

## ABSTRACT

Title of Document: Supply Chain Disruption Management: A Conceptual Framework and Theoretical Model

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Ph.D. in Logistics and Transportation 2008

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Logistics, Business, and Public Policy

Severe supply chain disruptions have a great impact on the firm. They can cause loss of sales to customers and lead to changes in the design and strategy of the supply chain.

This research works focuses on supply chain disruption management. It presents an overall conceptual framework and a theoretical model, highlighting the decision making process of disruption recovery. First, the literature concepts surrounding supply chain disruptions – risk management, mitigation, crisis management, supply chain resilience, supply chain security, business continuity planning, and sustainability – are defined and differentiated, since these concepts often have overlapping factors that can cause confusion. After defining each of these concepts and the latest research findings, a framework for understanding the relationships among the concepts is developed. Second, this framework reveals a gap in the literature surrounding the disruption recovery and decision making process. While an initial disruption management model can be built using factors from the literature, data are collected by conducting multiple interviews and analyzed using a structured grounded theory methodology to produce a more complete model. This also has the effect of building theory from which propositions are developed surrounding discovery of the disruption, recovery team composition, decision making, and others. These propositions can be tested empirically in future research.

SUPPLY CHAIN DISRUPTION MANAGEMENT: A CONCEPTUAL  
FRAMEWORK AND THEORETICAL MODEL

By

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Dissertation submitted to the Faculty of the Graduate School of the  
University of Maryland, College Park, in partial fulfillment  
of the requirements for the degree of  
Doctor of Philosophy in  
Logistics and Transportation  
2008

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## **Dedication**

To my wife, who sacrificed her time, energy, and career because of her love for me and our dreams as a family.

And to Sydney and Caleb, who provided the source of my motivation on a daily basis.

## **Acknowledgements**

My sincere gratitude goes to Tom Corsi who believed in me and was willing to tackle a dissertation topic with which he had limited initial familiarity. I want to thank my committee, Dr. Curt Grimm, Dr. Phil Evers, Dr. Sandy Boyson, Dr. Paul Schonfeld, and Dr. Jennifer Blackhurst, for their help and guidance during this process. Thanks also to Dr. Bob Windle, who was always willing to help financially support my dissertation and research.

The faculty and staff in the LBPP department have all been extremely supportive over the four years that I have been at the University of Maryland, literally teaching me everything I know about conducting research. I look forward to working with many of you on future research projects.

Special thanks also goes to Dr. Tom Darling for his advice, understanding, and most importantly his calming influence when things were the most challenging.

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## Chapter 1: Introduction

*“No plan has ever survived contact with the enemy” – Napoleon*

Supply chain disruptions, both potential and actual, are the enemy of all firms. By definition, disruptions, especially in the context of supply chains, have been defined as “unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain” (Craighead et al. 2007). More specifically, a disruption occurs when “the structure of the supply chain system is radically transformed...” (Gaonkar and Viswanadham 2007). Supply chain executives react in a number of ways to these disruptions. They can develop risk mitigation plans, implement contingency strategies, and/or redesign the entire supply chain network to be more resilient. While the general elements of a manager’s response are common, there are significant differences among the individual responses to the disruptions. After any given disruption occurs, and, depending on the severity, each supply chain executive is faced with a series of challenging decisions regarding risk mitigation plans, contingency strategies, and overall supply chain design. Each supply chain manager must decide the elements of the plans and strategies to implement as well as the changes to make. Some executives may view the situation and decide not to implement any mitigation plan or contingency strategy in the belief that the disruption is minimal. The important point, though, is that a supply chain disruption forces executives to make a decision about implementing a risk mitigation plan or a contingency strategy as well as a supply chain network redesign. Consider examples that illustrate two diametrically opposed disruption responses by supply chain executives.

In the past 10 years, Toyota has had two high-profile supply chain disruptions. In 1997, an earthquake in Japan affected the ability of Aisin Seiki Co. to produce a part they alone supplied to Toyota. This shut down Toyota's assembly line temporarily at a significant economic cost to the firm (Sheffi 2005). The second occurred recently, in 2007. Another earthquake shut down the Riken Corp. plant which produced piston rings for Toyota as its sole supplier. In a fashion similar to the first disruption, the impact of this disruption was short-lived, as the manufacturers and Toyota were able to restart their production lines in less than one week as Riken Corp. came back on-line (de Courson 2007). Immediately after the 2007 incident, articles placed blame for the production line shutdown on Toyota's just-in-time supply strategy as well as its policy of maintaining a single supplier for each of its critical parts (Chozick 2007a). However, Toyota later announced its firm belief that its decision to make no changes in its fundamental supply chain strategy was correct. Toyota emphasized that its fundamental supply chain strategy had served it well for many years (Chozick 2007b).

In another example from the auto industry, Boyson and Han (2007) describe a situation at Ford where disruptions led to a change in sourcing strategy. In 2001, Ford vehicles were involved in 28 recalls, and the firm placed much of the blame on the fact that it had outsourced too much of the engineering and production to suppliers. They proceeded to move from a base of 2000 suppliers down to 200 suppliers. One brake supplier was quoted as saying "Ford went from sourcing only brake components in the 1980s to sourcing complete systems in the late 1990s. And in just the past few months, the pendulum is swinging totally in the other direction." (Murphy 2003). Ford had adopted one strategy for many years and in the space of a few months changed that strategy, in part due to the disruptions it was experiencing.

In the Toyota example, the disruptions seem not to have altered at all the firm's strategy related to sourcing parts, while Ford, faced with a series of recalls in a short period of time, altered its strategy quickly and significantly. The observed differences in response by the supply chain executives of the two firms may be able to be explained, in part, by differences in the causes of the disruptions, the frequency of the disruptions, the severity of the disruptions, and the speed at which the disruptions impacted the various supply chain echelons (i.e., the clockspeed of the disruptions' impact) (Fine 1998). While information is known about the general nature of each firm's response to the respective disruptions, there are specific unknowns as well. For each, the above information does not inform us about whether either Toyota or Ford had risk mitigation plans or contingency strategies in place to deal with supply chain disruptions. Furthermore, there is no information regarding each firm's response decision process—either the speed of the process or the extent of involvement by supply chain executives. So, while the two examples aren't precisely comparable, they do highlight the phenomena and lead to the research questions at hand.

There are three key questions that can be asked when considering these and numerous other examples.

1. *What are the response differences?* How many different types of risk plans and/or contingency strategies have been developed to respond to various disruptions and what types of responses have these plans and/or strategies incorporated? After a disruption occurs, what response differences did firms have? Did they follow a risk plan, if one existed? Did strategies change over time in response to a disruption?

2. *What causes these response differences?* How influential is the disruption type on responses? At what managerial level were risk plans implemented? Are there any operational clues to help identify/predict disruption responses? Are there any behavioral clues to help identify/predict the responses? These behavioral clues include such things as decision maker experience, position in the firm, pre-determined mindset, etc. that affect disruption responses.
  
3. *What are the resulting implications? (Performance, strategy, structure)* Some firms do not implement the mitigation plans or contingency strategies in response to the disruption. When plans or strategies are not implemented, what happens to the structure or performance of the firm and the supply chain? Alternatively, if the plans or strategies are implemented, what are the performance results? Do firms that failed to plan at all consistently have greater changes or performance results?

The analysis of the response of supply chain executives to the disruption enemy has generated a significant academic research stream involving the analysis of executive actions in anticipation of the disruptions (risk management) as well as in the aftermath of the disruptions (disruption management). Risk management can be thought of as the “process for systematically identifying, analyzing and responding to risks” (Waters 2007). As Waters goes on to say, this means that firms first identify the risks, then analyze them, perhaps by using an impact vs. likelihood matrix (also found in Sheffi 2005), and finally to anticipate what the response to particular risks should be – prevention, avoidance, or impact reduction (Waters 2007). In general, risk management is performed before the realization of the risk, or actual disruption,

occurs. This is evidenced by papers that look at the value of using early supplier involvement as a mitigation strategy (Zsidisin and Smith 2005), the need for firms to be prepared through risk plans (Mitroff and Alpaslan 2003), how the network should be redesigned when / if the disruption is realized (Melnik et al. 2005), and what some strategies are for mitigating, or minimizing the impact, of disruptions (Tang 2006b).

Once the disruption occurs, then the focus shifts to how supply chain executives respond.

Blackhurst et al. (2005) describe well the general events that follow a disruption as discovery (recognizing the disruption in the first place), recovery (how the firm overcomes the disruption), and redesign (implementing resiliency for the next time). Post-disruption research has tended to focus on operational and structural factors such as information sharing and visibility (Wu and Blackhurst 2005), modeling how disruptions spread through the supply chain (Wu et al. 2007), their effect on the supply chain (Wu and Blackhurst 2005), and supply chain density (Craighead et al. 2007). As risk management and disruption research is still relatively new (Blackhurst et al. 2005), there are several gaps that can be identified from the paragraphs above.

### ***Gaps in Existing Knowledge***

The lengthening of the supply chain in the past two decades as well as key events such as the September 11<sup>th</sup> attacks and a West Coast labor strike in 2002 have served to advance interest and research in the area of risk management. The following paragraphs specifically discuss five gaps that have been observed in the existing literature on that subject. These gaps exist in part due to the relative newness of the topics as well as its complex nature, often requiring cross-disciplinary research, which is inherently slow to emerge.



The paragraphs below are organized in a specific order from the more generalized and overarching nature of the gap identified to more specific areas where research has not yet been done. They also are presented in a logical order of loose causality. This means that the first gap exists, and partly because of that, the second gap exists. These soft progressions (general to specific; loose causal nature to more direct causal link) will be explained in more detail in the specific paragraphs describing each gap.

## **Gap One: The Need for an Overarching Framework to Interrelate the Research Concepts**

For any research questions surrounding an observed phenomenon, one of the first steps is to survey the literature and understand what has been done before and can lend support to understanding that phenomenon. While performing that step for this research, it became somewhat difficult to differentiate the terminology being used in the published research. Several topical areas can be applied here. Following are some of the categories that can be referenced:

- Risk Management
- Supply Chain Disruptions
- Supply Chain Security
- Business Continuity Planning
- Crisis Management
- Supply Chain Sustainability
- Supply Chain Resilience

Clearly, the most used term is risk management, but the others also have large followings. How do they all fit together? Is crisis management just risk management but with a more critical “emergency” component? Does risk management apply to a broader scope than the supply chain? If yes, does that make supply chain security one branch of risk management?

The relationships among these concepts are complex, and these complexities have led to confusion among concepts. It is important to have an overarching framework tying these terms together for several reasons. First, it helps people using these terms to be discussing the same concept. Researchers and business persons especially need to be talking about the same concept in order to correctly diagnose critical issues. Second, a shared understanding of the complex interrelationships among these concepts will facilitate the identification of additional concepts and/or relationships that may be missing from our current understanding or that has emerged from existing research.

This is the broadest gap that needs to be filled. In order to build this framework, prior research findings, including definition of concepts and identified interrelationships, need to be used. Once built, the framework will help to show how much of the research fits together and reveal other gaps. In both cases, there is a need for theory to help drive the additional questions and research to be done.

## **Gap Two: The Need for Theory**

Psychology, economics, and strategic management theories have all been borrowed and used in the general supply chain literature to help drive the research agenda. However, there is still a need for strong theoretical backing in much of our work. This can be seen in several general attempts for an over-arching theory of supply chain and / or logistics (Mentzer et al. 2004; Storey et al. 2006).

Specifically, in the research areas identified above (such as risk management and supply chain disruptions), some of the academic research papers lack any theoretical underpinning, while others add theory as an afterthought as opposed to an integral part of the study. Ideally, a theory helps to drive the hypotheses/questions and methodology used to investigate the hypotheses and answer the research questions. Yet, across the scope of academic papers, there is not a consistency in theory application. This can be seen in the theories used such as resource dependency and strategic contingency theory (Blackhurst et al. 2005), institutional theory (Zsidisin et al. 2005), risk motivation theory (Shockley and Ellis 2007), and agency theory (Zsidisin 2003; Zsidisin and Ellram 2003). While more will be said on qualitative theory building later, several recent research papers have attempted to fill the void of a disruption-related theoretical perspective through qualitative and conceptual methods. Craighead et al. (2007) develop a qualitative model relating supply chain design characteristics and mitigation capabilities and propose several propositions to be tested later in a quantitative manner. Gaonkar and Viswanadham (2007) have developed a conceptual framework that attempts to classify various supply chain risks and various approaches that can be used to deal with those risks. Manuj and Mentzer (2008a) develop a theory of global supply chain risk management strategies

through a grounded theory methodology using targeted interviews. As this qualitative methodology is still growing in our traditionally quantitative field, more theoretical pieces are needed to continue to fill this gap of theory needed to motivate risk and disruption related hypotheses.

Much of the research done in the area of supply chain disruptions comes from an angle of risk management and supply chain security, meaning that the research is generally concerned with preventing or mitigating the effect any disruption may have. Some research has looked at post-disruption issues, but there is the need for much more. We now begin to identify some of the specific areas of disruption management research that is needed.

### **Gap Three: The Need to Understand Disruption-related Decision Making**

Disruption management research assumes that the disruption has already occurred. Blackhurst et al. (2005) effectively identify three important research areas that need further investigation, namely disruption discovery, recovery, and redesign. At this point, there are multiple ways to look at the choices and results that occur after the disruption, such as operationally and behaviorally. Currently, the majority of the post-disruption research has worked from an operational perspective. For example, papers have asked the question of what happens to the supply chain if a specific node in the chain is disrupted; namely which other downstream nodes will be most affected (Wu and Blackhurst 2005).

Risk management research approaches the disruption topic by attempting to understand what effect a disruption would have, and then working hard to prevent or mitigate it (Tomlin 2006). Similarly, business continuity planning generally looks at a disruptions effects and attempts to then plan what to do when that type of disruption occurs.

However, since disruptions at some level are unpreventable and since not all types of disruptions can be thought of and adequately planned for or avoided (Melnyk et al. 2005), additional research is needed to deal with this uncertainty. Specifically, the actual decision making process that managers and decision makers use after a disruption is discovered needs to be understood. The decision- making process from an organizational perspective has been looked at by Mintzberg et al. (1976). Hale et al. (2006) has proposed some hypotheses about what this process may look like during a crisis, but an adaptation to supply chain disruption related research has not been attempted.

Some of the simple questions that can be answered by filling this gap are:

- Do decision makers refer back to previously developed risk plans?
- Are there additional steps in the process compared to the more generalized Mintzberg et al. (1976) model?
- In a supply chain, are decisions centralized, as in crisis management teams?
- Is a supply chain considered, or just the firm-at-hand?
- What factors are considered by the decision maker and judged as most important?
- How does the impact level of the disruption affect the decision making process?

These and other questions are unanswered in the literature at this point in time. As mentioned earlier, the decision making process is influenced by both operational and behavioral factors. Behavioral factors remain an important gap that also needs to be filled in order to have a more complete understanding of disruptions and their effect on firms.

#### **Gap Four: The Need to Understand the Influence of Human Behavior**

Traditionally, the field of operations management focused on technical operations and patterns of cost and efficiency. The impact of human behavior on the operations processes has only recently gained the attention of researchers in this field. Several landmark studies have employed simulations to demonstrate how supply chain managers at various echelons in the supply chain can impact the level of total inventories in the system by their own perceptions of available quantities and demand patterns. The simulation model, labeled “the beer game,” has demonstrated the existence of the bullwhip effect in supply chains, i.e., fluctuations in ordering patterns that increase as you move up the supply chain from the point of sale to the point of manufacturing (Croson and Donohue 2003; Croson and Donohue 2006; Wu and Katok 2006). In this vein, Schulz, et. al, has conducted research to understand how worker flexibility affects behavior (Schultz et al. 2003) and to explore how low inventory affects work behavior (Schultz et al. 1999). However, this stream has remained small (Bendoly et al. 2006) and has not been applied to understanding factors related to supply chain disruptions and resulting strategic choices and performance.

An important similarity in much of the previous work is that the operational situation is considered the independent variable with the behavior acting as the resulting dependent variable. Another angle from which behavior can be approached is when the behavior is considered as the independent variable and the decisions or performance is the dependent variable. Examples of research questions that need answers from both perspectives are provided in the next paragraphs.

Several recent surveys have asked the question of respondents as to whether they have developed risk contingency plans for their firm. An interesting question is how the presence of a risk plan may affect the behavior of the decision makers after a disruption has occurred, especially if the disruption is any sort of a deviation from what was expected. Do risk plans lull decision makers into any false sense of security? On a second line of thinking, do low impact / high frequency disruptions cause similar decisions as high impact / low frequency disruptions? How does the disruption affect the behavior? Finally, a third line of thinking follows a somewhat similar principle of underweighting the supply line in the beer game (Croson and Donohue 2006). Decision makers have a propensity to overweight hard evidence that they can feel/see/touch (Massey and Wu 2005). A disruption qualifies as 'hard evidence' when compared to the disruption that 'might' occur in the future. The research questions revolve around how various factors are weighted when considering strategic options in the wake of a disruption.

From the opposite angle, previous research has looked at the experience of decision makers (Ahituv et al. 1998; Snizek et al. 2002) their thinking style (Cantor and Macdonald 2008), and the abilities that they possess (Alexander 2004). Schultz et al. (2007) have recently conducted a very interesting study where a very well established principle of risk reflection and reversal

produced results counter to expectations. A primary driver in the unexpected results was the sensitivity of the behavior to small changes in the complexity of the problem. For their experiment, Schultz et al. (2007) used a newsvendor problem, which contains relatively few choices. In contrast, supply chain disruptions come in numerous varieties, each of which has its own set of nuances. The need to begin understanding how these disruptions, along with their varieties and nuances, affect the decisions made is very important in order to help firms perform well after disruptions.

To reiterate, behavior differences will affect the choices that decision makers choose. The final gap will draw upon the need for decision making understanding as well as behavior inclusion and apply them both on performance implications.

### **Gap Five: The Need to Understand How Disruptions and Post-Disruption Strategic Decisions Affect Performance**

The final gap to be discussed here is the need to apply the previous observations and results to their effect on the performance of the applicable supply chain, firm, or decision maker. It is important to know whether certain behavioral propensities, for example, cause improved performance. Do changes in strategy after a disruption lead to greater or worse performance? Which strategies cost the most to maintain? Given the possibility of certain high-impact disruptions, is it better for a firm to not invest any money into mitigating the risk, but rather to just pay for the disruption when it comes and then continue in the previous way? Can it be seen that some types of choices lead to better recovery efforts? All of these questions are important to answer to fill out our understanding of the way that disruptions affect supply chains and firms.



## **Gap Summary**

To summarize, there are five observable gaps in the literature that have been briefly discussed here. Of first importance is to have a common starting point for research in this area. To that effect, a framework that ties the various concepts that have been used in research surrounding supply chain disruptions (such as risk, security, etc) needs to be built. Once that framework is established, then the phenomena that can be seen within that framework (such as the one described at the beginning of this research dealing with strategic decisions after disruptions) need to have some theories developed that can serve to drive the research investigating the questions.

The next two gaps dealt with decision making and behavior. Previous decisions obviously drive various behaviors and choices. However, behavior propensities following supply chain disruptions also drive decisions that are made. These both work together to lead to performance implications for the supply chain and firm.

The gaps previously identified are rather large, and it should be noted that the remainder of this paper will not attempt to fill each gap completely, but rather specific pieces of the gaps. It was important to list all of the gaps here for a more well-rounded understanding of the framework that can be built on for many future research opportunities. What this paper will focus on is described in the final section of this introduction that follows.

## ***Research Contributions and Remaining Paper Outline***

This research will make several contributions to the body of literature. One objective is to provide a literature review of the various concepts brought to bear in the first gap and propose a framework for the understanding of how the concepts fit together. Synergies and overlaps in the discoveries and principles of the literature on disruptions et al. will also be discussed.

The second focus of this work is to help build theory around supply chain disruptions and the recovery and decision making process after severe disruptions have occurred. We will use a grounded theory methodological approach to analyzing data that will be collected through means of interviews to supply chain managers. The operationalization of the theory building will come through a series of propositions which will be given. These propositions can then be subjected to empirical testing in future research.

The rest of this paper develops the literature and articles to start filling the gaps discussed previously. Chapter 2 covers two sections that first focus on reviewing the pertinent literature and various concepts surrounding supply chain disruptions, which includes risk management and business continuity planning. The second section then proposes a framework for understanding these concepts in a cohesive way. Chapter 3 begins with a review of the problem, or gap to be filled, and the relevant literature and factors needed to build an initial disruption management process model in sections 3.1 and 3.2. Section 3.3 introduces and discusses the methodology needed to complete the initial model through qualitative means of collecting a dataset comprised of interviews with supply chain managers. The rigor needed is also presented here. Section 3.4 displays many of the results from the formalized analysis (grounded theory methodology) and

the additional factors and concepts discovered through this process. Finally, several propositions are presented in section 3.5, supported by data from the results section. This research will end with Chapter 4 which includes a summary of the research, limitations and future directions for the research, and lastly the managerial implications of this research.

