty); and (3) connectedness (behavior to bend together; systematic coordination of efforts to avoid duplication and wastefulness of services). Reich concluded that incorporating
these key psychological principles of resilience into disaster planning would lead to a more comprehensive response resulting in improved effectiveness. That is, control, coherence and connectedness are key components of resilience’s efficient response.

These principles were underlying themes in other research as well. Stewart, Reid, and Mangham (1997) through an extensive literature research discovered several common premises related to psychological aspects of resilience:

- Resilience is a dynamic process that depends on life context.
- Resilience is a complex interplay between certain characteristics of individuals and their broader environments.
- Decreasing negative risk factors increases resilience.
- Resilience is developmental and most important during life transitions.

Grotberg (1995) reinforced the idea that the capacity to be resilient is not limited to individuals. Resilience is a “universal” capacity that spans multiple levels from individuals to communities to plan, respond, and recover from adversity.

**Economic perspective**

In general, static economic resilience refers to the ability or capacity of a system to absorb or cushion against damage or loss (Holling, 1973; Perrings, 2001). A more general definition that incorporates dynamic considerations is the ability of a system to recover from a severe shock or stress. A systems theory assumption is that systems try to maintain their stability even as they change. Rose (2004) distinguishes two types of resilience:

(1) *inherent* – ability under normal circumstances (e.g. the ability to substitute other inputs for those damaged by an external shock, or the ability of markets to reallocate resources in response to price signals); and
(2) *adaptive* - ability in crisis situations due to ingenuity or extra effort (e.g. increasing input substitution possibilities in individual business operations, or strengthening the market by providing information to match suppliers with customers).
Rose also identified three levels at which resilience can take place – microeconomic (individual); mesoeconomic (sector, market or cooperative group); and macroeconomic (all individual units and markets combined). These are applicable at the firm and supply-chain level.

The ultimate goal of resilience according to Hamel and Valikangas (2003) is to create a company that has the capability to quickly evolve without adverse effects to the organization. They also argue that resilience is not just concerned with recovery, flexibility or crisis preparedness; it implies that there is a capacity for continuous innovation based on an analysis of strengths, weaknesses, opportunities and threats. In order to build a decisive advantage, however, a company must be faster at generating options and realigning resources than its competitors.

Resilience in an Interdisciplinary Research Stream – Emergency Management

Emergency management is an interdisciplinary field that draws upon bodies of knowledge in the physical and social sciences. The relatively recent disaster recovery stream of emergency management research presents a learning perspective of resilience. Lindell, Prater and Perry (2007) suggested that a disaster resilient community learns from its experience, supports sustainable development policies, mobilizes the government, and demands that effective policies be implemented. They identified four stages of emergency management, including hazard mitigation, disaster preparedness (readiness), emergency response, and disaster recovery. These stages are directly related to the phases of supply chain resilience discussed later in this paper.

The learning perspective was also emphasized by Lindell, Prater and Perry. For example, the vulnerability of infrastructure could be decreased during the recovery stage (e.g. a bridge
destroyed by an earthquake could be replaced by a new one with a better, more robust design).

One of the most difficult parts of recovery after a disaster is restoring the social routines and economic activities. The process of recovery involves restoring people’s psychological stability. It also involves learning positive lessons from the experience.

**The Concept of Supply Chain Resilience**

For purposes of this research, the concept of supply chain resilience is defined as:

“The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function.” (Ponomarov and Holcomb, 2009)

This definition borrows several key elements from multiple disciplines and reflects the fact that a resilient supply chain must be able to anticipate, take action, and restore operations to the desired state within the needed time frame. Christopher (2000) states that resilient processes are flexible and agile and are able to change quickly. The dynamic nature of this adaptive capability allows the supply chain to recover after being disrupted, returning to its original state or achieving a more desirable state of supply chain operations. Christopher’s conceptualization of a resilient supply chain includes elements such a supply base strategy, collaborative planning, visibility, and factoring risk considerations into decisions.

