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I am submitting herewith a dissertation written by Serhiy Ponomarov entitled "Antecedents and Consequences of Supply Chain Resilience: A Dynamic Capabilities Perspective." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Business Administration.

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(Original signatures are on file with official student records.)

Antecedents and Consequences of Supply Chain Resilience: A Dynamic Capabilities Perspective

A Dissertation Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Serhiy Y. Ponomarov
May 2012

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DEDICATION

This dissertation is dedicated to my family.

ACKNOWLEDGEMENTS

I would like to thank many people who have either directly guided this research or provided various other kinds of encouragement and support during the entire process of my dissertation research and professional development. I am sincerely grateful for the excellent academic training that I have received at the University of Tennessee. I am indebted to many faculty members from the Department of Marketing and Supply Chain Management as well as from the other departments for that.

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ABSTRACT

Supply chain resilience is a comparatively unexplored area of supply chain research, that is related to risk management, but at the same time differs from traditional risk management approaches in that it focuses on firms' ability to absorb disruptions or enables the supply network to return to stable conditions faster. The increased risks that are the result of complex and geographically disperse global supply chains necessitate that companies gain a better theoretical understanding of this emerging critical topic in order to be sustainable in the long term and effectively operate in turbulent business environment. Thus, a better understanding of supply chain resilience, its major antecedents and consequences is warranted.

Employing a multi-disciplinary approach, this dissertation was exploring antecedents and value-based consequences of supply chain resilience from a firm perspective. A dynamic capabilities extension of the resource-based view was combined with several related theoretical perspectives to build a comprehensive conceptual framework filling the gaps in previous research. A combination of survey methodology and structural equation modeling was employed to collect and analyze the data drawing from a sample of supply chain and logistics managers. Quantitative data analysis resulted in significant theoretical and practical research implications. Finally, the directions for future research that have the potential to make a significant contribution to both business practice and academic research were proposed.

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CHAPTER 1 – INTRODUCTION

SUPPLY CHAIN MANAGEMENT

Supply chain management (SCM) is a phenomenon that touches nearly all functional business areas (Mentzer, Stank and Esper 2008). Today there is no one commonly accepted view of the SCM. Some ambiguity still exists in terms of clearly defining the domain of SCM and it's relationships with other disciplines (as evidenced by Mentzer et al. 2001, Mentzer 2001, 2004; Mentzer, Stank and Esper 2008; Cooper et al. 1997; Gibson et al. 2005; Frankel et al. 2008). According to the official Council of Supply Chain Management Professionals (CSCMP) definition (cf. Frankel et al. 2008):

> "*Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies*."

Naturally, planning and execution of multiple management activities, such as sourcing and procurement or logistics management, is a challenging task that requires efficient and effective coordination of physical, relational, informational, and financial flows that cross organizational boundaries (Mentzer, Stank and Esper 2008). There are inherent risks and vulnerabilities associated with each of the business processes. These risks make the task of coordination even more challenging, therefore proactive studying and managing such risks and the ways to address them becomes increasingly important, opening and reinforcing a new venue of business research.

SUPPLY CHAIN RISKS AND VULNERABILITIES

Every firm's supply chain is to some degree vulnerable and affected by a diverse set of risks (Knemeyer et al. 2009). Risks to the supply chain consist of anything that might interrupt the smooth flow of materials. Supply chain risk has 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). Many recent research publications deal with classifying all the supply chain risks, threats and disruptions defined as manifestations of risks. For example, Manuj and Mentzer (2007) classified risks into four categories: supply, operational, demand, and security risks. Zsidisin (2004) offered an analysis of supply risk assessment techniques and linked risk assessment to agency theory.

In general, two basic approaches to analyzing supply chain risk could be found in the literature. The first approach is purely qualitative, dealing with such categories as nature of the risk, qualitative view of possible consequences in terms of potential losses or gains, currently employed methods of risk management, and suggestions for improvement to risk management and new policies. It is presented mainly by descriptive case studies reviewed later in this paper. Such detailed views could be useful for describing the nature of risks and understanding related effects and consequences. They could serve as a good basis for discussion, but are limited in terms of not providing any empirical measures.

Qualitative supply chain risk research could be supplemented by quantitative approaches to analysis that are based on more specific empirical measures and calculation of expected values. While the specific studies vary, two factors are usually taken into account to assess risks empirically: (1) the likelihood of occurrence of the risky event; (2) the consequences in case of

event occurrence. Multiplication of these two factors results in expected value that could be used in ranking various risks (Manuj and Mentzer 2008). This approach also has its weaknesses. For example, according to Kunreuther (2006), inability to adequately characterize low-probability high-consequence events is the greatest weakness of risk management. Also, the traditional risk management approach often fails to respond adequately to unforeseeable events (Pettit et al. 2010). Similarly, Mitchell (1995) suggests risks contain different types of losses, and any particular type could be calculated by multiplying the probability of that loss by its significance. Other authors explore the connection between vulnerabilities and risks. Until the last decade, the concept of vulnerability had been relatively unexplored (Svensson 2000). Svensson (2002) defines vulnerability as unexpected deviations from the norm and their negative consequences and proposes the model that links the sources of vulnerabilities and risks. Sheffi and Rice (2005) extend this approach by assessing vulnerabilities and disruptions, and proposing a supply chain view of a resilient enterprise. Although, understanding and classifying supply chain-related risks and vulnerabilities is extremely important for supply chain scholars and business practitioners, it is just a first step in the process of supply chain risk management.

SUPPLY CHAIN RISK MANAGEMENT

Supply chain risk management is an emerging area of supply chain research that is being developed at the intersection of supply chain management and risk management (Christopher and Lee 2004; Jüttner 2005). A number of major trends have contributed to the increased importance of supply chain risk management during the last decade. Among them are globalization, outsourcing, transition to lean operations, and infrastructure-related issues (Manuj and Mentzer, 2008). Supply chain and logistics managers face a number of challenges on a daily

basis as they deal with uncertainties in demand and supply, shorter product life cycles, and changing customer requirements. Nevertheless, an element of risk and its structural complexity is often undervalued or not taken seriously (Jüttner 2005). When crises in a supply chain occur, managers tend to handle them as one-time events. As a result, only between 5% and 25% of Fortune 500 companies are prepared to handle supply chain disruptions due to risk situations (Mitroff and Alpasan 2003). The importance of effectively managing supply chain disruptions on a continuous basis as well as the lack of preparedness of most companies has drawn some attention in both academia and industry.

Today there is no generally agreed upon definition of supply chain risk management. One definition suggested by Norrman and Lindroth (2002, p.7) is:

> "*Supply chain risk management is applying risk management process tools collaboratively with supply chain partners to deal with risks and uncertainties caused by, or impacting on, logistics related activities or resources*".

While this definition is not very precise it brings 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 proposed by Jüttner, Peck and Christopher (2003), and subsequently used by Manuj and Mentzer (2008), provides greater specification:

> *"… [supply chain risk management is] 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."*

Subsequently, 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 included risk identification, risk assessment and evaluation,

selection of appropriate risk management strategies, strategy implementation, and mitigation of supply chain risks.

After reviewing a few hundred unique articles on supply chain and risk management, Paulsson (2004) concluded that the area of supply chain risk management has many sub-elements that have one thing in common: managing flow-related risks in the supply chain. Richie and Brindley (2004) add that there are many differing definitions of risk, supply chains and risk management. Examining existing research in more detail, however, demonstrates that the differences are primarily marginal and are simply based on different perspectives taken. 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.

In order to effectively manage supply chain risks and vulnerabilities, there is a need to go beyond risk classification. While risk identification and assessment are very important first steps, many authors go further to propose and analyze appropriate mitigation strategies (Manuj and Mentzer 2008, Svensson 2000, Kogut 2005). Knemeyer et al. (2009), for example, describe a proactive process for effectively planning for catastrophic supply chain events. Risk mitigation focuses on reducing the consequences of risk manifestations (Norrman and Jansson 2004) through developing risk management strategies (Manuj and Mentzer 2008). Seven main categories of risk mitigation strategies could be derived from the literature. These categories include: postponement, avoidance, hedging, control, sharing/transferring, and security (Juttner et al. 2003, Miller 1992, Manuj and Mentzer 2008). They additionally link supply chain agility to risk mitigation strategies. Similarly, Tomlin (2006) investigates the role of flexibility in the selection of countermeasures to mitigate risks by modeling the relationship of the firm with two suppliers: one reliable and one unreliable. The output of this model is based on the frequency and

duration of disruptions, the firm's level of risk aversion and supplier slack capacity. Sheffi and Rice (2005) investigate five aspects of flexibility and emphasize the role of developing a corporate culture that enables a firm to respond to disruptions quickly and effectively.

There is little empirical evidence to judge the effectiveness of risk mitigation strategies used in dealing with supply chain disruptions. Much of the justification is based on case studies and analytical models. As one of the few notable exceptions, Hendricks and Singhal (2003) analyzed the stock market reaction to supply chain disruptions based on a sample of 307 supply chain disruptions announced by publicly traded firms. They further investigated whether operational slack, business and geographic diversification, and vertical relatedness influence the stock market reaction to supply chain disruptions. Additional studies analyze the tradeoffs between the costs of risk mitigation investments, including the costs of management systems, and the expected costs of potential disruptions. Such an approach is emphasized for example by Kleindorfer and Saad (2005) who based their formulation on the risk mitigation framework originally proposed by Shavell (1984). At the same time, not all risks could be properly assessed and mitigated. One way to address this problem would be to develop the set of capabilities that prepare the company to adequately respond to a wide array of unexpected events and disruptions. That is where resilience comes into play.

SUPPLY CHAIN RESILIENCE

Supply chain resilience is a comparatively unexplored area of supply chain research. This area is related to risk management, but at the same time differs from traditional risk management approaches (Pettit et al. 2010; Ponomarov and Holcomb 2009) in that it focuses on firms' ability to absorb disruptions or enables the supply network to return to stable conditions faster (Sheffi

and Rice 2005). The concept of resilience is multidimensional and multidisciplinary. 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 of these areas, those definitions are discipline-specific (Ponomarov and Holcomb 2009). 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. Several different interdisciplinary perspectives inform this research adding to our understanding of supply chain resilience. Specifically, ecological, psychological, economic, and organizational perspectives were identified as the most related and appropriate for the understanding of the phenomena of resilience. These perspectives are reviewed in Chapter 2, followed by the definition and characteristics of supply chain resilience from the firm's perspective. Specifically, for the purposes of this research a firm's supply chain resilience is defined as:

> *"[supply chain resilience is]…the adaptive capability of a firm's supply chain to prepare for unexpected events, respond to disruptions, and recover from them in a timely manner by maintaining continuity of operations at the desired level of connectedness and control over structure and function."*

The details on how this definition was derived from the literature are also provided in Chapter 2 of this dissertation.

THEORETICAL FOUNDATIONS

There are a number of theoretical approaches that inform this research. Among the most important are: the resource-based view (RBV), the resource-dependence theory, the strategic choice theory and other related theoretical perspectives. The combination of the above approaches is used in this dissertation; therefore, it is important to review all the streams of related literature.

The fundamental question in the field of strategic management is how companies achieve and sustain competitive advantage (Teece, Pisano and Shuen 1997). The resource-based view (RBV) provides important insights for understanding how competitive advantage within firms is created and how such advantage is sustained over time (the concept of sustainable competitive advantage). The RBV is an influential theoretical framework widely discussed in the strategic and organizational academic literature. Briefly, the resource-based view states that firms obtain competitive advantage by accumulating internal resources and capabilities that are rare, valuable, and difficult to imitate (Barney 1991). The relational view is similar to RBV, but differs in a sense that a firm's critical resources and capabilities extend beyond the firm's boundaries. It could be manifested, for example, in buyer-supplier relationships.

A closely related resource dependence theory views interfirm governance as a strategic response to conditions of uncertainty and dependence (Pfeffer and Salancik 1978), building on early work in social exchange theory (e.g. Emerson 1962; Thibaut and Kelly 1959). This theory has its focus on environmental uncertainty and dependence as key antecedents for engaging in iterorganizational relationships. The main premise of resource dependence theory is that firms will seek to reduce uncertainty and manage dependence by purposely structuring their exchange

relationships (e.g. buyer-supplier relationships) by means of establishing formal or semiformal links with other firms (Barney et al. 2001, Ulrich and Barney 1984, Pennings 1981).

A strategic choice theory offers important additional insights that inform the formulation of proposed research framework. It was developed as an extension of a contingency theory in contrast to externally focused approaches such as institutional theory. Strategic choice theory emphasizes the role of managerial strategic decisions in organizational success or failure (Child 1972). A foundational assumption is that firms can actively shape their environment by making appropriate strategic choices (Ketchen and Hult 2007, Miles and Snow 1978). This dissertation uses a combination of the above approaches to develop the conceptual framework.

STATEMENT OF PURPOSE

Most of the related research to this point has dealt with defining the concept of resilience, emphasizing its importance, and identifying certain characteristics and components of resilient supply chains and organizations. The key elements of supply chain resilience and the relationships among them are still poorly understood. Furthermore, there are a limited number of studies that focus on analyzing antecedents and outcomes of resilience from the organizational perspective. Little theoretical justification exists for current supply chain resilience models, and the topic is currently evolving from the emerging state. Some of the obvious gaps are the failure to conceptualize the complexity of cause-effect relationships between related constructs, and to analyze the interactions between antecedents and consequences. Additionally, there is a definite need for empirical testing of the proposed conceptual models. Based on the previous discussion, a better understanding of a firm's supply chain resilience, its major antecedents and consequences is warranted.

The purpose of this dissertation is to contribute to such research efforts by proposing and empirically testing a comprehensive model that combines major hypothesized antecedents and consequences of supply chain resilience at the firm level of analysis. Answering the following research questions will contribute to the holistic understanding of the phenomena in question, its antecedents and consequences:

1) What are the antecedents of a firm's supply chain resilience from the organizational perspective?
2) What is the relative importance of specific capabilities for building resilient organizations?
3) What are some of the outcomes of supply chain resilience?
4) What are the ways to measure supply chain resilience, it's main antecedents and outcomes?

CONTRIBUTIONS OF THIS DISSERTATION

This dissertation has several potential theoretical and practical contributions. It contributes in terms of proposing and testing the conceptual model linking antecedents and consequences of a firm's supply chain resilience. A proposed conceptualization of resilience as a dynamic organizational capability is theoretically justified expanding the application of the resource-dependence theory and other related perspectives. Furthermore, a specific functional focus linking logistics capabilities and supply chain resilience is proposed and empirically tested. The strategic role of organizational orientations such as risk management and supply chain orientation is emphasized. Consequently, on the outcomes side of a conceptual model, organizational resilience is viewed as an antecedent to supply chain value creation and linked to

such important constructs as supply chain process variability and supply chain capital. Additionally, specific measures are developed for the theoretical constructs of firm's supply chain resilience, risk management orientation, supply chain orientation, supply chain process variability, and supply chain capital. The contributions are analyzed in more detail in Chapter 5 of this dissertation.

DISSERTATION ORGANIZATION

This dissertation is organized in five chapters. Chapter 1 provides the foundation for studying firm's supply chain resilience. In this chapter, the basic overview of concepts, existing gaps, and possible theoretical antecedents is provided followed by the statement of purpose and an outline of the organization of this dissertation. Chapter 2 presents the theoretical foundation for the supply chain resilience model. This chapter will develop and justify definitions of, and the interrelationships among the constructs of interest such as logistics capabilities, supply chain resilience, risk management orientation, and supply chain capital. The proposed model is accompanied by the literature review of the various components of the model as well as related research hypotheses. Chapter 3 contains a discussion of the research methodology used to test the proposed conceptual model and associated hypotheses. More specifically, it includes the discussions of the research design, sampling, measurement development and purification, pretest procedures and designs, and data analysis procedures. Chapter 4 provides an evaluation of the model and the results of hypotheses testing. Chapter 5 presents the conclusions based on the results of the hypotheses tests and structural equation modeling process. Theoretical and managerial implications and the directions for future research are provided.

CHAPTER 2 – THEORY BUILDING

ORGANIZING FRAMEWORK FOR THEORY BUILDING

Chapter 2 provides a comprehensive literature review which is further used to develop the theory of firm's supply chain resilience and justify the hypotheses for this research. This literature review illustrates the important ideas from various streams of previous research that could help in building the body of knowledge related to the topic of resilience in a systematic and organized manner (Creswell 2009). First, a general theoretical framework is proposed. Based on this framework, a resource-based view combined with dynamic capabilities perspective form a foundation for current research. Second, the theoretical framework is contextualized within logistic and supply chain management domains. Third, an interdisciplinary approach is taken to support and ground the conceptualization of supply chain resilience. Next, major relevant constructs related to the antecedents and outcomes of supply chain resilience are identified, conceptually defined, and analyzed through the theoretical lenses of resource-based view, resource-dependence theory, and strategic choice theory. Subsequently, important relationships among the constructs of interest are hypothesized and a conceptual model is proposed for testing.

THEORETICAL FRAMEWORK

Theoretical Lenses

A combination of theoretical lenses is used in this research to guide and support the development of a research model and its subsequent empirical investigation. Specifically, the following theoretical perspectives serve as the underpinning rationales behind the proposed research framework for a firm's supply chain resilience. First, the resource-based view and

related dynamic capabilities perspective serve as the major theoretical frameworks that inform current research. To a lesser degree this research is influenced by the resource dependence theory, strategic choice theory, and other related perspectives. Selected theoretical approaches are discussed in the following paragraphs.

Resource-Based View

The resource-based view (RBV), also referred to by some researchers as the resource-based theory (RBT) of the firm (Barney 1991, 1996; Conner 1991; Kogut and Zander 1992; Barratt and Oke 2007), was originally developed as a complement to the industrial organization (IO) view established by the works of Bain (1968) and Porter (1979, 1985). Focusing on the structure-conduct-performance paradigm, the IO researchers searched for determinants of firm performance outside the firm, specifically in its industry structure. In contrast, the RBV explicitly looks for the internal sources of sustainable competitive advantage (SCA) and aims to explain why firms in the same industry might differ in terms of performance (Kraaijenbrink et al. 2010).

In his original work Barney (1991) argued that sustained competitive advantage could be derived from the resources and capabilities the firm controls. These resources have been characterized as rare, valuable, not substitutable, and difficult to imitate. In addition, such resources and capabilities can be viewed as bundles of tangible and intangible assets that include a firm's management skills, its organizational processes and routines, and the information and knowledge it controls (Barney et al. 2001).

The RBV is currently one of the most influential frameworks for understanding strategic management and related disciplines (Barney et al. 2001). It was introduced almost twenty years ago, and subsequently developed through extensive theoretical development and empirical

testing. The RBV's principal development occurred between 1984 and the mid-1990's. Following Wernerfelt's (1984) initial study, many scholars offered valuable contributions to this view. Among the most significant of them are the contributions of Barney (1986, 1991), Rumelt (1984, 1987), Dierickx and Cool (1989), Conner (1991), Peteraf (1993), Conner and Prahalad (1996), Kogut and Zander (1992), and Teece et al. (1997) to name a few. Table 2.1 presents a summary of major contributions to the RBV (based on Olavarrieta and Ellinger 1997, Barney et al. 2001, Kraaijenbrink et al. 2010).

Table 2.1 Key Contributions to the RBV

Authors (year)	Major contribution
Penrose (1959)	Firms as bundle of resources, firm's growth is based on firm's resources and is limited by managerial resources.
Wernerfelt (1984)	Views firms as bundles of resources.
Rumelt (1984)	Offers a strategic theory of the firm based on the idea of firms as resource bundles.
Rumelt (1987)	Views firms as rent-seekers. The importance of isolating mechanisms to earn rents is emphasized.
Day and Wensley (1988), Grant (1991), Wernerfelt (1989)	Strategic formulation models that have firm resource as the central concept and as the sources of sustainable competitive advantage (SCA)
Dierickx and Cool (1989)	Established a link between specific firm assets and successful implementation of a firm's strategy.
Prahalad and Hamel (1990)	Core competences are viewed as the drivers of corporate strategy and diversification. Businesses should exploit and leverage core competences.

Table 2.1. Continued

Authors (year)	Major contribution
Hansen and Wernerfelt (1989), Rumelt (1991)	Empirical support for the hypotheses comparing firm-specific resources or organizational factors to industry factors and concluding that firm-specific resources are more important for explaining firm superior performance.
Barney (1991)	Key strategic resources can be sources of SCA if they are valuable, scarce, non-substitutable, and difficult to imitate.
Conner (1991)	Compares the resource-based theory with other strategy approaches derived from economics and offers a clarification of assumptions of the resource-based theory and its implications for rent-earning strategies.
Peteraf (1993)	Offers an integrative resource-based framework of SCA proposing that firms obtain superior performance by earning rents from scarce and efficient resources and from market power in the product markets.
Day (1994)	Offers a capabilities framework of SCA, distinguishing between outside-in, spanning and inside-out capabilities. Logistics and customer-order fulfillment capabilities were included in the framework.
Teece et al. (1997), Teece (2007)	Propose and develop a dynamic capabilities perspective.
Eisenhardt and Martin (2000)	Provide additional support for a dynamic capabilities perspective.
Mahoney (2001)	Offers an alternative perspective on the similarities and distinctions between the RBV and transaction cost economics (TCE).
Barney (2001)	Discusses the implications of linking the RBV to the neoclassical microeconomics and evolutionary economics literatures.
Barney et al. (2001)	Review up to date RBV research and offer a further research agenda.
Kraaijenbrink et al. (2010)	Offer a comprehensive review and assessment of key critiques related to the RBV, and offer additional suggestions for its future development.