## **Chapter 2: A Framework for Understanding Relationships between Disruption-related Concepts**

### **Section 2.1: Literature to Support the Relationship Framework**

The purpose of this section is to introduce the key concepts related to disruptions in the supply chain in the following order – risk management, disruptions, supply chain sustainability, supply chain resilience, supply chain security, supply chain vulnerability, business continuity planning, and crisis management. Each concept will be defined and any major research done will be highlighted. For risk management and disruptions specifically, since they have more research associated with them, a simple model for understanding them will be displayed. The section concludes with a summary that sets the groundwork for presenting the framework for relating the concepts together in Section 2.2.

#### ***Key Definitions***

It is important to start out by defining the supply chain context in which this framework will take place. The supply chain has been extensively defined by the Council of Supply Chain Management Professionals (CSCMP) as:

*“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 firms. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across firms into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology.”*

– CSCMP (2008)

Mentzer et al. (2006) have produced a graphical representation (shown in Appendix A, Figure A.1) of these concepts that specify the additional functions of marketing, production, and operations management. Within each of the functions listed in the diagram are additional functions or processes that help to make up the operations and supply chain of the firm. Examples include the transportation, pricing, procurement, inventory management, and quality aspects. The supply chain can, then, encompass both all the operations within a firm as well as join all possible firms together involved in a specific good to form the extended supply chain.

As a summary definition, supply chain management includes “all activities associated with the flow and transformation of goods from the raw material through to the end customer” (Handfield and Nichols 1999; Vachon and Klassen 2002). It is important to note that research dealing with risk, disruptions, security, and other concepts in a supply chain context do not always incorporate all of the above areas. Some deal more with supply risk (Zsidisin and Ellram 2003), while others deal more with the areas that a manufacturing manager may be able to affect (such as their suppliers and their direct customers) (Blackhurst et al. 2005). Research incorporating the full

scope of the supply chain is difficult and rare. Brindley and Ritchie (2004) introduce terms such as the “basic supply chain”, which “typically focuses on the linkages between a single organization and its immediate supplier and /or immediate customer.” An “extended supply chain” looks at additional echelons and includes multiple organizations, while the “ultimate supply chain” incorporates the complete scope all the way from securing raw materials to delivering products to the final customers. The research papers cited in the following sections will all fall within the supply chain context, but do not necessarily incorporate the whole supply chain. This will not diminish the proposed framework in any way, since it will still provide visibility into the conceptual relationships between various terms.

### ***Research Concepts***

Several authors have articulated the development of supply chain related disruption research. Blackhurst et al. (2005) discuss both September 11<sup>th</sup> and the 2002 West Coast labor strike as catalysts for research interest. On the other hand, Clare Brindley in the foreword to her edited book titled Supply Chain Risk mentions that she couldn't find a single catalyst, but rather that several researchers became interested at around the same time (Brindley 2004). Whatever the cause, a chapter in the same book shows that since 1995, the number of supply chain risk management articles has grown nearly every year (see Figure 6.3, page 85 in Paulsson 2004).

This research usually takes the form or title of risk management in the supply chain. However, several other research branches have developed or are related, such as supply chain disruptions, supply chain security, supply chain vulnerability, supply chain sustainability, crisis management, resilience in the supply chain, and business continuity planning (BCP). The question that arises

is how (or even *if*) these various branches fit together in relationships. The purpose of this section then is to first provide definitions for each of these concepts as well as some of the recent thoughts and research in each area. This will set the stage for the framework and relationship development in the following section.

## **Risk and Risk Management (in the Supply Chain)**

The term with probably the greatest usage and researched concept is risk or risk management. Risk management is not new. Waters (2007) in his book mentions that insurance companies in the 18<sup>th</sup> century were calculating the risk of insuring cargo against damage or loss at sea. Brindley and Ritchie (2004) mention that the economics field popularized risk in the 1920's (Dowling and Staelin 1994). More recently, risk has been looked at from management, psychological, and environmental perspectives. Today, there are journals that specifically cater to risk management – Journal of Risk Research, Journal of Risk and Uncertainty, Journal of Risk Finance, and Journal of Risk and Insurance – to name a few. Though the focus of this research deals with supply chains, the more frequent application of risk management today is in the financial and insurance sectors.

This section will start by defining risk and risk management in general, briefly discuss what research is being done in this area, and then focus on risk management in a supply chain context. Again, this will be defined, the steps in risk management espoused, and finally the research being done in this area will be summarized in related categories.

## ***Risk***

Risk has been defined in various ways, depending on the perspective taken. Ritchie and Brindley (2004) view the differences as more “marginal rather than substantive.” The simplistic view is that risk is the probability of incurring a [financial] loss (Knight 1921). Waters (2007) allows more ambiguity when he uses a definition of “potential harm from unforeseen events”. Risk can be “the extent to which there is uncertainty about whether potentially significant and / or disappointing outcomes of decisions will be realized” (Sitkin and Pablo 1992).

Risk can be categorized into variables. There can be internal and external risks (Waters 2007), but this simple categorization can be fleshed out. Variables suggested by Ritchie and Marshall (1993) include environmental, industry, organizational, problem specific, and decision-maker related variables. Brindley and Ritchie (2004) divide these variables into those that are context related and less under a firm’s influence (environmental, industry, and organizational) and those over which the firm has greater influence (problem specific and decision-maker).

Risk often is defined in the context of what it refers to and the concepts that make it up. For example, it can refer to a “*source* of risk and uncertainty” as well as the “consequences of risks” (Juttner et al. 2003). There are many different kinds of risk, such as political risks (Juttner et al. 2003) supply-side and demand-risks (Nagurney and Matsypura 2005), security risks such as terrorism (Sheffi 2001), operational risks (Zinn et al. 2006), macro risks, policy risks, competitive risks, and resource risks (Manuj and Mentzer 2008a).



Now that risks have been defined, with firms choosing how to categorize risks for themselves, there remains the challenge of how to deal with the risks. Risk management is the solution.

### ***Risk Management***

Risk management, or risk planning is first meant to prevent a risk from occurring or, second, to at least minimize or mitigate the damage if a risk becomes reality. Some authors would add that a third goal is to provide a way to deal with the risk when it occurs, also referred to by some as mitigation. This difference will be dealt with later in this section. In general, risk management is a method used to avoid, reduce, transfer, or share risks (Norrman and Lindroth 2004). There are many methods used to do this.

An exemplary survey of various authors and the steps that they espouse can be seen in the following table. The table shows the authors, the steps they use in their research, and a row at the bottom stating the preferred context for the steps. Two things should be pointed out. First, it should be noted that many of the steps may have different wording, but imply similar actions. In these different examples, the earlier steps represent the attempt to become aware that risks are a threat. The later steps aim to determine what can be done to prevent those that are preventable and to build a strategy for dealing with those that are at some point inevitable. The similarities in steps become more interesting when looking at the authors' context for the steps. Some are stated in the context of risk management (RM), supply chain risk management (SCRM), business continuity planning (BCP), and supply chain business continuity planning (SCBCP). RM and SCRM are being discussed here in this section, and BCP will be discussed later.

A typical four-step process will be discussed here. The first step advocated involves identification or awareness of the risk. A firm must be aware of the various risks that could pose a threat. The second step generally tries to prioritize or assess that risk. How dangerous is the risk that has been identified? Will it shut down a production line for 10 minutes or 10 days? For example, Gaudenzi and Borghesi (2006) demonstrate this principle by using the AHP (Analytical Hierarchy Process) as a way to achieve this prioritization.

Steps	<u>Gilbert and Gips 2000</u>	<u>Chapman et al. 2002</u>	<u>Morton 2002</u>	<u>Juttner et al. 2003</u>	<u>Melnyk et al. 2005; Zsidisin et al. 2005</u>	<u>Gaudenzi and Borghesi 2006</u>	<u>Manuj and Mentzer 2008a</u>	<u>Wu et al. 2006</u>
1	Risk identification	Risk identification	Provide top management guidelines	Assessing the risk sources	Risk awareness	Risk assessment	Risk identification	Risk classification
2	Risk assessment	Risk assessment	Identify serious risks	Identifying the risk concept – define most relevant risk consequences	Risk prevention	Risk reporting and decision	Risk assessment and evaluation	Input data
3	Risk ranking	Supply chain continuity management and coordination	Prioritize the operations to be maintained and how to maintain them	Tracking the risk drivers in supply chain strategy	Risk remediation	Risk treatment	Selection of risk management and mitigation strategies	Risk calculation
4	Risk management	Learning from experiences	Assign staff to disaster distributors	Mitigating risks in the supply chain	Knowledge management	Risk monitoring	Implementation of supply chain risk management strategies	Risk analysis
5			Take a complete inventory				Mitigation of supply chain risks (with feedback loop to Step 1)	
6			Know where to get help					
7			Document the plan					
8			Review the test plan with key employees and train all employees					
9			Maintain the plan					
Focus:	BCP	SCRM	BCP	SCRM	SCBCP	RM	SCRM	RM

Table 2.1: Steps in the management of risks as outlined by an exemplary set of authors

The third step starts to show differences between the process among the authors. Some are still prioritizing the risks that have been identified, while others are developing strategies to deal with the risks. The final step can be very different for the processes shown in Table 2.1. Gilbert and Gips (2000), for example, end with a step called ‘risk management’. They place their four steps under the umbrella of BCP. Chapman et al. (2002) advocates learning from the experience. How did the strategy work? Others such as Juttner et al. (2003) and Manuj and Mentzer (2008a) end with mitigating risks in the supply chain, which will be talked about later as there are differences in the definition of mitigation.

Quantifying or prioritizing a risk was shown to be one of the early steps taken in risk management. Efforts to quantify risk have resulted in the idea that the probability of the risk occurring can be multiplied by the effect on business that the risk would have leading to an expected value (Doherty 2000; Norrman and Lindroth 2004). This is frequently simplified into an impact vs. likelihood chart (Sheffi 2005). Ogden et al. (2005) used such a 2-dimensional matrix with ‘likelihood’ and ‘impact’ axes to help place the various supply strategies that firms could employ. A Delphi-study with professionals in the supply chain field mapped the available strategies to the impact vs. likelihood matrix. Norman and Lindroth (2004) developed a 3-dimensional model, or typology, to categorize risks in the supply. Their three axes are the ‘unit of analysis’ (or scope of the risk within a supply chain), ‘type of risk and uncertainty’, and ‘Risk and Business Continuity Management’ which was meant to display the level of risk management activities in a firm on a continuum from simple risk analysis to complete BCP.

One question that has arisen during this process is whether risk management in all its forms applies only to pre-risk or pre-disruption planning, or also includes strategies and process decisions after the risk or disruption is realized. The term ‘mitigation’ seems to be the source of this confusion.

An official Merriam-Webster definition of mitigate means to ‘make less severe or painful’ (Merriam-Webster 2008). In context, this would mean that mitigating a risk refers to finding a way to soften the blow of a risk or disruption should it occur. Juttner et al. (2003) begins this discussion by defining a risk mitigation strategy as one that an organization “deliberately undertake[s] to mitigate the uncertainties identified from the various risk sources”. Here the risk sources are identified, but it is acknowledged that the exact form each risk could take is still unknown and, hence, needs to be planned for. Similarly, Chopra and Sodhi (2004) discuss strategies for dealing with a risk or disruption before it occurs. Manuj and Mentzer (2008a) label it as “preparing for unforeseen events”. Faisal et al. (2006), in addition, label mitigation as a pre-disruption effort. Tomlin (2006) clearly defines mitigation tactics as those “in which the firm takes some action in advance of a disruption (and so incurs the cost of the action regardless of whether a disruption occurs)”. The goal of these efforts is to “reduce the consequences if an adverse event is realized” (Norrman and Jansson 2004). However, firms can find it difficult to justify these preparations for mitigating disruptions that may not occur (Tang 2006b).

A slight difference appears when the assumption is made that a disruption will occur. For example, Tang (2006b) talks about mitigating supply chain disruptions by finding strategies that are efficient, yet resilient to them. Craighead et al. (2007) calls mitigation capabilities

“organizational routines or regular patterns of activity that enhance the ability of the supply chain to recover expediently and create awareness of pending or realized disruption.” Instead of re-using the mitigation term, Tomlin (2006) separates a mitigation tactic and a contingency tactic. A contingency tactic is one which a firm employs only after a disruption occurs. These examples display a greater use of the concept to refer to post-disruption, or disruption management, activity.

The concept of mitigation has been used to refer to both pre- and post-disruption events. Is one more accurate? Mitigation should correctly refer to pre-disruption risk management. It can be used to refer either to an effort to reduce the likelihood of a risk occurring or reduce the effect the risk would have on the firm should it occur, as both can be viewed as efforts to lessen risk. The implication is that risk management is primarily a pre-risk activity. It does not deal with post-risk processes of restoring the firm to stability. Instead, the view of Tomlin (2006) is taken, which places these as contingency activities instead.

The concept of risk and risk management has now been discussed. It is acknowledged that not all readers may agree with this differentiation. It is offered primarily as a way to clearly define the boundaries of concepts to provide common understanding when communicating. A next step is to overlay these concepts in the specific arena of the supply chain.

### ***Supply Chain Risk (Management)***

Risks in the supply chain have been characterized as when “unexpected events might disrupt the flow of materials on their journey from initial suppliers to final customers” (Waters 2007).

Norrman and Lindroth (2002) define supply chain risk management as a procedure “to collaboratively with partners in a supply chain apply risk management process tools to deal with risks and uncertainties caused by, or impacting on, logistics related activities or resources.” Simply put, it is risk management in the context of a supply chain. The next paragraphs will attempt to show the various categories and dimensions of supply chain risk (SCR) that have been used in the literature, a short discussion on the consequences of risk in the supply chain, and some practical methods that have been suggested for conducting a risk assessment.

### **Categories of Supply Chain Risk (SCR)**

There are many categories of risk that have been discussed in the literature, often to mark a logical separation of various risks for the specific research of the author. No category is wrong, but the last paper discussed shows that the categories have settled down. The reader is reminded that the goal of this section is to discuss risk management, and this specifically in a supply chain context so that the concept can be more accurately placed in a relationship framework. It is important to discuss the specific categories of supply chain risk not only for perspective, but also to see how other authors have understood the relationship between SCR and the other concepts of disruptions, security, etc.

One way to look at supply chain risks is, similar to risks mentioned previously, as external, internal, or network related (Juttner et al. 2002). Another way is in a paper demonstrating the lessons that can be learned from the toy industry where Johnson (2001) boils down risk to the challenge of managing supply and managing demand. A third way, and next step to branching beyond the supply and demand differentiation, has Kleindorfer and Saad (2005) separating risks

into the categories of those from supply & demand problems and those stemming from a disruption that affects all other firm activities. For example, longer supply chains and changes in industry clockspeed (which is a measure of the rate of change in the product life cycle in an industry (Fine 1998)) fall into this second category of other firm activities.

As mentioned earlier, Norrman and Lindroth (2004) had three axes when analyzing a risk for the supply chain. One of those axes was the type of risk/uncertainty, which they have divided into strategic risks, financial, operational, commercial, and technical. Another axis was the supply chain level (unit of analysis). Both of these were effectively used by Gaonkar and Viswanadham (2007) to offer two models aimed at providing a more robust design of the supply chain against risk. An expanded set of categories of risk are found in Chopra and Sodhi (2004) who list delays, systems, forecast, intellectual property, procurement, receivables, inventory, capacity, and disruptions all as aspects of supply chain risk. It should be noted here that their examples of disruptions include natural disasters, labor disputes, and supplier bankruptcy. However, supplier under-production is considered a 'delay'. More will be mentioned on disruptions and a definition in the next section.

Another expansion to basic supply chain risk management was developed by Manuj and Mentzer (2008a) piece to look at the process from a global perspective. This has the effect of additional risks to the supply chain such as security, macro (such as exchange rates), and policy risks. They also tie many of these concepts together in a framework. They then take the framework and list some case studies that have used similar framework. Without this, the practicality of such a framework remains in doubt. The case studies also allow the beginning of theory development

to occur, with the theory simply being an attempt of explaining why firms operate the way they do. Several papers have worked to develop such a theoretical underpinning. Common approaches include case studies and interviews.

Various categories were introduced earlier in which various risks can be placed. These categories will be briefly expounded upon for the reader to understand the direction that research in these areas has taken. Recall that Juttner et al. (2003) made a distinction between sources of risk and the consequences of risk. The next two subsections will follow this distinction.

### **Supply Chain Risk Management Methods**

An excellent article that reviews supply chain risk management is Tang (2006a). Tang divides his methods for managing supply chain risk into supply management, demand management, product management, and information management. His paper focuses on quantitative models, which leaves all qualitative as well as other quantitative (using archival data or experimental sources) research.

#### *Supply Management*

Supply risk refers to the risk of supply to the firm being disrupted for any reason. This can happen through bankruptcy, under capacity for production, unconfirmed pricing structures, inadequate quality, inability of the supplier to procure their supplies, and many others. A more formal definition of supply risk has been offered by Zsidisin (2003): “potential occurrence of events associated with inbound supply that can have significant detrimental effects on the purchasing firm.”



In order to manage that risk, agency theory has provided a good overarching theoretical framework for understanding that as one party transfers risk to an agent, what the cost tradeoffs are from managing that agent's behavior and measuring the performance outcomes. One method of reducing supply risk can be to effectively manage supplier behavior (Zsidisin and Ellram 2003). They find that behaviors such as quality management and supplier certifications can help to manage that risk, as well as control variables such as industry, firm size, and the percentage of sales the purchasing firm has. Early supplier involvement is another means to reducing supply risk. This was found by using a case study approach also with agency theory (Zsidisin and Smith 2005).

#### *Demand Management*

Far less research on demand risk and strategies for its reduction has been done (Tang 2006a). Demand risk is that risk posed to a firm where they are unable to effectively forecast and / or meet demand. Hence, the firm incurs the possibility of lost sales as a customer shops elsewhere. The simplest way for a firm to manage this risk is to have plenty of inventories for every product sold. However, this is commonly known to be an untenable idea. Instead, firms manage this risk more effectively by shifting demand over time, markets, or products (Tang 2006a).

#### *Product Management*

As Tang (2006a) mentions, many firms respond to competition by offering greater product variety which increases inventory, design, and manufacturing costs. Managing these costs and

associated risks, many firms offer postponement (Manuj and Mentzer 2008a), and may reverse the process sequence of manufacturing where appropriate (Lee and Tang 1998; Tang 2006a,).

### *Information Management*

Managing information related to demand as well as between elements in the supply chain can be an effective way of managing risk. Such strategies as VMI (vendor managed inventory), collaborative forecasting, and managing products with short life cycles with delayed ordering (and thereby more accurate forecasts) are all means of achieving this end. Christopher and Lee (2004) advocate that no matter what strategy is used in any of these areas, end-to-end supply chain visibility is vital to gaining supply chain confidence and help to manage risks.

### *Other Issues to Manage*

Finally, a new area to consider is the role that creating sustainable or ‘green’ supply chains. Cousins et al. (2007) looks at the role that the greening of a supply chain may have on managing risk. In some cases it may make it worse as, for example, efforts to maximize transportation volumes may lead to more inventory than desired.

### **Consequences of Supply Chain Risk**

The consequences of supply chain risk are easy enough to understand – at some level, there is a loss. This loss can be financial, performance related, physical, social, psychological, or perhaps just a time loss (Mitchell 1995). More will be discussed on consequences in the following section on supply chain disruptions.

### ***Practical Risk Assessment***

After reading and absorbing this section on understanding the concept of risk and risk management, it may be a bit confusing on how to go about assessing the risks associated with the supply chain. Wu et al. (2006) advocate moving away from the traditional method that relies on the managerial experience in the firm and move toward more of a fuzzy logic approach with appropriate decision support help. Focusing on quality issues, improving processes, and reducing disruption chances are all ways that Zsidisin et al. (2004) found as a result of several case studies with manufacturers. They also list an 11-step process that can be followed to analyze each category of risk that a firm has identified. Finally, a recent book has been edited by Handfield and McCormack (2008) where many of the chapters are spent addressing the practical means of how to perform a risk assessment. The reader is referred to this excellent resource for further information.

### ***A Framework for Understanding***

In order to help the reader understand the how aspects of risk management that have been discussed tie together, especially in the supply chain context, a model is shown in Figure 2.1 that accomplishes this fairly well. It is taken from Manuj and Mentzer (2008a).

