Understanding the concept of supply chain resilience

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Abstract

Purpose – In the emerging disciplines of risk management and supply chain management, resilience is a relatively undefined concept. The purpose of this paper is to present an integrated perspective on resilience through an extensive review of the literature in a number of disciplines including developmental psychology and ecosystems. In addition, the paper identifies and addresses some of the current theoretical gaps in the existing research.

Design/methodology/approach – Supply chain resilience has been defined by a number of disciplines. An integrative literature review is conducted in an attempt to integrate existing perspectives. This review also serves as the basis for the development of a conceptual model.

Findings – The key elements of supply chain resilience and the relationships among them, the links between risks and implications for supply chain management, and the methodologies for managing these key issues are poorly understood. Implications for future research advocate testing the proposed model empirically.

Practical implications – Supply chain disruptions have adverse effect on both revenue and costs. Resilient supply chains incorporate event readiness, are capable of providing an efficient response, and often are capable of recovering to their original state or even better post the disruptive event.

Originality/value – Supply chain resilience has yet to be researched from the logistics perspective. Even in well-developed disciplines the unified theory of resilience is still under development. This research leverages existing knowledge and advances an interdisciplinary understanding of the concept.

Keywords Supply chain management, Risk management, Adaptability

Paper type Research paper

Introduction

Every activity that a supply chain conducts has inherent risk that an unexpected disruption can occur. The global reach of supply chains, shorter product life cycles, and increasing customer requirements have made businesses aware that supply chain disruptions can cause undesirable operational and financial impact. Disruptions such as the loss of a critical supplier, a major fire at a manufacturing plant, or an act of terrorism have the potential to adversely affect both revenue and cost. They can lead to lost sales and even market share as well as increase costs due to premium and expedited logistics services. To reduce this risk, supply chains must be designed to incorporate event readiness, provide an efficient and effective response, and be capable of recovering to their original state or even better post the disruptive event. This is the essence of supply chain resiliency.

The concept of resilience is multidimensional and multidisciplinary. On the one hand, resilience was a subject of scientific research for many years in such disciplines as developmental psychology and ecosystems. On the other hand, it is a subject of interest in relatively new emerging disciplines such as risk management and supply

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chain management. Even in well-developed disciplines, the existing definitions of resilience are often contradictory and confusing, and the unified theory of resilience is still under development. In order to justify the need for resilient supply chains, one needs to have an operational definition of the phenomenon of resilience as well as an understanding of the key elements and capabilities that characterize it. This research attempts to address that knowledge gap through a multidisciplinary integrative review of the different perspectives to identify current gaps in the supply chain resilience literature. This review provides the basis for developing a conceptual framework of the dimensions of supply chain resilience, its antecedents, and its consequences.

Supply chain disruptions can arise from many sources, including external sources such as a natural disaster and internal sources such as a failure to integrate all functions in a supply chain. Very often such events happen rapidly and without warning. Disruptions can also result from attempts to create a more efficient, cost-conscious supply chain environment. In many companies logistics activities such as raw materials supply, component assembly, manufacturing, and even product distribution are outsourced to partners that are located across the globe. This structure has created a supply chain-dependent environment in which any disruption can have a much more pronounced effect as it ripples either upstream or downstream in the supply chain.

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 an efficient and effective response and continuing with business as planned. Gaining a better understanding of resiliency in supply chains is not possible, therefore, without the consideration of logistics capabilities. The conceptual model presented in this study proposes a link between logistics capabilities and supply chain resilience.

Defining resilience and its scope

The study of resilience has its origins in development theory of social psychology and is an emerging theory in its own right. The concept of resilience is directly related to important issues such as ecological and social vulnerability, the politics and psychology of disaster recovery, and risk management under increasing threats. While there are commonly used definitions in each all of these areas they are discipline-specific. In many cases the domain covered by the resilience construct lacks clarity. Thus, in order to understand the phenomena of resilience, we need to first consider different perspectives and approaches from the various streams of literature. After an initial literature review, the following perspectives were identified as the most related and appropriate for the understanding of the phenomena of resilience.

Resilience from an ecological perspective

The Canadian ecologist Holling (1973) was one of the first researchers to note that systems have two distinct properties: resilience and stability. Resilience determines the ability of systems to absorb changes, and stability is the capacity of systems to return to an equilibrium state after a temporary disturbance. The faster a system returns to equilibrium, the greater its stability. 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).