Additionally, the theoretical and empirical development of the RBV has been reviewed and summarized by a number of researchers, including Barney et al. (2001), Acedo et al. (2006), Armstrong and Shimizu (2007), Newbert (2007), and Kraaijenbrink et al. (2010). The RBV has been applied to a number of research phenomena from several business disciplines. For example, it has made significant contributions to the areas of strategic human resource management (Wright et al. 2001), corporate governance (Lockett and Thompson 2001), entrepreneurship (Alvarez and Busenitz 2001), international business (Peng 2001), logistics (Olavarrieta and Ellinger 1997) and supply chain management (Ketchen and Hult 2006; Barratt and Oke 2007).

In the process of its development, the RBV has also been extensively criticized. After conducting an extensive analysis of the related literature, Kraaijenbrink et al. (2010) concluded that the critiques of the RBV could be summarized into several major categories. The most important and relevant to the current research categories of critiques are summarized in Table 2.2 along with an original assessment of such critiques and applicability to this research (adapted from Kraaijenbrink et al. (2010).

Table 2.2 Assessment of Selected Critiques to the RBV

Critique and authors	Assessment	Relevance to this research
1. The RBV has no managerial implications (Priem and Butler 2001).	Not all theories should have direct managerial implications. Through its wide dissemination, the RBV has evident impact.	A combination of the RBV and other theoretical approaches used in this research results in conceptual framework that has both theoretical and managerial implications.
2. The RBV's applicability is too limited (Miller 2003, Barney 2002).	The RBV applies only to firms in predictable environments.	A dynamic capabilities extension of the RBV could be successfully applied in the context of current research.

Table 2.2. Continued

Critique and authors	Assessment	Relevance to this research
3. SCA is not achievable (Fiol 2001, Eisenhardt and Martin 2000).	By including dynamic capabilities, the RBV is not purely static, though it only explains ex post, not ex ante, sources of SCA. Although no CA can last forever, a focus on SCA can still provide useful insights.	SCA is not directly measured in this research. Alternative value-based performance outcomes are researched instead.
4. The RBV is not a theory of the firm (Foss 1996).	The RBV does not sufficiently explain why firms exist, but it could offer some useful insights that should be used in combination with other theoretical approaches, such as TCE.	It is not a focus of current research. The RBV is used in combination with other theoretical frameworks to inform this research.
5. VRIN/O is neither necessary nor sufficient for SCA (Armstrong and Shimizu 2007, Newbert 2007).	The VRIN/O criteria are not always necessary and not always sufficient to explain a firm's SCA. The RBV does not sufficiently consider the synergy within resource bundles as a source of SCA.	SCA is not directly measured in this research. Alternative value-based performance outcomes are researched instead. A dynamic capabilities extension of the RBV applied in this research to some degree addresses the issue of synergy.

Note: SCA = sustained competitive advantage; TCE = transaction cost economics; VRIN/O = valuable, rare, inimitable, and non-substitutable resources and capabilities plus organization.

Kraaijenbrink et al. (2010) also offered some valuable suggestions for future development of the RBV. Perhaps, the most relevant to the context of present research is the suggestion related to the need for a more dynamic version of RBV. It is consistent with the recent developments in the streams of research on entrepreneurship (Langlois 2007, Sarasvathy and Dew 2005), dynamic capabilities (Teece et al. 1997, Teece 2007), and Austrian economics

(Foss 2007, Foss and Ishikawa 2007). Specifically, a dynamic capabilities perspective is applied in this research. It is described in the following subsections of this Chapter.

Resource Dependence Theory

Resource dependence theory (RDT) presents inter-firm governance as a strategic response to conditions of uncertainty and dependence between exchange partners (Pfeffer and Salanchik 1978; Heide 1994), building on social exchange theoretical perspective (Emerson 1962; Thibaut and Kelly 1959), RDT focuses on how some firms become reliant on others for needed resources such as goods and materials, and how firms can effectively manage such relationships (Pfeffer and Salanchik 1978). The asymmetric interdependence that is present in such relationships is often considered critical for reduction of environmental uncertainty (Ketchen and Hult 2007). In the supply chain context, supply chain members often work closely together to achieve common goals and become increasingly dependent on each other, thus, RBT offers a strong explanatory power in this context. Several authors discuss implications of this theory for key aspects of supply chain management (Crook and Combs 2007; Ireland and Webb 2007). In summary, RDT complements the RBV in that it views the organization as seeking to exploit and recombine unique and inimitable resources that may be outside the realm of the organization and where strategic orientation towards the relationships could lead to the appropriation of these resources (Fynes et al. 2004).

Strategic Choice Theory

A strategic choice theory was originally proposed by Child (1972) as a corrective extension to the classic contingency theory built on the basic assumption that it is possible to

achieve high organizational efficiency and performance through proper consideration of the context in which strategy is formulated and implemented (Wagner and Bode 2008). From the contingency theory perspective, strategies are viewed as merely necessary responses to the changes in the environment. The strategic choice perspective was developed as an alternative to the pure deterministic function between context and organizational structure. Child (1972) argued that organizations have strategic choice when designing their structure and processes, and while strategic decision-makers are to some degree constrained by contextual factors, they still have some room for strategic maneuvering (Wagner and Bode 2008). From a strategic choice perspective, matching or aligning organizational resources with the organization's context could be viewed as a major task for strategic decision-makers who should constantly evaluate environmental threats and opportunities and evaluate alternative strategic choices in order to achieve a strategic fit with the constantly changing environment (Miles and Snow 1978, Venkatraman and Camillus 1984). Thus, strategic renewal and repositioning are the central issues in strategic choice theory (Ketchen and Hult 2007). By choosing appropriate strategic alternatives, companies could increase their adaptability, while enacting and actively shaping their organizational environment. It could be manifested in the choice of strategic orientations.

Managing Firm Resources in Dynamic Environments

Value creation is regarded as a generally accepted purpose of a firm's existence. According to the RBV logic, possessing valuable and rare resources provides the basis for value creation (Sirmon et al. 2007). However firms do not function in a vacuum. There are inherent threats and opportunities presented by the surrounding environment. Firm resources are valuable

only when they are organized in a way to exploit opportunities and neutralize threats (Barney 1995).

A firm's external environment could be characterized in terms of constant change and uncertainty. For example, customer needs and expectations are continuously shifting, new technologies are developed, and new government regulations are introduced. Several authors have discussed the increasing complexity and velocity of change in organizational environments (Eisenhardt 1989; D'Aveni 1994; Eisenhardt and Martin 2000).

Various determinants of environmental uncertainty have been discussed in the academic literature (Achrol and Stern 1988; Aldrich 1979). In particular, environmental dynamism has been shown to be the strongest determinant of environmental uncertainty (Joshi and Campbell 2003; Bourgeois 1980; Duncan 1972). Environments that are frequently changing or shifting are described as dynamic (Aldrich 1979; Achrol and Stern 1988). Environmental dynamism generally refers to three sectors of a typical firm's external environment, including customer, competitor, and technology sectors (Jaworski and Kohli 1993). Thus, the business environmental dynamism has been typically defined in terms of unpredictable changes in products, technologies and market demand patterns (Zhou and Benton 2007; Miller and Freisen 1983).

From an organizational perspective, adaptation problems could be viewed as a result of environmental dynamism. It is especially challenging in the case of abrupt and unexpected changes such as supply, demand or operational disruptions. Under such circumstances the organizations need to adapt and reorganize quickly in order not only survive but also efficiently and effectively respond to a wide variety of environmental challenges. It could be done through strategic actions towards the development of dynamic capabilities.

Dynamic Capabilities within the Resource-Based Framework

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 specific firm assets. The organizational capability perspective views the firm as a bundle of relatively static and transferable resources, which are transformed into capabilities through dynamic and interactive firm-specific processes (Amit and Schoemaker 1993).

Due to their dynamics and complexity, however, capabilities are often difficult to identify. In addition, capabilities often span several functional areas making 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 capabilities. Thus, integration and coordination of resources are the key characteristics of capabilities.

Teece, Pisano and Shuen (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 of resources, organizational skills and functional competencies to respond to the challenges of the external environment. Thus, according to Teece, Pisano and Shuen (1997) dynamic capabilities could be defined as:

> *" [dynamic capabilities are]…the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments."*

Eisenhardt and Martin (2000) view dynamic capabilities as the antecedent organizational and strategic routines by which managers are acquiring, integrating, and recombining strategic resources in order to generate new value-creating strategies (Grant 1996; Zott 2003). They expand the definition of dynamic capabilities to include the firm's processes that use resources. Specifically, the processes to integrate, reconfigure, gain and release resources in order to create or match market changes are considered. According to this extended view, dynamic capabilities include well-known organizational and strategic processes that are valued for their ability to manipulate resources into value-creating strategies (Eisenhardt and Martin 2000).

Performance Outcomes

In contrast to traditional RBV approach, a dynamic capabilities perspective does not view dynamic capabilities as a source of sustained competitive advantage. RBV logic suggests that sustained competitive could be achieved when capabilities are valuable, rare, inimitable, immobile, and nonsubstitutable (Eisenhardt and Martin 2000). Dynamic capabilities are typically valuable and rare as they are not possessed by all the competitors equally, however the other conditions do not always hold. Thus, dynamic capabilities could be a source of competitive advantage, but there is usually not enough evidence to confirm sustainability. Moreover, long-

term competitive advantage is infrequently achieved in dynamic markets with high levels of environmental uncertainty. Therefore, it is necessary to consider some other possible value-based performance outcomes.

To summarize the above discussion, firms create value through the use of valuable and rare resources that are transformed into capabilities and could lead to positive performance outcomes. Dynamic capabilities evolve from individual firm capabilities as an adaptive response to the conditions of environmental uncertainty. A corresponding theoretical framework is presented in Figure 2.1.

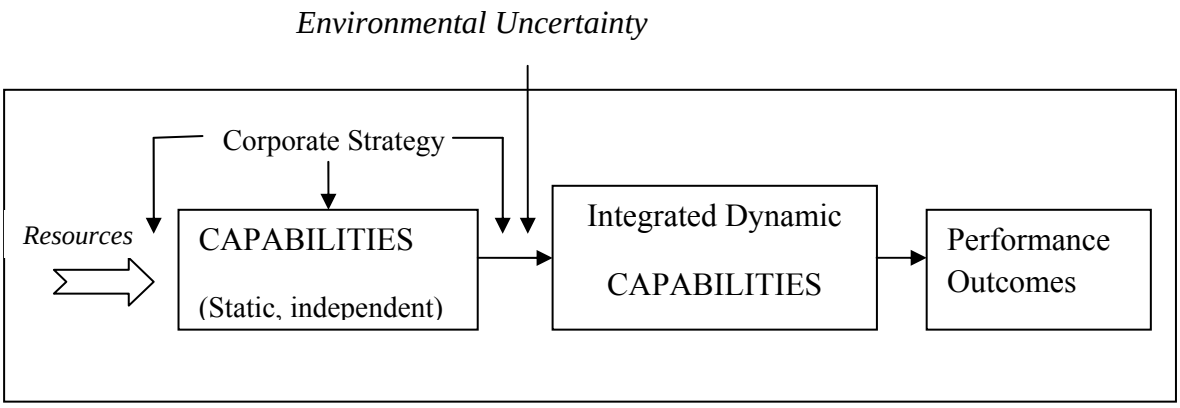

Figure 2.1
Theoretical Framework

CONTEXTUALIZATION OF THE THEORETICAL FRAMEWORK

Supply Chain Management Perspective

This research is purposefully conducted within a supply chain management domain. Effective supply chain management is essential for survival and success of any company. As mentioned earlier, this domain integrates planning and execution of multiple management activities, such as sourcing, procurement, and logistics management. This challenging task

requires efficient and effective coordination of physical, relational, informational, and financial flows that cross organizational boundaries in order to face the challenges presented by environmental uncertainty (Mentzer et al. 2008). Specifically, three different sources of uncertainty should be taken into account in the supply chain context. These include: supply uncertainty, demand uncertainty, and technological uncertainty (Fynes et al. 2004). Supply uncertainty refers to the unpredictable nature of the quantity of timing and supply which could occur as a result of manufacturing downtime, quality and yield problems, forecast inaccuracies or logistical malfunctioning (Walker and Weber 1987). Demand uncertainty is similar to supply uncertainty in that it relates to the unpredictable variations in the quantity and timing of demand as experienced in a supply chain. It is often operationalized as an amount of forecast error. Fynes et al. (2004) state that such factors as quantity and timing uncertainty could influence forecast accuracy and lead to either access inventory or shortages, and such problems could be further amplified by the bullwhip effect and additional demand distortion. Technological uncertainty refers to the rate of technological change, which could negatively affect the companies that are lacking appropriate capabilities.

There are inherent risks and vulnerabilities associated with each of the business processes. They are often manifested as supply chain disruptions that come in a variety of forms including transportation delays, port stoppages, accidents and natural disasters, quality and operational issues, and acts of terrorism to name just a few (Blackhurst et al. 2005; Mitroff and Alpaslan 2003; Chapman et al. 2002). Rice and Caniato (2003) state the fact that the supply chain is inherently vulnerable to disruptions, emphasizing that the failure of any one element of the supply network could cause the whole network to fail. Such failures could be extremely costly, and if handled poorly could results in significant supply chain delays triggering stock-

outs, inability to meet obligations, increases in costs, and decreases in shareholder value (Blackhurst et al. 2005; Hendricks and Singhal 2003; Knight and Pretty 1996). For example, Knight and Pretty (1996) found that a shareholder wealth could sharply decrease (by almost 8%) from the impact of publicly-announced supply-related disruptions. Similarly, based on the analysis of 519 public announcements related to supply chain glitches or disruptions, Hendricks and Singhal (2003) estimated a resulting 10.28% decrease in shareholder value. In a different study, Rice and Caniato (2003) utilized a survey methodology to estimate an average $50-100 million cost impact per day of supply chain disruption. Additional examples of quantifiable supply chain disruptions could be found in Radjou (2003) and other related studies. The bottom line is that disruptions could have severe negative consequences, potentially devastating to the whole supply chain. Therefore, it is important to proactively address supply chain risks and vulnerabilities at the strategic and operational levels.

Addressing such risks and vulnerabilities is an essence of organizational resilience. Thus, the choice of supply chain management domain as the main domain for this research is logical and theoretically sound. In a situation of increasing supply chain vulnerability, adopting a risk and uncertainty perspective to developing strategic capabilities becomes of paramount importance (Barry 2004). This approach is further narrowed down to focus on the effects of logistics capabilities discussed hereafter.

Focus on Logistics Capabilities

Logistics is often considered as an increasingly important area of strategic concern for firms (Bowersox et al. 1989, 1999; Lynch et al. 2000; Mentzer et al. 2001; Mentzer, Stank and Esper 2008). The boundary-spanning capabilities of logistics lie at the center of supply chain

management (Mentzer et al. 2001). Logistics includes managing transportation, inventory, facilities, materials order fulfillment, communication, third party providers and information within the firm in a way that contributes to customer value (Novack et al. 1992). Caputo and Mininno (1998) also emphasize that logistics is dealing with time and space utilities and generally refers to the inbound and outbound flow and storage of goods, services and information within and between organizations. CSCMP (formerly known as Council of Logistics Management (CLM) provides the following definition of Logistics Management (LM):

> "*LM is that part of SCM that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customer requirements*" (cited from Mentzer, Stank, and Esper 2008).

Internal logistics strategies and goals should be aligned with corporate strategy, functional structure and integrated logistics processes in order to improve logistics and firm performance (Defee and Stank 2005). Logistics enables firms to become efficient and effective via developing certain capabilities that are unique to that firm. Logistics capabilities could be viewed as valuable, scarce and difficult to imitate strategic resources that could explain differences in performance among firms (Olavarrieta and Ellinger 1997). Supply chain design, viewed as a formation of relevant capabilities into a unified supply chain, has been considered as the most fundamental competence of an organization, and the specific role of logistics capabilities in supply chain management could be explain with the help of resource-based and other relevant models (Fine 1998; Mentzer et al. 2001).

Studying and emphasizing the specific role of logistics capabilities in the development of firm's supply chain resilience is the focus of this research. Logistics capabilities are classified and further reviewed in the following sections of this chapter.

Resilience from the resource-based perspective

Bridging together two substantial streams of academic research, namely a strategic RBV theory and risk management perspective, in this research we propose to focus on a firm's supply chain resilience as a dynamic capability leading to several positive performance outcomes. In order to better understand the phenomenon of resilience, we need to first consider different perspectives and approaches from the various streams of literature. The following section of this research identifies and reviews significant contributions from different perspectives. Specifically, ecological, psychological, socio-economic, and organizational perspectives were identified as the most appropriate for understanding of the phenomenon of resilience.

THE CONCEPTUALIZATION OF SUPPLY CHAIN RESILIENCE

Contributions based on the Ecological Perspective

The Canadian ecologist C. S. Holling originally proposed a link between resilience and stability of an ecological system. Holling (1973) 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). The ability of an ecosystem to return to its original state after disturbance was specifically emphasized by 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 (1978) as the property of malleability. Amplitude is defined as a zone of deformation from which the system should recover (Orians 1975; Westman 1978). Clapham (1971) recognized that damping occurs after a disturbance when a system begins the process of restoration. Hysteresis compares the differences between the paths of distortion and restoration (Westman 1978; Westman 1986). Additional forces are present that alter the degree and manner of restoration. The commonly accepted definitions of the resilience and its components from the ecological perspective are summarized in the following table (adapted from Westman 1986):

Table 2.3 Components of Resilience from the Ecological Perspective

Resilience and its Components	**Source**	**Definitions**
Resilience	Westman 1978, Clapham 1971	Degree, manner, and pace of restoration of initial structure and function in an ecosystem after disturbance.
Elasticity	Orians 1975, Westman 1978	Rapidity of restoration of a stable state following disturbance.
Amplitude	Orians 1975, Westman 1978	The zone of deformation from which the system will return to its initial state.

Table 2.3 Continued

Resilience and its Components	Source	Definitions
Hysteresis	Westman 1978, Westman 1985	The extent to which the path of degradation under chronic disturbance, and a recovery when disturbance ceases, are not mirror-images of each other.
Malleability	Westman 1978	Degree to which the steady state established after disturbance differs from the original steady-state.
Damping	Clapham 1971	The degree and manner by which the path of restoration is altered by any forces that change the normal restoring force.

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).

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

Contributions based on the 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. These principles include: (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 band together; systematic coordination of efforts to avoid duplication and wastefulness of services). Reich emphasized that incorporating these key psychological principles of resilience into disaster planning would lead to a more comprehensive response resulting in improved effectiveness. Thus, from the psychological perspective, control, coherence and connectedness are viewed as key components of resilient response.

These principles were underlying themes in other research as well. For example, Stewart, Reid, and Mangham (1997) discovered several common postulates related to psychological aspects of resilience. First, resilience is a complex interplay between certain characteristics of individuals and their broader environments. Second, resilience is viewed as a dynamic process

that depends on life context. Third, resilience is developmental and most important during life transitions. Finally, resilience could be increased by decreasing negative risk factors and related vulnerabilities. At the same time, it is important to understand 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 (Grotberg 1995).

Contributions based on the Economic Perspective

According to Perrings (2001) static economic resilience refers to the ability or capacity of a system to absorb or cushion against damage or loss. A more general definition that incorporates dynamic considerations assumes the ability of a system to recover from a severe shock or stress. A systems theory assumption is that elements of any system are generally trying to maintain their stability even as they change. Based on this assumption, Rose (2004) describes 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).

Additionally, Rose (2004) identified three levels at which resilience can take place. These levels include: 1) microeconomic (individual level); 2) mesoeconomic (sector, market or community level); and 3) macroeconomic (including all individual units and markets combined).

The level of analysis discussion is directly applicable to the supply chain context. For example, resilience could be analyzed at the firm, buyer-supplier dyad, triad, or entire supply-chain levels. Important insights could be found at each level of the analysis. For example, at the community level economic perspective is usually supplemented by analysis of socio-economic factors as evidenced by the relatively recent disaster recovery stream of emergency management research. Lindell, Prater and Perry (2007) suggested that a disaster resilient community learns from its experience, supports sustainable development policies, mobilizes the government, and demands the implementation of the most effective policies. They identified four stages of emergency management, including hazard mitigation, disaster preparedness, emergency response, and disaster recovery. 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 also involves restoring people's psychological stability, and learning positive lessons from the experience.

Contributions based on the Organizational Perspective

From the organizational perspective, resilience has been viewed in terms of adjustment to capacities or abilities. For example, it has been defined in the literature as a dynamic capacity of organizational adaptability that grows and develops over time (Wildavsky 1988), as the capacity to adjust and maintain desirable functions under challenging or straining conditions (Weick et al. 1999; Bunderson and Sutcliffe 2002) or as the ability to bounce back from disruptive events or hardship (Sutcliffe and Vogus 2003; Mitroff and Alpasan 2003). Additionally, Mitroff and

Alpasan (2003) stated that resilient organizations are proactive by nature, which allows them to recover from hardship better. Hamel and Valikangas (2003) argue that resilience is not just concerned with recovery, flexibility or crisis preparedness. It also implies the capacity for continuous innovation, improvement, and serves as a distinct source of sustainable competitive advantage. The ultimate goal of building 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. Similarly, 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. To summarize, the organizational perspective emphasizes important aspects of resilience such as adaptability, flexibility, maintenance, recovery, and improvement. All of the above findings are extremely important for understanding the phenomena of resilience in general and firm's supply chain resilience in particular.

Synthesizing Interdisciplinary Contributions

In earlier supply chain research, resilience has been characterized as the ability of a firm's supply chain to react to unexpected disruption and restore normal supply network operations (MIT research 2003). Christopher and Peck (2004) added additional insights, defining supply chain resilience as the ability of the supply chain to return to its original state or move to a new, more desirable state after being disturbed. Additionally, resilience has been linked to firm performance and sustainable competitive advantage (Christopher and Peck 2004). Although the above definitions capture the essence of supply chain resilience, they are not fully taking into

account some important aspects that could be derived from the abovementioned interdisciplinary perspectives.