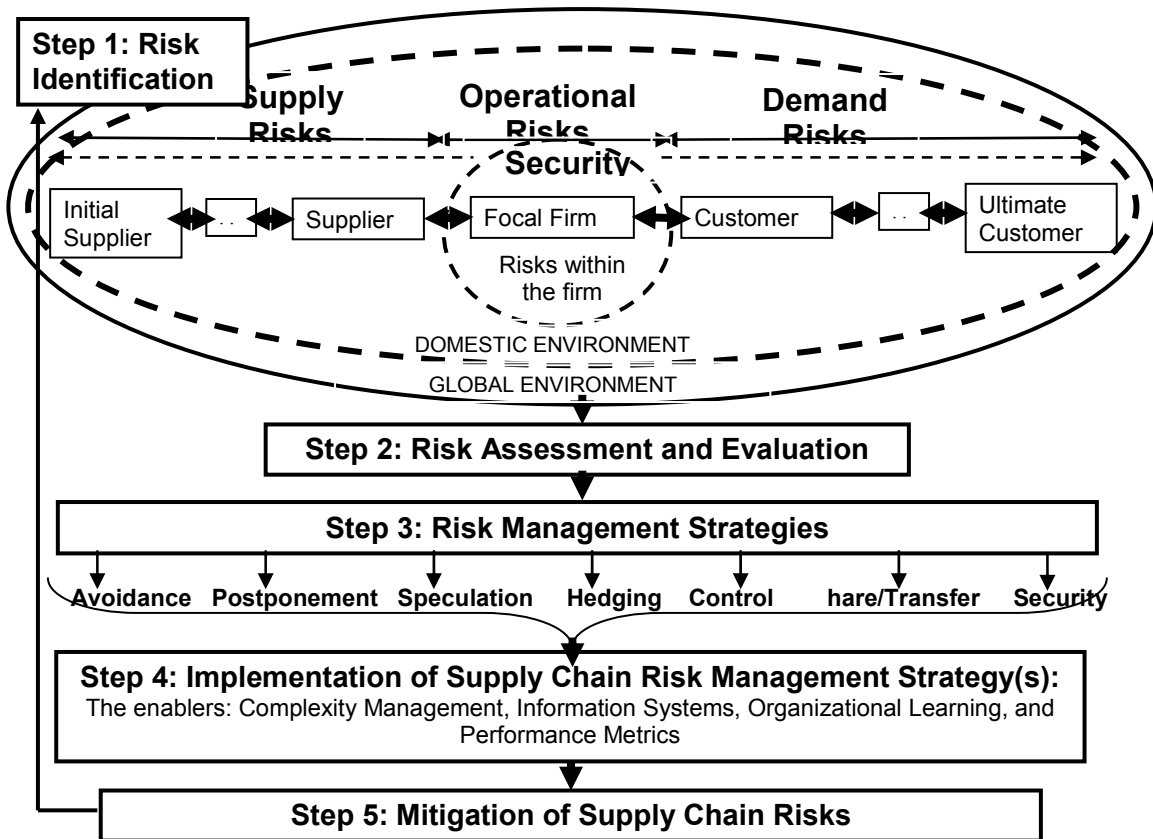


Figure 2.1: Global SCRM and mitigation framework from Manuj and Mentzer (2008a)

### *Summary*

In summary, although we have seen that the concept of risk management has started broadening to encompass a post-disruption event through the mitigation term, risks are generally looked at as pre-disruption possibilities. They need to be acknowledged, calculated, prevented if possible, and lessened if not prevented. The next section will look at research on supply chain disruptions. The reader will begin to notice similarities and differences between the concepts.

This section was meant to provide a definition of the terms as well as an over view of the research involved, and not to be an exhaustive literature review on risk and risk management.

This will set up the development of a framework for understanding the relationships between concepts later on as well as development of Chapter 3 which will develop a theoretical understanding of how firms deal with disruptions after the occurrence. The same disclaimer applies to all the concepts that follow in this chapter. Several excellent books and summary articles have been written on the subject of risk and risk management in the supply chain and the reader is referred to these texts for additional information: Brindley (2004), Tang (2006a), Waters (2007), and Handfield and McCormack (2008).

## **Supply Chain Disruptions**

As will be the pattern for all of these conceptual sections, it is important to first start out by defining the term. A supply chain disruption can be anything that affects the flow and supply of raw materials, sub-components, components, and finished goods all the way from origin to the final demand point. Craighead et al. (2007) add a component of unexpectedness in their definition, define a supply chain disruption as “unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain.” Gaonkar and Viswanadham (2007) indicate that there are three levels of these types of risk, namely deviation, disruptions, and disasters. A deviation is “when one or more parameters, such as cost, demand...stray from their expected or mean value.” A disruption (in their definition) occurs when “the structure of the supply chain system is radically transformed...” Finally, a disaster is “a temporary irrecoverable shutdown of the supply chain network...” The three terms increase in their intensity.

Supply chain disruptions can have a major impact on firms in multiple ways. There can be cost, operational, and service impacts as a consequence of the supply chain disruption. There are many general examples of disruptions that have been used in the literature. They can include the following: transportation delays, strikes by truck drivers or port workers, acts of terrorism, poor communication, IT malfunctions, industrial accidents, quality problems, operational problems, natural disasters such as hurricanes or lightning strikes, government regulations, and even opportunism by suppliers (Sheffi 2001; Chapman et al. 2002; Cooke 2002; Koch 2002; Machalaba and Kim 2002; Mitroff and Alpaslan 2003; Blackhurst et al. 2005; McKinnon 2006). Specific instances used are a 1996 General Motors labor strike (costing GM \$900 million) (Blackhurst et al. 2005), managing toy fads and busts (Johnson 2001), the UK fuel crisis of September 2000 (McKinnon 2006), the 2000 fire at the Philips Semiconductor plant in New Mexico leading to the ultimate exit of Ericsson from the cell phone market (Sheffi 2005, Tomlin 2006 and many others) and the 2003 Northeast US electricity blackouts (Zinn et al. 2006). As supply chains have grown from a local to a global scope, reduced inventories, and are allow less time to meet demand, their vulnerability to a disruption has increased (Melnik et al. 2005). In fact, an opening quotation portion by Melnyk et al. (2005) states simply that “You can’t avoid disasters...”

The impact of disruptions is negative in most respects. For example, when shipping lead times are long, disruptions in demand and international flows lead to unexpected costs (Levy 1995). Hendricks and Singhal (2003) looked at the impact of supply chain glitches on shareholder wealth. They defined glitches as simply the mismatch between demand and supply, but focused specifically on glitches that resulted in production or shipment delays as found in media articles.

They found that glitches decrease shareholder value an average of 10.28%. In another paper, the same authors looked at the effect of these types of glitch types on operating performance and found negative changes in operating income, sales, cost structure, assets, and inventories (Hendricks and Singhal 2005a).

In the above paragraphs, all disruptions were classified together. However, there are actually many ways of categorizing disruptions that have been used in the literature.

***Disruption Attributes***

There is not one correct way to categorize disruptions. Researchers have created or referred to categories that best fit their research question and / or data, and that is acceptable. Probably one of the most common attributes of disruptions is the impact factor of the disruption. In risk management, recall that a typical matrix looks at the likelihood of the risk (or disruption) matched against the impact factor of the disruption. There can be low- or high-impact disruptions.

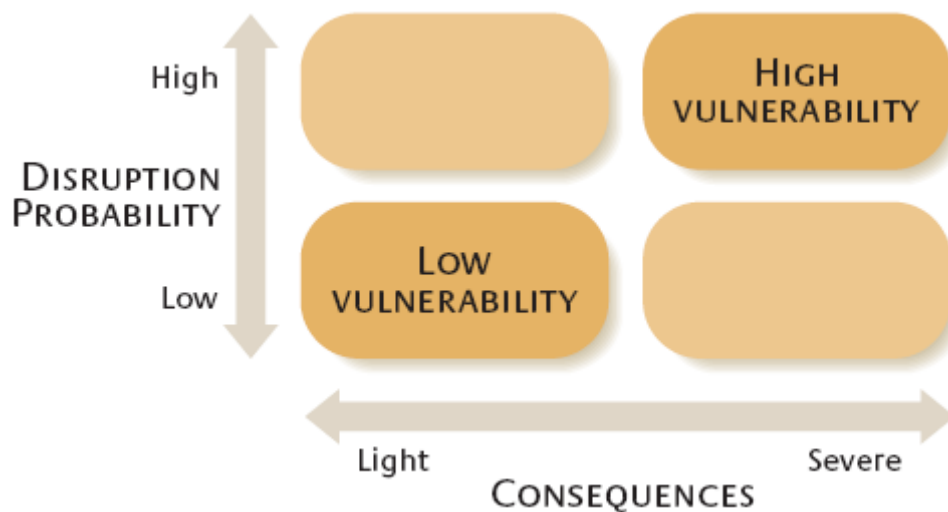


Figure 2.2: Mapping probability and consequences (from Sheffi and Rice 2005)

Following up with the example of Toyota from the paper introduction, a news article had this to say about the most recent (2007) supplier interruption:

*"The carmakers will suspend their production for one working day or so, which means they can just make it up by operating on a weekend. The impact should not be so significant" - 2007)*

Based on the capacity that Toyota had to compensate for the disruption, the article was essentially claiming that the supplier disruption had a low impact on Toyota. A high-impact disruption, on the other hand, would be the example of the Philips semiconductor plant fire that eventually cost Ericsson \$200 million (Norrman and Jansson 2004) and forced them to join Sony in a joint-venture company for the production and marketing of cellular telephones. Of course, looking purely at the cost in dollars is one way to measure impact, but it is also acknowledged that what is a low-impact disruption cost-wise for Toyota could, for example, put a far smaller firm out of business. Therefore, impact factor can also be firm or supply chain specific.

Another attribute of disruptions is the inherent cause of the disruption. For example, Murphy (2006) categorized disruptions into “natural events”, “external – man made events”, and “internal – man made events.” Blizzards, labor strikes, and product recalls would be examples of each category respectively (Murphy 2006). A third attribute of disruptions is on how many echelons of the supply chain has been affected by a given disruption at one time. Has the disruption affected a single business entity in the supply chain, the whole chain, or some portion in-



between? Most research focuses on disruptions that affect only one or two echelons at a time, such as a manufacturer facing disruption in supply because of a disruption occurring at a supplier (Zsidisin and Smith 2005). A fourth attribute is whether the disruption is associated with an environmental change. This could mean that a disruption directly causes a change in the business environment or that it happens to occur within the same time period as an independent shift in the business environment. An example of this is the impact on Sri Lankan logistics firms when the civil war resumed in 2007 and blocked whole areas of the country from receiving normal transportation loads. Disruptions that cause an environmental change usually impact some form of the infrastructure for either a long time period or permanently. Disruptions with this impact are more likely to affect countries or regional areas within a country as opposed to the entire world. Hurricane Katrina not only disrupted the firms operating in the area but also changed the business environment with the types of products that were in demand, the insurance rates (cost of doing business) in the affected area, and the difficulty in simply hiring labor for many areas that had people move out and never move back. A fifth attribute of a disruption is the duration of the event itself. Most disruptions are short in nature (a fire is out within 10 minutes in the Philips example (Sheffi 2005)), while others, such as a port strike, can last a week or longer.

Another example is shown below of how a supply chain disruption can be categorized according to its attributes (see Table 2.2).

Cause of Disruption	Disruption Impact		
	Low	Medium	High
<i>Internal – Man-made</i> <ul style="list-style-type: none"> <li>• Machine breakdown</li> <li>• Employee failure, accident</li> </ul>			
<i>External – Man-made</i> <ul style="list-style-type: none"> <li>• Supplier production delay</li> <li>• Labor strike</li> </ul>			
<i>External – Acts of Nature</i> <ul style="list-style-type: none"> <li>• Lightning strike</li> <li>• Hurricane</li> </ul>			

Table 2.2: Example of categorization of disruptions based on key attributes

There are two attributes represented in this table:

- *Cause of the disruption*: this designation follows the categorizations used by Murphy (2006) with slightly different labels. It first designates whether the disruption was caused by actions or activities within the firm (internal) or outside of the firm (external). It also designates whether the disruption was man-made or caused by acts of nature, and hence un-controllable.
- *Supply chain impact*: this breaks the idea of impact into three ranges. Low, medium, and high ranges are used similar to those used by Ogden et al. (2005). As in their research, there are no fixed cost points that define these ranges. They are perceptions that are influenced by the perception of the decision maker, the size of the firm, the type of disruption, and other variables.

This section has defined the supply chain disruption term and presented several different attributes of disruptions. Multiple factors can be integrated together, but the choice of terms is important to provide clarity to readers. The next section discusses some of the research that has been done in this area.

## ***Research on Disruptions***

Much of the research that has been done surrounding disruptions has focused on anticipating and planning for disruptions and is incorporated into the risk management literature. This has occurred because empirical research is inherently difficult in regard to disruptions. First, disruptions are normally unpredictable in their timing. Few disruptions have more than several hours or days warning (Murphy 2006), meaning that it can be difficult to place a researcher in the right place at the right time to gather any desired variables. Second, disruptions are also unpredictable in their frequency. A firm might allow researchers to have access to disruptions, but no one can guarantee how many disruptions will occur and what their attributes are. Along that line and third, gaining access to firms after disruptions have occurred can be difficult. The firm is dealing with a challenge and having a researcher “in the way” is not appealing. One answer to these concerns is more of a ‘staged’ disruption, but naturally, few firms want manipulations being done on their supply chains to test performance differences. As a result, there is less information and research being done on firms in post-disruption situations (Blackhurst et al. 2005). Among the studies that have been done, there is dispersion among qualitative, modeling, and empirical research.

One qualitative method that has been used is that of conducting interviews. Craighead et al. (2007) performed interviews among various echelons of a single supply chain related to a U.S.-based automobile manufacturer. After performing analysis on the interview transcripts, they make six propositions that relate to the severity of the disruptions and the effect on the supply chain. Using the same data set, Blackhurst et al. (2005) analyzed the interview transcripts for clues on what the needs were for managers to effectively manage disruptions and deal with the

key issues practically. They came up with the three areas or disruption management steps shown in Table 2.3.

Disruption Management Steps	<b><u>Blackhurst et al. 2005</u></b>
1	Disruption discovery
2	Disruption recovery
3	Supply chain re-design

Table 2.3: Three steps in managing disruptions after they occur

Discovery refers to the ability to observe and know that the disruption is occurring as quickly as possible. Recovery is the ability of the firm to adequately and quickly recover from the disruption in a manner that restores service to customers. Finally, re-design is the learning step where the firm takes the possible lessons from the disruption and re-designs the supply chain in such a way that will mitigate the effect of future disruptions. The authors offer several areas of future research for each of the three steps. To the best of our knowledge, very few have been researched.

Modeling is one method that has been used to look at the design of the supply chain and its susceptibility to disruptions. For example, in their 2005 article, Wu and Blackhurst developed a model that could help to understand the effects of a disruption occurring at just one point (or node) in the supply chain on other nodes. They then applied this in a case study to a major aircraft communication equipment firm. Wu et al. (2007) took this a step further and ran models with a similar single-node initial disruption, but then modeled the various states that were reachable from that initial state. Minimizing the effects of the disruption was the primary goal. In another example, Tomlin (2006) modeled the effect of various mitigation strategies, such as

whether to carry inventory or source from a single supplier or from multiple suppliers, on performance should a disruption occur.

The third methodology is largely constrained to a data set collected by Hendricks and Singhal. The data consisted of hundreds of incidents of a glitch in firms found in public media, such as magazines and newspaper. Their two papers were described earlier in the definition portion of this section (Hendricks and Singhal 2003; Hendricks and Singhal 2005a) but can be recapped by mentioning that they look at the effect of glitches on both shareholder wealth and operating performance. They find detrimental effects in both instances.

In summary, supply chain disruptions have been defined and many of their attributes described. Research in the area has largely focused on pre-disruption activities (namely supply chain risk management), but a few papers have begun to explore firms experiences after disruptions have occurred. The next few sections of this paper will continue defining additional terms, with supply chain sustainability following directly.

## **Supply Chain Sustainability**

Sustainability is one of the newest concepts to be linked to disruptions. It has been defined as “using resources to meet the needs of the present without compromising the ability of future generations to meet their own needs” (Linton et al. 2007). This is one of the first papers to look at sustainability in a supply chain context. The first foray was summarized well in a Kleindorfer et al. (2005) paper that looked at various themes over the first 50 issues of the Production and Operations Management Journal and tied them to sustainability in Operations Management.

Several of these themes will be re-iterated and expanded upon here. First, sustainability looks at the environmental concerns of running a supply chain. Methods to impact the negative impacts of the supply chain on the environment deal with the by-products of operations, extending the life of products, and looking into recovery and reuse of products. Second, the idea of running lean logistics and maximizing loads fits perfectly with sustainable supply chains. Similarly, one of the future research areas mentioned in Kleindorfer et al. (2005) is to look at OM (and supply chains) to become more agile, adaptable, and aligned (Lee 2004). Finally, public policy makers are looking at environmental concerns in many areas. It is only a matter of time before regulations are mandated for supply chains or activities that fall under the purview of supply chains.

The three areas described above bring several issues to mind. What impact does running leaner or maximized logistics operations have on the idea of risk? Does a lean supply chain take longer to recover after a disruption has occurred? What public policy decisions could come down that artificially create disruptions? For example, what if a law mandated stricter exhaust regulations for truck tractors, and there was a shortage of firms who had the more efficient trucks? If supply chains regularly become involved in working with re-manufactured goods, does this change the impact of a disruption, since perhaps the value of the good was less in the first place? Does the recapture of products affect risk if resources are being diverted to this activity and away from new products? Does a focus on creating an agile supply chain introduce more or less risk? Does an agile supply chain discover and recover from a disruption more quickly? Finally, would a manager whose emphasis is on sustainability and minimizing environmental impact make

different decisions about how to recover from a disruption should one occur? All of these questions provide ample opportunities for future research.

A final reason that this term has been included in this paper is that, similar to the scope creep of risk management and the confusion about the term ‘mitigation’, sustainability to some implies more of a ‘resilience’ meaning, or the ability of a supply chain to be ‘sustained’ even when being hit by a disruption. The concepts are not the same. The definition of sustainability from Merriam-Webster is “of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged.” Both this and the definition mentioned earlier focus heavily on the ‘resources’ as being the portion that must be maintained. The concept of resilience will be discussed next.

## **Supply Chain Resilience**

The term resilience in the supply chain was made popular by the book by Yossi Sheffi (2005) titled The Resilient Enterprise. The term originates from the material sciences and means the “physical property of a material that can return to its original shape or position after a deformation that does not exceed its elastic limit” (Rice and Caniato 2003) A more applicable definition has come to mean an organization’s ability to react to an unexpected disruption and restore normal operations, or network operations (Rice and Caniato 2003). Put even more simply – “the ability to bounce back from a disruption” (Sheffi and Rice 2005). However, Datta et al. (2007) have developed the definition that may be the most precise: “the ability of the supply chain to return to its original state or move to a new, more desirable state after being disturbed.” The new addition is the ability of the supply chain to move.

How can supply chains be made more resilient? Sarathy (2006) advocates a redesign of supply chains to “make them robust” which will help to lessen the impact of a disruption. Datta et al. (2007) believe that the keys lie in the structure of and visibility within the supply chain. Rice and Caniato (2003) conducted a survey and received many responses for how to increase resilience. Changing inventory levels, using a spot market for extra transportation capacity, and using multiple production facilities were listed as means of increasing flexibility and redundancy to create resilience. Interestingly, two responses seem to contradict. One was to “use multiple suppliers”, and the other was to “use a single supplier”. The authors mention correctly that there is “no one single ‘silver bullet’ response” (Rice and Caniato 2003).

In response to what is viewed as lots of high-level and important practice suggestions, but not enough empirical research, Datta et al. (2007) work to fill the gap in resilience by using agent-based simulation to look at the behavioral dynamics responses in the supply chain to various strategies. They first perform a case study of a major paper tissue manufacturer to gather an accurate picture of a full supply chain. Then agents are programmed to represent the various entities in the supply chain. Disruptions bombard the network and various levels of visibility, capacity, inventories, etc. are introduced, producing the “optimal” strategy for the network to produce resilience. It is expected that this type of methodology will become even more prevalent in testing propositions related to this and other disruption concepts.



A consideration that will end this section is whether resilience is a stand-alone concept, or just one way to manage risk. Another research area with similar questions as to its relationship with risk management is supply chain security, discussed next.

## **Supply Chain Security**

A recent Eyefortransport survey reported that 41% of managers prioritize the reduction of cargo theft in the supply chain. Furthermore, 56% think that developing a security program that increases overall efficiency is important (Eyefortransport 2006). Supply chain security is defined as not losing product during the production and transportation phase of the supply chain due to human pilferage causes. This topic has and remains important. It started with robberies of camels laden with goods in the Middle East, gunmen in the west robbing trains in the 1800's of the U.S., and now, even with technology advances, keeping containers in the possession of the carrier long enough to deliver it safely. The most important aspect of supply chain security and its place in this discussion is that a breach in security can become a supply chain disruption.