The concept of resilience has changed considerably since Holling's (1973) seminal paper. Several important dimensions of ecosystems resilience have been summarized by Westman (1986). The widely accepted definitions of resilience and its components from the ecological perspective are presented in Table I (Westman, 1986).

Gunderson and Holling (2001) defined resilience as the capacity of a system to experience disturbance and maintain it functions and controls. Carpenter *et al.* (2001) extended the research by examining 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). Carpenter *et al.* (2001) concluded that resilience has three primary properties:

(1) The amount of change that a system can undergo while retaining the same controls on structure and function.

(2) The degree to which the system is capable of organizing itself without disorganization or force from external factors.

(3) The degree to which a system develops the capacity to learn and adapt in response to disturbances.

Dovers and Handmer (1992) also stress the importance of this adaptive capacity while describing proactive resilience that accepts the inevitability of change and tries to create a system that is capable of adapting to new conditions and imperatives.

The ecological perspective presents a nondeterministic view of human behavior that declares behavior is not considered the outcome of a single cause but the result of multiple, complex person-environment exchanges over time (Gunderson, 2000). Because this point of view affords a holistic picture of life processes, ecological concepts are often used in conjunction with a resilience approach in social sciences.

	Definition
Resilience	Degree, manner, and pace of restoration of initial structure and function in an ecosystem after disturbance (Westman, 1978; Clapham, 1971)
Components of resilience	
Elasticity	Rapidity of restoration of a stable state following disturbance (Orians, 1975; Westman, 1978)
Amplitude	The zone of deformation from which the system will return to its initial state (Orians, 1975; Westman, 1978)
Hysteresis	The extent to which the path of degradation under chronic disturbance, and a recovery when disturbance ceases, are not mirror-images of each other (Westman, 1978, 1986)
Malleability	Degree to which the steady state established after disturbance differs from the original steady-state (Westman, 1978)
Damping	The degree and manner by which the path of restoration is altered by any forces that change the normal restoring force (Clapham, 1971)

Table I.
Components of resilience: ecological perspective

Social, psychological, and economic perspectives of resilience

The concept of resilience has been explored within the social sciences in three primary branches: social, psychology, and economics. In general, resilience has been used to describe the behavioral response of communities, institutions, and economies. Timmerman (1981) was one of the first to define resilience of a society as the measure of a system's capacity to absorb and recover from the occurrence of a hazardous event.

The United Nations International Strategy for Disaster Reduction (United Nations, 2005) offers a more comprehensive definition. Resilience is defined as the capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure.

This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve the effectiveness of risk reduction measures. System capacity is defined as the combination of all the strength, resources, and capabilities available within a community, society or organization that contribute to reducing the level of risk, or the effects of a disaster. Capacity, which may also be described as capability, can include physical, institutional, social, or economic resources and means, as well as skilled personal or collective attributes such as leadership and management that a community can bring to bear on management hazards. In addition to linking system capacity to resilience, previous research has identified several common levels of social resilience. These levels include: individual, family, tribe or clan, locality, or neighborhood, community, social associations (such as clubs and faith congregations), organization (such as a bureaucracy or a private sector firm), and systems (such as environmental and economic systems). This same hierarchal structure can be adapted in the study of supply chain resilience to reflect the multiple echelons that are found in the firm and across the supply chain.

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, and encompasses an understanding of biopsychological factors as well as the spiritual realm (Conrad, 1999). The specific area of study that addresses resilience is called developmental psychopathology, an examination of developmental differences in people's response to stress and adversity. Research in this area explores factors that serve as buffers, or prevents or moderates adverse reactions to stress.

In a recent paper, Reich (2006) examines 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).

(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 are underlying themes in other research as well. Stewart *et al.* (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, 1994). 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. Ross (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).

(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).

Ross 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 levels mirror the social system perspective and 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 from an organizational perspective

From the organizational perspective resilience has been defined in terms of adjustment to capacities or abilities. Definitions that are relevant to this research include:

- the capacity to adjust and maintain desirable functions under challenging or straining conditions (Weick *et al.*, 1999; Bunderson and Sutcliffe, 2002; Edmondson, 1999);

- a dynamic capacity of organizational adaptability that grows and develops over time (Wildavsky, 1988); and
- the ability to bounce back from disruptive events or hardship (Sutcliffe and Vogus, 2003).