Alternatively, Ponomarov and Holcomb (2009) made an original attempt to synthesize several interdisciplinary approaches to resilience with existing risk management research. They developed a definition of supply chain resilience using a multidisciplinary perspective. Following a similar approach, we propose a definition that incorporates multiple perspectives and is based on a comprehensive literature review. For example, Christopher (2005) stated that resilient processes are flexible and agile and are able to change quickly. Therefore, a valid definition of supply chain resilience must include the premises that the supply chain is able to change quickly in the face of shifting externalities. Similarly, Reich (2006) examines three psychological principles of resilience that occur as a result of natural or human-made disasters. One of these notions, connectedness, is particularly salient for supply chain managers, given their interorganizational responsibility for delivering desirable business outcomes. Therefore, any valid definition of supply chain resilience should also focus on the connectedness of the supply chain network as a whole. Thus, based on the discussed approaches, the following definition of a firm's supply chain resilience was adapted for the purposes of this dissertation:

> *"[supply chain resilience is]…the adaptive capability of a firm's supply chain to prepare for unexpected events, respond to disruptions, and recover from them in a timely manner by maintaining continuity of operations at the desired level of connectedness and control over structure and function."*

This definition borrows several key elements from multiple disciplines and reflects the fact that a resilient supply chain must be able to anticipate possible disruptions, take appropriate action, and restore operations to the desired state within the needed time frame.

Ponomarov and Holcomb (2009) also proposed a conceptual model linking logistics capabilities to supply chain resilience emphasizing the importance of the logistics perspective. While the proposed model is interesting, it lacks an empirically-based confirmation. Subsequently, Pettit et al. (2010) identified several dimensions of vulnerabilities and capabilities, combining them within a single conceptual framework. Balanced resilience in that case is viewed as a portfolio of capabilities matched to the pattern of vulnerabilities, and the zone of resilience is defined as the desired balance between vulnerabilities and capabilities. Although the proposed conceptual framework was refined through a focus group methodology, an additional empirical investigation was called upon to add a much-needed empirically-based support to theoretically-derived propositions.

Overall, the literature related to supply chain resilience is sparse. Although existing research is informative, it is primarily focused on presenting several fragmented 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. Several formative elements of resilience, such as flexibility, agility, visibility are also separately discussed. Some of the related perspectives are summarized in the following table:

Table 2.4 Summary of Selected Characteristics and Approaches to Supply Chain Resilience

Reference	Emphasized Characteristics	Relevant research summary
Christopher 2004	Agility, Responsiveness	Resilience in the supply chain could be viewed as a more rapid response to changed conditions and is closely related to the idea of agility.
Chopra and Sodhi 2004	Visibility	Increasing the visibility of demand information across the supply chain reduces the risks.
Rice and Caniato 2003	Flexibility/Redundancy	Suggested a hybrid flexibility/ redundancy approach for increasing supply chain resilience.
Van der Vorst and Beulens 2002	Reduction of Uncertainty	View reduction of uncertainty as the way to improve supply chain resilience.
Christopher 2000	Reduction of Complexity, Reengineering	Adds reduction of complexity through business process reengineering initiatives.
Sinha et al 2004, Lee 2004	Collaboration	Collaborative partnerships help to manage risks effectively.
Hong & Choi 2002	Structure and Knowledge	Knowledge and understanding of supply chain structures (both physical and informational) are important elements of supply chain resilience.

ANTECEDENTS OF SUPPLY CHAIN RESILIENCE

Logistics Capabilities within the Resource-Based Framework

This research builds on previous studies that view logistics capabilities from the resource-based perspective (Lynch et al. 2000; Zhao et al. 2001). 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). 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).

Top firms build these types of logistics capabilities to improve performance and sustain competitive advantage. 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. 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. Only the proper combination of such capabilities allows a firm's supply chain to respond adequately to supply chain disruptions and other challenges associated with changes in external environment. In this research logistics capabilities are classified as supply management capabilities and information management capabilities.

Capabilities, particularly dynamic ones, are often difficult to sustain under the conditions of uncertainty, especially in high-velocity markets (Eisenhardt and Martin 2000). Recognizing the importance of dynamic capabilities, Eisenhardt & Martin (2000) argue that dynamic capabilities themselves are not always sources of long-term competitive advantage. They see the potential for long-term competitive advantage in finding innovative and adaptive ways of using dynamic capabilities.

The adaptive nature of resilience fits well in this picture. Under the conditions of uncertainty supply chain resilience could be viewed as an adaptive and dynamic element that integrates individual capabilities creating positive synergetic effects (Ponomarov and Holcomb 2009). 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 it 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.

The Role of Vulnerability and Environmental Uncertainty

Until the last decade, the concept of supply chain vulnerability has been relatively unexplored (Svensson 2000). Svensson (2002) defines supply chain vulnerability as unexpected deviations from the norm and their negative consequences. A similar perspective is that vulnerability can be viewed as a combination of the likelihood of an event and its potential severity (Sheffi 2005; Craighead et al. 2007). These definitions were supported and expanded by other authors (Chapman et al. 2002; Zsidisin 2003; Peck 2005). Most recently, Pettit, Fiksel and Croxton. (2010, p.6) define supply chain vulnerabilities at the enterprise level as, "fundamental factors that make an enterprise susceptible to disruptions". This definition is used in this research as well.

Environmental uncertainty could be viewed as one of the main determinants of vulnerability. Environmental uncertainty, which firms strive to reduce (Beckman et al., 2004), refers to the difficulty firms have in predicting the future because of incomplete information or changing conditions. Demand and supply unpredictability is viewed as major contributors to overall uncertainty (Chen et al. 2000). Supply chain processes need stability and predictability for effective coordination. High levels of uncertainty in a buyer-supplier operating context create a less controlled situation. Burns and Stalker (1966) and Lawrence and Lorsch (1967) have related environmental uncertainty to organizational structure and concluded that unpredictable

environments require more organic structures while predictable environments require more mechanistic structures. Managing uncertainty through various structural mechanisms has been noted as an essential issue for organizational design (Thompson 2003; Williamson 1981; Workman et al. 1998).

Patton (2006) proposed a conceptual framework where the duality of vulnerability and resilience is presented. Vulnerability is viewed as the opposite of resilience, and their outcomes ("gains" as a general term for the outcomes of resilience, and "losses" as a general term for the outcomes of vulnerabilities) are at the opposite ends of the spectrum. Similar conceptualization in the supply chain context is advocated by Pettit et al. (2010). They view supply chain resilience as a balance between capabilities and vulnerabilities.

THE MODERATING ROLE OF FIRM ORIENTATIONS

Firm orientations play a strategically important role for the success of firm's operations. 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 the conditions of external environment. Broadly, this defines orientation. Several specific orientations were previously researched in the academic literature, including market orientation (Kohli and Jaworski 1990; Deshpande et al. 1993; Slater and Navier 1995; Jaworski and Kohli 1996), supply chain orientation (Mentzer et. al. 2001; Min and Mentzer 2004; Min, Mentzer and Ladd 2007), learning orientation (Hult et al. 2000), and relationship orientation (Panayides 2007; Ganesan 1994; Mentzer et al. 2001).

After studying various perspectives, the importance of different orientations to firm's success becomes evident. Based on the comprehensive review of the related literature, two

specific orientations are believed to be the most important and relevant in the context of this research: risk management orientation and supply chain orientation. The next two subsections provide more details on each of these orientations.

Supply Chain Orientation

In order to adequately address the increase of complexity and uncertainty in business environments and gain efficiency and effectiveness, firms increasingly explore collaborative organizational structures and norms (Achrol 1997; Stank et al. 2005). Resource dependence theory suggests that in uncertain times stronger relationships allow the firm to draw the necessary resources from partners in order to leverage resources and sustain performance (Fynes et al. 2004). In the supply chain context, the formation of close long-term relationships with supply chain partners, such as key suppliers, could be viewed as the means of creating governance mechanisms to reduce uncertainty and manage dependence. Thus, a strategic supply chain orientation becomes increasingly important.

Supply chain orientation (SCO) is not synonymous to supply chain management. 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." SCO naturally resides in a single firm, but assumes the existence of the entire supply chain, from the point of origin to the point of consumption, where individual supply chain members are embedded in the network of complex interrelationships. Similarly, Lambert and Cooper (2000) emphasized the difficulties in managing the entire supply chain that goes beyond the tier one suppliers due to the lack of visibility and control, while Bowersox et al. (2002) further confirmed a need to incorporate the entire supply chain into strategic decision-

making. Subsequently, the strategic role of SCO as a supply chain coordination mechanism was supported by other researchers (Stank et al. 2005, Fugate et al. 2006).

As emphasized 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. Maloni and Benton (2000) offer additional support for viewing SCO as a strategic manifestation of supply chain management. Subsequently, Stank et al. (2005) further clarified that a firm adopting SCO would demonstrate a systems approach to viewing a channel as a whole, a strategic perspective focused on cooperative efforts to synchronize and converge operational and strategic capabilities, and a customer focus to create unique sources of customer value.

Additionally, SCO represents a managerial philosophy that is manifested in company's cultural norms and procedures directed to mobilize capabilities and create competitive advantages on both tactical and strategic levels (Mello and Stank 2005). Supply chain orientation is also a multidimensional construct that includes such elements as trust, commitment, cooperative norms, organizational compatibility, and top management support (Mentzer et al. 2001, Min and Mentzer 2004, Min, Mentzer and Ladd 2007).

Risk Management Orientation

Although risk management orientation (RMO) is equally important, it is not as well established in the academic literature as supply chain or market orientation. For the purposes of this research, 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. An emphasis is made on inter-organizational culture of continual risk analysis, risk assessment, risk sharing, and top management support.

The support for developing and analyzing the concept of RMO is provided by the growing importance of risk management (Juttner et al. 2003, Juttner 2005, Manuj and Mentzer 2008) and is based on conceptual parallels that could be analytically derived from other related constructs, such as market orientation. For example, Kohli and Jaworski (1990) defined market 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 could be considered as an enabler for various outcomes. For example, multiple studies have examined the link between market orientation and firm performance (Piercy et al. 2002; Kohli and Jaworski 1990). 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. A risk management orientation, on the other hand, would require a more holistic perspective that emphasizes the strategic importance of risk management initiatives.

OUTCOMES OF SUPPLY CHAIN RESILIENCE

It has been noted that traditional performance measures do not always describe value creation in broad enough terms to allow a proper assessment (Stank et al. 2005), therefore there is a great value in exploring alternative value-oriented performance outcomes. Two specific constructs are of interest as potential outcomes of firm's supply chain resilience: supply chain process variability and supply chain capital. These constructs are described in the following paragraphs.

Supply Chain Process Variability

Supply chain process variability has been defined as the level of inconsistency, or volatility, in the material flow of goods into, through, and out of a firm (Germain, Claycomb, and Droge 2008). This concept is broader than extensively researched production process variability (Anthony et al. 1999, Lee and Tang 1998, Melnyk et al. 1992). It includes internal variability in production lead times and output rates, but also focuses on the inconsistencies in inbound and outbound operational flows. More specifically, three main sources of supply chain variability are discussed in the literature (Germain et al. 2001). First, upstream sources of variability such as inconsistent or variable delivery performance of suppliers generally correspond to supply-related disruptions. Second, internal sources of variability such as inconsistent throughput rates, inconsistent product quality, or highly variable inventory levels could be caused by either supply-related or operations-related disruptions. Finally, downstream sources of variability such as changes in customer orders or delivery time requirements are usually corresponding to demand-related disruptions. As resilience minimizes negative consequences of supply chain

disruptions, it is proposed that the higher levels of firm's supply chain resilience will correlate with lower supply chain process variability.

Supply Chain Capital and Supply Chain Knowledge Development

The supply chain capital construct is built on the basis of social capital theory (Granovetter 1973, 1985, Baldwin et al. 1997, Lin 2001, Moran 2005). Supply chain capital is defined as (Autry and Griffis 2008, p.159):

> *"[supply chain capital is]…the value of a firm's supply chain network, derived from both the structural configuration and the nature of direct and indirect relationships present within the supply chain."*

Based on this definition, both structural components and relational attributes of the supply chain networks should be taken into consideration. More specifically, in order to increase supply chain capital firms have to rely on certain supply chain structural configurations and portfolios of supply chain relationships that maximize overall performance (Autry and Griffis 2008). Thus, a supply chain capital construct could be operationalized as a combination of structural and relational capital where structural capital represents the value derived from the structural configuration, while relational capital reflects the value created as a result of relationships within the supply chain. Autry and Griffis (2008) subsequently propose the linkage between supply chain capital and firm performance, suggesting both direct and indirect (through supply chain knowledge development) connection.

Resilience could potentially contribute to both structural (e.g. through providing better control over structure and function at the times of uncertainty) and relational capital (e.g. through contributing to continuity of relationships with the selected suppliers and third-party logistics

providers during and after possible disruptions). It could also positively affect an intellectual capital operationalized in the form of supply chain knowledge development. This research is attempted to assess such potential contributions by testing the linkage between resilience and supply chain capital empirically. Additionally, the relationship between supply chain resilience and supply chain knowledge development is also assessed in this research.

BUILDING A CONCEPTUAL MODEL OF SUPPLY CHAIN RESILIENCE

The extensive 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 is extremely important at this stage of the discipline development. This means that there are conceptual aspects that can be borrowed from 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, firm orientations, logistics capabilities, and potential outcomes provide a fertile ground for establishing hypothesized relationships and provide a sufficient theoretical justification for formulating the conceptual model presented in Figure 1 below.

The model presented in Figure 2.2 shows a hypothesized relationship between antecedents and outcomes of firm's 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 2.2. 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. Risk management orientation and supply chain orientation are proposed to moderate the relationships between logistics capabilities and supply chain resilience. Subsequently, firm's supply chain resilience is leading to reduction of supply chain process variability and increase in supply chain value represented by the construct of supply chain capital.

Therefore the following specific hypotheses are proposed:

1) Hypotheses related to antecedents of supply chain resilience:

   H1a: Supply management capabilities have a positive impact on a firm's supply chain resilience.

   H1b: Information management capabilities have a positive impact on a firm's supply chain resilience.

   H2: Supply chain vulnerability has a negative impact on a firm's supply chain resilience.

   H3: A higher level of environmental uncertainty results in a higher level of supply chain vulnerability.

   Additionally:

   H6: A higher level of environmental uncertainty results in a higher level of risk management orientation.

2) Moderating Hypotheses:

   H4a: Risk management orientation positively moderates the relationship between supply management capabilities and firm's supply chain resilience.

   H4b: Risk management orientation positively moderates the relationship between information management capabilities and firm's supply chain resilience.

H5a: Supply chain orientation positively moderates the relationship between supply management capabilities and firm's supply chain resilience.

H5b: Supply chain orientation positively moderates the relationship between information management capabilities and firm's supply chain resilience.

3) Hypotheses related to outcomes of supply chain resilience:

H7a: A higher level of the firm's supply chain resilience results in a lower level of supply chain process variability.

H7b: A higher level of the firm's supply chain resilience results in a higher level of supply chain capital.

H7c: A higher level of the firm's supply chain resilience results in a higher level of supply chain knowledge development.

Additionally:

H8: Supply chain process variability is negatively associated with supply chain capital.

H9: Supply chain capital is positively associated with supply chain knowledge development.

CHAPTER SUMMARY

In conclusion, this chapter provided a concise theoretical justification from which the supply chain resilience model was developed. This justification was based on the comprehensive literature review. The theoretical approaches were integrated with previous research contributions that were selected from the extended body of literature based on their relevance and importance. The hypothesized relationships between the constructs of interest focused around firm's supply chain resilience were manifested and presented in the form of nine context-specific research hypotheses.

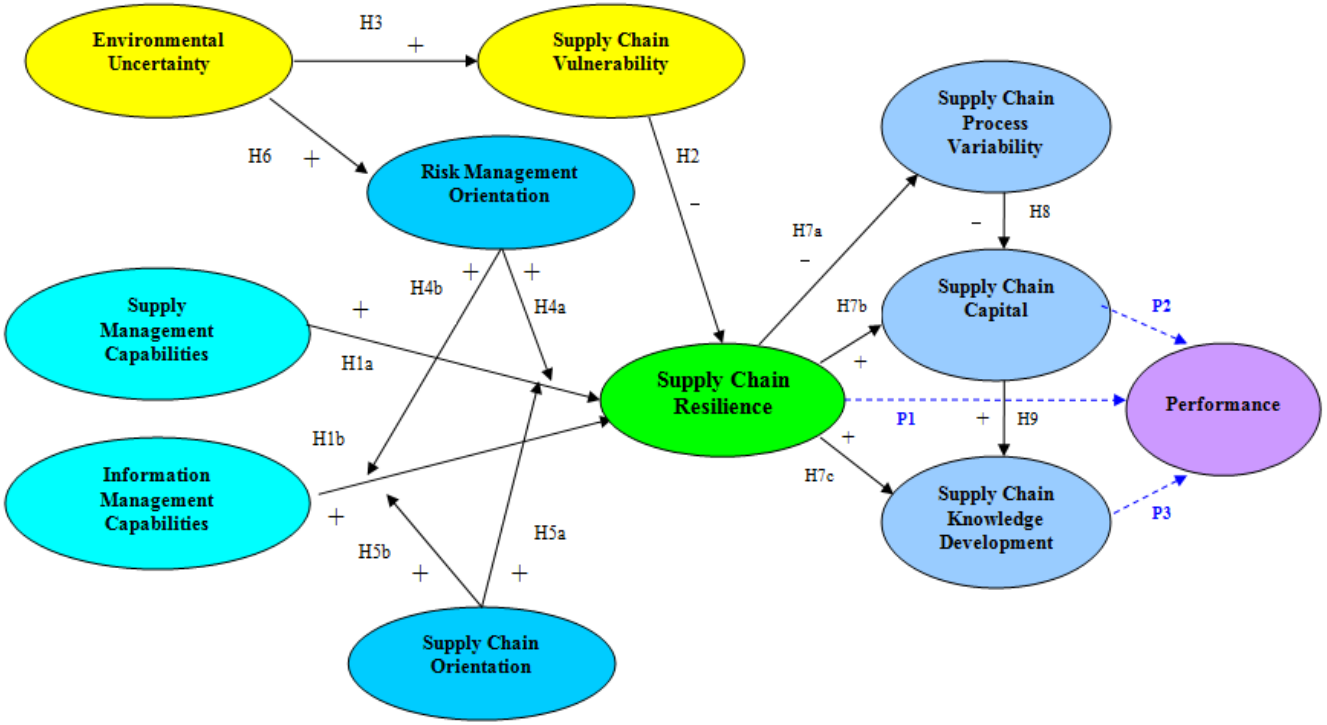

Figure 2.2

Antecedents and Outcomes of Firm's Supply Chain Resilience

CHAPTER 3 - METHODOLOGY

Chapter 3 provides details of the procedures used for testing fourteen theoretical hypotheses presented in the previous chapter. First, a structural equation model is formulated based on the hypothesized conceptual relationships among the theoretical constructs of interest. It is followed by a description of the research design that includes the sampling procedure and a discussion of the data collection methods. Next, construct operationalization and scale development are discussed. Finally, the rationalization for conducting a survey pre-test and main test is developed.

STRUCTURAL EQUATION MODELING

The theoretical model of the firm's supply chain resilience developed in Chapter 2 is converted into a structural equations model. The details related to this transformation are presented in this section. A Structural Equation Modeling (SEM) approach allows for modeling the structure of the hypothesized relationships and testing the validity in the process of theory building. SEM has been commonly used in recent years as a basis for theory development and testing within logistics, supply chain management, and other related disciplines (Wallenburg and Weber 2005). There are certain advantages that determine the choice of SEM methodology. First, in contrast to a widely used multiple regression analysis technique, SEM allows the modeling of complex structures including mediating variables. The covariance-based SEM not only allows incorporation of theoretical constructs as latent variables, but also correlations between different exogenous variables, as well as causal effects and correlations between different endogenous variables. It means that all hypothesized relationships could be tested simultaneously while indirect and direct effects on the endogenous variables could be separated.

Additionally, the model fit could be assessed using statistical tests and appropriate goodness-of-fit criteria. Also, measurement errors could be evaluated separately from other sources of errors which could help to facilitate model validation. However it is important to note that a comparatively large sample size is usually required to take advantage of the abovementioned benefits.

The basic structural equation model used in this research identifies four exogenous (independent) variables and five endogenous (dependent) variables. The nomological network of all the exogenous and endogenous variables is manifested in structural relationships among the ten constructs presented in this model. The exogenous variables include supply management capabilities, information management capabilities, supply chain orientation, and environmental uncertainty. The endogenous variables include supply chain resilience, risk management orientation, supply chain vulnerability, supply chain process variability, supply chain capital, and supply chain knowledge development.

RESEARCH DESIGN

A survey methodology was employed to gather the data necessary for testing the thirteen hypotheses presented earlier. The choice of this methodology is not accidental. First of all, surveys are appropriate for gathering a large number of responses in a comparatively cost-effective way (Kerlinger and Lee 2000). Also, this methodology allows for the quantification of responses and statistical testing for the validity of the obtained results. Additionally, the accuracy of survey data depends on the quality of the sampling procedures employed. Dillman (2000) proposed a theoretically-sound framework for such procedures, and it will be used in this research. More specifically, an Internet-based survey methodology will be followed based on

such comparative advantages as easier access to the target group of respondents, greater efficiency, cost-effectiveness, and the interactive dynamics between the respondents and the questionnaire (Dillman 2000; Dillman 2007).

Data Collection

All data was collected and analyzed at the firm level. A range of United States-based manufacturing firms that operate in various industries will be used for the purposes of data collection. This approach also allows achieving a reasonable level of external validity and generalizability (Cook and Campbell 1979; Shadish, Cook and Campbell 2002). The sample of survey respondents has been selected from the senior-level representatives of such firms. The potential respondents were pre-qualified in accordance with procedures described by Dillman (2000) and Kerlinger and Lee (2000).