There are several ways that have been discussed in recent literature that are aimed to protect products: physical means (such as fences around a building), smart containers (an electronic tag that alerts managers if a container has been opened), RFID systems (these can 'see' product walking out of a warehouse), and better screening of personnel to identify those that will restrain themselves of 'opportunities'. Rice and Caniato (2003) advocate both security and resilience in supply chains, saying that one without the other doesn't really create an efficient and effective supply chain. They divide the different means to securing supply chains into physical security,

information security, and freight security. Of these areas, freight security has garnered much recent attention and that especially within the food industry.

Freight security has become a prominent discussion in the age of terrorism (post-9/11 in the United States). The government has passed new container security initiatives (Thibault et al. 2006), and several of the five security-aware logistics tenets can be related back to freight security (Russell and Saldanha 2003). With regards to the food industry, articles have been concerned about the U.S. food supply being threatened by bioterrorism (Harl 2002) despite regular government mandates for the safety of food and other industries. One recent paper looked at specific internal and external security measures within the food industry and found that those firms having a greater focus on security had better performance results (Working Paper 2007). This helps firms justify the usually fixed expenses of having the three types of security mentioned earlier.

For readers interested in this topic beyond the definitions and partial scope discussed here, Sarathy (2006) has written an excellent overview article on the importance and some practical means of putting security methods into global supply chains before disruptions occur.

## **Supply Chain Vulnerability**

Vulnerability is another term that has been used in the literature, but is one of the newer terms to be used in describing the risk-disruption paradigm (Peck 2005). Vulnerability has been defined as “the existence of random disturbances that lead to deviations in the supply chain of components and materials from normal, expected or planned schedules or activities, all of which

cause negative effects or consequences for the involved manufacturer...” (Svensson 2000). The same author in a later article defined it as “a condition that affects a firm’s goal accomplishment dependent upon the occurrence of negative consequences of disturbance. The degree of vulnerability for a given disturbance may be interpreted as being proportional to the chance of disturbance and the expected negative consequence of the disturbance, given that it has occurred” (Svensson 2002). A final example can be seen in the definition used by (Chapman et al. 2002) when they suggest that supply chain vulnerability is “an exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain.” Synthesizing these definitions then, some key phrases are “the existence of...disturbances”, the “degree of vulnerability”, and “exposure to a serious disturbance.”

While risk defines the overall possibilities of disruptions that can occur, vulnerability refers to the *propensity* of a given risk to turn into a disruption, or the availability of that disruption to occur in a specific supply chain. This propensity could be a likelihood value as used by insurance firms (Zinn et al. 2006), or other arbitrary ‘value’ estimation by a manager or firm. Recall that in Figure 2.2, Sheffi and Rice (2005) applied the term ‘low vulnerability’ to firms for which the impact and likelihood of disruptions was low. ‘High vulnerability’ applied to firms for which the impact and likelihood of disruptions was great.

The term vulnerability is commonly used, but it appears that the term is more of an adjective describing supply chains rather than a focused research topic at this point. Future research could investigate strategies, supply chain designs, and circumstances that make supply chains more

vulnerable, but the question would remain as to how separate from other risk, disruption, security, etc. research this would be.

We now turn our attention to two concepts that are more general in nature, meaning that they apply less specifically to supply chains than they do to organizations or events in general. These two concepts are business continuity planning (BCP) and crisis management, accordingly.

### **Business Continuity Planning (Management)**

Business continuity planning (BCP) is a term that has been used extensively in practitioner-oriented journals and books (Hiles 2007) and as has been mentioned before, is similar to the term risk management. Recall that in Table 2.1 many of the steps between BCP and RM or SCRM were similar. BCP is a “system that has been developed primarily by practitioners to minimize the effects of unanticipated events on the firm’s ability to meet customer requirements” (Zsidisin et al. 2005). It has progressed substantially in its use and scope since September 11, 2001 (Benyoucef and Forzley 2007). Rice and Caniato (2003) use BCP as an overarching means of developing plans to be resilient and improve security. BCM (‘management’ instead of ‘planning’) is defined as “the development of strategies, plans and actions which provide protection or alternative modes of operation for those activities or business processes which, if they were to be interrupted, might otherwise bring a seriously damaging or potentially fatal loss to the enterprise (Hiles and Barnes 2001; Norrman and Lindroth 2004). These two terms can and often are used interchangeably.

The scope of BCP will become important for determining how it fits into the framework for relationships at the end of this chapter. BCP takes a step back from a pure supply chain focus and includes other facets such as IT (Savage 2002) and leadership succession, for example.. Support for this view comes with the viewpoint that the integration of information and formalized procedures will help firms recover from disruptions (Barnes 2001). Norrman and Lindroth (2004) include crisis management, disaster recovery, business recovery, and contingency planning. This implies both a pre- as well as post-incident scope. In fact, Musson (2001) lists a few specific post-incident strategies that can be used to speed recovery such as using any spare capacity that exists in the organization, perhaps getting assistance from competition, outsourcing any pertinent activities, and others.

Others however, view BCP as no more than risk management. Some say that BCP is a means of managing all of an organization's risk (Zsidisin et al. 2005), while others say that BCM can be "seen as part of risk management and sometimes vice versa" (Norrman and Lindroth 2004).

The final concept to be looked at before building a framework for relationships between the concepts is crisis management.

## **Crisis Management**

An organizational crisis is "a low-probability, high-impact event that threatens the viability of the organization and is characterized by ambiguity of cause, effect, and means of resolution, as well as by a belief that decisions must be made swiftly" (Pearson and Clair 1998; Hale et al. 2006). Pearson and Clair (1998) further define crisis management as "... involve[ing]

minimizing potential risk before a triggering event. In response to a triggering event, effective crisis management involves improvising and interacting by key stakeholders so that individual and collective sense making, shared meaning, and roles are reconstructed. Following a triggering event, effective crisis management entails individual and organizational readjustment of basic assumptions, as well as behavioral and emotional responses aimed at recovery and readjustment.” These two definitions offer an excellent summary of what crisis management and a crisis are.

In comparison to risk management, crisis management has been described as focusing more on “dramatic events” as opposed to managing the continuum of events that are found between “mundane” to “dramatic” (Herman and Oliver 2002). Crisis management involves both proactive and reactive strategies that help firms minimize damage and recover from distressing situations (Naglewski 2006). Smith (2005) describes a similar scope for crisis management:

*“...management (as both a function and a process) [is] at the center of the crisis generation and response function...management should not be seen as operating in isolation from the generation of those crises that they subsequently have to manage, but rather as an integral component of the generation of such events...management processes and procedures sit at the heart of the generation of crisis potential...”*

According to Smith (2005), the literature on crisis encompasses contingency planning, business continuity, crisis prevention, and also “points to...the pre-crisis phase as a means of shaping the nature of the problem as it emerges.” What we can gather from this and preceding clues is that crisis management encompasses all the functions of pre-, concurrent-, and post-crisis activities.

There are many events that can qualify as a crisis. Pearson and Clair (1998) offer quite a few in their paper; bribery, product tampering, natural disaster, plant explosion, and executive kidnapping just to name a few. One way of categorizing them could be: human resource, product, reputation, capital, and supply chain crises. Some organizations have been termed “prone” to crises. Mitroff and Alpaslan (2003) suggest that being prone to a crisis means that an organization is only prepared to handle something that they have already experienced.

There are some unique characteristics of an organization in crisis. A few selected characteristics are discussed here from the research of Dubrovski (2004). One is that firms tend to look to a single manager to lead the charge of making decisions on dealing with and recovering from the disruption. This is an important point because the benefits of having multiple managers trying to coordinate together to decide current and future strategy are not available. Part of the reason firms look to one manager is that time is simply not available to bring people together and / or have discussions on the best policy (Dubrovski 2004). Another is that decision makers face a shortened time for making decisions and have “constant psychological pressure” with little ability to stop and reassess a situation (Drabek and Hoetmer 1991; Dubrovski 2004).

It should be noted that several disciplines have done research on crisis management. Three primary viewpoints – psychology, socio-political, and technological-structural – have been integrated into one framework in an excellent review article by Pearson and Clair (1998). Their framework ends with a continuum of the decisions and results between success and failure. This is important because it sets a stage for the need to learn from mistakes that were made previously that will be included in the framework at the end of this chapter.

All of this is included and is related to disruptions on multiple fronts. First, a crisis can be the extreme end of a disruption in terms of impact. Second, there may be some very pertinent methods to be learned for how a crisis is managed and how disruptions should be managed. Finally, looking at the various viewpoints brought up by Pearson and Clair (1998) may add to our understanding of supply chain disruptions as well.

### ***Summary***

Seven concepts - risk management, supply chain disruptions, supply chain security, supply chain vulnerability, sustainability, business continuity planning, and risk management – have been presented with definitions and a sample of the research trend for each area. All of these concepts relate to supply chain disruptions in some capacity. In some cases, a concept is clear in its scope and contribution, while others can sometimes appear to heavily overlap another concept. It is important that we as researchers understand how these concepts fit and work together. This will help us to identify gaps for future research and communicate clearly to others what work we are doing. In the next section, an overarching framework that works to interrelate these research concepts will be proposed.



## **Section 2.2: Building the Relationship Framework**

This section's primary contribution is the development of a framework for understanding the relationships between the terminology and concepts presented in Section 2.1. Each of the terms described in Section 2.1 will be included in the framework at the most appropriate location. The goal of this framework will be to provide a common base with which the terms and concepts can be understood and researchers can position their research. The framework will be described and selected research gaps will be discussed. One section of the framework identified as a gap will then be identified which will be studied further in Chapter 3.

### ***Framework***

In addition to consulting the literature for clues as to conceptual relationships in the preceding paragraphs, the framework below was also presented to other leading academics as well as practitioners as a means of soliciting feedback. There were several competing contexts from which to develop the framework. How do the firm and supply chain point of views overlap? How much does each concept contribute that is exclusive to that concept, since we have seen that several concepts seem to offer "steps" for planning or responding to disruptions.

The framework is shown here, followed by descriptions in detail about each part of the framework.

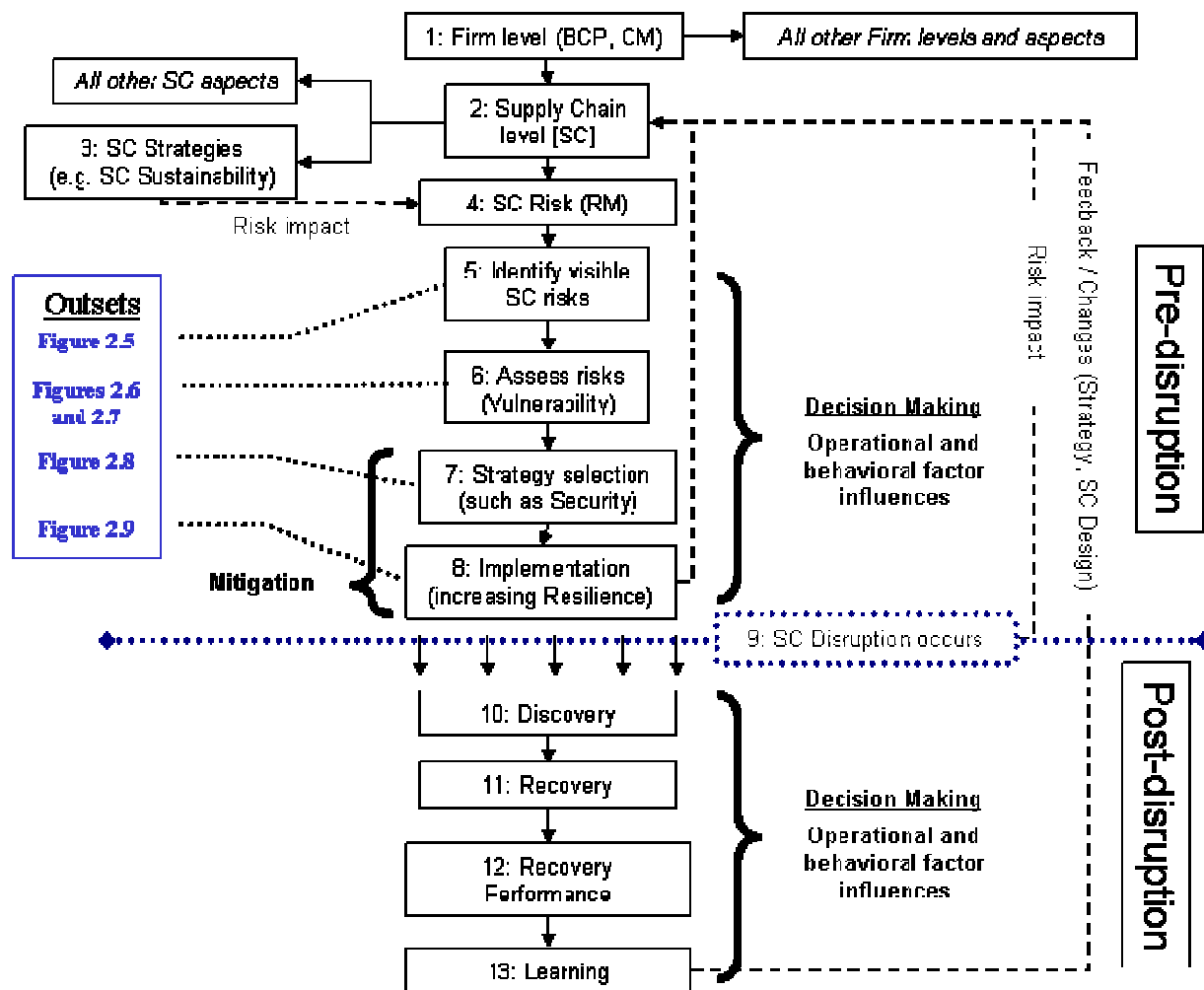


Figure 2.3: Framework for understanding relationships between disruption-related concepts

- The firm level is the starting point of the framework (Box 1 in the Figure 2.3 framework). This is primarily to accommodate the concepts of *BCP* and *CM*. Portions of *BCP* and *CM* can be adapted to the supply chain, but they deal with a broader array of issues that can beset the firm than just those that might affect the supply chain. Emergency CEO succession is an example of this. For purposes of this framework, *BCP* and *CM* are treated roughly equal in scope and process. Recall that Norrman and Lindroth (2004) placed *BCP* as the overarching concept with crisis management then being the method of

managing the recovery and post-disaster planning. However, they also felt that the concepts were interchangeable and noted such in their writing.

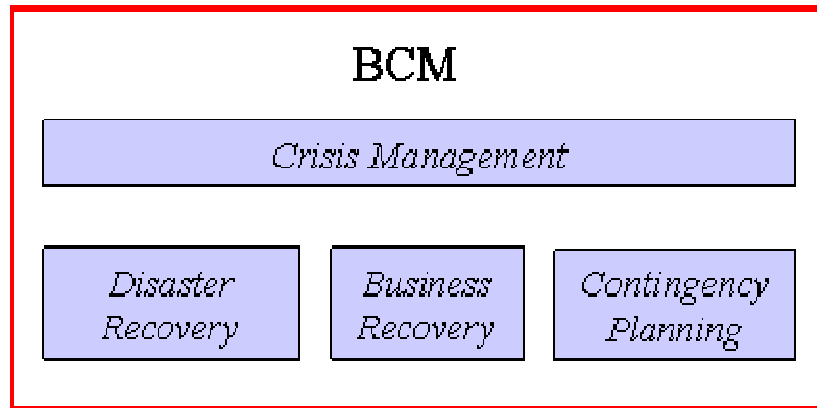


Figure 2.4: Source: Norrman and Lindroth 2004

On the other hand, Smith (2005) spoke of the literature on crisis management as encompassing contingency planning, business continuity and crisis prevention instead of the other way around. Similarly, Heath (2007) maintains that “BCM fits under the umbrella of CM activities as the important component called recovery management.” He goes on to acknowledge that the scope of both BCM and CM have over time expanded to include pre-, concurrent-, and post-event activities.

Barton (2008) makes a distinction between BCP and CM according to the time frame under which they are activated. In his understanding, CM is implemented during the crisis event and for only the first 8 hours after the crisis. BCP then takes over after the 8-hour period when CM is ‘shutting down’ and continues until the end of the recovery process (Barton 2008).

As there is still discussion about how they are to be viewed, this research follows Norrman and Lidroth 2004 in casting them as interchangeable concepts.

- Box 2 represents a focus within the framework on the supply chain level of the firm. While there are many other levels within a firm, since this framework is meant to deal with severe disruptions, the emphasis on the supply chain level is included.

There are three boxes that are linked to the supply chain level of the firm. Box 3 denotes the strategies of the supply chain, while Box 4 denotes risk in the supply chain. The final box simply accounts for all remaining supply chain categories.

- There are many supply chain strategies that exist – from location of DCs to the number of suppliers that are used. The concept of *supply chain sustainability*, then, is one of these supply chain strategies and belongs at this step in the framework. While these strategies don't directly cause a severe disruption, it should be noted that sustainability, along with other supply chain strategies, likely have an impact on firm risk. This is noted in the framework.

- Box 4 represents risk in the supply chain. This is sometimes referred to as *RM*, *SCRM*, or supply chain risk management, in the literature.
- The next several boxes are the well documented steps to *SCRM* from the literature. However, the outset that are included here are meant to add detail to these steps. As shown in Table 2.1, a first step in *RM* is to identify the risks (Box 5) asking the question ‘What types of disruptions can occur to the supply chain?’ The word ‘visible’ has also been included here. While normally implied that only those risks that are visible can really be assessed and decisions made and implemented as a result, it is now explicitly mentioned.

Examples of severe risks can include natural disasters, product recalls, and supplier production problems (leading to product shortages). More are mentioned in the supply chain disruption section of Chapter 2. These risks can be categorized in many ways, with one example being shown in Outset Figure 2.5 where supply, product, physical, demand, information, and freight risks are included.

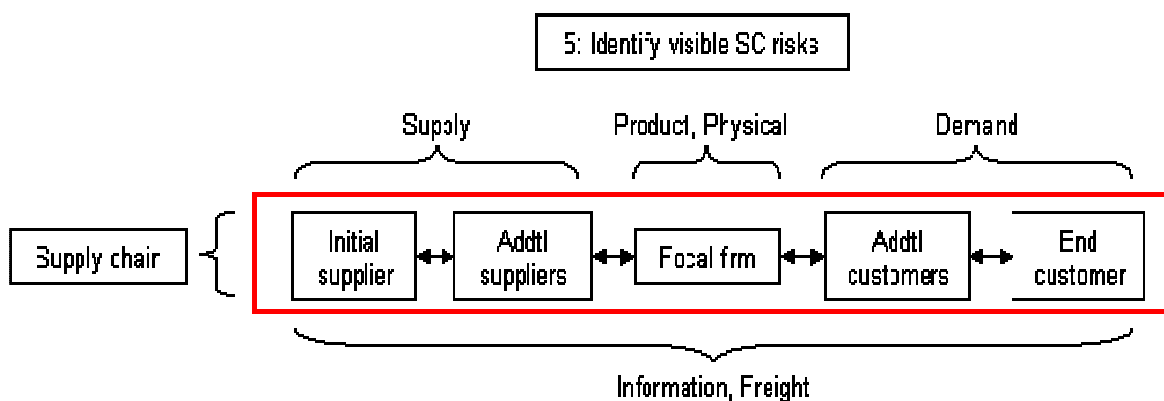


Figure 2.5: Outset showing types of disruption risks that can occur in the supply chain

- The next step is to start mitigating the risks by assessing or analyzing the risks (Box 6) identified. The concept of *vulnerability* fits here, where the primary function is to determine the probability of disruptions occurring. Assessment is commonly done through an Impact vs. Likelihood matrix, as shown in Figure 2.6.

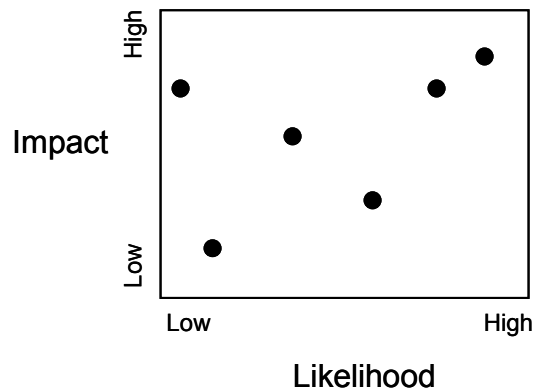


Figure 2.6: Outset showing impact vs. likelihood matrix for risk assessment

In this matrix, the risks are placed (shown by the example dots) according to whether the expected likelihood of their occurrence is low or high, and whether their expected impact is low or high. For example, it might be expected that a tornado would have a low likelihood but a high impact. In contrast, a truck delay would have a high likelihood and a lower impact, resulting in a simple disruption rather than a severe disruption.