The ability to recover from disruptive events was also examined by Mitroff and Alpasan (2003). They state that resilient organizations are proactive and recover better from hardship. However, resilience is more than just recovery; it also implies a certain level of flexibility and ability to adapt to both positive and negative influences of the environment. To summarize, the organizational perspective emphasizes important aspects of resilience such as adaptability, flexibility, maintenance, and recovery.

Another important aspect discussed in the organizational context is dealing with the outcomes of resilience. Hamel and Valikangas (2003) stress that resilience is not just concerned with recovery, flexibility, or crisis preparedness. It is also a distinct source of sustainable competitive advantage. Coutu (2002) indicates that resilience is a critical capability for success. Focusing on resilience as a distinctive organizational capability, Stoltz (2004) stated that resilience is the key to developing a strategic plan that is sustainable and capable of producing results that are better than less resilient competitors. All of the above findings are extremely important for understanding the phenomena of resilience in general, and supply chain resilience in particular.

Resilience in emerging interdisciplinary research streams

Emergency management and sustainable development perspective

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 *et al.* (2007) suggest that a disaster resilient community learns from its experience, supports sustainable development policies, mobilizes the government, and demands that effective policies be implemented. They identify 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. They also emphasize the learning perspective. 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). In addition, one of the most difficult parts of recovery is restoring social routines and economic activities. The process of recovery involves restoring people's psychological stability. It also involves learning positive lessons from the experience. In terms of logistics, Esper *et al.* (2007) note that the learning capability is a primary contributor to sustainable advantage that is achieved through competitive logistics strategy.

From the event management perspective, resilience is also referred to as one of the prerequisites for sustainable economic development that parallels the previously discussed organizational view of resilience as a source of competitive advantage. As an example, Folke *et al.* (2003) cite special interest groups in the Grand Canyon that have developed an "Adaptive Management Work Group" to learn more about enhancing the resilience of that ecosystem. This is contrasted to special interest groups in the Florida Everglades who do not seemingly understand how to build flexibility for adaptive

change that leads to resilience. These groups have not developed a culture for institutional learning that is necessary for sustainable economic development.

Supply chain risk management perspective

If emergency management deals with the issues of risks, disruptions, and recovery at the macro level of communities, societies, and humanity in general, risk management looks at the same issues from a business perspective. Supply chain management has been an established research area for at least ten years now and risk management for much longer than that. In recent years, we have evidenced the growing importance of risk management research, and supply chain risk management is at the forefront of this growing interest. This new research area has developed at the intersection of supply chain management and risk management (Paulsson, 2004). Supply chain resilience deals with multiple types of risks at multiple stages of the risk management process at the supply chain unit of analysis. Because resilience is one of the core elements of supply chain risk management this perspective must also be examined to determine how it should be incorporated into the resilience conceptual framework.

Today there is no generally agreed definition of supply chain risk management. Norrman and Lindroth (2004) 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. A more widely accepted definition was proposed by Jüttner *et al.* (2003) and Jüttner (2005); this definition was adopted later by other authors in their research (Manuj and Mentzer, 2008). According to this definition, supply chain risk management is defined 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." 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 present a classification of risks in four categories: supply, operational, demand, and security risks. While the discussion of multiple supply chain risks is beyond the scope of this review, the framework proposed by Norrman and Lindroth (2004) demonstrates the complexity of the issues and a growing potential of supply chain risk management research. Three primary dimensions – unit of analysis, type of risk/uncertainty, and stage of the risk management process – are used by Norrman and Lindroth to show the multidimensional nature of supply chain management risk research.

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. A supply chain's event management strategy is mitigated by logistics capabilities. These capabilities determine the extent to which the supply chain is ready and able of responding to unexpected events.

The concept of supply chain resilience

The concept of supply chain resilience proposed in this paper represents a multidimensional phenomenon. It is a relatively new concept within a broader supply chain risk management research stream. As such, it requires a clear understanding and conceptualization. The following definition of supply chain resilience was developed using multidisciplinary perspectives:

> 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.

This definition borrows several key elements from the previously reviewed disciplines. Adaptive capability is noted as a critical component of resilient ecosystems. Respond and recover at the same or better state is a common characteristic across all the perspectives examined including ecological, social, psychological, economics, organizational, and emergency management. Retaining (or maintaining) the same control over structure and function when a disruption occurs is a primary property of an ecosystem's resilience. This same theme is found in the organizational perspective, which states that resilience is the capacity to maintain desirable functions and outcomes during strain. While not directly specified, the psychological perspective also

addresses characteristics of resilience that enhance direction and understanding. Control, connectedness, and continuity (coherence) are three psychological principles of resilience that are believed to improve the response when natural or human-made disasters occur.