Sampling and Research Procedures

Dillman's (2000) total design method was used for conducting the pre-test and the main study. Target respondents were senior-level managers with the knowledge of supply-chain and logistics functions and direct involvement in strategic and operational decision-making. Such individuals have been selected as key organizational informants due to their set of skills, business responsibilities, and functional expertise. In accordance with the data collection approach commonly used in business studies (Seidler 1974, Jap 1999), key informants were asked to explain the behavior of their respective organizations rather than individual behavior. To gain access to research informants, samples have been drawn from the databases maintained by a third-party organization specializing in integrating and regularly updating such data.

Specifically, the necessary contact information was obtained from "Dan & Bradstreet", a company that is offering such contact lists for sale. Only those respondents who met all the required qualifications were asked to participate in the research by responding to the survey questions. An executive summary of the research findings was provided by request as an incentive for participants.

SURVEY PRE-TEST AND MAIN TEST

In order to validate both adapted and newly developed measures and to ensure face validity a pretest was conducted. The five step process for a web-based survey was followed (Dillman 2000). A random sample was drawn from the database of potential participants and the pre-qualification calls were conducted. This was followed by the first wave of emails directing potential participants to the web-based survey. The second wave of emails was sent to those potential responders who do not respond within ten days. Subsequently, the respondents who would have indicated a willingness to participate but failed to respond were contacted to clarify the response status. Required non-response information was also collected. All the collected surveys were properly examined for respondent errors and missing data for each respondent and each variable. Next, the survey has been revised appropriately based on the results of the pre-test, and the pre-test respondents were removed from the list to avoid potential duplication. The same general procedure was used for the main test (Dillman 2000).

VALIDATION AND SCALE PURIFICATION

The issues of construct unidimensionality, reliability, convergent validity, and discriminant validity were addressed using the general procedure described by Garver and

Mentzer (1999). The unidimensionality was assessed in order to verify the existence of one latent construct underlying a set of corresponding measures (Hattie 1985). A confirmatory factor analysis was used to test each construct individually, then for all possible pairs, and finally for the overall measurement model and each construct in the presence of other constructs (Garver and Mentzer 1999). The final number of items used to measure each construct was adjusted accordingly.

Reliability was assessed using Cronbach's Alpha Coefficient. Specifically, the cut-off point of .70 was used to assess the value of this coefficient. In general, the value of Cronbach's Alpha above that cut-off point would indicate a good correlation between the item and the true scores (Churchill 1979). In other words, a measure would be considered a good indicator of the construct that is measured. Additionally, SEM scale reliability measures, construct reliability, and variance extracted will be also calculated for the purposes of validation (Garver and Mentzer 1999).

Construct validity was assessed through convergent and discriminant validity. Convergent validity describes the convergence of different measures of the same construct on a common statistical factor. Discriminant validity evaluates how measures of different constructs load on different factors (i.e. discriminate from each other). Convergent validity was assessed through the overall fit of the measurement model, the magnitude, direction, and statistical significance of the estimated parameters between the latent variables (Garver and Mentzer 1999). To assess discriminant validity, paired correlation of the constructs were evaluated. Correlations among the constructs of the measurement model were compared to the theoretical model with the help of the appropriate chi-square tests.

CONSTRUCT MEASUREMENT

Since several of the constructs used in this research were already tested empirically, the first step in developing the set of appropriate measures was to review the scales that were previously used in similar studies. As a result, the scales for logistics capabilities, environmental uncertainty, supply chain orientation, and supply chain process variability were adapted from previous studies with some necessary alterations, while the scales for risk management orientation, supply chain resilience, supply chain vulnerability, supply chain capital, and supply chain knowledge development were newly developed. The following paragraphs describe the operationalization and measurement of these theoretical constructs in greater detail.

Measuring Logistics Capabilities

The effects of two types of capabilities are studied in this research: supply management capabilities and information management capabilities. Supply management capabilities can be operationalized in terms of the relationships with selected suppliers, while information management capabilities can be operationalized as information technology capability, information sharing, and connectivity (Zhao, Droge, and Stank 2001).

Specific items for measuring each of the capabilities were adapted from previous research mentioned above. The operationalization proposed in this research, however, differs as it views supply management and information management capabilities as the first order constructs. The following specific items are proposed to be measured on a 7-point Likert-like scale:

Table 3.1 Measurement of Supply Management Capabilities

Supply Management Capabilities (SMC) – adapted from Zhao et al. 2001, Mentzer et al. 2004	**Strongly Disagree**			**Neutral**			**Strongly Agree**
1. Our firm has increased operational flexibility through collaboration with suppliers.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. Our firm actively pursues business relationships and programs designed to achieve supplier involvement over and above individual sales transactions.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. Our firm's logistical operations can be synchronized to integrate with supplier operations.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. Our key suppliers have established programs to authorize and perform our special requests.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Table 3.2 Measurement of Information Management Capabilities

Information Management Capabilities (IMC) – adapted from Zhao et al. 2001, Mentzer et al. 2004	**Strongly Disagree**			**Neutral**			**Strongly Agree**
1. Our firm effectively shares operational information between departments	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. Our firm effectively shares operational information externally with selected suppliers	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. Logistics databases are integrated across applications within our firm	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. Our firm's logistics information systems capture and maintain timely data	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. Logistics information systems in our firm are being extended to include more integrated applications	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. The information available in our firm is accurate	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7. Our firm has invested in technology designed to facilitate cross-organizational data exchange	**1**	**2**	**3**	**4**	**5**	**6**	**7**
8. Our firm has adequate ability to share customized information internally	**1**	**2**	**3**	**4**	**5**	**6**	**7**
9. Our firm has adequate ability to share information externally with key suppliers	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Environmental Uncertainty

The most popular operationalization of environmental uncertainty focuses on the unpredictability of the environment (Rindfleisch and Heide 1997). For example, Anderson (1985, 1988) employed a nine-item scale that addressed elements related to both the instability associated with environmental dynamism such as complexity or volatility, and the dangers of venturing into new activities such as entering new markets. Heide and John (1990) also conceptualize environmental uncertainty as unpredictability, but differ from Anderson by specifying technological and volume unpredictability. Similar scales were also employed by other authors (Stump and Heide 1996; John and Weitz 1989). More recently, environmental uncertainty has been operationalized in terms of combination of demand, supply and technological uncertainty (Fynes et al. 2004; Chen and Paulraj 2004; Slater and Naver 1994).

Table 3.3 Measurement of Environmental Uncertainty

Please evaluate the following aspects of your firm's external environment:

Environmental Uncertainty (EU) – adapted from Fynes et al. 2004, Chen and Paulraj 2004, Slater and Naver 1994	**Strongly Disagree**			**Neutral**			**Strongly Agree**
1. Our demand fluctuates drastically from week to week.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. Our supply requirements vary drastically from week to week.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. Our suppliers consistently meet our requirements.							
4. Our suppliers produce materials with consistent quality.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. The technology in our industry is changing rapidly.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. Technological changes provide big opportunities in our industry.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Supply Chain Vulnerability

Supply chain vulnerability could be operationalized at the enterprise level in terms of fundamental factors that make an enterprise susceptible to disruptions (Pettit et al. 2010). Based on this operationalization, the following measurement is proposed.

Table 3.4 Measurement of Supply Chain Vulnerability

Supply Chain Vulnerability (SCV)	**Strongly Disagree**			**Neutral**			**Strongly Agree**
1. Our firm's supply chain is vulnerable to supply-related disruptions.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. Our firm's supply chain is vulnerable to demand-related disruptions.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. Our firm's supply chain is vulnerable to operational disruptions.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. Our firm's supply chain could be characterized as having a high level of vulnerability.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Supply Chain Resilience

As defined in the current research, a firm's supply chain resilience was modeled as a latent variable and measured by several items on a seven-point Likert-scale. All items were newly developed based on related literature review and several unstructured interviews with supply chain management professionals and pre-tested by a panel of experts. They are presented in Table 3.5.

Table 3.5 Measurement of Supply Chain Resilience

Supply Chain Resilience (SCR)	Strongly Disagree			Neutral			Strongly Agree
1. Our firm's supply chain is able to adequately respond to unexpected disruptions by quickly restoring its product flow.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. Our firm's supply chain can quickly return to its original state after being disrupted.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. Our firm's supply chain can move to a new, more desirable state after being disrupted.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. Our firm's supply chain is well prepared to deal with financial outcomes of supply chain disruptions.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. Our firm's supply chain has the ability to maintain a desired level of connectedness among its members at the time of disruption.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. Our firm's supply chain has the ability to maintain a desired level of control over structure and function at the time of disruption.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7. Our firm's supply chain has the ability to extract meaning and useful knowledge from disruptions and unexpected events.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Supply Chain Orientation

Supply chain orientation has been measured based on a reflective five-construct scale (Mentzer et al. 2001, Min, Mentzer and Ladd 2007). The specific constructs included the following: trust, commitment, cooperative norms, organizational compatibility, and top management support. This operationalization is presented in Figure 3.1.

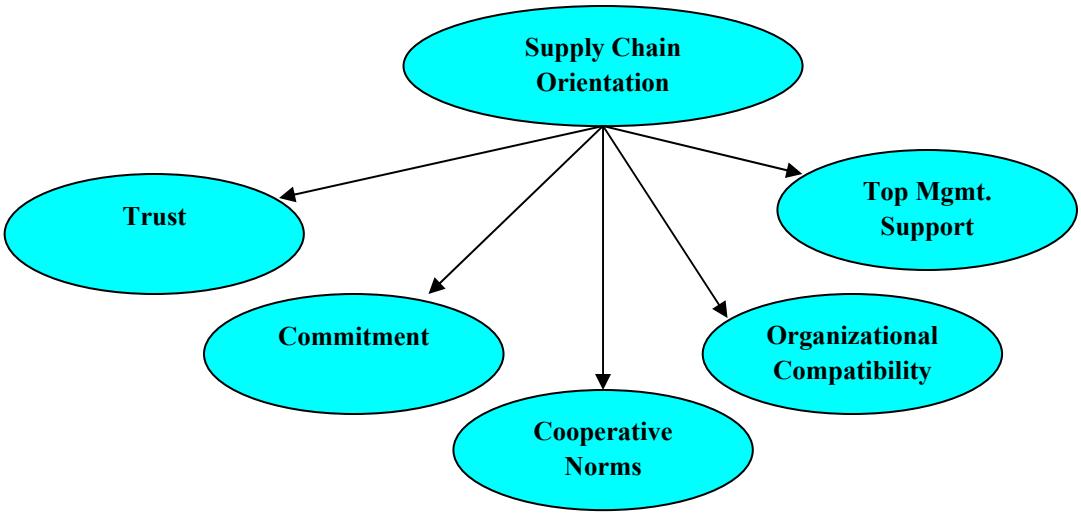

Figure 3.1
Operationalization of Supply Chain Orientation

Alternatively, we propose to measure supply chain orientation as a first order construct that is not relationship-specific as in the above operationalization. Thus, specific measurement items were adapted from the previous research after undergoing the process of re-clarification and appropriate adjustment.

Table 3.6 Measurement of Supply Chain Orientation

Supply Chain Orientation (SCO)	Strongly Disagree			Neutral			Strongly Agree
1. We trust our key suppliers.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. We trust our key customers.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. We believe that our key suppliers trust us.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. We believe that our key customers trust us.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. Our organization places a high priority on maintaining relationships with our key suppliers.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. Our organization places a high priority on maintaining relationships with our key customers.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7. Our objectives are consistent with those of our key suppliers.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
8. The culture of our firm is similar to the culture of our key supply chain partners.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
9. We view our supply chain as a value added piece of our business.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
10. Top managers reinforce the need of building, maintaining, and enhancing long-term relationships with our supply chain members.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
11. Top managers reinforce the need of sharing valuable information with our supply chain members.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Risk Management Orientation

As defined in the current research, a risk management orientation will be modeled as a latent variable and measured by several items on a seven-point Likert-scale. All items were newly developed based on related literature review and several unstructured interviews with supply chain management professionals and pre-tested by the panel of experts. They are presented in Table 3.7.

Table 3.7 Measurement of Risk Management Orientation

Risk Management Orientation (RMO)	Strongly Disagree			Neutral			Strongly Agree
1. Our organizational culture values risk assessment actions.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. Our organizational culture supports risk mitigating actions.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. Our organization places a high priority on risk management.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. Our firm has business continuity plans addressing major supply chain risks.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. We regularly monitor our suppliers for possible supply chain risks.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. In our firm, an employee or a team is dedicated to supply chain risk management.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7. If possible, we ensure that excess supplier capacity exists to deal with unplanned variations in demand.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Supply Chain Process Variability

Supply chain process variability was operationalized as a perceived level of consistency of logistics-related flows and processes. A combination of adapted and newly-developed measurement items will be used. They are measured on a 7-point Likert-like scale from 1-Very inconsistent to 7- Very consistent and presented in the following Table 3.8:

Table 3.8 Measurement of Supply Chain Process Variability

Supply Chain Process Variability (SCPV) (Adapted from – Germain et al. 2008)	**Very Inconsistent**			**Neutral**			**Very Consistent**
1. Amount of time for shipments to arrive from our key suppliers.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
2. Amount of time for shipments to reach our key customers.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
3. Manufacturing time based on a fixed production schedule.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
4. Daily production output rate.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5. Response to the everyday needs of key customers.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
6. Accommodation of special customer service requests.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7. Meeting as promised delivery dates.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
8. Providing desired quantities on a consistent basis.	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Supply Chain Capital

The supply chain capital construct is operationalized as a combination of structural and relational capital, a combination of which is related to the development of supply chain knowledge (Autry and Griffis 2008). Structural capital represents the value derived from the structural configuration, while relational capital reflects the value created as a result of relationships within the supply chain. The following operationalization of supply chain capital has been developed.

Table 3.9 Measurement of Supply Chain Capital

Supply Chain Capital (SCC)	Strongly Disagree			Neutral			Strongly Agree
1. Our firm has a strong channel position within our supply chain.	1	2	3	4	5	6	7
2. Our supply chain has a well defined organizational structure	1	2	3	4	5	6	7
3. Structural ties are strong among the key members of our supply chain.	1	2	3	4	5	6	7
4. The members of our extended supply chain are properly connected with each other.	1	2	3	4	5	6	7
5. Our firm's supply chain could be characterized by strong relationships among its members.	1	2	3	4	5	6	7
6. Our firm's supply chain could be characterized by the longevity of the relationships among its members.	1	2	3	4	5	6	7

Supply Chain Knowledge Development

For information to be leveraged as a value-added asset, it is necessary to convert it to usable supply chain knowledge. The supply chain knowledge development construct is operationalized based on Autry and Griffis (2008).

Table 3.10 Measurement of Supply Chain Knowledge Development

Supply Chain Knowledge Development (SCKD)	Strongly Disagree			Neutral			Strongly Agree
1. Our firm's supply chain has developed a strong knowledge base.	1	2	3	4	5	6	7
2. Knowledge is freely shared among the members of our supply chain.	1	2	3	4	5	6	7
3. We see a high value of knowledge related to our supply chain.	1	2	3	4	5	6	7

The responses to additional demographic questions related to the business experience of respondents, industry affiliations of the represented companies, and specific firm characteristics were also collected at the end of the survey.

CHAPTER 4 – DATA ANALYSIS

INTRODUCTION

Chapter 4 presents a detailed analysis of the research design and the data collected from the pre-designed survey. The test of the measurement model was followed by the detailed analysis of the theoretical model presented in the previous chapter. As planned, a pre-test was performed and described first with the purpose to explore potential measurement and procedural modifications needed prior to the launch of the main survey test. The main test was launched next with all the necessary improvements and modifications. Analysis of the data collected from the main survey started with the descriptive statistics and the missing data analysis. This was followed by appropriate reliability and validity checks and refinement of the measurement model. The formulated structural model was analyzed to test the hypotheses and post hoc analysis was also conducted. Finally, the findings from the data analysis were summarized to conclude this chapter.

SURVEY PRE-TEST

The pre-test was administered using a web-based survey following the process described in Chapter 3 according to the procedures proposed and tested by Dillman (2000). A personalized e-mail was sent to a pre-qualified set of business executives with appropriate supply chain management experience and responsibility. The pre-test sample was drawn from the database of top level supply chain executives who participated in the University of Tennessee Supply Chain Forums. Potential survey participants were asked to respond to the set of pre-designed questions and share their thoughts on the clarity and relevancy of the survey instrument. Out of the 228 potential pre-test participants 65 completed the survey, yielding a response rate of 28.5%. No

significant differences between early and late respondents were detected, thus an early-late response bias was not considered a concern for this pre-test. A non-response bias was not assessed for the pre-test sample due to the nature of the sample, however it was assessed later in this research for the main test (Armstrong and Overton 1977) and no problems were found.

Descriptive Statistics

The participants in the pre-test survey answered 68 substantive questions related to the hypotheses and the theoretical model as well as nine additional demographic/ control-type questions and several question related to the nature of the survey. The breakdown of pre-test survey respondents by industry is presented in Table 4.1.

Table 4.1 Pre-Test Participants by Industry

Industry	**Frequency**	**(%)**
Automotive	7	12.07%
Aerospace	5	8.62%
Apparel / Textiles	3	5.17%
Appliances	6	10.34%
Electronics	7	12.07%
Industrial Products	6	10.34%
Chemicals/plastics	3	5.17%
Consumer Packaged Goods	14	24.14%
Medical/Pharmaceutical	5	8.62%
Other	9	15.52%
TOTAL	**65**	**100.00%**

Results indicate that approximately half of the 65 respondents in the pre-test sample came from either consumer packaged goods (24.14%), automobile (12.07%), or electronics (12.07%) industries. Appliances and industrial products industries accounted for 10.34% of respondents each. Aerospace, medical / pharmaceutical, apparel and other industries were also represented by the qualified survey participants.

Annual sales statistics for the companies represented by the survey participants was also collected. The majority of the pre-test participants (77%) reported they worked for firms with approximate annual sales of more than $501 Million, including 21 respondents (32.31%) from the firms with annual sales between $501million and $1 billion and 29 respondents (44.62%) from the firms with approximate annual sales greater than $1 billion. Another 23% of respondents reported approximate annual sales revenue of their firms between $1 million and $51 million. An average respondent had approximately 13 years of related experience. Only 3 respondents had less than 5 years of related industry experience. The majority of respondents reported job titles at the manager or higher level representing supply chain management, logistics, and purchasing functions. Overall, responses to the questions related to experience, job responsibilities, and knowledge of the participants lend confidence to the suitability of these respondents as the key informants in this research.

Pre-Test Data Analysis

After recording all the completed responses, the data was downloaded to SPSS 18 software for further analysis. At the preliminary stage the survey responses were examined for errors and missing data. Surveys completed in their entirety accounted for 85.9% of all collected responses and an additional 5.6% of the remaining cases contained five or less missing items.

The remaining 8.5% of responses had a significant number of missing data and were therefore discarded, bringing the total number of usable surveys to 65 (from original 71). Upon close item by item examination, missing values accounted for less than one percent (0.3%) of all responses. The results of the SPSS-based missing value analysis indicated that the data was missing at random.

Overall, missing values were not a threat to the integrity of the pre-test data. A few missing data points were estimated and replaced. The Expectation Maximization procedure was used for this purpose. It is a commonly used method based on computing maximum likelihood estimates for data missing at random which is generally considered more accurate than other similar procedures for dealing with missing values (Schafer and Olsen 1998).

The summary of descriptive statistics for the pre-test is presented in Table 4.2. Means and standard deviations were measured for each of the 68 substantive scale items and the normality analysis was conducted. Most items were worded as statements and most response choices were based on a seven-point scale ranging from "strongly disagree" to "strongly agree". The seven-point scale for Supply Chain Process Variability (SCPV) was the only exception. It was ranging from "very inconsistent" to "very consistent". Mean values ranged from 3.46 to 6.39, while the standard deviations ranged from 0.87 to 1.71. Such ranges were considered acceptable for the purposes of this analysis. The normality assumption was also tested, and the measures of kurtosis for each of the items are presented in Table 4.2 as well. Six scaled items raised concerns in terms of the normality distribution based on kurtosis values ranging from 2.1 to 6.76. Three of those items represented risk management orientation scale (RMO2, RMO6, and RMO7) and the other three represented supply chain orientation scale (SCO2, SCO7, and SCO9). A closer examination of such cases was conducted and several outliers were identified as causes of

relatively high estimates of kurtosis. Those extreme values were pulled out to remedy the problem, and the recalculated kurtosis values demonstrated new acceptable levels.