- Firms then identify whether they will be using a proactive or reactive strategy (Box 7) for a given risk. Reactive means that little or nothing is done to soften the impact or prevent this type of risk from occurring. It might be a risk that will not have a great impact, or one in which preventing it would be done at an extremely high cost. This loosely applies more to the low likelihood-low impact section of the matrix in Figure 2.7. Alternatively,

a proactive approach means that strategies for dealing with the risk will be identified. These generally are the high likelihood - high impact risks. Since the means of making these decisions have many operational and behavioral antecedents and factors involved, there is no constant boundary to those categories. Each risk is looked at independently.

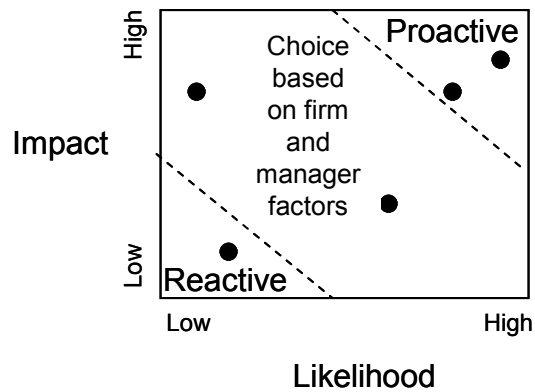


Figure 2.7: Outset showing proactive and reactive strategies in the Impact vs. Likelihood matrix

- Continuing in the strategy selection phase (Box 7), some strategies may simply be to develop a risk or disruption recovery plan which will be pulled out and used after a given type of disruption occurs. Other strategies may be implemented (Box 8) before the disruption occurs in an effort to reduce the potential impact of a severe disruption or prevent the occurrence from happening in the first place. Implementation of a strategy can increase the *resilience*, another concept from Section 2.1, of the supply chain (see Figure 2.8). Alternatively, if the decision was made (explicitly or implicitly) to be reactive, than nothing is implemented at the current time.

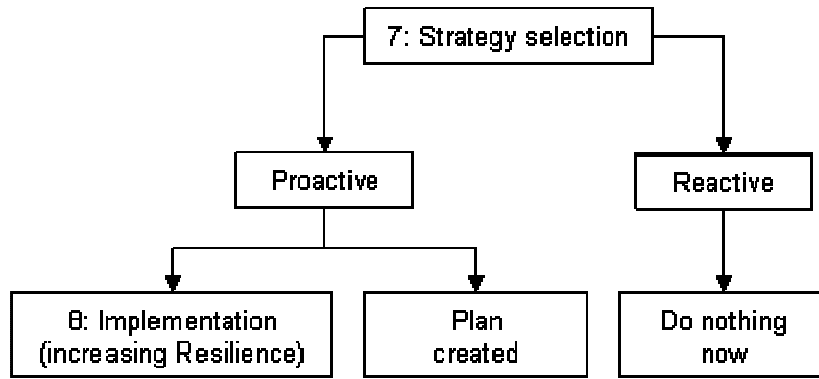


Figure 2.8: Outset showing proactive strategies lead to a risk plan or implementation phase

- Many different strategies for implementation can be chosen. Some involve altering supplier characteristics and reconfiguring or redesigning the supply chain network (see Figure 2.9). Others, such as a safety stock policy change and *supply chain security*, probably do not require a supply chain redesign. As seen in the framework, a feedback loop now occurs between the final implementation back to the level of the supply chain and assessment of supply chain risks. This sequence of risk assessment and prevention then begins again.

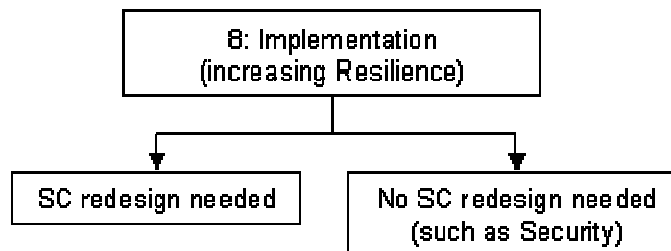


Figure 2.9: Outset showing proactive strategies lead to a risk plan or implementation phase

- A severe disruption of now occurs (Box 9) and the firm must begin the discovery and recovery phase of the framework. According to Chopra and Sodhi (2004), a disruption was labeled as one of nine categories of supply chain risk. Indicating that there is probably a feedback loop, Hendricks and Singhal(2005b) contemplate what the effect of



disruptions on the risk of the firms is. Does a disruption help to increase or decrease future risk? As with supply chain strategies, it is possible that severe disruptions may also affect the overall risk of the firm, hence, a dotted-line is drawn back to the supply chain level of the framework.

- At some point, preferably sooner than later, the firm makes the discovery of the disruption (Box 10). A first cursory impact or severity assessment occurs. If the severity is low, fewer resources will probably be allocated to the recovery effort. However, if the impact is (or is going to be, depending on when the discovery is made) high, then more resources are spent ending and recovering from the disruption.
- In the recovery phase (Box 11), the firm works to restore the supply chain and recover from the disruption. This can be done in many ways, depending on the type and severity of the disruption. If a shipment is delayed on the water, an emergency supply of product can be flown in from overseas. If a fire damages a warehouse, a new warehouse can be found nearby to store the product on either a temporary or permanent basis.
- After the discovery and recovery phases, an assessment of the total and final ‘damage’ is done, also known as the performance of the recovery effort (Box 12). How much the effort cost and how long it took to recover are frequent measures of performance.
- Finally, Box 13 represents the learning process that the firm goes through. The recovery process is analyzed to determine if things could have been managed better. Perhaps a

more proactive emphasis could have prevented the disruption in the first place. Perhaps during the recovery the group did not work well together. Most importantly, there may be strategies that need to be changed. For example, will the firm change supplier strategies based on the disruption that occurred? Is the network designed incorrectly or in such a way that the propensity for minor disruptions to escalate increases? Many other examples of questions are provided at the beginning of Chapter 3.

Finally, this learning feedback is fed back to the supply chain level of the framework and the process starts again.

- During the complete process in the framework, many decisions are being made. Some of these are made prior to the disruption in the planning and strategy selection steps, and others are made after the disruption has already occurred. There are likely many factors, both operational and behavior-based, that impact the decisions that are made. Such details as cost, experience of the decision makers, clockspeed of the industry (Fine 1998), duration of the disruption, network of the supply chain nodes, and many others are examples of these factors. The decision-making process is denoted in the framework simply by the bracket to the right of the process steps.
- Finally, one bracket to the right warrants mentioning. The term *mitigation* was defined earlier and likely fits into the framework in the pre-disruption section as a method of helping to alter the severity of any disruption that should occur.

As mentioned earlier, this framework can be used for several functions: understanding the conceptual relationships which also leads to common understanding, finding the gaps that the literature has not yet filled, and allowing for propositions to be made on potential further relationships or causal models that can then be tested. A brief discussion on some of the gaps that the model reveals is in the next paragraphs.

### ***Discussion***

In comparing the framework with the literature that has been looked at, the areas of RM, BCP, and CM are well covered in the research from a conceptual point of view. Some applications of specific strategies and performance implications remain. An area needing more understanding is how various events or strategies affect risk and vulnerability to the supply chain. Examples of this can be seen as sustainability, which is nascent at best, and a disruption itself.

Strategy selection has been developed from a definitional point of view and looked at as a discrete choice (which one is better), but not all scenarios have been researched, nor have the processes or behaviors that are involved in choosing strategies. After all, despite being perhaps more efficient, not all decisions are optimally made such as the models suggest. Post-disruption activities have gotten probably the least amount of researcher focus, and among the discovery, recovery, and assessment phases, again, the processes and behaviors that are included in decision selection. This is the area that will be researched in the remainder of this paper.

The next chapter will look into a portion of the framework above, specifically related to disruption management activities. It will start by explaining the questions that remain to be answered and then investigate the theories available to find the answers. What will be shown is that while some theories can be molded to fit the questions, a grounded theory methodology will provide a clean sheet with which to develop some theory on post-disruption decision making.

# Chapter 3: Disruption Management

## Section 3.1: Introduction

*Nothing is more difficult and therefore more precious than the ability to decide. - Napoleon*

In the introduction to this paper, two examples of disruptions and their responses were given. One of the points highlighted was the difference in the two firms' decisions after the disruption. The challenge is to understand what factors contribute to the various types of decisions that are made in response to disruptions. Chapter 2 was devoted to understanding some of the research being done in the area of disruptions, and showed that much of the completed research focused on the pre-disruption period. Questions that have been asked along this line are: how many firms develop risk plans in anticipation of disruptions, what are the nature and sophistication of these disruption plans, what differentiates effective from ineffective plans, and many more.

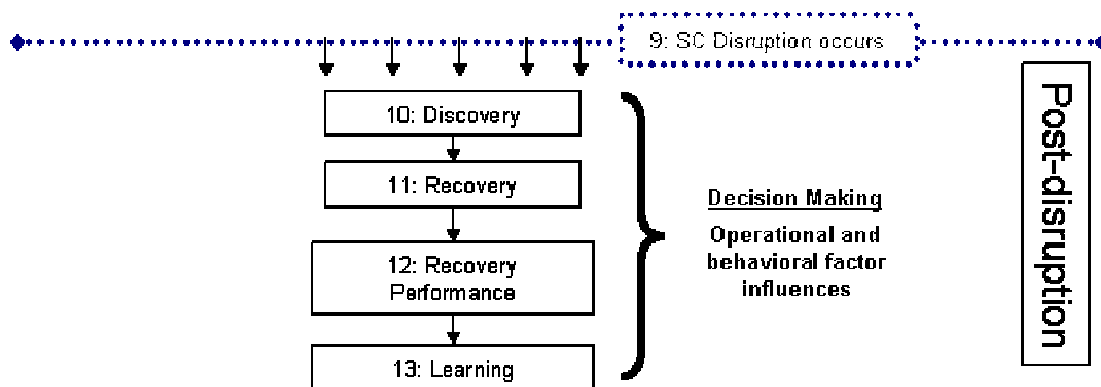


Figure 3.1: Initial disruption management model

However, many questions exist about the recovery and decision making process after a severe disruption has occurred (hereafter referred to as disruption management). These questions focus on the portion of the framework shown in Figure 3.1.

These questions can be divided into several groups.

- 1) *Disruption descriptions.* How frequently do the firms, themselves, face disruptions? How frequently do their customers or their suppliers face them? What types of disruptions occur? What have been the impacts of the various disruptions the firms have faced in the past? If a firm uses a 3PL, do they rely on the 3PL for help during the disruption? Does the use of 3PLs cause disruptions to occur more frequently than if the firms handled their own logistics activities internally? How are disruptions detected in organizations?
  
- 2) *Disruption response differences and causes.* Given that there are different types of disruptions, what are the response strategies of the firms? How do the firms detect these disruptions? How have recovery plans been implemented in the past? How does the severity of the disruption impact the firm's choice of inventory strategy? How does the type of disruption influence the response selected by the firm? At what managerial level were risk plans implemented? Are there any operational clues to help identify/predict disruption responses? Are there any behavioral clues to help identify/predict the responses? These behavioral clues involve the characteristics of decision makers, such as their experience, their position in the firm, their pre-determined mindset, etc. How many different types of risk plans and/or contingency strategies have been developed to respond to various disruptions and what types of responses have these plans and/or

strategies incorporated? After a disruption occurs, what response differences did firms have? Did they follow a risk plan, if one existed? Did strategies change over time in response to the disruption?

3) *Impact of a disruption on supply chain relationships.* How does the severity vs. cause of the disruption affect relationships with suppliers, with customers, and with 3PL's? At what point does trust in a relationship get eroded due to the negative consequences associated with disruptions?

4) *Impact of a disruption on supply chain and firm performance.* Some firms do not implement the mitigation plans or contingency strategies in response to the disruption. When plans or strategies are not implemented, what happens to the structure or performance of the firm and the supply chain? Alternatively, if the plans or strategies are implemented, what are the performance results? Do firms that failed to plan at all consistently have greater changes or performance results?

The framework in Chapter 2 exposed a gap in research covering the decision-making activities of firms during a disruption. Stated clearly, the two research questions to be investigated are:

*What factors should be included in our understanding of disruption management?*

*How do these factors impact one another in terms of relationship direction and strength?*

At least two perspectives emerge to analyze the research question: operational and behavioral. Operational is more familiar as a perspective and would look at specifics of the structure of supply chains. Behavior is a much newer perspective (for those in the Operations Management genre of research) since it has traditionally been a black box, not explored in any systematic fashion. Current researchers such as Bendoly, Donohue, and Shultz are bringing light to the behavioral subject area (Bendoly et al. 2006). Indeed, it is vital to include the behavioral lens since the decision makers/mangers can experience anxiety, over- and under-reactions and possible irrationality (Connelly 1997) during the stress of dealing with a severe disruption. To only understand the operational side of the matter would miss much in our overall understanding of the total response to disruptions. In this research, both perspectives, or lenses, will be used as a base for discovering the factors involved.

Clearly, supply chain disruption related research is a relatively new field of research (Blackhurst et al. 2005; Waters 2007). This type of research has really advanced as the concept of supply chains has been developed and as supply chains, themselves, have gotten longer and more complex through globalization. Research on disruptions is also inherently difficult since the disruptions, themselves, are unpredictable along several facets such as frequency, timing, and impact. Therefore, research relies often on data about something that happened in the past. Several of the questions posed in this section can be answered simply by surveying managers. For example, it is straightforward to obtain from managers an answer to the following question: “How many disruptions have you had and what response did you take in response to each disruption? Eyefortransport is one of many organizations that provide annual surveys that contain some of this valuable informative information (see 2006 survey on cargo security trends



as an example). However, for a deeper understanding, the question of ‘why’ needs to be asked, and for that, a theoretical base is needed.

Good research has, among other things, a theoretical framework that can provide support for hypotheses about the research questions at hand. The theories that have been used in risk management, disruptions, supply chain security, and others are often imported from other disciplines to help explain the phenomena we observe. For example, Blackhurst et al. (2005) use strategic choice theory which originated in the management literature (Child 1972).

Unfortunately, many research papers are not able to or simply don’t apply a theory.

The research that follows will first describe a preliminary model developed about disruption management with brief references back to the literature. This model will be fleshed out by conducting interviews of supply chain managers following a structured, yet flexible interview protocol. These interviews will both confirm the factors in the model as well as reveal many additional factors that will be used to reconfigure the model. This model will then be used as a basis upon which propositions will be suggested. These propositions can be tested in later research.

## **Section 3.2: Literature and Model**

A short section on decision making from the management literature is needed to help frame the rest of this research. Additionally, a few paragraphs will pull important factors from the literature found in Chapter 2 that will be used to build the model.

### ***Decision Making and Behavior***

One of the challenges with any new area of research such as supply chain disruptions (Blackhurst et al. 2005) is that there is limited direct preceding research upon which to draw as a support for hypotheses in new research. The appropriate step, then, is to draw on principles that may be close to the present research context, such as decision making in the context of management.

It is the assessment of supply chain disruption factors (i.e., type of disruption, cause of disruption, potential impact of disruption) by a decision maker that will impact how they respond to the disruption in the discovery and recovery phases. The interesting research questions involve an understanding of how decision makers use and react to the supply chain disruption factors in shaping their response to the disruption. For example, in the disruption involving the earthquake that impacted a key Toyota supplier, the Toyota decision maker probably ranked the disruption as a low-impact, external disruption. Hence, the decision was to maintain the supply chain strategy as it stood. However, what if the disruption were internal to Toyota? What if the estimated cost impact were higher? Would the strategic decision have changed?

Decision making processes have been documented by researchers like Mintzberg et al. (1976). They have listed several recurring steps in the decision making process to include: recognition of the problem, its diagnosis, search for possible answers/solutions/responses, evaluation of alternatives considered, and authorization (selection of a course of action). In his book on risk management, Waters (2007) states that “a reasoned approach gives the best decisions, and managers should always use rational analyses for their decisions.” However, we know that during disruptions, and particularly during those that can be categorized as crises, that the timeframe, among other things, for making decisions is shortened. Not all decisions are made rationally (Connelly 1997).

In an attempt to understand how decision making can be different during crises, Hale et al. (2006) adapt the model from Mintzberg et al. (1976) and offer some new hypotheses. These attempt to account for crisis factors. For example, one of their hypotheses states: “Crisis response process will include predominately ready-made solutions.” However, as their paper is exploratory, none of the hypotheses are tested. Unfortunately, no overarching theory was used either.

The behavioral traits of decision makers have also been explored, as this naturally has an effect on the types of decisions that they make. Naglewski (2006) looked for common traits in decision makers by examining several case studies: the battle at Little Round Top, the infamous sinking of the Titanic, and the rise and fall of the auditing firm Arthur Anderson. He found that ego-neutrality, a presence of mind, a focus on the outcomes, forward thinking, and a willingness to learn from past mistakes were several of the key traits distinguishing effective from ineffective

decision makers. Interestingly, decision makers have been found to consistently overweight (consider too heavily) the strength of evidence (Massey and Wu 2005). In an experimental setting, these decision makers react not as much to the system that produces a signal, but rather to the signals themselves. They under react in environments that are unstable but have precise signals, while overreacting in stable environments with noisy signals (Massey and Wu 2005). A disruption can be found usually in a stable environment with a potentially noisy signal, which could lead decision makers to overreact to disruptions. Finally, Levy (1995) found that decision makers tended to handle disruptions in demand and supply as one-time events when shipping times are longer. This could lead to not planning adequately for future disruptions.

To summarize, while decision making in organizations has been explored, it has not been adequately applied to decision making in a supply chain setting with all of the unique factors that are involved. Therefore, there is still a great need to understand the factors and consequences of decision making surrounding disruptions in the supply chain. The proposed details of the research are presented next.

### ***Building the Model***

The basic steps of the post-disruption process from the framework were used to initially build the model. Shown again here, recall that the steps are the occurrence of the disruptive event, its discovery, and the recovery process. Subsequent to the recovery, there is an overall performance assessment. Finally, learning occurs from any mistakes made or in aiming to prevent similar future disruptions.

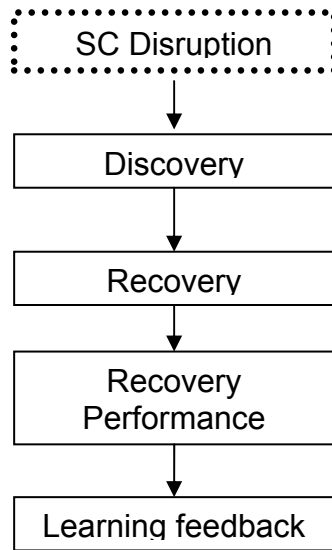


Figure 3.2: 5 Steps in disruption management process

In building the model, it is recognized that there are likely factors in place before the event (i.e., the severe supply chain disruption) that influence the management response within the process. Typical factors would include industry differences, firm size, and the financial health of the firm. Craighead et al. (2007) define supply chain operational factors that shape the overall management response. These include: the number of DC's, plants, and suppliers in the supply chain, its geographic scope (local vs. global), and its complexity as a whole (density) should be included. Other important pre-disruption factors shaping the overall management response include: the inventory position of the firm (as a potential hedge against disruptions) and the existence of a risk plan available for implementation in the event of a disruption.

Our focus begins with the actual occurrence of a severe supply chain disruption (first box in Figure 3.2). This research will focus on severe supply chain disruptions, with 'severe' being the emphasized word. Indeed, the focus on severe disruptions will be incorporated into the research design and interview protocol. The purpose of this focus is part of the critical incident technique

(CIT) defined in the interview protocol section. There are several factors discussed in previous literature that should be incorporated into the research model as an aspect of the disruption factor. First, from the operational literature, it is important to establish the exact point in the supply chain where the disruption occurred and the number of supply chain nodes likely to be impacted by the disruption. Second, the cause of the disruption should be investigated (Murphy 2006). Third, there should be a focus on the duration of the disruption, focusing on the time period during which the disruption impacts the performance of the supply chain. Finally, attention is centered on estimates of the severity of the disruption.

Discovery is the next step from Figure 3.2. From Blackhurst et al. (2005), we know that visibility and the speed with which the disruption is discovered is important to firms.

The recovery step follows next. This can be broken out into a few phases of recovery. First, it is predicted that the firm will face a decision, based on the type of disruption, on whether to implement a risk plan or not (assuming it has the option). The firm will then try to determine all of the options available to it. Should it use up the safety stocks? Should it use an alternate mode of transportation? Finally, decisions related to these options will be made. In some cases, it is anticipated that some of these decisions will be made by single decision makers (Dubrovski 2004). Others will be made by teams. The level of managerial / team experience is expected to be another factor. Similar to experience, the level of training provided to handle disruptions could play into the choices that decision makers select.