A resilient supply chain must be adaptable, as the desired state in many cases is different from the original one. Christopher (2005) 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. While it presents an interesting point of view, unfortunately, no theoretical justification is provided for this model. It is yet another confirmation of the emerging stages of discipline development, which presents a good opportunity for further scholarly research.

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 *et al.*, 2002; Sheffi *et al.*, 2003). 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. Several formative elements of resilience, such as flexibility, agility, and visibility are also separately discussed. Some of the related perspectives are summarized in Table II.

The gap in the research is the holistic conceptual picture. Many key elements, the relationships among them, the links between risks and implications for supply chain management, and methodologies to manage these key issues are poorly understood (Blackhurst *et al.*, 2005). Specifically, the logistical perspective has yet to be researched. The following sections propose an approach to address this gap in the research.

Linking logistics capabilities and supply chain resilience

The discipline of supply chain management is relatively new, and the concept of supply chain resilience is even newer. After reviewing all the different perspectives on resilience and discussing the need for a holistic conceptual framework for supply chain resilience, it is 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. For this research, the following questions are of interest:

- What are the antecedents of supply chain resilience from the logistics perspective? What is the link to logistic capabilities?
- What are some of the outcomes of supply chain resilience? How could it help companies gain a competitive advantage?

Most of the related research to this point has dealt with defining the concept of supply chain resilience, and identifying characteristics and components of resilient supply chains. One of the obvious gaps is the failure to conceptualize the complexity of

Discussed aspects	Relevant research summary
Agility, responsiveness	Christopher (2004) describes agility as one of the most powerful ways of achieving resilience in the supply chain. Agile supply networks are capable of more rapid response to changed conditions
Visibility	Increasing the visibility of demand information across the supply chain reduces the risks (Chopra and Sodhi, 2004)
Flexibility/redundancy	Christopher (2005) states that resilient processes are flexible and agile and are able to change quickly. Flexibility enables a manufacturer to respond quickly and efficiently to dynamic market changes (Swamidass and Newell, 1987). Rice and Caniato (2003) suggested a hybrid flexibility/redundancy approach for increasing supply chain resilience
Structure and knowledge	Knowledge and understanding of supply chain structures-both physical and informational-are important elements of supply chain resilience (Hong and Choi, 2002)
Reduction of uncertainty, complexity, reengineering	van der Vorst and Beulens (2002) view reduction of uncertainty as the way to improve supply chain resilience Christopher (2000) adds reduction of complexity through business process reengineering initiatives
Collaboration	Collaborative partnerships help to manage risks effectively (Sinha *et al.*, 2004; Lee, 2004)
Integration, operational capabilities, transparency	In describing the operational capabilities of resilient supply chains, Smith (2004) emphasized the importance of integrated environment that provides end-to-end interaction of orders, inventory, transportation and distribution to facilitate supply chain transparency

Table II.
Supply chain resilience: summary of selected aspects

cause-effect relationships between some related constructs. Answering the above research questions will contribute to the holistic understanding of the phenomena in question, its antecedents and consequences. The findings from the reviewed perspectives on resilience provide a fertile ground for establishing the hypothesized relationships. While the discussion of the relationship between logistics and supply chain management is far beyond the scope of this research, the related literature provides a sufficient theoretical justification for formulating the first research question presented above. Moreover, the relationships between the researched constructs and such concepts as flexibility, agility, visibility, and responsiveness should be clarified. Interestingly, enough, while some authors view them as logistics capabilities, others consider them as important characteristics of resilient supply chains (Christopher, 2005; Sheffi, 2007).

Logistics capabilities, supply chain resilience and sustainable competitive advantage

It is the thesis of this paper that the dynamic integration of logistics capabilities enables supply chain resilience that leads to sustainable competitive advantage. The resource-based view (RBV) of the firm provides important insights for understanding how competitive advantage within firms is created and how such advantage is sustained over time. Briefly, RBV states that firms obtain competitive advantage by accumulating internal resources and capabilities that are rare, valuable, and difficult to imitate (Barney, 1991). Thus, one of the main objectives for firms applying a RBV is to

identify their capabilities and develop them further (Day, 1994). Owing 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 (1991) 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.