Table 4.2 Pre-Test Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
RMO1	1	7	5.46	1.413	0.85	0.239
RMO2	1	7	5.47	1.345	1.221	0.239
RMO3	1	7	5.83	1.219	2.426	0.239
RMO4	1	7	5.26	1.408	0.591	0.239
RMO5	1	7	5.36	1.384	0.476	0.239
RMO6	1	7	6.08	1.308	4.318	0.239
RMO7	1	7	5.17	1.388	0.627	0.239
EU1	1	7	4.13	1.708	-1.224	0.239
EU2	1	7	3.91	1.717	-1.133	0.239
EU3	1	7	5.10	1.199	1.304	0.239
EU4	1	7	5.43	1.121	2.06	0.239
EU5	1	7	4.78	1.588	-0.814	0.239
EU6	1	7	5.28	1.444	-0.133	0.239
EU7	1	7	4.58	1.598	-0.989	0.239

Table 4.2 Continued

	Minimum	Maximum	Mean	Std. Deviation	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
SCV1	2	7	5.26	1.288	0.574	0.239
SCV2	2	7	5.06	1.356	-0.127	0.239
SCV3	1	7	4.94	1.407	-0.312	0.239
SCV4	1	7	5.12	1.528	-0.099	0.239
SCV5	1	7	4.30	1.518	-1.029	0.239
SCO1	1	7	5.54	1.13	1.904	0.239
SCO2	1	7	5.65	1.044	2.022	0.239
SCO3	1	7	5.61	1.076	2.011	0.239
SCO4	2	7	5.89	1.019	2.108	0.239
SCO5	1	7	5.82	1.132	1.837	0.239
SCO6	2	7	6.39	0.867	6.762	0.239
SCO7	2	7	5.09	1.174	0.158	0.239
SCO8	1	7	4.51	1.358	-0.494	0.239
SCO9	2	7	6.06	1.052	3.59	0.239
SCO10	1	7	5.86	1.216	1.95	0.239
SCO11	1	7	5.59	1.31	1.605	0.239
SCO12	1	7	5.27	1.388	0.566	0.239
SCR1	1	7	4.88	1.289	-0.038	0.24
SCR2	1	7	4.94	1.28	-0.033	0.239
SCR3	1	7	4.66	1.276	-0.144	0.24
SCR4	1	7	4.84	1.329	-0.075	0.239
SCR5	1	7	5.15	1.195	0.668	0.239

Table 4.2 Continued

	Minimum	Maximum	Mean	Std. Deviation	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
SCR6	1	7	4.98	1.226	0.133	0.239
SCR7	1	7	4.98	1.289	0.504	0.239
SMC1	1	7	5.32	1.212	1.192	0.239
SMC2	1	7	5.20	1.407	0.787	0.239
SMC3	1	7	4.91	1.343	0.383	0.239
SMC4	1	7	5.26	1.144	1.401	0.239
IMC1	1	7	5.00	1.452	0.389	0.239
IMC2	1	7	4.64	1.486	-0.267	0.239
IMC3	1	7	4.63	1.684	-0.777	0.239
IMC4	1	7	5.03	1.362	0.385	0.239
IMC5	1	7	4.73	1.605	-0.453	0.239
IMC6	1	7	4.83	1.587	-0.339	0.239
IMC7	1	7	4.37	1.713	-0.916	0.239
IMC8	1	7	5.13	1.308	1.026	0.239
IMC9	1	7	4.83	1.679	-0.46	0.239
IMC10	1	7	5.05	1.419	0.392	0.239
IMC11	1	7	4.69	1.489	-0.55	0.239
IMC12	1	7	3.46	1.87	-1.293	0.239
SCC1	1	7	5.13	1.288	0.542	0.239
SCC2	1	7	5.16	1.48	0.372	0.239
SCC3	1	7	4.47	1.495	-0.7	0.239
SCC4	1	7	4.92	1.377	0.337	0.239

Table 4.2 Continued

	Minimum	Maximum	Mean	Std. Deviation	Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
SCC5	1	7	5.06	1.381	0.51	0.239
SCC6	1	7	5.07	1.325	0.243	0.239
SCC7	1	7	5.32	1.222	1.12	0.239
SCKD1	1	7	5.24	1.218	1.093	0.239
SCKD2	1	7	4.92	1.358	0.26	0.239
SCKD3	1	7	5.19	1.397	0.632	0.239
SCPV1	1	7	5.10	1.401	0.365	0.239
SCPV2	1	7	5.56	1.28	0.973	0.239
SCPV3	1	7	4.83	1.539	-0.334	0.239
SCPV4	1	7	5.12	1.376	0.186	0.239

Evaluation of Measures

Both quantitative and qualitative tools were employed to evaluate measures used in the pre-test. Statistical validity and reliability were assessed quantitatively. Principal component analysis was conducted taking into account the relatively small sample size of the pre-test. Reliability was assessed with Cronbach's alpha coefficient estimates using the common rule of thumb of 0.70 or higher values of satisfactory correlations (Churchill 1979). Discriminant validity was also assessed through the principal component analysis. All of the scales demonstrated coefficient alpha values of 0.70 or above, and most evaluated items showed strong

loadings on single factors with the exception of several items from the environmental uncertainty and supply chain orientation scales. Those scales were consequently modified in the main survey and some of items were dropped in order to improve the fit of the model. Additionally, a qualitative assessment was used to clarify and revise the wording of several items in order to avoid any unnecessary confusion among respondents. In summary, the pre-test provided preliminary validation for both the newly developed scales and the scales adapted from the literature. It also helped to identify potential problematic areas, and clarify the items to ensure a higher level of validity of the main test results.

SURVEY MAIN TEST

After conducting the pre-test and making all the necessary refinements of the survey measures, the final version of the survey instrument was developed. This version is presented in the following table (Table 4.3).

Table 4.3 Main Survey Items

Scale	Items
Risk Management Orientation (RMO)	RMO1-Our company places a high priority on risk management
	RMO2-Our organizational culture values risk assessment
	RMO3-Risk mitigation is important for our company
	RMO4-Major supply chain risks are addressed through our continuity/contingency plans
	RMO5-We regularly monitor our suppliers for possible supply chain risks
	RMO6-If possible we ensure that excess supplier capacity exists to deal with unplanned variations in demand

Table 4.3 Continued

Scale	Items
Environmental Uncertainty (EU)`	EU1-Our demand fluctuates drastically from week to week
	EU2-Our supply requirements vary drastically from week to week
	EU3- Our suppliers consistently meet our requirements
	EU4-Our suppliers produce materials with consistent quality
	EU5-Technological changes provide big opportunities in our industry
	EU6-The technology in our industry is changing rapidly
Supply Chain Orientation (SCO)	SCO1-We trust our key suppliers
	SCO2-We believe that our key suppliers trust us
	SCO3 – We trust our key customers
	SCO4-Our organization places a high priority on maintaining relationships with our key suppliers
	SCO5-Our organization places a high priority on maintaining relationships with our key customers
	SCO6-Our objectives are consistent with those of our key suppliers
	SCO7 The culture of our company is similar to the culture of our key supply chain partners
	SCO8 – We view our supply chain as a value added piece of our business
	SCO9-Top managers reinforce the need of sharing valuable information with our supply chain members
	SCO10-Top managers reinforce the need of building, maintaining, and enhancing long-term relationships with our supply chain members
Supply Management Capabilities (SMC)	SMC1-Our firm has increased operational flexibility through collaboration with suppliers
	SMC2-Our firm actively pursues business relationships and programs designed to achieve supplier involvement over and above individual sales transactions
	SMC3-Our firm's logistical operations can be synchronized to integrate with supplier operations
	SMC4-Our key suppliers have programs to authorize and perform our special requests

Table 4.3 Continued

Scale	Items
Supply Chain Resilience (SCR)	SCR1 - Our supply chain-...is able to adequately respond to unexpected disruptions by quickly restoring its product flow
	SCR2- Our supply chain-...can quickly return to its original state after being disrupted
	SCR3 - Our supply chain-...can move to a new more desirable state after being disrupted
	SCR4 - Our supply chain-...is well prepared to deal with financial outcomes of supply chain disruptions
	SCR5 - Our supply chain-...has the ability to maintain a desired level of connectedness among its members at the time of disruption
	SCR6 - Our supply chain-...has the ability to maintain a desired level of functionality at the time of disruption
	SCR7 - Our supply chain-...has the ability to extract meaningful knowledge from disruptions and unexpected events
Information Management Capabilities (IMC)	IMC1-Our firm effectively shares operational information between departments
	IMC2-Our firm maintains an integrated database to facilitate information sharing
	IMC3-Logistics information systems in our firm are being extended to include more integrated applications
	IMC4-Our firm's logistics information systems capture and maintain timely data
	IMC5-Logistics operating and planning databases are integrated across applications within our firm
	IMC6-The information available in our firm is accurate
	IMC7-Our firm has invested in technology designed to facilitate cross-organizational data exchange
	IMC8-Our firm has adequate ability to share customized information internally
	IMC9-Our firm has adequate ability to share customized information externally with key suppliers

Table 4.3 Continued

Scale	Items
Supply Chain Capital (SCC)	SCC1-Our firm has a strong channel position within our supply chain
	SCC2-Our supply chain has a well defined organizational structure
	SCC3-The members of our extended supply chain are connected with each other through structural ties
	SCC4-Structural ties are strong among the key members of our supply chain
	SCC5-Our firm's supply chain could be characterized by strong relationships among its members
	SCC6-Our firm's supply chain could be characterized by the longevity of the relationships among its members
Supply Chain Knowledge Development (SCKD)	SCKD1- Our firm's supply chain has developed a strong knowledge base
	SCKD2 - Knowledge is freely shared among the members of our supply chain
	SCKD3 -Knowledge development has a high value in our supply chain
Supply Chain Process Variability (SCPV)	SCPV1 - Amount of time for shipments to arrive from key suppliers
	SCPV2 - Amount of time for shipments to reach key customers
	SCPV3 - Production lead-time (fixed production schedule)
	SCPV4 - Daily production output rate
Marker Variable	Form1-Internally in my unit, if a written rule is not specified in a certain situation, we make up informal rules as we go along
	Form2-Contacts with my company and its representatives are on a formal pre-planned basis
	Form3-When rules and procedures exist in my organization they are usually written agreements
	Form4-Most things in my business unit are covered by formal procedures

All potential respondents for the main test were selected from a database obtained from Dun & Bradstreet (D&B) marketing firm. Following the selection criteria of desired participants discussed in the previous chapter, names of potential participants were pulled from several categories of titles in the D&B database. Specifically, supply chain, logistics, operations, and purchasing managers at the Manager, Vice President or Director levels were targeted. The selection criteria included job titles, responsibilities, perceived knowledge of supply chain management processes and firm performance. In order to minimize potential bias from multiple respondents at a single company, only up to two contacts per company were allowed in the final database selection. Based on the described criteria, the final database purchased from D&B contained critical contact information for a total of 3,050 potential respondents. A personalized e-mail was sent to each potential participant, inviting them to participate in this research. It was followed with reminder e-mails to those participants who did not respond to the first request to complete the survey. Overall, three reminder e-mails were sent through equally distributed time intervals. This procedure resulted in 818 unique visitors to the survey website (26.8% of qualified potential respondents actually assessed the survey). 451 respondents submitted their completed responses (55.1 % of the 818 who accessed the site or 14.8% of the 3,050 targeted respondents). The remaining 47.6% of potential respondents dropped off quickly or within the first few pages of the survey.

MISSING DATA ANALYSIS

Obtained responses were analyzed for the degree of completeness and missing values. Analysis resulted in 387 fully completed surveys (85.8%) and 64 (14.9%) partially completed responses. Out of those partially completed responses 57 contained more than ten missing

questions each and were excluded from the final count and further analysis. An additional 11 surveys were missing less than ten questions and were deemed usable. Missing values represented an insignificant number of all responses, and they did not present a threat to the survey data integrity. The patterns of missing values were evaluated using separate variance t-tests, and it was determined that the missing values were missing completely at random. Next, the expectation maximization (EM) method was used with the purpose of estimating and replacing values that were missing. This method is based on calculating maximum likelihood estimates and is considered reliable for the purposes of this research. This resulted in 398 usable responses (88.2% out of 451 completed responses) that were included in the final analysis.

DATA DISTRIBUTION

Similarly to the pre-test sample analysis, normality distribution analysis was conducted using SPSS statistical software. Several of the analyzed scales raised normality concerns due to relatively high levels of kurtosis. Additional examination of those responses resulted in identification of potential outliers. For example, responses for cases 17, 134, 155, 194 and 288 included outliers that affected normality measures for several different scales. More specifically, the scaled items RMO3, RMO6, SCO2, SCO6, SCO9, and EU4 were normalized after removing those outliers. This corrective action was followed by two more sequential runs of the analysis for kurtosis statistics and potential outliers. A few more cases had to be removed before obtaining acceptable levels of kurtosis values. The details of this analysis are summarized in Table 4.4.

Table 4.4 Summary of Normality Analysis for the Main Test

Scale	Kurtosis	Outlier Cases
RMO3	2.43	194, 288
RMO6	4.38	17, 134
SCO2	2.15	194
SCO6	3.14	194, 288
SCO9	7.11	155, 119, 288
EU4	6.77	17, 194
EU6	3.15	288

Additionally, Mahalanobis D^2 test was conducted using AMOS 18 extension of SPSS software. This test estimates the distances between the dataset centroid, also known as the mean center of the observations, and each of the observations in the multidimensional space. Seven observations were determined to be significantly distant from the centroid and were removed from the further analysis. Thus, the dataset was reduced to 391 useful observations (86.7% of 451collected responses).

In order to conduct a proper analysis of potential non-response bias, additional responses to a selected sample of questions were collected next from a sample of 45 potential participants who did not complete their responses during the main survey data collection process described earlier (Mentzer and Flint 1997). These 45 non-respondents were asked to respond to five substantive questions originated from two scales from the survey (Garver and Mentzer 1999).

An independent t-test was conducted and resulted in no statistically significant difference ($p<0.05$) between the answers of these non-responders and the answers of original survey respondents. An early-late response test was also conducted with the purpose of investigating the existence of potential bias between early and late respondents (Armstrong and Overton 1977). Surveys were classified as early or late based on the time of response and the number of follow-up reminders sent to participants. No significant differences between those groups ($p < 0.05$) were indicated after conducting an independent samples t-test. Based on the combination of results mentioned above and an acceptable response rate, potential bias in the responses was not considered a significant concern for this research.

DESCRIPTIVE STATISTICS

The breakdown of the main test survey respondents by industry is presented in Table 4.5. Results indicate that the majority of the main test survey participants are from the consumer packaged goods industry (18.41%). The medical/ pharmaceutical industry and industrial products industry contributed 16.11% and 15.09% of participants respectively. Participants from the electronics industry accounted for an additional 10%. Other industries included appliances, automotive, apparel/ textile, aerospace and other industries.

Table 4.5 Main Test Participants by Industry

	Frequency	(%)
Automotive	21	5.37%
Aerospace	14	3.58%
Apparel / Textiles	18	4.60%
Appliances	23	5.88%
Electronics	39	9.97%
Industrial Products	59	15.09%
Chemicals/plastics	28	7.16%
Consumer Packaged Goods	72	18.41%
Medical/Pharmaceutical	63	16.11%
Other	54	13.81%
TOTAL	**391**	**100.00%**

Annual sales statistics for the companies represented by the survey participants was also collected. The majority of the main test participants (more than 57%) reported they worked for firms with approximate annual sales of between $1 million and $500 million. Another 14% reported approximate annual sales revenue of between $501 million and $1 billion. Almost 28% of participants worked for firms with approximate annual sales of more than $1 billion while the remaining less than 1% of participants worked for firms with annual sales of less than $1 million. The results are summarized in Table 4.6.

Table 4.6 Annual Sales of Participating Companies

Annual sales	Frequency	Percent
Less than $1 million	3	0.77%
$1-50 million	99	25.32%
$51-500 million	125	31.97%
$501 million - $1 billion	55	14.07%
Greater than $1 billion	109	27.88%
Total	**391**	**100.00%**

An average respondent had approximately 14.5 years of related experience. Only 29 respondents had less than 5 years of related industry experience. Similarly to the pre-test results, the majority of respondents reported job titles at the manager or higher level representing supply chain management, logistics, and purchasing functions. Overall, responses to the questions related to experience, job responsibilities, and knowledge of the participants lend confidence to the suitability of these respondents as the key informants in this research.

EVALUATION OF MEASUREMENT ITEMS

A combination of statistical tests and modeling techniques was used in order to evaluate the psychometric properties of the latent variables in the proposed variance model and assess the unidimensionality, validity and reliability of all measures (Garver and Mentzer 1999). SPSS 18 and AMOS 18 statistical software packages were used for the purposes of model development

and statistical analysis. More specifically, the analysis started with first-generation statistical techniques such as principal component factor analysis (PCA), Cronbach's alpha coefficient estimation and analysis of correlation matrices. It was followed by more robust approaches available within the confirmatory factor analysis component of SEM (Anderson and Gerbing 1982, Gerbing and Anderson 1988).

Multiple criteria developed in the literature (Garver and Mentzer 1999, Shook et al. 2004) were used to evaluate the goodness of fit of the models. More specifically, the following list of assessment metrics and their heuristics were used in this research as specific guidelines for model fit evaluation and comparison:

1) The chi-Square ($\chi 2$) goodness of fit is known as an absolute measure of fit indicating the degree to which the estimated model corresponds with the pattern of variances and covariances in the observed data. At the same time, the χ^2 *difference* test is commonly used as a measure of incremental fit for comparing nested models, e.g., testing for measurement invariance across groups. While a significant finding usually indicates the lack of fit, it is important to remember that this test is very sensitive to sample size, i.e. the larger the sample size, the more likely negligible and unimportant departures will be detected (Gulliksen and Tukey 1958, Garver and Mentzer 1999). Therefore, the chi-square test is usually used in combination with other fit indices, such as CFI or RMSEA and should be interpreted carefully in light of other statistical results (Garver and Mentzer 1999).
2) The chi-square ratio (CMIN/df) takes degrees of freedom into consideration and therefore not as dependent on sample size as the chi-square fit index by itself. This ratio is calculated as the chi-square fit index divided by degrees of freedom. Some

authors consider ratios in the range of two to five as acceptable measures of fit (Hair et al. 1998), while others suggest a more conservative approach to evaluation recommending the range of this ratio to be no too exceed two to three threshold (Garver and Mentzer 1999).

3) The comparative fit index (CFI) is a commonly accepted incremental statistical measure of fit. This index compares the existing model fit with a fit of the model that assumes uncorrelated latent variables. In general, CFI index could range from 0 to 1, while the value of the index greater than 0.90 is generally considered as an acceptable measure of fit. Such index value could be interpreted as 90% of the covariation in the data can be reproduced by the model (Medsker et al. 1994).
4) The Tucker-Lewis index (TLI) is another measure of fit that compares the fit of the proposed model to a null model that serves as a baseline. Additionally, this index evaluates proposed model's parsimony by comparing the degrees of freedom of proposed and null models Similarly to the CFI index, TLI could range from 0 to and the value of the index greater than 0.90 is generally considered acceptable (Medsker et al. 1994).
5) The root mean square error of approximation (RMSEA) measures absolute fit of the proposed model by comparing the average difference per degree of freedom expected to occur in the population. This measure is not affected by sample size and is considered reliable. RMSEA values between 0.08 and 0.05 (or less) are deemed acceptable (Medsker et a. 1994) indicating a reasonable error of approximation, while RMSEA values of less than or equal to 0.05 fit a more traditional standard in business research.

A combination of the above criteria was used in this research for the purposes of model formulation and refinements.

MEASUREMENT MODEL REFINEMENT

A formulated a-priori measurement model was run in AMOS 18 using the refined data set in order to assess overall measurement fit. Initial runs of the CFA model (conducted prior to any model refinements) resulted in marginally acceptable fit statistics ($\chi 2$=3554, df=1724, $\chi 2$/df=2.06, CFI=0.87, TLI=0.86, and RMSEA=0.055). However, it was evident that further improvements of the initial measurement model were needed. All refinements of the a-priori model were carefully evaluated based on the principles of statistical fit and theoretical justification.

Further analysis was conducted by examining modification indices, standardized residuals, item weights for each construct, and overall fit statistics, and several problematic areas were flagged as the result. After careful examination of each item based on such criteria, several items were deleted from further analysis. Additionally, the measurement errors for several items (e.g. within supply chain orientation, risk management orientation, and information management capabilities) were allowed to covary based on theoretical and statistical justification. Only several measurement errors within each variable were allowed to covary. It resulted in significant improvements in modification indices and statistical fit. All of the final refined scales are shown in Table 4.6, and the refined CFA model formulated after several modifying iterations is provided in Figure 4.1. Overall, the final refined measurement model demonstrated much better fit statistics ($\chi 2$=1967, df=1265, $\chi 2$/df=1.55, CFI=0.94, TLI=0.93, and RMSEA=0.038).