One of the fundamental interests of management research deals with the question of performance, and this research is no less interested in it. How fast was the firm able to recover from the disruption? How much did the disruption cost the firm?

Finally, the last step in Figure 3.2 is the learning that the firm does after the disruption is over. What were the lessons learned from the disruption and can the firm do anything differently to prevent a similar disruption in the future?

All of these factors taken together lead to model shown in Figure 3.3. The pre-existing supply chain conditions and readiness of the firm are found on the far left. Then the event, discover, recovery, and performance evaluation follow. Finally, the learning evaluation is found as the last step on the far right.

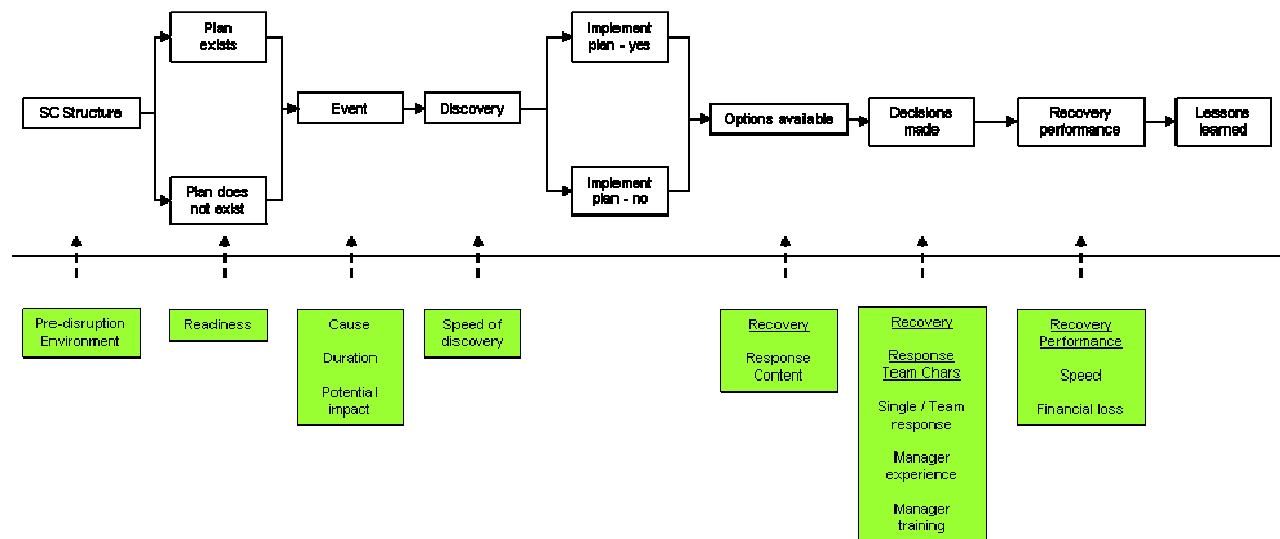


Figure 3.3: Pre-interview model of disruption management process

The methodology for conducting this research follows and the model in Figure 3.3 will be used to develop the interview protocol.

### **Section 3.3: Methods**

Theory is vital to advancing scientific research. It offers perspective and understanding of observed phenomena. Theory can be operationalized through a series of propositions which is then subjected to empirical testing. The goal is to explain severe supply chain disruptions with solid theory. However, developing theory in a new field of study is quite challenging. No sufficient reservoir of previous research exists to draw upon in developing sound theory.

Research methods are needed to enhance and facilitate the process of theory development along with a series of research propositions that can be tested empirically. Our approach then is to use a qualitative methodology to develop first the underlying theoretical foundation that allows propositions to be built and tested empirically in future research.

#### ***Qualitative Methods***

A recent book identified that theory development happens in four, usually overlapping and non-mutually-exclusive stages: tension, search, elaboration, and proclamation (Smith and Hitt 2005).

*Tension* can be described as a disagreement in the standard viewpoint of a given phenomena, among other things. *Search* is the process of trying to discover the reasons for the tension, and the answers that might resolve the tensions. The *elaboration* stage of theory development is where research is completed using the theory and the initial ideas are expanded. Finally, the presentation of the theory to community at large occurs in the *proclamation* stage.

Research in theory development for the area of disruptions is still very much in the tension stage and the use of a qualitative methodology is the most effective way of moving from the tension through to the elaboration stage.



There are two primary ways to collect qualitative data. One is through the case study approach, and the other is through interviews. Several examples of the case study data collection method have been done recently. Wu and Blackhurst (2005) used a case study approach as a method to develop theoretical propositions for a model they had built to represent a supply chain system and its performance during a supply chain disruption. The case study approach was also used by Zsidisin and Smith (2005) and Zsidisin et al. (2005) when studying early supplier involvement and business continuity planning against supply risk, respectively. In both cases, the authors developed propositions from their case studies about the underlying relationships. These fundamental propositions could then be subjected to empirical testing in a scientific study design. The strength of conducting case studies is that a significant depth is gained by gathering data from a given firm, conducting interviews within a firm or supply chain, and observations from the researchers through conducting tours, etc.

Interviews with many firms (without the specific focus on one case study firm) have also been used to gather data. For example, several interviews were conducted from parties in an auto manufacturing supply chain by Craighead et al. (2007). Their end result was also a collection of propositions and, for the first time, a theoretical synthesis model involving supply chain design characteristics, disruption severity, and mitigation capabilities. Interviews with multiple firms tend to provide more breadth on a topic. It was for this reason that this was the preferred data collection method for this research. We were interested in collecting the broadest sweep of factors that could be included in the disruption management model.

What is needed after the data collection is a strong and rigorous methodology for analyzing the data that is collected, which is where Grounded Theory Methodology can be employed.

## **Grounded Theory Methodology**

Grounded theory methodology was developed in 1967 by Glaser and Strauss. The intent of the methodology is to take the data that has been collected and allow the theory and / or desired models emerge from the data using a systematic analysis. Glaser later followed up his approach by recommending, among other things, using literature as an additional source of data whenever possible (Glaser 1998) in addition to interviews.

Structured interviews that meet several trustworthiness criteria are conducted around the topic of interest with the protocol being developed from the literature base that Glaser suggests.

Interview transcripts are then methodically coded so as to develop categories (factors) surrounding disruption management. Some of the original codes will become “supercodes”, which simply means that there are too many factors actually coded together as one. These supercodes are then broken down into appropriate subcodes. This process continues until the core factors are obtained and can support theoretical propositions.

Two recent disruption-related papers that used grounded theory in their research were found in the literature. Grounded theory was first employed to stress the need to use interviews as the primary method of data collection and the importance of capturing a wide range of perspectives and experiences during the interviews (Juttner et al. 2003). This led the authors to desire a “purposive or ‘theoretical’ sampling plan” as advocated in the early Glaser and Strauss (1967)

work. A later work by Manuj and Mentzer (2008b) also used the method. Their reasoning adds some excellent insight as to why this is appropriate for their research, but ours as well.

*“...an advantage of grounded theory is the ability to handle complex phenomenon such as risk management because the methodology emphasizes the need for developing multiple concepts and their linkages in order to capture a great deal of the central phenomenon.”* (Manuj and Mentzer 2008b)

Manuj and Mentzer (2008b) also performed in-depth interviews. They collected data from 14 senior supply chain executives from various firms as well as a focus group with 7 executives from one firm. The papers that used the grounded theory methodology have these points in common:

1. they were exploratory or framework-building articles
2. they used interviews as the primary data source
3. propositions and frameworks (defined as the process of managing supply chain disruptions and the processes that surround disruptions) were developed more adequately after the model was proposed

Additional specifics on the mechanics of grounded theory are given in the data collection and analysis sections that follow where the interviews are to be discussed.

## ***Data Collection***

This section outlines the details of how this study was approached and completed. First, the method of data collection (interviews) and the protocol are described. Second, the means of sample selection and information about the interviews that took place are detailed out. A discussion of criteria used to ensure reliability of the study is included. Finally, a description of the data analysis procedure is provided.

### **Interview Protocol**

A more structured interview protocol was used according to the suggestion of Eisenhardt (1989). While some grounded theory purists may advocate more of an unstructured approach to the interview protocol, there are important differences to note between the two degrees of structure. A completely unstructured approach indicates that the topic is defined but it is not known what questions should even be asked in an interview, whereas a structured approach indicates that most of the questions to be asked are known (meaning a relationship is suspected between factors), but the answers to those questions (the strength and direction of the relationship) are unknown. Others using qualitative methods have used the semi-structured or structured approach to the interview protocol (Pagell 2004, Closs et al. 2008).

The initial protocol was developed using the basic factors and constructs from the model of disruption management shown earlier (Figure 3.3). The questions were developed through an iterative process of the two primary researchers comparing protocols until a completed draft list of questions was developed. This protocol was then given to four additional outside researchers, who were familiar with qualitative methods and the topic of supply chain disruptions but not

previously involved with this project, for confirmation. This eliminated potential bias in the protocol and ensured that the questions matched the model. The interview protocol and initial questions are presented in Appendix C.

Part of the protocol included some questions that utilized the critical incident technique (CIT) (Flanagan 1954). The CIT does not require any type of specific qualification of respondents, and helps to guide the research questions around a specific incident instead of generalities. As Twelker (2004) summarizes, the respondent only needs to have “simple types of judgments”, and can be anyone that is able to interpret behavior and events that have been experienced.

Following Craighead (2007), the respondent was asked to recall a severe supply chain disruption that was well-managed from their perspective and answer a series of questions about that specific incident. The respondent was then asked to recall a severe supply chain disruption that had the opportunity to be better managed and answer the same series of questions about the incident.

This method allows a direct comparison of two severe disruptions and the ability to discover the factors that may have contributed to the positive or negatively perceived decision making and recovery efforts.

The initial protocol was provided to each participant at least a week before the interview for them to be better prepared for the interview. However, each interview was treated as a replication of the process following other qualitative research in Yin 1994 and Pagell 2004. This allowed for the master set of questions (held by the researchers) to be updated after each interview if needed. Especially during the first few interviews, questions and issues can be discovered that should be added to each subsequent interview. More importantly, at the end of

the interview process, any questions that were asked of later respondents, but not of early respondents, were sent to those who had not had the opportunity to answer them. They then sent their replies so that all respondents were ultimately asked the same set of questions. In this manner, reliability and rigor was ensured not only by providing all respondents with the same starter questions, but also that all respondents were asked all important questions revealed in the process.

## **Sample Selection and Interviews**

The scope of the project was limited to U.S.-based, international manufacturers or brand managers. The distinction between the two is simply that some firms outsource 100% or nearly 100% of manufacturing, effectively making them act more as a brand manager than an actual manufacturer. The key attribute between the two had to be that the product design and quality assurance needed to be done by the firm that was interviewed. This focus on specific types of firms was to ensure that a large and diverse enough supply chain existed where severe disruptions could occur. The objective of theory *building* is not complete generalization, which will later be the objective of theory *testing* research, but rather to dig deeply into an area through several key informants. The proposed theoretical model that results from this research will initially be generalizable only to the firms and persons that were interviewed (Manuj and Mentzer 2008a). The number of interviews was not pre-determined. Instead, the objective was to conduct enough interviews such that a point of theoretical saturation (Flint et al. 2002) was reached. This was evident by redundancy in the information that the final interviews provided. In the end, 18 interviews were conducted with 17 firms. This is in line with other research using interviews as the data collection method (Manuj and Mentzer 2008b).

An important aspect of how the interview sample was collected was the principle of theoretical sampling. The first few interviews reveal relationships between concepts, terms and their dimensions, and important variations (Corbin and Strauss 2008). These will lead to a desire to learn more about some of these revelations, and the way to add to the knowledge about an area is to find the next observation (sample) based on theoretical, relational, and discriminative reasons (Flint et al. 2002). This is meant to help complete the picture about the phenomenon at hand. As an example, while several industries were represented in the initial sample, the hi-tech industry was not. It was revealed during one discussion that that industry might represent specific differences worth discovering. An effort was made to then reach out to firms in this industry, netting the additional interviews in the hi-tech industry. In one interview, the respondent was able respond from the perspective of multiple industries due to the scope of responsibility that they maintained and the fact that the firm has multiple distinct industries that they are involved in.

The means of data collection was through interviews and they lasted between 45 – 135 minutes, with an average of 75 minutes. All interviews were audio recorded. The interviews were conducted in person whenever possible, leading to 10 of the interviews being conducted on-site. 3 of the phone interviews were with firms where one of the researchers had worked on-site with the respondents as a consultant previously. Conducting interviews via telephone does not lead to differences in the results collected and has been done before (Craighead et al. 2007, Blackhurst et al. 2005). The interviews were also conducted by two researchers in 14 out of the 18 interviews. The remaining four were transcribed, reviewed, and coded by the second researcher. Any clarifications needed or questions that were raised were communicated back to

the respondent who then emailed their responses. Table 3.1 is a description of the respondents themselves, while Table 3.2 displays some of the firm specifics. The strict confidentiality agreements preclude us from being able to provide additional specifics.

<u>Respondent</u>	<u>Gender</u>	<u>Title</u>	<u>Industry</u>	<u>Position Experience</u>	<u>Total Experience</u>
Adam	Male	Manager of Worldwide Logistics Quality	Agricultural Equipment	4 years*	34 years
Bob	Male	Director Current Material Availability, Mfg. Supply Operations	Automotive	3 years	31 years
Doug	Male	Executive Director for Global Logistics	Chemical	3 years	20 years*
Edward	Male	Global Vice President for Planning and Logistics	Chemical	3.5 years	23 years
Fred	Male	Warehouse Lead North America	Chemical	3.5 years	29 years
Greg	Male	Director of Global Transportation Logistics and Warehousing	Construction	3.5 years	15 years
Hal	Male	VP of Global Supply Chain	Consumer Durables	6 years	6 years
Ivan	Male	Global Purchasing Manager	Consumer Products	3 years*	16 years
John	Male	Executive Director for Global Inbound Logistics	Cosmetics	3 years*	25 years
Kevin	Male	Vice President of Supply Planning	Food & Beverage	5 years	20 years*
Larry	Male	Senior Manager of Operations Planning	Food & Beverage	3 years	18 years
Matthew	Male	Supply Chain Manager	Healthcare	4 years	15 years*
Nick	Male	Senior Manager for Global Transportation	Hi-tech	4 months	20 years*
Oliver	Male	Logistics Manager for the Americas	Hi-tech	4 years	40 years
Paul	Male	Director of Transportation	Home Building Supplies	2 years*	20 years*
Randy	Male	Supply Chain Manager	Paper	6 years	25 years
Steve	Male	Leader - Global Transportation Organization	Pharmaceutical	8 years	24 years
Teresa	Female	Manager of International Logistics	Apparel	2 years	2 years

\* Conservative estimated values based on experience descriptions

\*\* Names are pseudonyms only and not actual names

Table 3.1: Demographics of respondents



Firm	Industry	Size (Sales)**	# of Employees
A	Automotive	\$10+	25,000+
B	Pharmaceutical	\$10+	25,000+
C	Chemical	\$10+	< 10,000
D	Agricultural Equipment	\$10+	25,000+
E	Food and Beverage	\$10+	10,000 - 25,000
F	Consumer Products	\$2 - \$10	10,000 - 25,000
G	Apparel	\$2 - \$10	25,000+
H	Cosmetics	\$2 - \$10	25,000+
I	Consumer Durables	\$2 - \$10	25,000+
J	Paper	\$2 - \$10	25,000+
K*	Chemical	\$2 - \$10	10,000 - 25,000
L	Construction	\$2 - \$10	< 10,000
M	Hi-tech	< \$2	< 10,000
N	Hi-tech	< \$2	< 10,000
O	Food and Beverage	< \$2	10,000 - 25,000
P	Healthcare	< \$2	< 10,000
Q	Home Building Supplies	< \$2	10,000 - 25,000

\*Firm that provided multiple respondents

\*\* In billions of dollars

Table 3.2: Demographics of firms represented

One of the pre-requisites for the target firm for an interview was the presence of disruptions that a respondent was able to discuss. This was confirmed in targeted firms in multiple ways. The first was, in some cases, the presence of a significant disruption that was publicized in news media. The second method was verification through the recruitment process that interviewees were in an appropriate position in the firm to discuss disruptions, and that they knew that they would be asked about specific disruptions their firm had faced. This is advocated by Yin (2003). An example of the initial recruitment letter (sent through email) can be seen in Appendix B. Third, all interviewees were sent the list of starter questions one or two weeks

ahead of the interview for review. This helped to ensure familiarity with the questions as well as facilitation of the interview.

There are nine criteria for trustworthiness of the interview protocol that are listed by Flint et al. (2002). In order to ensure that the results from this study are able to be trusted, close adherence to these criteria was followed. They will be introduced in the next few paragraphs, with a table at the end (Table 3.3) that lists each criterion and how it was met in this research.

The first criterion, *confirmability*, addresses the level of researcher bias that is in the study as opposed to the participants and the phenomenon. It is important to limit the researcher bias in the model, and it can effectively be dealt with through other researchers looking independently at the transcripts of the interviews after they take place to ensure that appropriate coding was used. *Control* deals with the amount of influence the firms and interview participants have over the theory and phenomenon. This was dealt with by picking firms that had an appropriate supply chain as well as interview participants who had decision making scope and authority in the event of a supply chain disruption.

*Credibility* is how acceptably the results seem to represent the data. Having other researchers and even the interview participants review the results at different stages and provide input leads to greater credibility of the final results. Another criterion is the level of *dependability*. How specific are the results to one type of firm or one type of disruption? In order to deal appropriately with this, firms from different industries who have experienced different disruptions were interviewed. This provided results that are more consistent across multiple

disruptions. *Fit* refers to the ability of the results to fit the phenomenon that is being studied. Similar to several other criteria, interviewing appropriate persons with appropriate questions ensured adequate fit.

It was important to capture as many aspects of the phenomenon as possible, identified as the generality criteria. Interviews needed to be of sufficient length, open-ended, and the respondent comfortable enough to discover multiple facets. The length is similar to others and the questions used have been shown to alleviate any generality concern (Ellram et al. 2008). In a similar vein, it is vital that the interviewees not evade questions, provide misleading information, or lie. This was mitigated by interview confidentiality, observing body language, and acting at all times professional (which included location, dress, tone of voice, etc.).

The final two criteria are *transferability* and *understanding*. *Transferability* is similar to dependability, and aims to determine the generalizability of the results to other contexts. Flint et al. (2002) use theoretical sampling, which was also used in this research, to be as generalizable as possible. Finally, *understanding* is the extent that the interviewees agree with the results and that it accurately represents the phenomena as they deal with it. Again, the results were shown to interviewees for feedback before the final version was decided upon to garner any remnant ideas or correct mistakes.

<b>Criteria</b>	<b>Method for Meeting the Criteria</b>
Confirmability	A researcher outside of the primary researcher separately coded several transcripts. Discrepancies were resolved
Control	Firms with supply chains and interviewees with decision making power were interviewed
Credibility	Interviewees and other researchers reviewed the results and model prior to finalization
Dependability	Multiple firms in multiple industries provided data across multiple types of disruptions
Fit	Relevant questions were asked and persons interviewed that addressed the phenomena adequately
Generality	Interviews were of sufficient length and open-ended to capture multiple facets
Integrity	Confidentiality and professionalism was used in interview process
Transferability	Theoretical sampling was employed
Understanding	Interviewees and other researchers reviewed the results prior to finalization

Table 3.3: Nine criteria for ensuring trustworthiness of research findings

As alluded to earlier, after all interviews were completed and the transcripts reviewed, a list of questions that were asked in later interviews but not in earlier interviews was compiled.

Additionally, if there were any clarifying questions for a given interview, these were added to the list. A respondent-specific email was then sent to each of the respondents requesting the additional information. This ensured that all general questions were asked of every respondent, allowing consistency and reliability across the interviews.

### ***Data Analysis***

The interviews were transcribed verbatim and analyzed using Atlas.ti v.5.2. Software programs such as Atlas allow the transcripts to be digitized and easily accessed, coded, searched, and the factors and codes linked to one another. The programs are not capable of automating the coding process or taking away the thought process from the researcher. Instead, these programs act as an aid to the theory building process. The process of data analysis was initiated after the first

few interviews in contrast to waiting until all interviews were complete. The reason this was done is part of the theoretical sampling methodology. The first few interviews can reveal areas or factors of the phenomena which can be asked about in more detail in subsequent interviews. Waiting until completion of all interviews limits the amount of new factors that can be explored.