Teece *et al.* (1997) develop the RBV approach one step further by formulating the dynamic capabilities perspective. According to their study, the term "dynamic" refers to the capacity to renew competences so as to achieve congruence with the changing environment. 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 or distinctive competencies consist of those attributes, abilities, organizational processes, knowledge, and skills that allow a firm to achieve superior performance and sustained competitive advantage over competitors.

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 *et al.*, 1998; Lynch *et al.*, 2000; Zhao *et al.*, 2001; Mentzer *et al.*, 2004; Esper *et al.*, 2007). Morash *et al.* (1996) found a correlation between strategic logistics capabilities and firm performance. The four key logistics capabilities that were identified – delivery speed, reliability, responsiveness, and low cost distribution – were significantly related to performance and were noted as critical components for sustained competitive advantage. Olavarrieta and Ellinger (1997) show that logistics capability qualifies to be a distinctive capability (the one leading to sustainable competitive advantage) by reviewing characteristics such as added value, rarity, and difficulty for imitating. Mentzer *et al.* (2004) stress that logistics capabilities play a distinctive role in the integrative strategic process due to the expected benefits of improving firm efficiency and effectiveness leading to long-term firm profitability and survival.

In times of uncertainty, however, supply chain resilience also comes into play. It is a premise of this research that it is a missing link to sustainable competitive advantage. Dynamic capabilities themselves are often difficult to sustain under the conditions of uncertainty, especially in high-velocity markets (Eisenhardt and Martin, 2000). Under such conditions, the principles of resilience come into play. This suggests that resilience plays a key role in sustaining dynamic capabilities and maintaining the link between dynamically integrated capabilities and sustainable competitive advantage. This aspect is also supported by the nature of supply chain operations under constant change and uncertainty.

Second, an integrative aspect finds its theoretical justification in the recent stream of literature on demand-supply integration (Mentzer and Kahn, 1996; Jüttner *et al.*, 2007). It is also supported by the fact that no single capability alone, however strong it is, is sufficient for achieving a sustainable competitive advantage. Thus, logistics capabilities should be considered in appropriate combination rather than stand-alone abilities. In other words, they should be classified and integrated in order to make a significant impact on the formation of supply chain resilience and sustainable competitive advantage. It is proposed that only the integration of dynamic capabilities,

strengthened by the adaptive and coherent nature of supply chain resilience, can lead to a sustainable competitive advantage under the conditions of uncertainty. Also, risk perceptions of strategic decision-makers within the company and supply chain orientation are hypothesized to moderate the relationship between integrated logistics capabilities and supply chain resilience. A generalized macro-level model incorporating some of the concepts discussed in this section is presented in Figure 1. This generalized model results in the following research proposition:

RP1. The better the dynamic integration of logistic capabilities, the greater the supply chain resilience.

The supply chain resilience framework

The proposed model addresses the relative importance of specific logistics capabilities during each of three phases of supply chain resilience: readiness, response, and recovery. Three psychological principles of resilience defined previously (control, coherence, and connectedness) are also incorporated as part of the supply chain resilience framework. The hypothesized relationships between the phases and elements are presented in Table III.

Selected logistic capabilities are strategically placed within the matrix to reflect their relative importance at each phase of resilience. These capabilities are also grouped into three major categories of coherence, connectedness, and control. In the context of supply chain management, control relates to the direction and regulation of strategic and tactical actions within the supply chain network. Lambert and Cooper (2000) state that planning and control of operations is one of nine management components that are needed for successful supply chain management. Planning and control are key factors in moving an organization or supply chain in a desired direction. In their examination of supply chain redesign strategies for food companies, van der Vorst and Beulens (2002) state that uncertainty will result if decision makers are unable to accurately determine the impact of control mechanisms on supply chain