In general, the literature related to supply chain resilience is sparse. Although existing studies are informative, they are primarily focused on presenting several fragmental perspectives of the phenomenon (Sheffi, 2001; Christopher and Lee, 2004; Christopher and Towill, 2000; Sheffi et al., 2003; Christopher and Peck, 2004). These perspectives provide some understanding of the importance of the topic for supply chain research. The issues of risks classification, reliability and vulnerability of supply chains are covered a little better.
Supply Chain Risk Management

The review of the literature regarding the concept of resilience supports the notion that vulnerability can be reduced and resilience increased through interactive factors that have ability to adapt and learn from challenges. This view provides the foundation for supply chain risk management as defined by Manuj and Mentzer (2007) as, “the identification of potential sources of risk and implementation of appropriate strategies through a coordinated approach among supply chain members, to reduce supply chain vulnerability.” Norman and Lindroth (2002) suggest that supply chain risk management involves the collaborative application of risk management process tools for the purpose of dealing with uncertainties related to logistics activities. This definition introduces some important aspects, such as collaboration, a process-based view and the importance of logistics elements into the domain of supply chain risk management. Supply chain risk has also been defined as any risk to the information, material and product flow from original suppliers to the delivery of the final product (Christopher et al., 2003).

A number of major trends contributed to the increased importance of supply chain risk management during the last decade. Among them are things such as globalization, outsourcing, transitioning to lean and agile operations, and increased terrorist and other threats. In fact, many recent research publications deal with classifying all the risks, threats and disruptions. For example, Manuj and Mentzer (2008) summarized the existing literature from supply chain and related disciplines to suggest a five-step model for global supply chain risk management. Those five steps include risk identification, risk assessment and evaluation, selection of appropriate risk management strategies, strategy implementation, and mitigation of supply chain risks.
Manuj and Mentzer (2008) also presented a classification of risks in four categories: supply, operational, demand, and security risks. After reviewing more than 400 unique articles on supply chain and risk management published in scientific journals, Paulsson (2004) concluded that the area of supply chain risk management has many sub-areas that have one thing in common: managing flow-related risks in the supply chain. Richie and Brindley (2004) concluded that while there are many differing definitions of risk, supply chains and risk management the differences are marginal rather than substantive. These differences, in fact, contribute to the richness and depth of the research, which helps to establish risk management in supply chains as a valid and valuable emerging field of study. It is also indicative of an emerging discipline that has a need for a unified definition. Emerging disciplines grow by researching new constructs and building new theories. Supply chain resilience is one of such constructs for supply chain risk management.

It has been suggested by Christopher and Lee (2004) that one of the best ways to deal with supply chain risk is to increase confidence in the supply chain. Confidence in the supply chain cannot be gained unless it has the ability to recover from or adjust easily to adversity or change. This reflects an element of resilience that was also noted in the ecological perspective. Christopher and Lee also propose that supply chain confidence can be increased through visibility and control. One mechanism for increasing control is event management where pre-determined limits at critical links and nodes are used to manage material flows across the network. In the event that an activity exceeds the control limit an alert is sent to the specified supply chain members to enable corrective action. Event management implies the proper detection, reporting, and reaction to issues that arise in the supply chain (Stiles 2002). An effective supply chain event management system can significantly reduce risk and improve
operations by providing data on changing conditions that would otherwise take longer to recognize and respond to.

Risk Management Orientation

Throughout the literature on the concept of resilience, there is repeated mention of organization and alignment of resources for the development of capability to respond to external conditions. Broadly, this defines orientation. Mentzer et al. (2001) stated that a company has a supply chain orientation when it recognizes the “systematic, strategic implications of the tactical activities involved in managing the various flows in a supply chain.” Shin et al. used the concept of supply chain orientation to describe the management efforts or philosophy necessary for coordinated buyer/supplier interactions. Juttner (2005) examined the extent to which companies have formulated a systematic supply chain perspective on risk management. The findings suggest that most firms are using a single company perspective that is not appropriate in a supply chain context. That is, they do not have a risk management orientation.