The coding categories were developed iteratively by two researchers based on the original exploratory model. These categories were then used to code the data. An initial subset of the data was coded by both researchers. The coding was then compared and differences were resolved. The coding then proceeded by the primary researcher. A final model incorporating the factors discovered during the analysis (and presented in the results section that follows) was developed. This model was then sent to all respondents for them to offer any final comments. Credibility and understanding of the model and research are met most effectively by doing this. Most respondents felt that the model was accurate, but a few had added comments that are listed in the results section.

The next section will present the results of the interviews including some of the definitional results of what a severe supply chain disruption is. The updated disruption management model will be presented at the end of the results section. The final section will then use the relationships between factors presented in the model to proffer relevant propositions that further the factor relationship concept by adding a directional component to that relationship. This will be able to be tested in later research.

## **Section 3.4: Theory Building Results**

As noted, the grounded theory methodology employed here used a series of semi-structured interviews to build upon and enhance the elements of a broad disruption management model. The expectation is that the interviews will provide insights that will facilitate the development of a refined and more comprehensive disruption management model. This more comprehensive model will facilitate the development of propositions regarding management decision-making and response to severe supply chain disruptions. This section will focus on the transition from the broad management disruption model, the starting point for the grounded theory methodology, to the more detailed model that will form the basis for a series of testable proposition regarding the underlying phenomena.

This section will use the initial supply chain disruption management model in Figure 3.3 as the starting point. The emphasis will be on using the results from the semi-structured interviews to enhance the basic supply chain management disruption model. This process will involve the review of the firm's environment and industry structure in the pre-supply chain disruption setting. It will document insights from the interview process regarding the definition of a severe supply chain disruption as well as an examination of differences between well-managed disruptions versus disruptions that were not as successfully managed. The end result of this section will be an enhanced model capturing management response to a severe supply chain disruption, which will provide the basis for a series of propositions capable of being tested through an empirical research process. The structure of this section will also follow the final model (Figure 3.4).

## ***Pre-Disruption Environment: Industry, Firm, Supply Chain, and Product Characteristics***

The initial supply chain disruption model recognized the need to establish the firm's context/environment in the pre-disruption period, since that environment would have relevance in explaining the post-disruption response. As a result of the interviews, the firm's context/environment in the pre-disruption period was distilled into four major areas: industry, firm, supply chain, and product characteristics. Each of these four, and the factors contained within them, will be briefly discussed in the next paragraphs

### **Industry Characteristics**

The initial supply chain disruption model accounted for the importance of a firm's industry in defining the management response. Each industry has unique characteristics with elements of importance to impact of and potential response to a severe supply chain disruption. However, the interview process suggested that the mere identification of a firm's industry was not sufficient. In addition to an industry definition, the interviews revealed that the clockspeed of the industry, the number of component/parts suppliers, and its overall competitiveness helped shape the response to the supply chain disruption. These factors were added to the industry section of the model.

Clockspeed, a measure of the rate of change in the product life cycle in an industry (Fine 1998), can be fast or slow. Severe disruptions are usually fast paced, and have an energizing effect on the persons involved. Since everything occurs more quickly in fast clockspeed industries,

disruption recovery is also more likely to occur quickly. One respondent from a slower clockspeed industry (and hence, a slower, longer supply chain) in our dataset discussed grappling with the slowness of the supply chain having a dulling effect on the complete recovery. He described the following challenge:

*“As you’re working through [the disruption] there is a stabilization that takes place probably...3 - 4 months after the issue. Sometimes you see more supply disruption, this bubble, or this void, [that] moves through your supply chain that may be 60-90 days long. So a lot of times the crisis has already occurred and has already been mitigated but your disruption occurs 3-4 months after the actual event.”*

The slower clockspeed industry has a corresponding slower supply chain speed, and hence, a slow return to normalization. The respondent went on to describe how managers will forget about the bubble and hence no preparedness has occurred. This second ‘disruption’ then occurs and again, mitigation efforts have to be used.

The number of suppliers to an industry can make difference in how some disruptions, especially supply disruptions, affect a firm. One respondent described a typical supply disruption.

However, because his supplier provided most of the firms in the industry, the disruption was felt by nearly all of the end-customers, i.e., all of the respondent’s competitors. This can be similar if there is a high concentration of firms in an industry (HHI) and a disruption of any kind affects most or all of the firms. This in turn creates more of an ‘equality’ of how the disruption is affecting the firms.



Clearly, the initial disruption management model is enhanced by examining the clockspeed of the firm's industry, its supply base, and the overall competitiveness of the industry sector in helping to understand the management response to a severe supply chain disruption.

### **Firm Characteristics**

The initial disruption decision model did identify firm characteristics as important in shaping the response to severe supply chain disruptions. The interview process suggested the discussion of a firm's characteristics should be expanded to include an understanding of the firm's views of their supply chain relationships with customers, suppliers, or 3PL's and transportation providers.

This factor appeared to be of significance in the first few interviews as respondents described their attitudes and actions in several situations. Additional interviews only provided more evidence of how important this factor was. The following quotations provide a range of viewpoints as well as positive and negative attitudes toward relationships with various members of the supply chains. Sometimes these relationships are formed also because of some dependence on, for example, a supplier. One quotation also reflects the attitude of the customer toward the respondent firm after a disruption.

<u>Viewpoint</u>	<u>Quotation</u>
Positive relationship with supplier – willing to invest	<i>“We might help them out with cash for a period of time, now a limited period of time....it’s a way of, sometimes the cost of doing that is less than the cost of re-supply so it’s a trade off.”</i>
Distrustful relationship with supplier	<i>“No, we probably discounted 50% [of what they said], they were too positive”</i>
Positive relationship with 3PL provider	<i>“...we had our President of Operations go and their CEO was there in a meeting... and the President of Operations was ... 60-65% sure that he was going to walk out of that building that day saying we’re moving in a different direction. So that 35-40% on the underside came through. It helped that he was able to bond with the 3PL CEO. They got along pretty well, so there was some personality driving that but also he could see pretty quickly what type of fix they put in place and how much control that fix would generate. It’s a long term relationship, you know it’s not something that we’ve just been doing for 5 or 6 years it’s been going on as both companies have grown for the last 20 years or so, so it’s a pretty long standing operation.”</i>
Negative attitude toward relationships with providers	<i>“We were given some advice to nurture the carriers and I remember joking at the time that I just can’t embrace the word nurture when it comes to a motor carrier, you know that’s a little too mushy for me.”</i>
Positive attitude toward relationships with Freight Forwarder	<i>“You know I made the comment to other day I think people in my organization thought I was crazy but our relationship with the current air ocean forwarder is only about... 2 years old and quite frankly they still really don’t know us. I think it takes 4-5 years, I mean if you’re a shipper bouncing from provider to provider to provider, even every year, you’re really not doing yourself any services because I mean it takes a long time for that forwarder to really know who you are.”</i>
Damaged relationship with Customers	<i>“Between [firm name] and the customers it was really bad, and that’s what I said.... it takes a long time for you to get your credibility back....and the customers took advantage of that. What happened is even after the situation was under control everything that was going bad would be like a value chain fault, like in the first months. So you could have the information, you could have the report but it would be very difficult for you to convince people that you were not really causing that issue.”</i>

Table 3.4: Quotations from respondents about supply chain relationships

There are several attributes to relationships that can be seen from these quotations alone. One is the level of trust in the relationship. During one disruption, one respondent said that they discounted 50% of what the supplier was telling them. Another attribute is the attitude toward

being patient with the 3PL and transportation provider. Some had the attitude of giving a couple of chances, while others felt that it would take a few years to really work out all the kinks in the relationship to make it as smooth as possible. A third attribute is the feeling towards developing relationships in the first place. Some embrace the process, while others would prefer to maintain “transactional” distance with their service providers.

Thus, the enhanced supply chain disruption management model defines each firm’s relationships with its suppliers, customers, and 3PLs as an important attribute of impact on management decisions.

## **Supply Chain Characteristics**

The starting management decision model focused on identifying U.S. based manufacturers who to a greater or lesser degree imported components and or raw materials in the manufacturing / assembly process. However, during the interview process, it became clear that most of our U.S. based manufacturers outsourced most of their manufacturing/assembly processes to offshore locations.

In a discussion with one of the initial respondents, the following was mentioned during a discussion about outsourcing:

*“Over the last 5-7 years [the firm] changed dramatically from a manufacturer and marketer to a marketer with the vast majority of our products. Our outsourcing now I think is in the neighborhood of 70% of our total products are outsourced, versus 5-7 years ago it was probably 20%.”*

While outsourcing is not new, it was still amazing to hear how fast and how much of the production had been outsourced / off-shored by U.S. based manufacturers. This same scenario was repeated in many, but not all, of the interviews. Much of the production had been outsourced and off-shored. Increasingly, the U.S. based manufacturers have transferred their outsourced and off-shored operations from Mexico to Asia. Indeed, several firms in the interview sample had become marketers or brand-owners with very little manufacturing remaining in the United States.

There seem to be certain characteristics that link those industries that are outsourced and those that kept more internal to the firm. The manufacturing that had stayed more domestic and internal to the firm was heavy manufacturing, such as automobile and agricultural equipment, as well as high-value / research and development intensive products such as medical supplies or pharmaceuticals.

The impact of this outsourcing trend is that the firms with outsourced and off-shored manufacturing found that their supply chain disruptions involved supplier and transportation related issues. In contrast, firms with continuing U.S. manufacturing operations had supply chain disruptions involving a more comprehensive array of issues and challenges. Thus, the enhanced management disruption model includes the outsourcing, off-shoring variable to define the supply chain structural characteristics.

## **Product Characteristics**

The initial management decision model did not include product characteristics as a pre-disruption category with relevance and importance to understanding management response to a disruption. The various interviews, however, demonstrated the importance of considering four product characteristics as being important in shaping and understanding these responses. These are the perishability, life cycle, manufacturing cost, and substitutability of the product.

When dealing with a perishable product, the decision makers have far less time to make decisions regarding the recovery efforts and the cost to the firm before the product may expire. If the product expires, the focus of the recovery effort becomes product replacement rather than trying to speed up whatever delays have occurred. A pharmaceutical firm described at one point that the transportation delay they were experiencing with their product had the effect of rendering the entire product as expired, costing the firm the value of the product.

The life cycle of the product can also impact the decisions that need to be made, especially in relation to a product quality disruption. Shorter life cycles, similar to perishability, may render the product as less desirable if it arrives late. On the other side of the spectrum, long life cycles almost dictate that the firm cannot offer a new model of a product as an alternative to repairing or simply replacing the current product.

The cost of the product can be closely related to both of the previous two characteristics. If the product is very costly to manufacture, than recalling and repairing a product is preferable to replacing a product. Consider the cost incurred by one manufacturing firm that experienced a

product quality disruption on a long life cycle, costly to manufacture product. They decided to repair the product as part of their recovery efforts.

*“In terms of the repair kits as they went out and the teams went out, actually teams some employees went out mechanics were sent out [to the product] with the kits to fix I think most of them....Monetary amount was well over \$100 million dollar fix but it was a matter of [the firm] re-gaining their reputation or not losing it anymore.”*

The final attribute of products revealed was how substitutable the product was. One respondent firm deals with a product that is extremely specific and always make-to-order. Whenever there is a disruption to the product (such as a quality issue), the specific product is not able to be repaired or reworked in any way. This attribute can influence and quickly impact customers (who now don't receive their product as promised) depending on the length of time to bring a fresh product back through the supply chain from its overseas location.

In summary, there are several factors that were added to the pre-disruption environment section under the categories of industry, firm, supply chain, and product characteristics.

### ***The Event Occurs: A Severe Supply Chain Disruption***

The initial management decision model's central event is the occurrence of a severe supply chain disruption. The interview process facilitated a greater understanding of the exact definition of a severe supply chain disruption, including both its operational and behavioral aspects, as well as an ability to develop a typology of severe supply chain disruptions.

The actual supply chain disruption is what sets off the entire disruption management process. Without the disruption actually occurring, the disruption can still be considered only a risk; something that might or might not happen. This section will discuss the typology development of severe supply chain disruptions only. The definition of a disruption, containing both the operational and behavioral aspects, will be looked at in the immediate response section of the results. This is due to the fact that this aspect of the disruption, the categorization as ‘severe’, impacts not the disruptive event itself, but rather the initial reaction.

There were many types of disruptions mentioned by the respondents. These were not only brought out by the direct questions, but also during the course of conversation. Some were the large natural disasters that are well known, but others were limited to the firm only. They are categorized below as the three types listed in the literature section, namely natural disasters, man made – internal, and man made – external. There is a further distinction between supply chain disruptions viewed by the respondents as well-managed (WM) versus disruptions with an opportunity to be better managed (OBM). During the interview process, respondents were asked to identify two severe supply chain disruptions, one in each of the above identified categories. This technique, known as the critical incident technique, is frequently used by researchers as a way to focus the respondents on particular events as opposed to making generalized statements.

In the Natural Disasters section, respondents identified two types of severe supply chain disruptions falling into the well-managed category and two identified as providing an opportunity for better management. Four different respondents mentioned Hurricane Katrina as

a supply chain severe disruption that was well-managed. One respondent identified a flooding disaster that knocked out some transportation structures as a severe disruption that was also well managed. In contrast, two respondents identified snowstorm disasters (one in the US and one in China) that provided the opportunity to be better managed.

	<u>Well Managed</u>	<u>Opportunity to be Better Managed</u>
<i>Natural Disaster</i>	Hurricane (4 times), Flooding of transportation structures	Snowstorm (2 times)
<i>Man Made – External</i>	Customs delay (2 times), Supply chain coordination, Supplier labor strike, Port labor strike, Damaged product (during shipping), Supplier quality (3 times), Raw material shortage, Supply delay (due to transportation), Terrorism	3PL merger woes, 3PL warehouse start-up, Customs delay (2 times), Demand spike, Supplier quality (2 times), Terrorism, Transportation availability, War in supplier’s country
<i>Man Made - Internal</i>		Product recall (2 times), Product manufacturing quality, Improper import documents, New product development quality

\* The two respondents from the same firm, though interviewed separately, listed the same WM and OBM disruptions. Hence, only 17 disruptions are listed above each for WM and OBM

Table 3.5: Listing of the well managed and opportunity to be better managed disruptions mentioned

Naturally, a wide-range of supplier related issues dominated the Man Made – External category. Respondents identified lots of different events in this category, with many being well-managed and many providing the opportunity for better management. These external events included many issues with suppliers as well as 3PL providers. They included mundane customs delays as well as wars. They also involved unanticipated demand spikes.



It is interesting to note that if the disruption resulted from internal issues or mistakes, these seem to overwhelmingly be placed in the category of a disruption that could have been handled better. There were several other disruptions described during the course of discussion, such as suppliers with financial difficulties, the bullwhip effect, and plant explosions. One firm also mentioned multiple times about the possibility of ‘bubbles’ in long, international supply chains only showing up a month or two after the initial cause of the disruption had occurred. As a result, many staff at the firm forgot about the disruption and would be surprised when product would suddenly be missing from the supply line.

The factor of *when* in the business cycle a disruption occurs was revealed by the analysis as having an effect on the type and severity of the disruption. Three separate respondents discussed in conversation the end of a fiscal cycle can impact disruptions. Specifically, an initial respondent described major events such as “*end of quarters, or any kind of event like Katrina.*” The two additional respondents described how a disruption can either cause a normally benign disruption to become a large risk or how an end-of-quarter can mask and exacerbate a disruption that was already occurring. Their respective quotations can be found in Table 3.6.

Quotation where the end of a fiscal time period causes a simple disruption to escalate:

*“And it never fails, I’ll tell you at the end of our quarter another scenario pretty similar [occurred]....the end of our fiscal year was May 30<sup>th</sup>. On May 30<sup>th</sup> here I am, you know typically we planned to have all of our products in-bound and received the Thursday of that last week at the very latest but we have a 9am cut off on Friday morning to do all of our receipts and I had stuff that was shipping Wednesday afternoon from China and I was supposed to get it into Tennessee so they could receive it and then outbound it because every bit of it was revenue for us and we needed every penny. So we ended up having to charter a charter flight to come out of Chicago when the stuff landed. Then we find out that before the charter left, some stuff missed the line haul that was supposed to go down and be there for Friday morning at 9am, so I had to get another hot shot truck. So I had a hot shot truck going down and a charter jet flying down to Smyrna from Chicago and they had to go through one of the worst storms that’s gone through the area in a long time and the jet was actually delayed by an hour and 40 minutes, he was at risk of being out of fuel and not being able to land in Tennessee. So we’ve had some disruptions, luckily most of those guys who fly those charter jets are cowboys and they are able to take a little bit of a risk...”*

Quotation where the end of a fiscal time period hid and exacerbated a severe disruption:

*“What had happened was, at the end of June is the end of our second quarter. It’s a high volume month, we got through that fairly well. We expected to see a downturn in volume the first two weeks of July and that’s when we brought in that transportation management system. We did see a downturn and felt pretty comfortable and the first week and a half we were actually staying on top of every order, we were on-time every day and we could see ourselves kind of getting into a [rhythm] here, or at least we thought we were. What happened was this system wasn’t completely tested correctly and we were starting to get phone calls asking us, [and] customer service, ‘where’s my order? I ordered this 2 weeks ago’. [Customer service would] say ‘what order, we haven’t got an order, we never got an order’. We started to check into it and we had lost probably the equivalent of 3 or 4 days [of orders] over a week and a half through I’m not sure again how it was random but it was the EDI sets coming between us and the TMS, were just dropping the orders and we actually lost track of where we were on orders because we never got them. And I mean it took that long to figure it out because of an expected downturn anyway...and that kicked into a second level now of something in gear, and one of the other things that we had difficult with here was trying to get a handle on where we were everyday.”*

Table 3.6: How the end of a fiscal time period plays a role in the disruption

Additionally, though implied in the initial model, the factor of ‘what’ occurred was added to the final model. This was brought out as one of the respondents had seen the model and simply mentioned that we had the ‘where’, ‘when’, ‘how’, and ‘why’, but were missing the ‘what’. The ‘what’ can be a physical disruption, a technology disruption, a financial disruption, and others.

### ***Readiness: Planning for a Severe Disruption***

The initial model of disruption management included the existence of a risk plan as a factor that might impact the managerial response to a severe disruption. The in-depth interview process provided further insight beyond whether managers did or did not have a risk planning process in place at the time of a disruption. The further insights, gleaned from the interview process, included whether or not the managers communicated their plans to their operational / planning staffs, the degree to which the plans were developed, and the extent to which the plans were rehearsed. Finally, and perhaps most importantly, there is the fundamental question of whether the existence of risk planning did impact whether the managerial response to the severe supply chain disruption could be characterized as a well-managed response or one that provided opportunities for improvement.

Readiness is used here to describe ways that a firm prepares and is ready for disruptions. However, that readiness is put to the test when a disruption actually happens. Many firms have been applying the idea of risk management in different ways. Postponement, larger inventory safety stocks, redundancy in manufacturing, and using multiple suppliers are all ways to spread risk out (Manuj and Mentzer 2008b). While respondents did mention some of these, our focus is

on the attitude toward risk, the ways that risk plans are developed, attitudes toward these plans, whether they actually get used, and how readiness can affect the outcome of the severe disruption. To reiterate, we will not focus on operational risk mitigation techniques meant to prevent disruptions from occurring. Behavioral perspectives on readiness planning of a post-disruption recovery effort will be the focal point of discussion.

## **Managerial Attitudes toward Planning and the Importance of Practicing the Plans**

Attitude toward risk planning can refer simply to whether a firm even considers the planning process to be important or not. Other surveys have examined whether firms even have disruption management plans in place. Some of our respondents definitely did have plans in place, while others indicated that they were not involved in any planning. The following quotation shows the importance placed on the planning process by one firm.

*“We do risk management with air conditioners in our computer room. We’ve done it with redundancy in communication, redundancy in printers, [and] redundancy in back up systems for the computer system. You name it. It is something we talk about here.”*

Table 3.7 shows the number of firms in our interviews that indicated they did have some degree of planning within the supply chain. It is important to recall the position and scope of the respondents in our research. It is more likely that manufacturing facilities have some risk plans in place, while a supply chain manager more focused on transportation / logistics may not have

such a focus. Table 3.7 shows that the majority of firms interviewed did, in fact, have active disaster recovery plans in place for at least some disruptions at the time of the interview.

<u>Respondents and the existence of recovery plans for disruptions within their job scope</u>		
<u>Yes, active plans exist</u>	<u>Plans (probably) exist in some form</u>	<u>No plans exist</u>
10	3	4

Table 3.7: The number of firms involved in recovery planning

A plan existing in some form can mean several things. In some cases, it can mean that the plans were begun but not completed. In other cases, the plans may have been completed, but not updated in some years. Finally, it can mean that the respondent thought that plans existed, but couldn't confirm their existence.