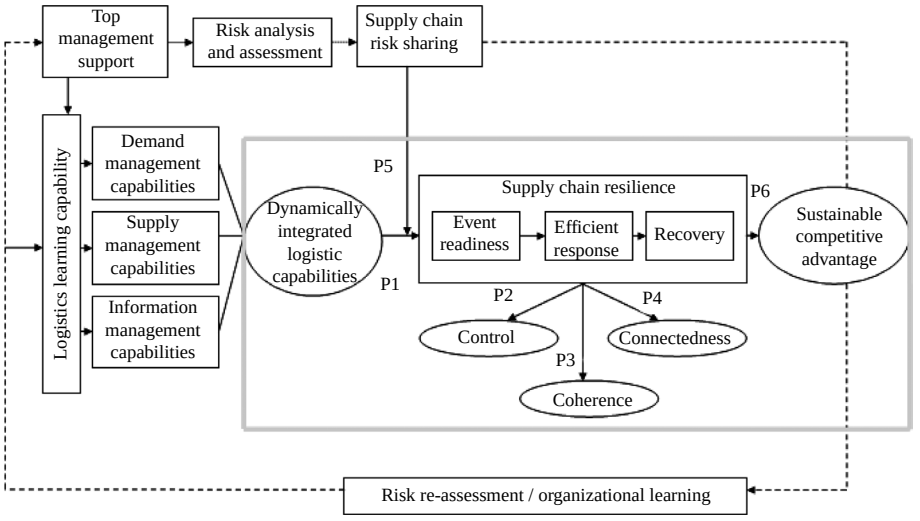

Figure 1.
Conceptual framework of the relationship between logistic capabilities and supply chain resilience

Resilience/capabilities matrix	Readiness	Response	Recovery
Control	Logistic quality, efficiency, cost minimization, risk-hedging capabilities, back-ups of systems and processes	Timeliness, postponement	Cycle-time reduction, delivery competency
Coherence	Effectiveness of logistic processes, systematic contingency planning	Flexibility, agility, risk-sharing	Customer service, efficiency of warehouse operations, knowledge management
Connectedness	Information technology upgrades, supply chain relationship building	Information sharing	Highly integrated systems and processes

Table III.
Resilience-logistics capabilities matrix

behavior, or if the supply chain lacks effective control actions. Perea *et al.* (2000) found that the performance of the supply chain is highly sensitive to operational control mechanisms, and that the control policies should be viewed as trade-offs in accomplishing the overarching objective. The following relationship of control to supply chain resilience is proposed:

RP2. The greater the resilience of the supply chain, the better it maintains control of logistics capabilities when disruptions occur.

Coherence in the emergency management literature is defined as the enhanced meaning, direction and understanding that results from disruptive events or potential threats. Reich (2006) discusses the need to have processes and procedures in place to provide order and structure to reduce uncertainty. A system without this element of resilience will be unable to prevent or counteract the results of a disruption. Woods *et al.* (2002) addressed coherence from the perspective of a value network. Their research suggests that the goal of the value network is to build supply chain coherence so that the network has the capability to act and innovate to facilitate new value and competitive advantage. Tan (2002) examined factors that hinder a supply chain in achieving the desired level of success. Nine primary concerns were reduced to three underlying factors including supply chain coherence. Jain *et al.* (1999) surmise that the best (or desired) outcomes can only be achieved through coherence which they define as the systematic or logical integration of diverse elements. According to the psychological principles of resilience, it is coherence that enables entities to create order and structure (i.e. desired outcomes) after a disaster occurs to (Reich, 2006). The various perspectives of coherence can be used to formulate the following proposition:

RP3. The greater the resilience of the supply chain, the better it maintains coherence of logistics capabilities when disruptions occur.

Connectedness is the third psychological principle of resilience that refers to the behavior of people to band together during times of disaster. From a supply chain point of view connectedness is often defined as the extent or degree to which a group of suppliers, manufacturers, distributors, third-party providers, retailers, and customers develop an integrated network to enable them to effectively and efficiently coordinate among the many different entities (Hertz, 2001; Thadakamalla *et al.*, 2004).

The integrated network provides a systematic coordination of efforts to avoid unwarranted replication and wastefulness of resources. A resilient community (or supply chain) is characterized by this interconnectivity:

RP4. The greater the resilience of the supply chain, the higher the levels of integration (connectedness) across logistics capabilities when dealing with disruptions.