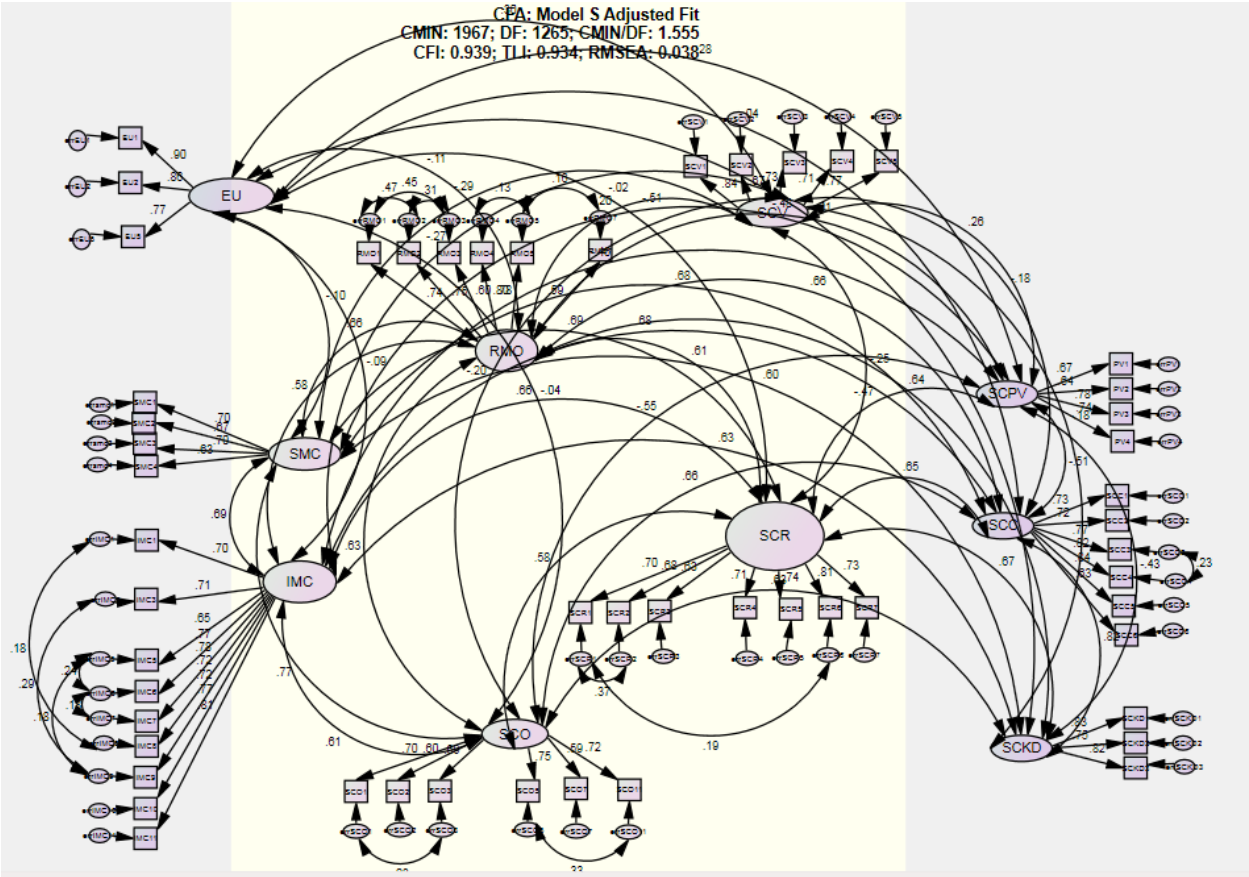

Figure 4.1
CFA Measurement Model

Table 4.7 Refined Scales – Main Test

Scale	Scale Reliability	Items	Mean	SD
Risk Management Orientation (RMO)	0.86	RMO-Our company places a high priority on risk management	5.56	1.288
		RMO-Our organizational culture values risk assessment	5.56	1.230
		RMO-Risk mitigation is important for our company	5.93	1.059
		RMO-Major supply chain risks are addressed through our continuity/contingency plans	5.37	1.295
		RMO-We regularly monitor our suppliers for possible supply chain risks	5.47	1.270
		RMO-If possible we ensure that excess supplier capacity exists to deal with unplanned variations in demand	5.29	1.270
Environmental Uncertainty (EU)	0.88	EU-Our demand fluctuates drastically from week to week	4.14	1.711
		EU-Our supply requirements vary drastically from week to week	3.94	1.718
		EU-The technology in our industry is changing rapidly	4.36	1.174
Supply Chain Vulnerability (SCV)	0.86	SCV - Our supply chain-...is vulnerable to supply-related disruptions	5.24	1.294
		SCV - Our supply chain-...is vulnerable to demand-related disruptions	5.06	1.346
		SCV - Our supply chain-...is vulnerable to operational disruptions	4.92	1.412
		SCV - Our supply chain-...is vulnerable to transportation disruptions	5.10	1.532
		SCV - Our supply chain-...could be characterized as having a high level of vulnerability	4.27	1.506
Supply Chain Orientation (SCO)	0.83	SCO-We trust our key suppliers	5.63	1.006
		SCO-We believe that our key suppliers trust us	5.72	.927
		SCO-Our organization places a high priority on maintaining relationships with our key suppliers	5.68	.987
		SCO-Our objectives are consistent with those of our key suppliers	5.89	1.078
		SCO-We view our supply chain as a value added piece of business	5.18	1.094
		SCO-Top managers reinforce the need of building, maintaining, and enhancing long-term relationships with our supply chain members	5.70	1.183

Table 4.7 Continued

Scale	Scale Reliability	Items	Mean	SD
Supply Chain Resilience (SCR)	0.87	SCR - Our supply chain-...is able to adequately respond to unexpected disruptions by quickly restoring its product flow	4.96	1.256
		SCR - Our supply chain-...can quickly return to its original state after being disrupted	4.99	1.264
		SCR - Our supply chain-...can move to a new more desirable state after being disrupted	4.73	1.231
		SCR - Our supply chain-...is well prepared to deal with financial outcomes of supply chain disruptions	4.92	1.290
		SCR - Our supply chain-...has the ability to maintain a desired level of connectedness among its members at the time of disruption	5.23	1.128
		SCR - Our supply chain-...has the ability to maintain a desired level of functionality at the time of disruption	5.07	1.164
		SCR - Our supply chain-...has the ability to extract meaningful knowledge from disruptions and unexpected events	5.06	1.234
Supply Management Capabilities (SMC)	0.77	SMC-Our firm has increased operational flexibility through collaboration with suppliers	5.39	1.149
		SMC-Our firm actively pursues business relationships and programs designed to achieve supplier involvement over and above individual sales transactions	5.26	1.349
		SMC-Our firm's logistical operations can be synchronized to integrate with supplier operations	4.98	1.283
		SMC-Our key suppliers have established programs to authorize and perform our special requests	5.34	1.068
Supply Chain Knowledge Development (SCKD)	0.84	SCKD-Our firm's supply chain has developed a strong knowledge base	5.32	1.158
		SCKD-Knowledge is freely shared among the members of our supply chain	5.02	1.281
		SCKD-Knowledge development has a high value in our supply chain	5.31	1.287

Table 4.7 Continued

Scale	Scale Reliability	Items	Mean	SD
Information Management Capabilities (IMC)	0.91	IMC-Our firm effectively shares operational information between departments	5.08	1.376
		IMC-Our firm maintains an integrated database to facilitate information sharing	4.72	1.628
		IMC-Logistics information systems in our firm are being extended to include more integrated applications	4.81	1.567
		IMC-Our firm's logistics information systems capture and maintain timely data	4.90	1.536
		IMC-Logistics operating and planning databases are integrated across applications within our firm	4.44	1.687
		IMC-The information available in our firm is accurate	5.22	1.231
		IMC-Our firm has invested in technology designed to facilitate cross-organizational data exchange	4.89	1.651
		IMC-Our firm has adequate ability to share customized information internally	5.13	1.346
		IMC-Our firm has adequate ability to share customized information externally with key suppliers	4.74	1.459
Supply Chain Capital (SCC)	0.89	SCC-Our firm has a strong channel position within our supply chain	5.20	1.248
		SCC-Our supply chain has a well defined organizational structure	5.25	1.410
		SCC-The members of our extended supply chain are connected with each other through structural ties	4.56	1.449
		SCC-Structural ties are strong among the key members of our supply chain	5.01	1.314
		SCC-Our firm's supply chain could be characterized by strong relationships among its members	5.16	1.291
		SCC-Our firm's supply chain could be characterized by the longevity of the relationships among its members	5.15	1.265

Table 4.7 Continued

Scale	Scale Reliability	Items	Mean	SD
Supply Chain Process Variability (SCPV)	0.80	SCPV-Amount of time for shipments to arrive from key suppliers	2.82	1.339
		SCPV-Amount of time for shipments to reach key customers	2.37	1.223
		SCPV-Production lead-time (fixed production schedule)	3.11	1.507
		SCPV-Daily production output rate	2.82	1.352
Marker Variable	0.85	Form-Internally in my unit, if a written rule is not specified in a certain situation, we make up informal rules as we go along	4.47	1.542
		Form-Contacts with my company and its representatives are on a formal pre-planned basis	4.86	1.392
		Form-When rules and procedures exist in my organization they are usually written agreements	5.30	1.389
		Form-Most things in my business unit are covered by formal procedures	5.26	1.479

Unidimensionality

To ensure unidimensionality, within-factor items should possess one and only one underlying construct in common (Hair et al. 1998). It was assessed by measuring the overall goodness of model fit and examining convergent and discriminant validity. Only those scales that possess both convergent and discriminant validity are considered unidimensional (Anderson and Gerbing 1988; Gerbing and Anderson 1988). Additionally, unidimensional variables should be measured by the items with low modification indices (Anderson and Gerbing 1988). After conducting an initial assessment, several covariations of the error terms were necessary in order to improve the modification indices. The selected error terms were allowed to covary only after careful consideration of the items involved with respect to the theoretical rationale. It is

important to note, however, that there could be some potential unidimensionality issues for the scales with the error terms that were allowed to covary in this model. Specifically, it relates to the scales for risk management orientation, supply management orientation, and information management capabilities. The measurement of these scales will require some additional empirical testing in future research.

Convergent Validity

Convergent validity describes the convergence of different measures of the same construct on a common statistical factor (Mentzer and Flint 1997). It is achieved when items have substantial loadings on the constructs they are intended to measure. The standardized regression loading of an item on its intended dimension or construct is used to measure convergent validity in practice. A good measure of convergent validity is achieved when item loadings are greater than or equal to 0.70 and they are statistically significant, but even item loadings as low as 0.40 could be acceptable in some instances (Garver and Mentzer 1999). After examining the a-priori model several items were removed from further analysis based on their low loadings.

Discriminant Validity

Discriminant validity, on the other hand, evaluates how measures of different constructs load on different factors (i.e. discriminate from each other). While certain pairs of constructs are likely to be highly correlated, items from one scale should not converge too closely with items from a different scale, nor should the items that are meant to discriminate different dimensions

and constructs load together on one variable. If they do, then the model needs to be carefully examined to see if variables should be combined or separated (Garver and Mentzer 1999).

Discriminant validity of the measurement model was assessed in several ways. First, the average variance extracted (AVE) was computed by the equation (1):

$$\Sigma\lambda^2 / [\Sigma\lambda^2 + \Sigma(1-\lambda_j^2)], \qquad (1)$$

where λ is the standardized regression coefficient of the item (Fornell and Larcker 1981). An AVE of .50 or higher is considered a measure of acceptable discriminant validity. Second, the average variance extracted of a dimension or construct was compared to the shared variance between all possible pairs of dimensions or constructs in the model. This test of discriminant validity is more conservative and is only supported when the AVE of a construct exceeds shared variance with all other constructs. Table 4.8 provides a summary of average variances extracted for the measurement model. All comparisons met the stated criteria where AVE values exceeded calculated shared variance.

. **Table 4.8 Average Variance Extracted (AVE)**

	EU	RMO	SCO	SMC	IMC	SCV	SCR	SCPV	SCC	SCKD
EU	**0.7202**									
RMO	0.0243	**0.5041**								
SCO	0.0021	0.1840	**0.5122**							
SMC	0.0146	0.2611	0.1927	**0.5230**						
IMC	0.0188	0.2819	0.1697	0.2819	**0.5432**					
SCV	0.2540	0.0424	0.0231	0.0625	0.0784	**0.5540**				
SCR	0.0011	0.2642	0.1296	0.2362	0.3014	0.0576	**0.5010**			
SCPV	0.0949	0.1722	0.1197	0.1369	0.1560	0.0645	0.1384	**0.5002**		
SCC	0.0035	0.3260	0.1781	0.2430	0.3481	0.0303	0.2704	0.1739	**0.5652**	
SCKD	0.0004	0.3505	0.1841	0.2107	0.3376	0.0346	0.3181	0.1376	0.5055	**0.6409**

Diagonal = Average Variance Extracted (AVE)

Lower Matrix = R^2

Reliability

Reliability generally refers to an extent to which an experiment, test, or other measurement procedure yields the same result on repeated trials. Traditionally the reliability could be assessed using Cronbach's alpha coefficient, however this approach tends to underestimate reliability, has several other limitations, and could be inaccurate (Malhortra et al. 2006; Garver and Mentzer 1999). Therefore, an alternative measure of reliability was also

utilized. The following equation (2) was used for calculating this alternative measure of construct reliability:

$$(\Sigma\lambda)^2 / [(\Sigma\lambda)^2 + \Sigma(1-\lambda_j^2)], \qquad (2)$$

where λ is the standardized regression coefficient of the item (Fornell and Larcker 1981). All variables in the measurement model exceeded the 0.70 threshold for good construct reliability. Finally, AVE of reliable constructs generally exceeds a 0.50 benchmark (Bagozzi and Yi 1991). This criterion of construct reliability was also achieved as shown in the Table 4.6.

COMMON METHOD VARIANCE

Common method variance (CMV) or common method bias is known as a potential threat to the validity of the results in survey research (Podsakoff et al. 2003). Although some of the researchers suggest that CMV does not always impact the results (e.g. Malhortra et al. 2006), there is still a need to control and minimize its potential influence. Several steps were taken to minimize potential common method variance in this study. First, the potential respondents were pre-qualified to ensure that they possess relevant knowledge of the subject area. Second, the respondents were informed about the anonymity of their responses. Next, the order of independent and dependent variables in the survey was distanced and the responses within each construct were randomized. Finally, following the recommendations of Lindell and Whitney (2001) and Podsakoff et al. (2003), a marker variable was included in the survey in order to diagnose and control for potential CMV effects. The marker variable in this research was adapted from Ferrel and Skinner (1988). It represents a theoretically unrelated construct placed within the survey and allowed to co-vary with all the other constructs. At the same time, this

variable is relevant to the decision-making reality in most organizational settings. Four reflective items were used in this construct (Table 4.8).

Table 4.8 Marker Variable Measurement

Scale	Scale Reliability	Items	Mean	SD
Marker Variable "Formalization"	0.85	Internally in my unit, if a written rule is not specified in a certain situation, we make up informal rules as we go along	4.47	1.542
		Contacts with my company and its representatives are on a formal pre-planned basis	4.86	1.392
		When rules and procedures exist in my organization they are usually written agreements	5.30	1.389
		Most things in my business unit are covered by formal procedures	5.26	1.479

The construct's coefficient alpha was 0.85 and AVE was 0.75 and exceeded shared variance with all the other constructs. None of the correlations with other survey constructs were significant at the 0.05 level. In summary, the results indicated that CMV was not a significant concern in this research.

HYPOTHESES TESTING

After measurement model refinement and validation, the hypotheses presented in Chapter 3 were tested. The structural model results are presented in Figure 4.2 and the standardized regression weights and fit statistics for the structural model are summarized in Table 4.9.

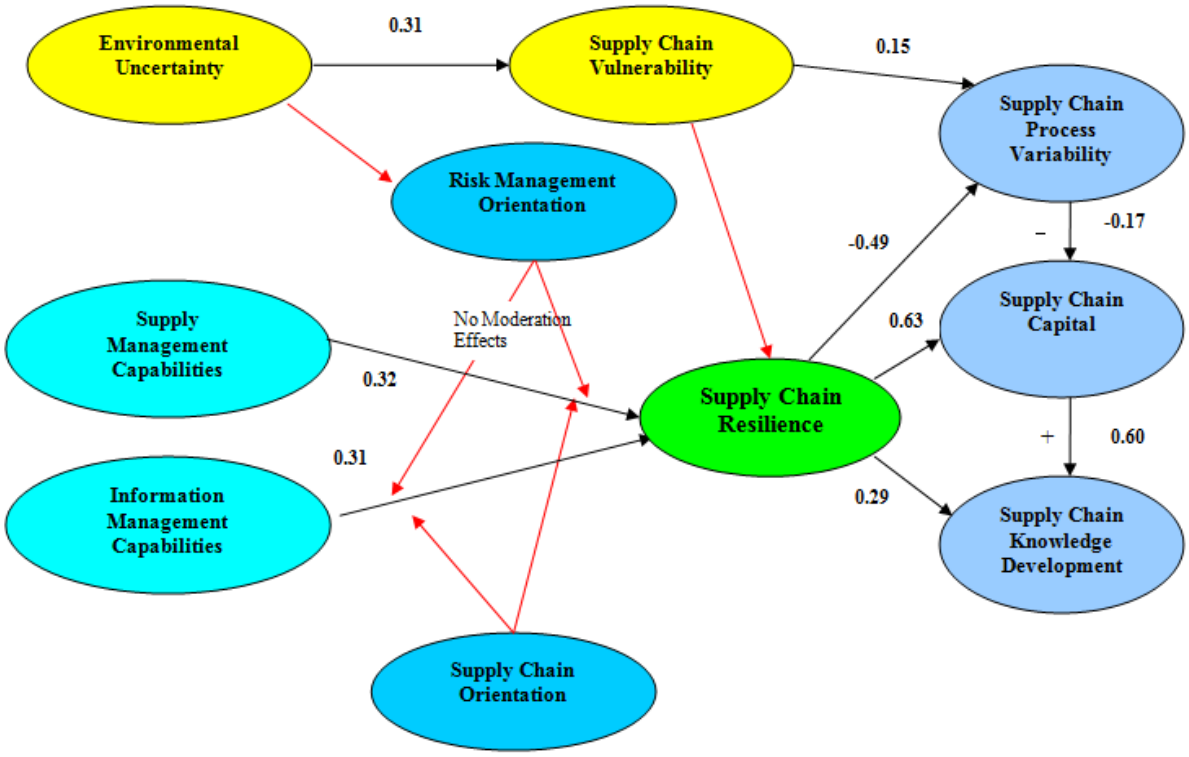

Figure 4.2
Structural Model Tested

Table 4.9 Structural Model Statistics

Model Fit:				
$\chi 2$ = 2147.98 **$\chi 2$/df = 1.67**	**df = 1290** **CFI = 0.93**	**RMSEA = 0.041**		
Hypothesized Relationship			Estimates	Result
Supply Management Capabilities (SMC)	(+) →	Supply Chain Resilience (SCR)	0.32***	Supported
Information Management Capabilities (IMC)	(+) →	Supply Chain Resilience (SCR)	0.31***	Supported
Supply Chain Vulnerability (SCV)	(-) →	Supply Chain Resilience (SCR)	-0.03*	Not supported
Environmental Uncertainty (EU)	(+) →	Supply Chain Vulnerability (SCV)	0.31***	Supported
RMO SCO	Moderators	SMC-SCR IMC-SCR	No Moderation Effects	
Environmental Uncertainty (EU)	(+) →	Risk Management Orientation (RMO)	0.04*	Not supported
Supply Chain Resilience (SCR)	(-) →	Supply Chain Process Variability (SCPV)	-0.49***	Supported
SCR	(+) →	Supply Chain Capital (SCC)	0.63***	Supported
SCR	(+) →	Supply Chain Knowledge Development (SCKD)	0.29***	Supported
SCV	(+) →	SCPV	0.15**	Supported
SCPV	(-) →	SCC	-0.17**	Supported
SCC	(+) →	SCKD	0.60***	Supported
***p>.05; ** p<.01; ***p<.001**				

Summary of Hypotheses Tests

The following hypotheses were tested:

4) Hypotheses related to antecedents of supply chain resilience:

H1a: Supply management capabilities (SMC) have a positive impact on a firm's supply chain resilience (SCR).

The path from SMC to SCR was significant ($p<0.001$), in the direction hypothesized, and strong (0.32). The data strongly supported the hypothesis that supply management capabilities are an antecedent to supply chain resilience.

H1b: Information management capabilities (IMC) have a positive impact on a firm's supply chain resilience (SCR).

The path from IMC to SCR was significant ($p<0.001$), in the direction hypothesized, and strong (0.31). The data strongly supported the hypothesis.

H2: Supply chain vulnerability (SCV) has a negative impact on a firm's supply chain resilience (SCR).

The path from SCV to SCR was in the hypothesized direction, but it was not significant ($p = -0.03$). Therefore, the hypothesis that supply chain vulnerability is an antecedent to supply chain resilience was not supported by the data.

Additionally:

H3: A higher level of environmental uncertainty (EU) results in a higher level of supply chain vulnerability (SCV).

The path from EU to SCV was significant ($p<0.001$), in the direction hypothesized, and strong (0.31). This hypothesis was supported by the data.

5) **Moderating Hypotheses:**

H4a: Risk management orientation positively moderates the relationship between supply management capabilities and firm's supply chain resilience.

H4b: Risk management orientation positively moderates the relationship between information-focused capabilities and firm's supply chain resilience.

H5a: Supply chain orientation positively moderates the relationship between supply management capabilities and firm's supply chain resilience.

H5b: Supply chain orientation positively moderates the relationship between information-focused capabilities and firm's supply chain resilience.

None of the moderation hypotheses H4a-b and H5a-b were supported. The details of the moderation analysis are provided in the following section.

Additionally:

H6: A higher level of environmental uncertainty (EU) has a positive impact on risk management orientation (RMO).

The path from EU to RMO was in the hypothesized direction, but it was not significant ($p = 0.04$). Therefore, this hypothesis was not supported by the data.

6) **Hypotheses related to outcomes of supply chain resilience:**

H7a: A higher level of the firm's supply chain resilience (SCR) results in a lower level of supply chain process variability (SCPV).

The path from SCR to SCPV was significant ($p<0.001$), in the direction hypothesized, and strong (-0.49). The data strongly supported the hypothesis that supply chain resilience leads to a reduction of supply chain process variability.

H7b: A higher level of the firm's supply chain resilience results in a higher level of supply chain capital.

The path from SCR to SCC was also significant ($p<0.001$), in the direction hypothesized, and strong (0.69). The data strongly supported the hypothesis that supply chain resilience leads to an increase in supply chain capital.

H7c: A higher level of the firm's supply chain resilience (SCR) results in a higher level of supply chain knowledge development (SCKD).

The path from SCR to SCKD was also significant ($p<0.001$), in the direction hypothesized, and strong (0.29). The data strongly supported the hypothesis that supply chain resilience leads to increase in supply chain knowledge development.

Other outcomes:

H8: Supply chain vulnerability (SCV) is positively associated with supply chain process variability (SCPV).

The path from SCV to SCPV was significant ($p<0.01$), in the direction hypothesized, but not very strong (0.15). This hypothesis was supported by the data.

H9: Supply chain process variability (SCPV) is negatively associated with supply chain capital (SCC).

The path from SCPV to SCC was significant ($p<0.01$), in the direction hypothesized, but not very strong (-0.17). This hypothesis was supported by the data.

H10: Increased supply chain capital (SCC) increases supply chain knowledge development (SCKD).

The path from SCC to SCKD was significant ($p<0.001$), in the direction hypothesized, and very strong (0.60). This hypothesis was strongly supported by the data.