Kohli and Jaworski (1990) define the marketing orientation as the generation of information about customer needs and external environmental factors, in addition to the dissemination of the information to functional areas. They noted that a third dimension – the development and implementation of strategies in response to the information – is a critical component of orientation. It is proposed that these elements of orientation should also be considered in the formulation of a risk management orientation. Additional literature on market orientation (Deshpande et al., 1993; Slater and Narver, 1995; Jaworski and Kohli, 1996; Hurley and Hult, 1998), in combination with research on the learning orientation (Panayides, 2007; Ganesan, 1994; Kalwani and Narayandas, 1995) suggest and further support the idea that a risk
management orientation must be considered as an enabler for various outcomes. For example, multiple studies have examined the link between market orientation and firm performance (Erdil et al., Piercy et al., 2002; Kohli and Jaworski, 1990).

For purposes of this research, risk management orientation (RMO) is defined as the organizational culture that (1) places the highest priority on risk management; (2) provides norms for behavior regarding the organizational development and responsiveness to risk-related market information. Furthermore, it is proposed that the RMO must have a culture of continual risk analysis, risk assessment, risk sharing, and top management support to be effective. As noted by Mentzer et al. (2001), a company with a supply chain orientation understands the implications of managing the flows of products, services, finances, and information across their suppliers and customers.

**Logistics Capabilities**

The term ‘capabilities’ reflects the major role of strategic management in adapting, integrating and reconfiguring resources, organizational skills and functional competencies to respond to the challenges of the external environment. Capabilities determine a company’s capacity of general efficiency and ability. Capabilities or distinctive competencies consist of those attributes, abilities, organizational processes, knowledge, and skills that allow a firm to achieve superior performance. Barney (1986) stated that firms that do not exploit internal resources they already control can only expect to obtain “normal” returns from their strategic efforts. This idea was advanced by Dierickx and Cool (1989) who noted that successful implementation of a strategy often requires high specific firm assets. Morash, Droge and
Vickery (1996) identified four key logistics capabilities – delivery speed, reliability, responsiveness, and low cost distribution – as being significantly related to performance.

Due to their dynamics and complexity, however, capabilities are often difficult to identify. In addition, capabilities often span over several functional areas which makes it even more challenging. Grant (1996) argues that while some capabilities can be identified using the standard functional approach, the most important capabilities often arise from an integration of individual functional capability. Thus, integration and coordination of resources are the key characteristics of capability.

Logistics capabilities have been categorized into demand-management capabilities, supply-management capabilities, and information management capabilities (Bowersox et al., 1999; Mentzer, Min and Bobbitt, 2004). This classification has proven to be successful in facilitating further research and practical implementation. Esper et al. (2007) contributed to the discussion by summarizing the existing views of logistics capabilities and proposing their own classification. Their proposed classification includes five components including: (1) customer focus capability (Zhao, Droge, and Stank, 2001; Morash, Droge, and Vickery, 1996; Bowersox, Closs and Stank, 1999), (2) supply-management capability (Morash, Droge, and Vickery, 1996; Mentzer, Min, and Zacharia, 2000), (3) integration capability (Daugherty, Stank, and Ellinger, 1998; Stank, Davis and Fugate, 2005), (4) measurement capability (Global Logistics Research Team at Michigan State University, 1995; Bowersox, Closs, and Stank, 1999), and (5) information exchange capability (Zhao et al., 2001; Mentzer, Min, and Bobbitt, 2004).

A number of logistics and supply chain related capabilities leading to improved firm performance and sustainable competitive advantage are discussed in the existing literature
(Olavarrieta and Ellinger, 1997; Daugherty, Stank and Ellinger, 1998; Lynch, Keller and Ozment, 2000; Zhao, Droge and Stank, 2001; Mentzer, Min and Bobbitt, 2004; Esper et al., 2007). The research findings by Zhao et al. provided empirical evidence that customer-focused capabilities and information-focused capabilities are significantly related to firm performance. Customer-focused capabilities are driven by the needs and desires of top customers and they require the firm to assess their own strengths and weaknesses in this area. Top firms build these types of logistics capabilities to sustain competitive advantage. Interestingly, the research found that information-focused capabilities alone cannot be considered a distinctive factor directly relating to firm performance. Instead they must be used to facilitate the creation of other capabilities that are difficult for competitors to imitate.