Sharing both risks and rewards between the members of a supply chain is one of the key components of effective supply chain management (Mentzer *et al.*, 2001; Faisal *et al.*, 2006). Such risk sharing requires continuous risk analysis and assessment which is only possible with the presence of top management support. Supply chains usually operate in a dynamic business environment where specific risk situations are dependent on multiple factors. In order to assess supply chain risk exposure supply chain members need to identify both direct and indirect risks as well as the potential causes and sources of those risks at every significant link along the supply chain (Christopher *et al.*, 2003; Norrman and Janson, 2004). Thus, risk assessment and sharing among the members of a supply chain is an essential element of risk mitigation. The sharing of risk enables more effective decision making under uncertainty, strengthening the relationships between integrated logistics capabilities and supply chain resilience:

RP5. The greater the level of risk sharing in a supply chain (based on continual risk analysis, assessment and top management support) the stronger the relationship between logistics capabilities and supply chain resilience.

Competitive advantage is created through logistics capabilities which are comprised of demand, supply and information management capabilities (Fawcett *et al.*, 1997; Mentzer *et al.*, 2004). Tracey *et al.* (2005) found that firms that have three types of capabilities (outside-in, inside-out, and spanning) are able to act on and anticipate changes in markets. The dynamic nature of global business necessitates that a supply chain be capable of adjusting to change. Furthermore, it must be capable of efficiently handling unexpected events or disruptions both small and large. This resilience differentiates a firm from its competitors. That is, it builds competitive advantage that is sustainable. It is appropriate, therefore, to examine the role of logistics capabilities in producing sustainable competitive advantage:

RP6. The greater the supply chain resilience, the greater the sustainable competitive advantage.

The conceptual framework of the relationship between logistics capabilities and supply chain resilience presented in Figure 1 also includes the element of organizational learning. The learning aspects of resilience were discussed earlier from the perspectives of ecology and social sciences. The capacity to learn from an unexpected event and develop better preparedness for future disruptions is a principal property of resilience that is also found in emergency management. From a logistics viewpoint, Esper *et al.* (2007) state that learning outcomes are needed to develop new logistics strategies, tactics, and operations that will support further logistics capabilities. Organizational learning provides the means for these capabilities to continuously evolve and develop thereby enabling supply chain resilience to also advance and grow.

Suggestions for future research

As with any relatively new research area, the conceptual model presented in this paper is just one of the possible views. As such, it is an obvious limitation. This research contributes to the existing body of knowledge by summarizing several existing perspectives on the phenomena of resilience (with a specific focus on supply chain resilience). In addition it identifies gaps in the literature and proposes a framework to address the existing gaps. The logistical aspect of supply chain resilience which is underrepresented in the existing literature was directly addressed. The idea of establishing a meaningful linkage between logistics capabilities and supply chain resilience was a central concept for this research.

The key elements of supply chain resilience and the relationships among them, the links between risks and implications for supply chain management, and the methodologies for managing these key issues are poorly understood. Little theoretical justification exists for current supply chain resilience models that confirm the emerging state of this topic. Furthermore, the logistical perspective has yet to be researched. The relationship between logistics capabilities and supply chain resilience is largely unknown. In order to justify the need for resilient supply chains, one needs to have an understanding and clear definition of the phenomenon of resilience. The increased risks that are the result of complex and geographically disperse global supply chains necessitates that companies gain a better theoretical understanding of this emerging critical topic in order to effectively manage in this business environment.

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 disruptive events more effectively and with increased confidence. Second, managers are encouraged to examine logistics capabilities and supply chain connectedness to ensure more effective structure and more efficient response. New ways to evaluate logistics performance at the time of disruption could be used to maintain continuity of supply chain flows. Managers may also consider proactively addressing issues with logistics capabilities and supply chain risk sharing prior to the occurrence of supply chain disruptions.

The opportunities for further research are abundant. Further conceptualization using different research perspectives would be highly recommended. For instance, knowledge-based theory could help to develop the learning perspective 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.

The next phase of research is to test the proposed model empirically. After operationalizing selected constructs, specific measures should be developed, and the hypothesized relationships should be tested. Logistics capabilities could be grouped using exploratory factor analysis procedure, measuring specific logistics capabilities and exploring their factor loadings on factors such as connectedness, coherence and control. Performing such a procedure at each stage of supply chain resilience (readiness, response, and recovery) will determine the relative importance of specific logistics capabilities at each stage. In addition, supply chain risk assessment, top management support, and risk sharing were briefly discussed in this paper. The relationship between these items needs to be examined to gain a better understanding of their link to

integrated logistics capabilities and supply chain resilience. Knowledge-based theory could help to develop the learning perspective of supply chain resilience and its relation to organizational and logistics learning.

Additional understanding of the phenomenon 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 tradition. 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 different state. 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.

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