MODERATING EFFECTS OF FIRM ORIENTATIONS

Testing for moderating effects of a variable in SEM is similar to testing for group differences. The moderating effects of supply chain orientation and risk management orientation were tested one at a time. The responses were divided into two groups and treated as categorical data. While identical models are used for the groups tested, parameters take on different values for the different groups based on the theoretical justification. More specifically, splitting the data into groups permitted analysis of the moderating effect of risk management orientation (RMO) under two conditions relevant to this study: High RMO and Low RMO. Similarly, supply chain orientation (SCO) was categorized as High SCO and Low SCO. Next, the parameters of interest (paths from Supply Management Capabilities (SMC) and Information Management Capabilities (IMC) to Supply Chain Resilience (SCR) were labeled in order to constrain the estimates of their values and the fit statistical parameters of the constrained model were compared to the fit statistics of the unconstrained model. Two models were compared for each of the moderators. The paths were set free to vary in the first (moderated) model to allow for differences in RMO (or SCO) to change the path weights. In the second (no-moderation) model, on the other hand, each path was constrained once (Path 1 High = Path1 Low etc.) such that the path weights were set to be the same regardless of the level of RMO (or SCO). Next, the two models were compared to check for statistical and practical differences in fit. The same procedure was conducted for the other firm orientation. Upon comparison, the calculated Chi-square change between models was minimal and statistically not significant ($p>0.05$). Thus, the results indicated that Risk Management Orientation was not a significant moderator for both hypothesized antecedents of Supply Chain Resilience (Supply Management and Information

Management capabilities). Similarly, Supply Chain Orientation was not found to be a significant moderator for both hypothesized antecedents of Supply Chain Resilience.

In the final analysis, it was not totally surprising to find hypotheses H4a-b and H5a-b (moderating effects of two firm orientations) not significant since the literature on this issue is scarce and an alternative view of the role of these orientations could be proposed. Therefore, a post-hoc analysis was conducted to further explore the role of risk management and supply chain orientations in the hypothesized framework of relationships among the constructs of interest.

ALTERNATE MODEL ANALYSIS

It has been suggested in the literature that researchers should propose and analyze rival models by conducting post hoc analysis (Bollen and Long 1992; Min, Mentzer and Ladd 2007). Based on the results of the hypotheses testing and additional theoretical insights from the literature, an alternate model was proposed to examine the role of firm orientations in the updated theoretical framework. This alternate model is presented in Figure 4.3. While no moderation effects were found in the original model, an alternate model might be able to explain how risk management orientation and supply chain orientation fit in the theorized conceptual framework. Alternatively to the initial framework, risk management orientation and supply chain orientation are viewed in this model as antecedents of logistics capabilities. In addition to an empirical support from the preliminary analysis, such a view of the role of firm orientations is supported by the Strategy-Structure-Performance (SSP) paradigm and related stream of literature (Chow et al.1995; Stock et al. 1998; Stank and Traichal 1998; Rodrigues, Stank and Lynch 2004; Defee and Stank 2005).

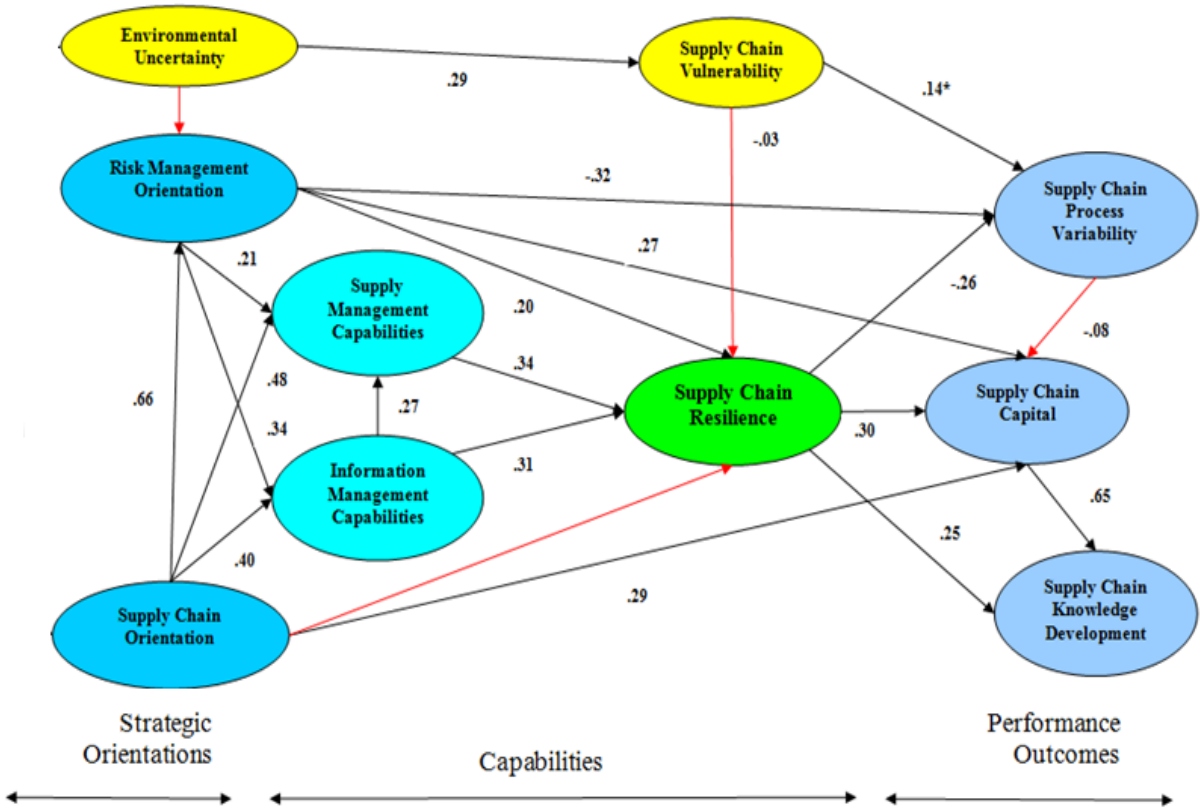

Figure 4.3
Alternate Model tested

The selected results of the alternate model analysis are summarized and presented in Table 4.10.

Table 4.10 Structural Model Statistics (Alternate Model)

Model Fit:				
$\chi 2$ = 2047.98 $\chi 2$/df = 1.59	df = 1287 CFI = 0.934		RMSEA = 0.039	
Hypothesized Relationship			Estimates	Result
Supply Management Capabilities (SMC)	(+) →	Supply Chain Resilience (SCR)	0.34***	Supported
Information Management Capabilities (IMC)	(+) →	Supply Chain Resilience (SCR)	0.31***	Supported
Information Management Capabilities (IMC)	(+) →	Supply Management Capabilities (SMC)	0.27***	Supported
Supply Chain Vulnerability (SCV)	(-) →	Supply Chain Resilience (SCR)	-0.03*	Not supported
Environmental Uncertainty (EU)	(+) →	Supply Chain Vulnerability (SCV)	0.29***	Supported
Environmental Uncertainty (EU)	(+) →	Risk Management Orientation (RMO)	0.03*	Not supported
Supply Chain Resilience (SCR)	(-) →	Supply Chain Process Variability (SCPV)	-0.51***	Supported
SCR	(+) →	Supply Chain Capital (SCC)	0.30***	Supported
SCR	(+) →	Supply Chain Knowledge Development (SCKD)	0.25***	Supported
***p>.05; ** p<.01; ***p<.001**				

Table 4.10 Continued

Model Fit:				
$\chi2$ = 2047.98 $\chi2$/df = 1.59	df = 1287 CFI = 0.934		RMSEA = 0.039	
Hypothesized Relationship			Estimates	Result
Supply Chain Orientation:				
SCO	→	SMC	0.48***	Supported
SCO	(+)	IMC	0.40***	Supported
SCO	(+)	RMO	0.66***	Supported
SCO	(+)	SCR	0.07*	Not supported
SCO	(+)	SCC	0.29***	Supported
Risk Management Orientation:				
RMO	→	SMC	0.21***	Supported
RMO	(+)	IMC	0.34***	Supported
RMO	(+)	SCR	0.20***	Supported
RMO	(-)	SCPV	-0.32***	Supported
RMO	(+)	SCC	0.27***	Supported
SCV	(+) →	SCPV	0.14**	Supported
SCPV	(-) →	SCC	-0.08*	Not supported
SCC	(+) →	SCKD	0.65***	Supported
***p>.05; ** p<.01; ***p<.001**				

This model also has a very good statistical fit ($\chi2$=2047.98, df=1287, $\chi2$/df=1.59, CFI=0.934, TLI=0.92, and RMSEA=0.039), and, most importantly, highlights the role of risk management and supply chain orientations as shown by their strong direct effects on logistics capabilities, supply chain resilience, and other outcomes of interest. Perhaps the most intriguing

result from the post-hoc model was that the direct path between supply chain orientation and supply chain resilience is not significant, while both the path from risk management orientation to supply chain resilience and the path from supply chain orientation to risk management orientation are strong and statistically significant. This might indicate the existence of hierarchical structure in the network of firm orientations under different contextual conditions and such relationships should be further explored. For example, in the context of supply chain management the results of analysis indicate that supply chain orientation is an antecedent not only to logistics capabilities, but also to risk management orientation. Similarly, such hierarchical relationships could exist on a capabilities level. For example, information management capabilities could be viewed as an antecedent to supply management capabilities. However, not all hypothesized relationships were supported. For example, no significant direct relationship was found between Supply Chain Orientation (SCO and Supply Chain Resilience (SCR) which could be explained by existence of the mediating effects of Risk Management Orientation and logistics capabilities. Similarly, the relationships between Environmental Uncertainty (EU) and Risk Management Orientation (RMO) as well as between Supply Chain Vulnerability (SCV) and Supply Chain Resilience were not significant. These and other important findings are discussed in more detail in the next chapter.

CHAPTER SUMMARY

This chapter provided details of the pre-test and main study data analyses. The data and quality of measurement were evaluated and the proposed model was tested. Structural equation modeling was used to test hypothesized theoretical relationships as formulated in Chapter 3.

Based on the results of the analysis, the structural model had an overall good fit. Nine of the hypothesized relationships including those related to antecedents and outcomes of Supply Chain Resilience (SCR) were also found statistically significant. The significance of these relationships provides evidence of the role of logistics capabilities in creating SCR as well as the evidence of the role and importance of SCR in creating value-based performance outcomes. At the same time, the relationship between Supply Chain Vulnerability (SCV) and SCR as well as the relationship between Environmental Orientation (EU) and RMO were not found statistically significant. Moreover, the hypothesized moderating roles of RMO and SCO in the relationships between logistics capabilities and SCR were not supported.

Additionally, a post-hoc analysis was conducted in order to test the alternative model. It was concluded that Risk Management Orientation (RMO) and Supply Chain Orientation (SCO) in fact play significant roles is the hypothesized relationships. These orientations, however, serve as antecedents instead of moderators. RMO has significant direct effects on SMC, IMC, SCR, SCPV, and SCC, while SCO has significant direct effects on SMC, IMC, SCR, RMO, SCR, and SCC. The empirical findings of an alternate post-hoc model find additional theoretical support in the extended literature base.

Chapter 5 illustrates what these and other important results mean in light of the research objectives and contributions to the extant body of knowledge. It provides a detailed explanation of the hypotheses testing results from the main test and an alternate model, highlights the implications for scholars and managers as well as research limitations and opportunities for future research.

CHAPTER 5 – CONCLUSIONS AND IMPLICATIONS

OVERVIEW

This dissertation set out with the purpose of investigating the phenomenon of supply chain resilience at the firm level of analysis, as well as its antecedents and value-based outcomes. The first three chapters dealt with a review of the relevant literature, the development of a comprehensive conceptual framework, and the formation of an appropriate methodology for collecting data and testing the hypothesized relationships. The results of the quantitative study were reported in Chapter 4. In addition to the main test, a post-hoc analysis was conducted with the purpose of further investigating the role of risk management and supply chain orientations. This phase of the analysis was conducted due to the fact that no significant moderation effects were initially found. Thus, an alternative framework of hypothesized relationships was proposed. This chapter discusses the findings of data analysis, theoretical and managerial contributions, limitations, and directions for future research.

The research that comprises this dissertation is distinct from previous research on supply chain resilience in several ways. First, a holistic perspective that links supply chain resilience to its antecedents and value-based consequences in a cohesive conceptual framework is developed. Second, based on the extensive multidisciplinary literature review, supply chain resilience is defined, operationalized, and empirically tested at the firm level of analysis. Specific measures are proposed and successfully validated and new relationships between supply chain resilience and related constructs, such as risk management orientation and supply chain capital, are discovered. These findings are contributions in that they fill the gaps in the existing literature and they open the doors for future research. Third, this dissertation builds on previous research through its emphasis on the role of logistics capabilities in developing firm-level competencies

(Olavarrieta and Ellinger 1997, Zhao, Droge and Stank 2001, Mentzer, Min and Bobbitt 2004) and it expands the theoretical reach of the resource-based theory and its dynamic capabilities extension (Teece, Pisano and Shuen 1997, Eisenhardt and Martin 2000). Finally, this research presents a methodological variation which is unique for supply chain resilience studies. Although the combination of survey-based methodology and structural equation modeling applied in this research is widely used in the field of logistics and supply chain management (Mentzer and Kahn 1995), it offers a new methodological approach for researching supply chain resilience. Previous studies on supply chain resilience have either been conceptual in nature (Sheffi 2001, Christopher and Peck 2004, Ponomarov and Holcomb 2009) or employed a focus group or case study methodology (Rice and Caniato 2003, Christopher and Peck 2004, Christopher 2005, Sheffi 2005, Pettit et al. 2010). The methodology chosen for this research allows for the collection of a relatively large amount of data in an efficient manner, and it enables the validation of the collected data through rigorous statistical techniques (Kerlinger and Lee 2000). The procedures related to data collection and validation were discussed in the previous chapter. It is important to note, however, that all research methods are flawed and have their own limitations. For this reason, testing the same theory using multiple methods and techniques (also known as triangulation) as a good way to handle the limitations of each method (McGrath 1982) is suggested in the recommendations for future research. The following sections offer a more comprehensive discussion of the research findings, theoretical and managerial implications, limitations, and future research directions along with concluding thoughts.

DISCUSSION OF THE FINDINGS

This section reviews some major findings of the current research. The research findings are combined into several groups, including: antecedents of supply chain resilience and strategic orientations, external factors and their influence, and outcomes of supply chain resilience. Most importantly, the overall emerging research framework of supply chain resilience provides a novel conceptual understanding of the phenomenon of interest as demonstrated by a significant empirical verification of the data analysis results.

Findings Related to Antecedents of Supply Chain Resilience

Logistics capabilities, classified into supply management capabilities and information management capabilities, were hypothesized as antecedents of Supply Chain Resilience (SCR). Specifically, Hypothesis 1a posited that supply management capabilities (SMC) have a positive impact on a firm's supply chain resilience (SCR) while Hypothesis 1b posited that information management capabilities (IMC) have a positive impact on a firm's Supply Chain Resilience (SCR). Both parts of Hypothesis 1 were supported by the main test (Figure 5.1).

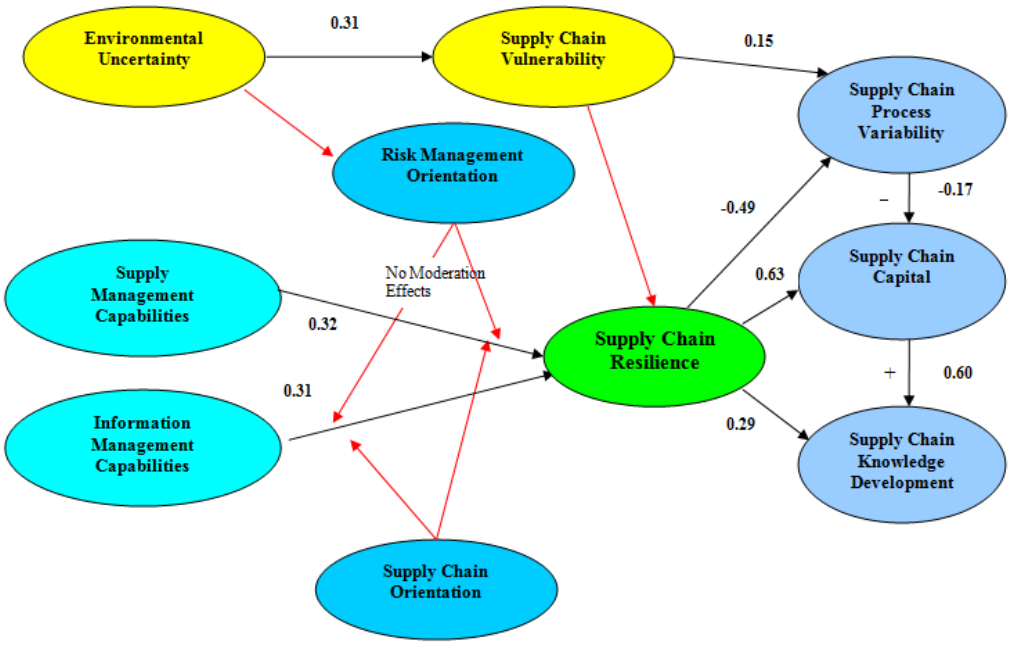

Figure 5.1
Main Test Model Results

Results of the analysis indicate that supply management and information management capabilities combined together account for 63% of variation in SCR. It is a significant finding that adds to our understanding of the phenomenon of supply chain resilience. Effective management of supply and information flows is essential for maintaining resiliency and continuity of business operations. These empirical results are especially important for understanding the nature of SCR as well as those factors that contribute significantly to building resilience at the firm level. Moreover, the important role of logistics capabilities as valuable strategic resources is highlighted and emphasized expanding on the related previous research (Olavarrieta and Ellinger 1997; Lynch et al. 2000; Zhao, Droge and Stank 2001).

The Role of Strategic Firm Orientations

The role of two strategic orientations was tested in this research. First, supply chain orientation (SCO) was originally hypothesized as a moderating variable in the relationships between logistics capabilities (including supply management capabilities (SMC) and information management capabilities (IMC)) and supply chain resilience (SCR). Similarly, risk management orientation (RMO) was hypothesized as a moderator in the relationships between logistics capabilities and SCR. The moderation tests were not statistically significant, and none of the moderating hypotheses was supported. After further exploration, it was noted that a direct link from risk management orientation (RMO) to supply chain resilience (SCR) is statistically significant, while the link from supply chain orientation (SCO) to supply chain resilience (SCR) is not statistically significant. The difference in the effects of the two orientations was one of the surprising findings of this research. Additionally, significant relationships were discovered between the strategic orientations and logistics capabilities. Both orientations were found to play a critical role as potential antecedents of information management and supply management capabilities. Such statistical findings required careful consideration and necessitated additional theoretical justification. Thus, combining the obtained results with an extended literature review resulted in a proposed alternative conceptual framework.

A post-hoc analysis was conducted with the purpose of further exploring the roles of risk management orientation and supply chain orientation in the hypothesized framework of relationships among the constructs of interest (Figure 5.2).

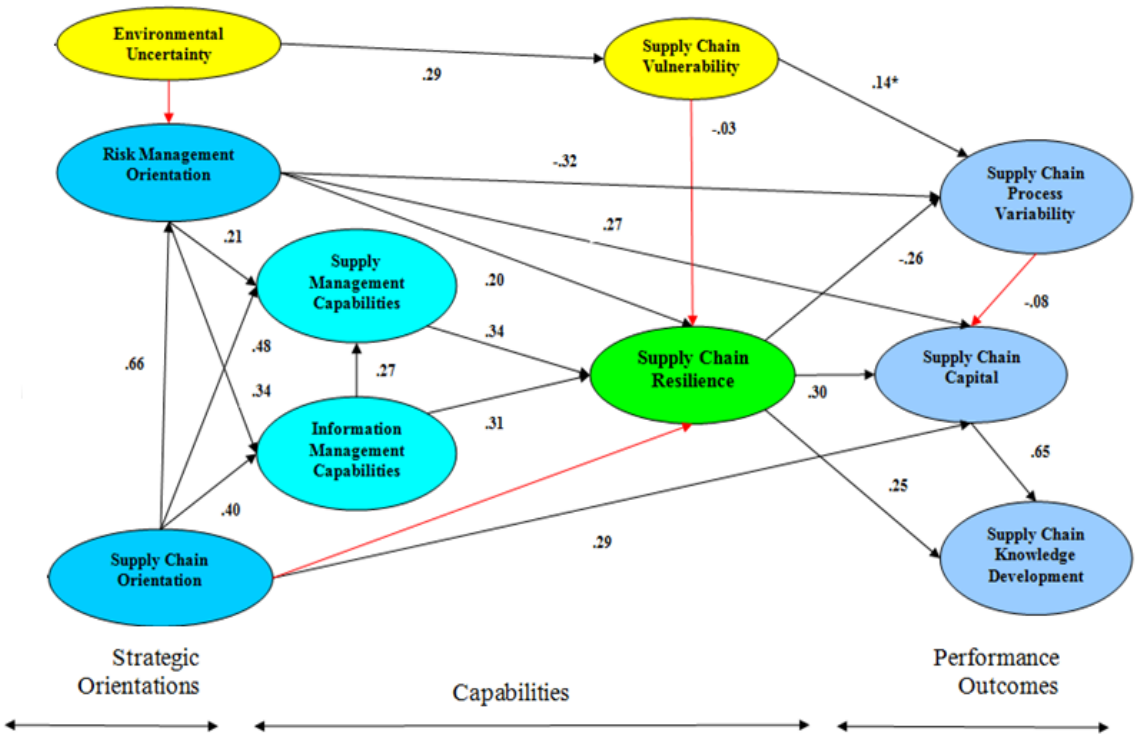

Figure 5.2
Alternate Model Results

Additional theoretical justification for the proposed post-hoc model was found in the stream of literature related to the Strategy - Structure - Performance (SSP) paradigm. Briefly, this stream of literature supports the idea that a firm's strategy, formulated in consideration of the factors of external environment, drives the development of organizational structure, capabilities and processes and leads to the desired performance outcomes (Miles and Snow 1978; Chow et al. 1995; Stock et al. 1998; Stank and Traichal 1998; Defee and Stank 2005). Expanding on the logic of the SSP paradigm, the proposed alternative model could be viewed in terms of Strategic Orientations – Capabilities – Performance Outcomes. In this alternative conceptualization, consistent with the theoretical arguments outlined, the firm's strategic orientations play a vital

role as important antecedents to logistics capabilities, supply chain resilience, and some of the hypothesized outcomes, such as supply chain capital and supply chain process variability.