In times of uncertainty, however, supply chain resilience comes into play (Ponomarlov and Holcomb, 2009). Capabilities, particularly dynamic ones, are often difficult to sustain under the conditions of uncertainty, especially in high-velocity markets (Eisenhardt and Martin, 2000). The construct of dynamically-integrated logistics capabilities combines two important characteristics. First, a dynamic aspect is supported by a fairly extensive research stream on dynamic capabilities (Teece, Pisano and Shuen, 1997; Eisenhardt and Martin, 2000). This aspect is also supported by the nature of supply chain operations under constant change and uncertainty.

Second, an integrative characteristic finds its theoretical justification in the recent stream of literature on demand-supply integration (Mentzer and Kahn, 1996; Juttner, Christopher and Baker, 2007; Speier, Mollenkopf and Stank, 2008). Logistics capabilities should be classified and integrated in order to make a significant impact on the formation of supply chain resilience. It is also supported by the fact that no single capability alone, however strong it is, is sufficient.
Linking Logistics Capabilities and Supply Chain Resilience

The review of the different perspectives on resilience and supply chain risk management highlights the need for a holistic conceptual framework for supply chain resilience. Given the current state of research on the topic of supply chain resilience, it is also logical to assume that theory building will be extremely important at this stage of the discipline development. This means that there are conceptual aspects that can be borrowed from the related disciplines, readjusted to the supply chain context and empirically tested to gain a better understanding of the interdisciplinary phenomenon of resilience. The logistical perspective has yet to be researched. Findings from the reviewed perspectives on resilience, supply chain risk management, and logistics capabilities provide a fertile ground for establishing hypothesized relationships and provide a sufficient theoretical justification for formulating the conceptual model presented in Figure 1 below.

Figure 1
Antecedents and Outcomes of Supply Chain Resilience
The model presented in Figure 1 shows a direct relationship between logistics capabilities - classified as customer-focused and information-focused - and supply chain resilience. Risk management orientation is also proposed to be linked to supply chain resilience.

As discussed in the previous section, logistics capabilities have been classified a number of ways. Zhao et al. (2001) provided evidence that logistics capabilities that are classified as customer- and information-focused do lead to better firm performance. This classification is used for the proposed supply chain resilience model in Figure 1. While a number of research studies have shown that these capabilities lead to improved firm performance and sustained competitive advantage, there are other research studies that suggest that in times of uncertainty it will not be possible to sustain capabilities. This leads to the hypotheses that supply chain resilience comes into play. Therefore:

H1: Customer-focused capabilities have a positive impact on supply chain resilience.

H2: Information-focused capabilities have a positive impact on supply chain resilience.

A firm’s orientation towards marketing and supply chain management is present when the information about needs and external factors is gathered, disseminated and used to formulate (or re-formulate) strategic direction. Marketing and supply chain management orientations provide a basis for the firm to be responsive to market-related information. Therefore, this suggests that Risk Management Orientation will assist the firm in planning for, responding to, and recovering from unexpected events or disruptions in the supply chain. These are the basic fundamentals of supply chain resiliency. Therefore:

H3: Risk Management Orientation has a positive impact on supply chain resilience.
While the main focus of this study is in building supply chain resilience through logistics capabilities, the possible outcomes of supply chain resilience were also examined. The following research hypotheses were formulated:

H4: The greater the supply chain resilience, the greater the perceived competitive advantage.

H5: The greater the supply chain resilience, the lower the supply chain process variability.

H6: There is a negative relationship between supply chain process variability and perceived competitive advantage.

Research Methodology

Based on a comprehensive review of the relevant literature on the concept of resilience, supply chain risk management, and logistics capabilities, a survey was constructed to empirically test a portion of the conceptual model. The instrument was pre-tested with a group of logistics/supply chain concentration MBA students in their final semester of the program. This group of individuals has an average of 3-5 years work experience. Based on the results of the pre-test, scale purification was performed in which five items were removed and seven items were clarified and/or revised. This resulted in 50 substantive 7-point Likert scale (or similar) items and five demographic questions.

The final survey instrument was posted to an Internet site and an email invitation to participate in the research study was sent to a targeted sample of logistics and supply chain professionals. The sample consisted of individuals who had participated in previous research studies on logistics trends and issues conducted by Georgia Southern University and the University of Tennessee. These individuals are senior managers, directors, and vice presidents
of transportation, logistics and supply chain functions at Fortune 1000 companies. Some 1420 individuals were contacted for participation in this research. A total of 225 surveys were completed, resulting in a response rate of 15.8%. Table 1 shows the demographic breakdown of respondents by industry sector.

Table 1
Study Participants by Industry Sector

<table>
<thead>
<tr>
<th>Industry Sector</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy/chemical/mining</td>
<td>7.6</td>
</tr>
<tr>
<td>Retail</td>
<td>12.4</td>
</tr>
<tr>
<td>Manufacturing - General</td>
<td>13.3</td>
</tr>
<tr>
<td>Manufacturing - Consumer Products</td>
<td>15.6</td>
</tr>
<tr>
<td>Manufacturing - High tech</td>
<td>12.9</td>
</tr>
<tr>
<td>Manufacturing - Automotive</td>
<td>3.6</td>
</tr>
<tr>
<td>Life Sciences - Pharmaceuticals and Medical Devices</td>
<td>4.4</td>
</tr>
<tr>
<td>Transportation service providers</td>
<td>18.2</td>
</tr>
<tr>
<td>Other sectors</td>
<td>12.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

The data indicate that the two largest sectors represented in the study are transportation service providers (which include third party logistics providers) and consumer product manufacturers. Overall, the study participants reflect representation across a variety of industry sectors. In terms of size of firm, Table 2 shows that there is a good distribution of small, medium and large companies in the study.

Table 2
Study Participants by Size of Firm

<table>
<thead>
<tr>
<th>Size of Firm ($ Revenue)</th>
<th>Percent of Respondents</th>
</tr>
</thead>
</table>

< $10 million 4.1
$10 million - $99 million 15.6
$100 million - $500 million 19.3
$501 million - $1 billion 14.7
$1 billion - $5 billion 19.7
> $5 billion 26.6
Total 100.0

The majority of the participants in the study (92.4%) have seven or more years of logistics / transportation / supply chain management experience. The company spend on logistics operations is a reflection of size of firm, with the largest proportion of participants (71.7%) reporting that this expenditure is more than $250,000 per year.

Results and Discussion

The obtained survey data were analyzed using such methods as exploratory factor analysis and regression analysis. Since a detailed description of these methods would lengthen this paper considerably, we have chosen to simply summarize the results for each hypothesis in Table 3.

Table 3
Hypotheses and Results

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Description</th>
<th>Regression coefficient</th>
<th>P-value</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Customer-focused capabilities have a positive impact on supply chain resilience</td>
<td>2.71</td>
<td>0.0073</td>
<td>Positive relationship confirmed</td>
</tr>
<tr>
<td>H2</td>
<td>Information-focused capabilities have a positive impact on supply chain resilience</td>
<td>3.28</td>
<td>0.0012</td>
<td>Positive relationship confirmed</td>
</tr>
<tr>
<td>H3</td>
<td>Risk Management Orientation has a positive impact on supply chain resilience</td>
<td>10.27</td>
<td>&lt;.0001</td>
<td>Positive relationship confirmed</td>
</tr>
</tbody>
</table>
positive impact on supply chain resilience confirmed

| H4   | The greater the supply chain resilience, the greater the perceived competitive advantage | 5.85 | <.001 | Positive relationship confirmed |
| H5   | The greater the supply chain resilience, the lower the supply chain process variability | -5.22 | <.001 | Negative relationship confirmed |
| H6   | There is a negative relationship between supply chain process variability and perceived competitive advantage | -1.44 | 0.151 | Slope is negative but not significant |

Also, Tables A1 and A2 in the Appendix present the summary statistics on the selected constructs and scaled items used in this study.