A post-hoc analysis revealed new and interesting relationships among the constructs of interest. For example, it was discovered that SCO is a strong antecedent to both information management capabilities (IMC) and supply management capabilities (SMC). Similarly, RMO was also found to be a strong antecedent to both information management capabilities (IMC) and supply management capabilities (SMC). Both orientations combined explain 74% of variance in IMC and 69% of variance in SMC. These research findings extend previous work on logistics capabilities and the relationship between strategy and structure in the supply chain context (Lynch et al. 2000; Zhao, Droge and Stank 2001; Defee and Stank 2005).

Additionally, the post-hoc model findings indicate that RMO is a significant antecedent to supply chain resilience (SCR). In contrast, the findings also indicate no significant relationship between supply chain orientation (SCO) and supply chain resilience (SCR). The later finding seems to be counterintuitive at first; however it could be explained in light of the relationship between the two orientations. Perhaps the most intriguing result is that supply chain orientation (SCO) is an antecedent to risk management orientation (RMO). This might indicate the existence of hierarchical structure. In other words, in the supply chain context, the development of supply chain orientation (SCO) precedes the development of risk management orientation (RMO). Thus, the relationship between SCO and SCR could be fully mediated by risk management orientation. Future research should clarify the nature of the relationship between the two orientations discussed here. Similarly, such hierarchical relationships could exist on a level of logistics capabilities. The results indicate that information management capabilities (IMC) serve as an antecedent to supply management capabilities (SMC). This could mean that timely and accurate

information is needed before supply management issues could be properly addressed. Both hierarchical structures are intriguing in their own right and require further empirical investigation.

Another set of interesting findings is related to the relationships between orientations and hypothesized outcomes of supply chain resilience. The results of the post-hoc model analysis indicate that an increase in risk management orientation (RMO) leads to a decrease in supply chain process variability (SCPV). Finally, both RMO and SCO serve as important antecedents to supply chain capital (SCC). Combined together these orientations explain about 56% of variation in SCC, while supply chain resilience contributes additional 30%. These research findings contribute to the previous work on supply chain capital (Autry and Griffis 2008; Min et al. 2008).

The Role of External Factors

The role of external factors in the resilience framework was acknowledged by testing the impact of environmental uncertainty (EU). It was hypothesized (Hypothesis 6) that a higher level of EU has a positive impact on risk management orientation (RMO). At the same time, another hypothesis (Hypothesis 3) stated that a higher level of EU results in a higher level of supply chain vulnerability (SCV). Hypothesis 3 was supported, while Hypothesis 6 was not supported, suggesting that RMO might play a different role in the conceptual framework. This is consistent with the findings related to an antecedent role of strategic orientations in the conceptual framework discussed earlier. Since it was found that a firm's RMO plays an important role as an antecedent of IMC, SMC and SCR, the alternative contributors to RMO should be investigated in the future research as well.

Subsequently, Hypothesis 2 posited that SCV has a negative impact on the firm's supply chain resilience (SCR). The directionality of this hypothesis was supported, which is consistent with the earlier findings of negative relationships between vulnerabilities and resilience proposed by Pettit et al. (2010). The proposed relationship, however, was not statistically significant. At the same time, another hypothesis linked SCV to performance outcomes. Specifically, Hypothesis 8 stated that supply chain vulnerability (SCV) is positively associated with supply chain process variability (SCPV). This hypothesis was supported. Interestingly, while no significant relationship between supply chain resilience (SCR) and supply chain vulnerability (SCV) was found, both variables are influencing SCPV, but in different directions. While increases in SCV lead to an increase in SCPV, higher levels of SCR lead to lower levels of SCPV as stated by Hypothesis 7a. As companies try to find ways to decrease supply chain process variability, the findings of this research offer valuable insights on approaching such a task. Additionally, these results lead to a conclusion that further theoretical and empirical exploration of the relationships among environmental uncertainty, supply chain vulnerability, supply chain resilience, and related outcomes is necessary. The discovery of the true nature of the relationship between SCV and SCR would be especially intriguing.

Findings Related to the Outcomes of Supply Chain Resilience

Three specific value-based hypothesized outcomes of SCR were tested in this research. First, Hypothesis 7a posited that a higher level of the firm's supply chain resilience results in a lower level of supply chain process variability. Second, Hypothesis 7b stated that a higher level of the firm's supply chain resilience results in a higher level of supply chain capital. Finally, Hypothesis 7c posited that a higher level of the firm's supply chain resilience results in a higher

level of supply chain knowledge development. All three hypotheses were supported. It is important to note that these relationships have not been established previously.

Additionally, it was hypothesized that supply chain vulnerability (SCV) is positively associated with supply chain process variability (Hypothesis 8); supply chain process variability (SCPV) is negatively associated with supply chain capital (Hypothesis 9), and increased supply chain capital (SCC) leads to supply chain knowledge development (Hypothesis 10). All three hypotheses (8-10) demonstrated right directionality and were statistically significant. They revealed the relationships among the outcomes of supply chain resilience. For example, earlier research has contributed to explaining the link between supply chain capital and supply chain knowledge development and called for further empirical investigation (Autry and Griffis 2008). This research contributes by proposing the operationalization of these constructs and testing the discussed relationship. Furthermore, this research finds that supply chain resilience and risk management orientation positively contribute to supply chain capital, while the relationship between supply chain process variability and supply chain capital are negative, but also statistically significant. These findings are very important for understanding how firms could contribute to increasing their supply chain capital.

This dissertation makes some important and significant contributions to the knowledge base. Both expected and unexpected results add to our understanding of the phenomenon of supply chain resilience and all the related constructs and interrelationships. The importance of supply management and information management capabilities was supported as well as the link between supply chain resilience and value-based outcomes such as supply chain capital and supply chain knowledge development. The role of supply chain resilience in reducing supply chain process variability was also confirmed. On the other hand, the hypothesized role of

strategic orientations as potential moderators in the relationship between logistics capabilities and supply chain resilience was not supported. An alternative conceptual model, where strategic orientations play a role of antecedents of both capabilities and resilience, was proposed as a result. The hypothesized role of environmental uncertainty and supply chain vulnerability was only partially supported. These and some other hypothesized relationships require additional empirical and theoretical justification in the future studies. The following narrative describes implications of the research findings as well as specific theoretical and managerial contributions.

CONTRIBUTION

This dissertation offers several important theoretical and practical contributions. One of the major contributions is that this research provides a better understanding of supply chain resilience by defining it and explaining the relationships between supply chain resilience and the set of antecedents and value-based consequences. Any meaningful contribution to the body of knowledge should integrate current theories in the literature and make an attempt to take them to a new level with conceptual thoroughness and rigor (Churchill and Perrault 1982; Flint and Mentzer 1999). From a theoretical standpoint, this dissertation utilizes existing theories such as resource-based view, resource dependence theory, and strategic choice theory to explain the major antecedents and outcomes of supply chain resilience. Building on previous research, and filling the gaps in the existing literature, this research offers new and valuable insights. It also provides empirical evidence of the potential impact of supply chain resilience, logistics capabilities, and strategic orientations on supply chain process variability, supply chain capital, and supply chain knowledge development. The role of environmental uncertainty and supply chain vulnerability is also researched. Most of investigated constructs and interrelationships

among them were underexplored in the previous literature. Thus, this research opens the doors for new and intriguing questions and fruitful future research, while at the same time serving as a catalyst for further conceptualization and subsequent theory testing.

From a managerial standpoint, it becomes increasingly important to understand the factors that influence the continuity of business operations and minimize the negative effects of supply chain disruptions. Relevance to practitioners assumes that they could use the research findings by applying the investigated concepts in their specific organizational settings, adjusting and manipulating related variables as needed (Varadarajan 2003). The increased risks and challenges of operating in a global domain require that managers gain a better theoretical understanding of the emerging critical topic of supply chain resilience in order to effectively manage their companies in the turbulent business environment. The findings of this research suggest that more attention should be given to cultivating a specific set of strategic orientations, information management and supply chain capabilities with the purpose of creating a resilient enterprise. More specific theoretical and managerial implications of this research are described in the following sections of this chapter.

THEORETICAL IMPLICATIONS

Defining and Measuring Supply Chain Resilience and Risk Management Orientation

One of the important theoretical contributions of this research is defining and measuring the concept of supply chain resilience (SCR). This contribution is important for several reasons. First, it is based on multidisciplinary perspectives adding to our understanding of the phenomenon in the supply chain context. Second, supply chain resilience is conceptualized at the firm level of analysis in the holistic conceptual framework of interrelated antecedents and

outcomes. Next, this research proposes a psychometrically sound way of measuring supply chain resilience. The appropriate measures were developed, tested, and successfully validated. This opens the doors for further empirical research and conceptualization. Additionally, this dissertation indicates several opportunities for future research and offers specific recommendations for conducting future research projects.

This research also introduces the conceptualization and measurement of risk management orientation (RMO) which fills the gap in the existing literature. Proposing this concept and testing the role of RMO is important for several reasons. First, supply chain risk management is a relatively new area of research. As with all new areas, it grows by developing and testing new constructs. RMO is one of such constructs. Development of a RMO construct also expands the stream of literature on different organizational orientations such as supply chain management orientation or market orientation. These orientations are important indicators of strategic focus. Finally, similarly to SCR, the appropriate measures of RMO were developed, tested, and successfully validated in this research, opening the door for further conceptual and empirical exploration.

Understanding the Antecedents of Supply Chain Resilience

Another objective of this research was to determine the antecedents of supply chain resilience at the firm level of analysis. The focus on logistics capabilities not only reveals the significant role of logistics capabilities as antecedents in the proposed theoretical framework, but also suggests that these capabilities are vitally important for the success and even survival of firms following disruptive events. This finding contributes to the established stream of literature related to logistics capabilities and their outcomes (Olavarrieta and Ellinger 1997; Zhao, Droge and Stank 2001; Mentzer, Min and Bobbitt 2004). Supply chain resilience in this sense could be

viewed as one of the missing links between logistics capabilities and sustainable competitive advantage.

The role of strategic orientations was also discussed in detail. An alternative way to operationalize supply chain orientation (SCO) was proposed and successfully tested. Specifically, the proposed view of SCO in this dissertation is not relationship-specific; the model also measures SCO as a first order construct instead of a second-order construct. Traditionally SCO has been measured as a second order construct with several dimensions. For purposes of this research such measurement was adjusted and an alternative way of measurement was proposed. The approach presented in this research opens the doors for further theoretical debate and discussion of the role and position of supply chain orientation (SCO) in supply chain management research. Furthermore, this research offers important initial insights into the hierarchical structure of strategic firm orientations and capabilities as discussed in the previous section.

Understanding the Outcomes of Supply Chain Resilience

In contrast to many studies in the area of supply chain management that focus on measuring performance as the main and only outcome, this research offers an alternative approach focusing on more intermediate value-based performance outcomes, such as supply chain process variability, supply chain capital, and supply chain knowledge development. This is an important theoretical implication that contributes in two major ways. Firstly, it contributes to the literature stream related to risk management and resilience by proposing and confirming that resilience leads to such value-based outcomes. And secondly, it contributes to the literature stream related to the relatively new area of supply chain capital that also could benefit from additional empirical confirmation (Autry and Griffis 2008). Furthermore, the way to

measure such important new constructs as supply chain capital (SCC) and supply chain knowledge development (SCKD) was proposed, empirically tested, and validated in this research. In summary, proposing and testing an alternative set of intermediate value-based outcomes, this research advances two emerging areas of supply chain management research and opens a new path for further exploration and empirical testing.

MANAGERIAL IMPLICATIONS

There are also important managerial implications arising from this research. Previous studies have discussed the significance of supply chain resilience for success and long-term sustainability of companies. This research makes an impact by defining and measuring supply chain resilience at the firm level of analysis and offering much needed empirical support. It is done by combining important antecedents, external factors, and value-based outcomes of supply chain resilience in a testable conceptual framework. The following two categories of implications are especially important from a managerial perspective.

Defining and Measuring Supply Chain Resilience and Risk Management Orientation

Changes to and disruptions of business operations are inevitable in the global marketplace. Taking into account the volatility of the competitive global environment, companies would serve themselves well by preparing to adapt to the threats and challenges of the external environment. Defining and measuring supply chain resilience and risk management orientation equips managers with the knowledge and tools necessary to prepare their companies for various risks and disruptions. This research contributes to such an understanding. Drawing on the dynamic capabilities extension of the resource-based view (Teece, Pisano and Shuen 1997;

Eisenhardt and Martin 2000), supply chain resilience is defined as a dynamic capability at the firm level, while risk management orientation is viewed in terms of specific organizational culture that should be cultivated and maintained. Additionally, managers need to be aware of the potential benefits related to supply chain resilience. For top level business executives, it is critical to know whether or not their firms should invest in building and maintaining supply chain resilience and where such investments should be directed. This research reveals specific ways to increase supply chain resilience. The findings from this research suggest that in order to increase resilience companies should focus on developing a specific set of strategic orientations and logistics capabilities such as information management and supply management capabilities. For example, making an investment in an integrated database could facilitate information sharing which is important for maintaining resilience. Similarly, managing supplier relationships strategically is also essential for maintaining operational flexibility and resilience at the time of disruptions.

Understanding the System of Antecedents and Outcomes of Supply Chain Resilience

This research offers a systemic perspective and shows that it is not wise to wait passively until supply chain disruptions occur. On the opposite, proactively investing in building a risk management orientation and appropriate organizational culture as well as developing a specific set of information management and supply management capabilities would be a much wiser strategy for establishing supply chain resilience. Building such awareness is another important managerial contribution. Furthermore, this research offers the ways to measure the return on such investments by analyzing specific value-based outcomes such as supply chain capital, supply chain process variability, and supply chain knowledge development. Additionally, new

approaches to evaluating logistics performance at the time of disruption and maintaining continuity of supply chain flows are proposed. For example, if supply chain managers want to minimize supply chain process variability in terms of unwanted variations in lead time and production output, the appropriate investments in establishing and maintaining supply chain resilience through developing specific capabilities and strategic orientations should be made. Managers may also consider the knowledge development aspects of the supply chain resilience framework and strive to proactively learn from previous events in order to manage supply-related risks better in the future. Maintaining a well-functioning organizational system of supply chain knowledge development could help managers create an effective repertoire of responses to the challenges of the external environment and avoid repeating the same mistakes. Those companies that make such proactive efforts a primary focus of managerial attention will be better positioned for long-term survival and sustainability.

LIMITATIONS AND FUTURE RESEARCH OPPORTUNITIES

LIMITATIONS

All research methods and designs have their own flaws and limitations (McGrath 1982). The limitations of this research include inherent weaknesses of cross-sectional methodology, limitations associated with the nature of the chosen sample, and constraints related to the scope of the survey as well as the depth of information that could be captured from perceptual measures collected from single informant representatives of each participating company.

One major limitation of a cross-sectional study design is that investigation of the phenomenon of supply chain resilience is limited to a point-in-time assessment. Longitudinal

research designs, on the other hand, could capture a dynamic nature of the phenomena of interest, which is especially important for capturing the effects of various supply chain disruptions on resilience and performance outcomes in the long run. Thus, a longitudinal focus is recommended for future studies in order to obtain additional valuable insights that would complement the results of this research. Additionally, it could be recommended to improve the quality of the data by obtaining the data from multiple informants. This was achieved only for some companies in the researched sample. Similarly, a dyadic or triadic data collection could also provide valuable insights as well as extending the reach of the survey to the non US-based companies.

Most latent variables in this research were measured by more than five items. Environmental uncertainty (EU) and supply chain knowledge development (SCKD) are two notable exceptions that were measured based on the three-item scales. While SCKD was originally conceptualized that way and the scales were properly validated, EU became a three-item construct in the process of scale refinement. While all the scales (including those for EU and SCKD) went through a rigorous process of statistical validation in this study, future research might benefit from a more comprehensive way to operationalize EU, capturing additional dimensions.

While every effort was made to validate the obtained results and address a common-method bias, collecting additional hard data for some of the variables could be additionally recommended. For example, more objective data on lead time variability could be used in the extension of this research if the researcher is provided with access to such database from one or several companies. Additional potential insights from such efforts could be well worth an inevitable sacrifice in generalizability.

In general, each method has its own limitations, strengths and weaknesses. Therefore, every research endeavor, qualitative or quantitative, must be evaluated in terms of the specific assumptions and procedures of the research methods that were used to generate the findings. McGrath (1982) recognizes this method-selection process as optimization and concludes that while research will always be flawed due to the trade-off between strengths and weaknesses inherent in every method, a well thought out selection of methods is crucial to the strength of research. Thus, it is impossible to do flawless research, but testing the same theory using multiple methods is a good way to handle the limitations of each method.

SUGGESTIONS FOR FUTURE RESEARCH

The opportunities for further research are abundant. This research generates multiple questions that could be answered in the future. For example, the following research questions could be proposed:

1) What are some of the other potential antecedents of supply chain resilience at the firm level of analysis? What other capabilities are important for building supply chain resilience?
2) What additional variables could be included in the proposed framework? What are some of the potential moderators of the relationships between logistics capabilities and supply chain resilience? For example, could supply chain complexity be a potential moderator?
3) What is the nature of the relationship between supply chain vulnerability and supply chain resilience?

4) Could a direct link between supply chain resilience and operational performance be established?
5) Could the results of this research be replicated under different contextual conditions, such as international settings or dyadic or supply chain network level of analysis? For example, resilience could be further studied in the context of dyadic buyer-supplier relationships.

The following recommendations could assist researchers in answering the questions stated above as well as many other related research questions.

Addressing methodological limitations in future research

First of all, the methodological limitations discussed in the previous section could be addressed in related future research by using the principles of methodological triangulation and employing a variety of quantitative and qualitative methods. For example, a simulation study could be conducted to investigate the elements of supply chain resilience framework in relation to specific supply chain risks and disruptions. Similarly, several experimental design studies could be also proposed based on developing different scenarios of supply-, demand-, and operations-related disruptions. Alternatively, conducting a longitudinal study could address the methodological limitations of cross-sectional research and further emphasize the role of importance of the outcomes of supply chain resilience.

Additional understanding of the phenomena of interest could be gained by using a qualitative approach. For example, supply chain resilience could be further researched from the managerial perspective using grounded theory qualitative tradition. This approach is proven to be useful in generating depth of understanding when complex social processes such as

managerial decision-making under uncertainty are researched. Future research should enhance our understanding of the resilience framework at the managerial level, emphasizing the division of responsibilities between functional areas and levels of management in the organization.

The future research agenda for supply chain resilience could also benefit from diversifying data sources, times of collecting data, and data collection methods. Investigator triangulation could be also achieved with the help of different investigators collecting data independently. The sources of common method variance could be additionally minimized if a researcher could obtain access to a reliable source of hard data for some of the investigated variables such as supply chain process variability or other variables (Lindell and Whitney 2001; Podsakoff et al. 2003).

Extending this Research by Adding New Variables and Making Conceptual Modifications

Analyzing the effects of additional variables could also benefit future research in order to further develop a theory of supply chain resilience. For example, the moderating effects of long-term relationship orientation could be of interest. The construct of long-term relationship orientation (LTRO) in buyer-seller relationships was proposed by Ganesan (1994) and developed in subsequent studies. Through a long-term relationship, the supplier becomes a part of a well-managed chain and could have a lasting effect on the competitiveness of the entire supply chain (Choi and Hartley 1996). Heide and John (1990) find that close long-term relationships emerge in response to the need for protecting relationship-specific assets. Using this view in the context of the research presented in this dissertation could potentially contribute to the exploration of the relational dimensions of supply chain resilience and supply chain capital, adding a new interesting perspective.

This research could be also extended by incorporating a feedback loop between the supply chain knowledge development outcome of supply chain resilience and the antecedent strategic orientations with subsequent development of the appropriate combination of capabilities. A social network perspective could be further explored both theoretically and empirically based on the findings related to supply chain capital and supply chain knowledge development. Additionally, demand-supply integration aspects of supply chain resilience could be researched by analyzing the influence of customer-focused logistics capabilities and related outcomes, adding them to the proposed conceptual framework. A direct link from supply chain resilience to performance could be separately addressed. Similarly, supply chain process variability, supply chain capital, and supply chain knowledge development could be also directly linked to performance. Subsequent creative modifications of the conceptual model are also possible.

Extending this Research to Different Contexts

Direct extensions of this research could incorporate several contextual directions. For example, resilience could be studied in the context of multicultural buyer-supplier relationships. Risk management becomes especially important in the international context where buyers and suppliers represent different cultures (Manuj and Mentzer 2008). As supply chain risks increase, companies also need to develop resilient logistics processes and capabilities that enable them to adequately respond to such challenges. Incorporating logistics capabilities of both buyers and suppliers into an extended conceptual framework could benefit the supply chain resilience research. The nature of the relationships between buyers and suppliers should also be considered in a future study of this type.

Further conceptualization using different research perspectives would be also 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 research agenda.

CONCLUDING REMARKS

This research attempted to push the boundaries of the current knowledge of supply chain resilience by exploring the phenomenon at the firm level of analysis, defining it, and identifying its antecedents and value-based consequences. In the final analysis, the main purpose of this dissertation is accomplished. This research serves as a catalyst for driving further inquiry by summing up past research, identifying existing gaps in the literature, advancing the body of knowledge in the area of supply chain risk management and resilience, and offering future research directions. It also offers guidance to supply chain managers who are searching for ways to deal with increasing complexity, risks, and challenges of the external environment while maintaining long-term survival, resilience, and sustainability of their companies. A strong foundation for an ongoing program of research is also established.

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