The analysis of each of these items for internal reliability (using the standardized Cronbach’s alpha) for each of the constructs, indicated that the results were consistent with the findings from previous studies. The reliability coefficients ranged from 0.61 to 0.88. The highest reliability was achieved for the constructs related to logistics capabilities. All the reliability values exceed those conventionally asserted as a cut-off (0.51) in exploratory studies. It is also noted that coefficient alpha as an estimate of reliability is neither a necessary nor sufficient condition for unidimensionality (Hattie, 1985). Therefore, we also would recommend assessing the convergent and discriminate validity of these constructs by using structural equation modeling. Additionally, the mean and standard deviation of the scaled items was used to analyze each of the constructs and some of these findings are interesting (Appendix, Tables A1 and A2).

Regression analysis was used to test Hypotheses H1 through H6. All the results for the hypotheses tests are summarized in Table 3 above. As noted in the table, the results indicate that there is a positive and significant relationship between customer-focused (H1) and information-
focused (H2) capabilities to supply chain resilience. This classification of logistics capabilities was also used by Zhao et al. (2001); their findings showed that customer-focused capabilities had a significant and positive impact on competitive advantage. Information-focused capabilities alone, however, were not shown to have a direct impact on competitive advantage. The results of the analysis for this study suggest that there is a significant and positive relationship of information-focused capabilities is to supply chain resilience.

To test hypothesis H3, the following model was evaluated:

$$SCR=\beta_0 + \beta_1 \times RMO + \varepsilon$$

where SCR is the average of the scaled items (SCR1 to SCR6); RMO the average of the scaled items (RMO1 to RMO5); $\varepsilon$ - the error term in the regression model. We expected that the results from this analysis will support Hypothesis H3 that risk management orientation has a positive impact on supply chain resilience. Specifically, it was predicted that the regression coefficient in this case would be positive and significant ($p<0.05$). The results from this analysis support Hypothesis H3. The overall regression was significant ($R^2=0.714$), and the regression coefficient was positive (10.27) and significant ($P < .0001$). Thus the obtained results are consistent with the theoretical expectations. The regression results also provide support for hypotheses related to logistics capabilities: H1 ($t=2.71, P=0.0073$) and H2 ($t=3.28, P=0.0012$).

Similarly, there is a support for Hypothesis H4: The greater the supply chain resilience, the greater the perceived competitive advantage. The regression coefficient was positive (5.85) and significant ($P < .0001$) in this case as well. However, Hypothesis H6 was not supported. While a perceived relationship between supply chain process variability and perceived competitive advantage was negative, as expected, the results were not statistically significant in this case.
To test hypothesis H5, the following model was evaluated:

\[ SCPV=\beta_0+ \beta_1* SCR+ \varepsilon \]  

(2)

where SCR is the average of the scaled items (SCR1 to SCR6); SCPV the average of the scaled items (SCPV1 to SCPV4); \( \varepsilon \) - the error term in the regression model. It was anticipated that the results from this analysis would support Hypothesis H5 that supply chain resilience has an impact on decreasing supply chain process variability. Specifically, it was expected that the regression coefficient in this case would be negative and significant (\( p<0.05 \)). The regression coefficient was negative (-5.22) and significant (\( P < .0001 \)). Thus obtained results are also consistent with the theoretical expectations.

**Conclusions**

This study makes several important contributions to the body of knowledge. First, it provides greater understanding of the largely unknown area of supply chain risk management and begins to fill a gap in the literature. Second, the empirical results of this study lend additional support to several existing theories such as a resource-based theory of the firm. Third, to the best of our knowledge, it is a first attempt to develop meaningful measures for such important constructs as supply chain resilience and risk management orientation. Finally, this study prompts additional questions that can lead to new research streams and further empirical testing. For example, a little is known about formative elements, conditions, antecedents and consequences of supply chain resilience. This study shows one way to explore the phenomenon gaining additional understanding from the similar constructs found in the related disciplines and exploration of hypothesized relationships. Specifically, the logistical aspect of supply chain resilience, underrepresented in the existing literature, was directly addressed.
There are several implications for managers as well. First, the model provides additional insight into the area of risk management when managerial decisions are especially important such as responding to supply chain disruptions. Managers can use this process knowledge to respond to such disruptive events more effectively and with increased confidence. Second, managers are encouraged to examine logistics capabilities and supply chain connections to ensure that they have the most effective structure and efficient response possible. New ways to evaluate logistics performance at the time of disruption could be used to maintain continuity of supply chain flows. The results of this study suggest that managers should consider proactively addressing issues with logistics capabilities and supply chain confidence prior to the occurrence of supply chain disruptions. They may also focus on how to cultivate a high level of supply chain confidence among members of the supply chain. Such efforts might lead to better performance outcomes and eventually to sustainable competitive advantage.

The opportunities for future research are abundant. Further conceptualization using different research perspectives would be highly recommended. For instance, knowledge-based theory could be used to develop the learning orientation of supply chain resilience. Different risk assessment paradigms, such as probabilistic choice, systems theory and the theory of constraints could also be applied to advance the discussed research topic.

Additional understanding of the phenomena of interest could be gained by using a qualitative approach. For example, supply chain resilience could be researched from the managerial perspective using grounded theory qualitative methodology. This approach is proven to be useful in generating depth of understanding when not much is known about a phenomenon of interest and when it concerns complex social processes such as managerial decision-making under uncertainty.
Finally, the measurement of supply chain resilience represents a future potential research stream that will provide important knowledge regarding the outcomes of this phenomenon. It will be important to understand how (and if) supply chains can return to an original or better state. More precise metrics will need to be developed and tested in future research. Such measurement will assist firms and their respective supply chains to determine the extent to which elements and components of supply chain resilience should be developed.
## Appendix

### Table A1

Risk Management Orientation

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority placed on risk management</td>
<td>5.35</td>
<td>1.50</td>
</tr>
<tr>
<td>Transparency and sharing of information</td>
<td>4.88</td>
<td>1.54</td>
</tr>
<tr>
<td>Contingency plans for supply chain risks</td>
<td>4.82</td>
<td>1.59</td>
</tr>
<tr>
<td>Regular monitoring of suppliers for possible risks</td>
<td>4.83</td>
<td>1.54</td>
</tr>
<tr>
<td>Dedicated personnel for supply chain risk mgmt.</td>
<td>4.11</td>
<td>1.98</td>
</tr>
<tr>
<td>Insuring against supply chain risks</td>
<td>3.99</td>
<td>2.09</td>
</tr>
</tbody>
</table>

### Table A2

Supply Chain Resilience

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quick restoration of product flow following</td>
<td></td>
<td></td>
</tr>
<tr>
<td>unexpected disruptions</td>
<td>4.78</td>
<td>1.54</td>
</tr>
<tr>
<td>Recovery to original or new state after disruption</td>
<td>4.83</td>
<td>1.45</td>
</tr>
<tr>
<td>Prepared for dealing with financial outcomes of supply chain disruptions</td>
<td>4.57</td>
<td>1.50</td>
</tr>
<tr>
<td>Able to maintain desired level of connectedness among members during disruption</td>
<td>4.83</td>
<td>1.53</td>
</tr>
<tr>
<td>Able to maintain desired level of control at time of disruption</td>
<td>4.73</td>
<td>1.55</td>
</tr>
<tr>
<td>Extract meaning and knowledge from disruptions</td>
<td>4.79</td>
<td>1.54</td>
</tr>
</tbody>
</table>
References