The several reasons that impact the decision by managers to develop recovery plans from supply chain disruptions are shown in Table 3.8. Important factors include the manager's personality and their previous experiences. One respondent discussed a particular disruption that the firm predicted would be forthcoming. Extensive planning and resources were thrown at the problem in preparation for the anticipated event. However, the disruption never happened and the respondent now takes a much cooler approach to planning for future disruption possibilities.

<u>Reasons Planning Occurs</u>	<u>Reasons for Not Planning</u>
Personality (organized)	Personality (disorganized)
Positive past experiences	Negative past experiences
Resources available	No resources available
Named to corporate planning team (forced to)	
Firm specific reasons (such as pharmaceuticals)	
Reaction to specific disruptions*	

\*this was the most common answer given.

Table 3.8: Reasons given for why planning does or does not occur

A third reason differentiating those managers who plan from those who do not is whether the firm has sufficient available resources for the planning effort. One respondent discussed their resource availability in this manner:

*“And it’s very hard to keep playbooks up to date, it requires a tremendous amount of organizational resource just...for a ‘just in case’ situation and I think what we have to figure out is where is it worth doing that and where is it just better to say ‘okay, we’re going to put 10 people on this and you guys are going to figure this [disruption] out’ ...That’s a lot less resources spent than having one person spend half their time always updating that playbook.”*

The interview process identified three additional factors facilitating the development of risk response plans. Some managers develop risk disruption plans as a result of being assigned to corporate planning and BCP teams. Others noted the life-saving importance attached to uninterrupted product delivery to the customer base. The best example of this was the pharmaceutical respondent who emphasized how their products save the lives of others and are needed at all times, especially during disruptions such as natural disasters. Therefore, planning is a vital component. The final reason is also the most cited reason for planning to occur: it is a reaction to a disruption that affected the firm. The September 11<sup>th</sup> terrorist attacks were frequently cited as a wake up call, especially for one of the respondents on Long Island when the attacks occurred. Transportation to and from the island was greatly restricted as a result, and corporate planning and redundancy have increased in reaction to that experience.

Among those that planned, however, there were mixed messages as to the usefulness of the actual plans. The next four quotations discuss the sentiments about having plans and, more importantly, about the planning process (underlines are our emphasis). The final quotation summarizes the responses well.

*“The business continuity plans were just to kind of have at least gone through a thought process. The continuity plans seemed to be more of a thought process than a specific plan.”*

*“As far as plans going down on paper, I think we’ve got our plans down on paper on our bigger stuff like quality issue things - we’ve got that down on paper. As far as a lot of the other things, I’m always thinking about contingencies; I know that contingencies and how we deal with them if I know it’s going to be something we’re going to need to deal with then I put down plans on paper. To be honest with you, we do have, and I do have a lot of things that if I need to, I’ll pull them out. But, for the most part, I try to build it into people’s normal operations so that it’s no longer going to be contingency mitigation because it’s part of the normal business.”*

*“I’d say the plan isn’t as valuable to us, and this is heresy for me to say this in [this firm] but this whole exercise of having the plan isn’t as valuable as people just calmly getting their arms around a solution and calmly organizing who needs to know about it and what we’re doing.”*

*“The problem is that...if it’s a new person in a role that’s got to tackle something and they go to the play book... what we find is no situation is the same, and so the play book can be directionally helpful but not really. It’s not a play book, it’s a, you’re uncle giving you advice about something. See that’s the other problem, we may have a playbook and then we don’t reference it until the next problem because it’s just like nobody knows where it is, wasn’t aware that we had one, didn’t respect the person that put it together and said there’s no way that guy can give me any advice or it’s considered outdated because that happened 3 years ago and the world’s a different place today. We just tend to throw bodies at problems, smart people to figure things out. But where we have a pretty good playbook is how we deal with recalls. And that’s partly because we’ve had a lot of them lately. and so we can see why the investment is worth keeping those play books relevant.”*

Some of the important points from these quotations are the fact that in nearly all cases, those who had a plan felt like the plan was not as important as the process of thinking through what can be done when a disruption occurs. This can be especially helpful in creating a calmer environment for handling disruptions. Some believe that the plan shouldn’t sit on the shelf; it should be incorporated into the daily procedures. Another way is to try to constantly remind the decision makers and other recovery team members of the disruptions.

There are two aspects of continued preparedness of those who would be involved in disruption recovery. The first is specific training while the second is rehearsal of a disruption. None of the managers that were interviewed mentioned that they had received training related to disruptions



beyond normal HAZMAT (2 respondents) and Import/Export documentation (2 respondents) training. Secondly, of the 17 firms that were interviewed, only 4 of them expressed that they have active rehearsals of disruptions. The rehearsals perform the important function of not only giving practice of how to recover, but also how to think during the disruption. As one respondent discussed:

*“I think what’s more important is our team has a mindset of, we call it “we deliver product or we deliver solutions”. So if there is a problem with us delivering product we’re at least going to articulate what the issue is and what the possible scenarios are the back up plans and we’re going to deal with it.”*

Of the four firms that rehearse, one does it on a plant level. Another has various mock scenarios play out for their employees on a regular basis; an average of every 6 months. The other two, however, stood out in their preparedness levels. A quotation from a manager at one of the firms is provided. What is visible in the quotation is that the firm excelled at the rehearsal plan and evaluation itself. The respondent’s team would receive team grades for given scenarios.

*“We have an annual renewal process where we refresh the information, we re-train everybody, and we go through another tabletop exercise where an examiner will come in and give us a scenario and for 4 hours we have to act out what we would do immediately, during recovery, and post recovery. So we kind of have to play out what we would do for the next two weeks including our immediate response like who has to call whom, what kind of people need to be assembled, who do we need to communicate it to and then who is responsible for certain activities. Who is going to develop the plan including the communication plan and then how are we going to execute it. In transportation we had*

*two [mock] exercises. The first one was UPS goes on strike with no notice and the second one was all the ports, US ports, were shut down because of expected nuclear attack. So we had to follow our manual. Who would get involved, how we would develop our plan, how we would implement our plan....rated on it each team gets a grade, 1-5 grade.”*

The second firm has a continually fine tuned preparedness document (checklist) for every disruption that occurs. Examples on the checklist are whether an interpreter would be needed for this disruption, is a 3PL service provider needed in the war room, and many others. This latter firm also had a specific group monitoring risk and planning for disruption continuously as their primary jobs. The group was about 20 members strong.

Two primary reasons were given for not conducting rehearsals. The more common reason was the time and resources required to adequately execute the scenario. The other reason was that no practice was necessary. One respondent mentioned the following:

*“We don’t do any dry runs. We don’t necessarily do it on our side because there [are] enough of those little minor interruptions that I think we get enough practice in how to manage through identification of problems and how do we recover. Cause you can’t simulate a big scale one, I mean you just have to go through it, and unfortunately we’ve had a couple of good practices.”*

In summary, the basic supply chain disruption management model identified the existence of a disruption plan as a factor that might impact the response to a disruption. The interview process

yielded insights going beyond the mere existence of a disruption plan to include factors differentiating managers with plans from those without plans, differentiating managers who communicated their plans to their operational / planning staffs from those who did not, differentiating managers with well-developed plans from those with immature plans, and differentiating managers who rehearsed their plans from those who did not.

### **Planning and the Well-Managed Disruption**

An important question to answer after recovery is whether the recovery went well or not. If there was a plan, and it was implemented, did it help in the recovery efforts? Decision makers are always being asked to justify their actions, and they want to ensure that the effort put into planning for the recovery effort was worth it. The hope is that disruptions can be recovered from faster, more cost effectively, more correctly, and more efficiently than if no plan existed. This is one of the reasons we wanted to compare the readiness efforts of well managed disruptions and those that were not. However, there did not seem to be a large effect of having a disruption plan and the perception of whether a disruption was well managed or not.

The quotations in the following table are divided into statements about recovery efforts that were well managed, and those that were not as well managed (Table 3.9).

<u>Well Managed</u>	<u>Opportunity to be Better Managed</u>
<i>“We really don’t, I’m not aware of any plan; we pretty much react as it comes up.”</i>	<i>“We know how to handle it I just think there was some higher up misalignment that caused just a lot of work and a lot of cost.”</i>
<i>“It’s all institutional knowledge there is no documentation of it.”</i>	<i>“Now is there a written plan in process? Not to my knowledge.”</i>
<i>“Anytime we have even a minor delay we have these address groups set up on lotus notes, so that all the players, the planning people, the operations people, sourcing, customer service, everybody knows.”</i>	<i>“Basically what happened is we didn’t ship for almost like 8 days I think, it was a total disaster and it really proved that we had zero type of contingency plan in place to deal with that type of crisis.”</i>
<i>“Yeah and the thing with the can one is we had, there were apparently I don’t know 6 months before they had established this corporate policy program but they never, it had bounced around a few people in [HQ] but it never was communicated to everyone else so we did this whole can thing without knowing that there was a firm policy and procedure for escalating and involving all the people, so we just did it on our own.”</i>	<i>“And it’s going to happen again, maybe not at the same plant or the same thing, I just think, plus because of the style of the people on the team particularly that one person in my opinion, there is no desire to engage them on working this through, and that’s not people being cowardly it’s just, you know what, they probably don’t feel like they are going to get a whole lot out of it.”</i>
<i>“There was no plan.”</i>	
<i>“No, it’s ad hoc.”</i>	
<i>“I don’t think so, maybe by the railroad but not by us.”</i>	

Table 3.9: Does planning or not planning occur more often in disruptions that are well managed or those that were not as well managed?

Another way to view this information is by the specific numbers. If a plan existed, were more of these disruptions categorized as well managed or as having the opportunity to be better managed? Table 3.10 shows that only in one situation where the plan existed did it result in a disruption where there was an opportunity for it to be better managed. In contrast, where a plan

existed, four of those disruptions were well managed. A plan counts as having existed if it was specific to the disruption that occurred and was recorded either on paper or electronically.

	<u>Well Managed</u>	<u>Opportunity to be Better Managed</u>
Plan Existed	4	1
No Plan Existed	13	16

Table 3.10: The number of disruptions that were WM or OBM and whether or not a plan for that disruption existed.

It appears that a disruption has a much greater likelihood of being well managed if a plan exists beforehand. However, many disruptions were classified as well managed despite not having prior risk plans in place.

In the original model, (Figure 3.3), the ‘readiness’ box was placed before the supply chain disruption. However, since readiness in the context of this research is dealing not with the development of plans themselves, but rather the implementation of and reaction to plans, we determined that at the least, the idea of how readiness affects the rest of the factors should at least come after the disruptive event.

The next question is, where after the event should the factor of readiness be located? Readiness as a concept affects the reaction of the decision makers so it also needs to come before the formation of the response group. It now needs to be determined if readiness affects the discovery of the disruption.

For some disruptions, readiness does not help a firm to discover its disruption more quickly than if it had not been prepared. Consider the examples of this in Table 3.11 and explained in the paragraph that follows.

<i>We'd had a couple consumer complaints and then a couple, I think one customer complained. Consumer being I think they called the 800 number on the side of the bottle. Customer being it was in a DC of a customer.</i>
<i>It took us probably close to 2 weeks to figure out that we were not getting the full answer.</i>
<i>[Describing September 11<sup>th</sup>] It was my middle son's first day of nursery school, so I take him for his first day. I come back and was just going to stay home for a minute then come into work late, turned on the TV. Saw it all, 10 minutes later I said I got to get to work.</i>

Table 3.11: Disruptions where readiness was not a factor in discovery

These three examples represent a product quality issue that was discovered by the end customers, a supplier that was deceitful, and the September 11<sup>th</sup> terrorist attacks in the U.S. In each of these situations, readiness was not an important factor in the discovery of the event. In the first example, readiness could not have been found through quality checks, instead, the product, a food product, only displayed signs of the quality issue after a set period of time. In the second example, readiness could not have helped to have a supplier tell the truth about the issues they were having. It was only after continued missed shipments occurred that the firm finally knew that a true disruption was occurring. Finally, it can safely be said that everyone knew about the September 11<sup>th</sup> attacks at the same time, and that readiness could not have sped the discovery of that disruption.

The next table (Table 3.12) shows two quotations where readiness did play an important role in the discovery of disruptions.

<p>[Describing Hurricane Katrina] <i>We called them as soon as we saw because we knew that they had their plants located in that area so we called them but we also saw on the news immediately.</i></p>
<p><i>We knew, we knew when their labor contract was expiring a month before.</i></p>

Table 3.12: Disruptions that were discovered more quickly because of readiness

In the first example, the respondent is describing the proactive steps that the firm took once Hurricane Katrina was known of. They called the suppliers to determine whether or not the firm would be facing a supply disruption. In the second example, due to constant monitoring, a firm was well aware when a specific labor contract was due to expire that later did cause a disruption. Both of these examples show that readiness led to much quicker discovery than having the supplier contact the firm and the labor strike “suddenly” occurring in these two examples respectively.

Therefore, as will be reflected in the model at the end of this section (Figure 3.4), the factor of ‘readiness’ will be shown to always impact and precede the immediate reaction factor, and at times impact the discovery of the event.

In summary, being prepared is considered important to successfully managing disruptions. Many firms have begun to have risk or business continuity plans for some parts of their supply chain. However, very few offer or receive training in disruptions, or rehearse these plans. In some cases the plans can become outdated and irrelevant. One aspect of performance in managing disruptions is the perception of success. From the interviews with the respondents, it does appear that having a plan makes a strong difference in perception of whether a disruption was well managed or not. It may or may not, however, make a performance difference in other aspects, such as financial impact. This aspect will be discussed in the recovery metrics section later.

### ***Discovering a Severe Supply Chain Disruption***

The initial disruption management model identified the disruption discovery process as an important event in shaping the overall response to the situation. During the interview process, it became clear that beyond the timing of the event discovery, it was also important to understand the speed with which the event discovery is communicated to others in the firm as well as the manner in which the discovery took place and was communicated. Indeed, answering the “how” question proved important in the overall post-event management response process. These added factors can be seen in the disruption management model (Figure 3.4).

Discovery can be predictive, within 10 minutes of the event, or perhaps much longer; even weeks after the event began. Table 3.13 shows an example of each of these.



	Time of Discovery
Predictive	<i>We knew. We knew when their labor contract was expiring a month before. (WM)</i>
Near immediately	<i>I think that we only knew we were in a crisis when on the first day, [manager name] will describe that extremely well, I love the way that he describes it, he called the first day and asked how many trucks were shipped and the answer was one. On average we would need to ship like 35-40 something like that, and when the answer was one he freaked out. (OBM)</i>
One week or more after event began	<i>Yeah, it took us a while to figure out what was going on, which is the first scenario, so it probably went on for between 60 and 90 days, but it probably took us the first 30 to figure out that there was actually something going on. (WM)</i>

Table 3.13: Three examples of when disruptions have been discovered

Obviously, the longer it takes a firm to discover a disruption, the more damage is done to the firm before the recovery process begins. Being able to predict disruptions, or discover them in a near-immediate scenario, is what all of the respondents desired. Disruptions can be discovered in many ways. A common method is through customers who call a customer service phone number with a complaint. One firm in the data set conducts a customer feedback survey after each of its products are purchased and discovered a disruption after several responses indicated customers were very unhappy with the quality of the product. Another method, in cases of transportation delays, involves the notification of the firm by a third-party logistics firm. A third method for discovery is an IT system that flags problems with delays or oversize orders.

When examining how the disruption is discovered, ideally, it is automatically or by intentional observation, as described above. However, some of them are discovered adventitiously. One respondent described stopping at home momentarily and watching TV on the morning of the Sept. 11 attacks and knowing that there were going to be problems. Another respondent

described the unfortunate discovery of a disruption by a VP in a completely unrelated area of the firm:

*“...but the one person in our department who knew this was traveling. We learned about it from a VP and it was ugly, so that was a failure on our part for not communicating issues better. Because when he came down here and asked us what was going on, we didn't know anything about it. Well see by the time we learned about it, it had been going on for almost a week. That is when the s\*\*\* hit the fan.”*

The above quotation actually displays all three factors involved in discovery. The primary decision maker discovered the disruption in an adventitious way – through the VP. He only discovered it after it had been going on for a week. However, the reality of the situation was that the disruption had been discovered much earlier, but communication between the person traveling and the people that needed to make decisions about the disruption did not occur.

The lack of communication had made the situation much worse than it needed to be and plays a major role in the disruption management process as a whole, not only in the discovery phase. After the initial decisions are made, those decisions need to be communicated to the response group. After the response group forms and makes decisions, these decisions need to be communicated to those that need to implement the decisions. Finally, after lessons have been learned, these lessons need to be communicated to all who can learn from the disruption recovery process. Communication needs to occur throughout the process and should be considered an important factor.

Disruptions, characterized as well-managed by the interview participants, can be either quickly or slowly discovered. The same occurs for disruptions labeled as providing the opportunity for better management. It was thought that perhaps a correlation existed between a discovery that happened adventitiously and it being classified as OBM or WM. However, this appears to be inconclusive. Adventitious discoveries involve finding out about the disruption through a VP in an unrelated area, happenstance to look at order logs, or more commonly a denial by the guilty party in the supply chain that a disruption is occurring until it cannot be hidden any longer. See the examples in the following two tables.

<u>Adventitious discovery reason for OBM disruptions</u>	
3PL denials	<i>“...to the degree that we knew what was going on and the difficult thing is for people to come and tell you when something is broken as with the scenario on the third party, we found out from other sources not from them. “</i>
Improperly functioning IT	<i>“What we’ve identified is we need the capability to flag orders and if any order that comes in on a unit basis exceeds a certain percent of normal monthly demand we need the capability to flag that, but we don’t have that capability today.”</i>
Inadequate communication due to translation issues	<i>“So communication was difficult at best and it was cryptic. As I said, if it weren’t for one individual [that took] a slew of pictures and that allowed us to better understand what was being conveyed or what was trying to be conveyed. In some cases we just took it upon ourselves [and] had to work in a little bit of a vacuum....”</i>

Table 3.14: Adventitious discovery reasons for OBM disruptions

<u>Adventitious discovery reason for WM disruptions</u>	
Sister-division denials	<i>“It was discovered because we kept trying to get more [product] from our sister division and our sister division [was] saying ‘this is the best we can, you know this is all you can have this week, we’re trying to get more next week’. [We were] trying to get more information there as to what’s going on and then ultimately it started to become apparent that we were losing ground each week.”</i>
Supplier denials	<i>“It took us probably close to 2 weeks to figure out that we were not getting the full answer.”</i>
3PL denials	<i>“Yeah, it took us a while to figure out what was going on, which is the first scenario, so it probably went on for between 60 and 90 days, but it probably took us the first 30 to figure out that there was actually something going on.”</i>

Table 3.15: Adventitious discovery reasons for WM disruptions

All of the adventitious reasons for discovery in WM disruptions, however, seem related to delays and temporary denials by other supply chain members. Therefore, the primary factors to be included in the discovery phase of the disruption management process are when the disruption is discovered and how it is discovered.

***Recovery from Disruptions***

The recovery effort is what determines the impact to the firm from a severe supply chain disruption. The impact has both short-term as well as long-term consequences. Obviously, the objective is to minimize both impacts, with a special emphasis on minimizing the long-term consequences of the disruption. In general, the faster managers react to the disruption, the quicker will be the recovery. After the disruption has been discovered, the response starts. The

initial model (Figure 3.3) proposed that a plan would either be implemented or not, the decision makers would look at the options available, and then the recovery team would make decisions. However, the interviews have revealed several additional factors to be included in the final model (shown later in Figure 3.4).

There are six steps in this recovery process, with two new areas added to the initial model based on the interviews. First, there is an immediate reaction to the discovery of the disruption. The response group then forms and decides whether or not to implement recovery plans available to them. Next, the team discusses the options available and then makes decisions about them. There is an iterative aspect to this process however, as the team frequently has to look at new options after initial decisions have been made and continue to make new decisions before the disruptive event is done.

### **The Initial Reaction to the Disruption**

The term ‘initial reaction’ is used to describe what occurs between the time of the discovery and when the official response group is formed. This dimension was inserted into the model based on the interviews. During that process, we noted that while some firms chose to do “nothing” until the proper group was formed, most firms acted in some way to quickly respond to the disruption.

When the disruption is discovered, the person making the discovery has two primary factors that feed into the initial decision. First, do they understand what the disruption is and why it is

occurring, also known as the root cause. Second, is there a set protocol for that type of disruption? This leads us to display a 2x2 matrix, shown in Table 3.16.

	<u>Root Cause (Known or Unknown)</u>	
<u>Response Action</u> (Preplanned or Reactive)	Known, Preplanned Action	Unknown, Preplanned Action
	Known, Reactive Action	Unknown, Reactive Action

Table 3.16: Matrix of root cause and response action attributes

There are four boxes to describe. In the top-left is the case where the cause of the disruption is known and the reaction has been pre-planned. A good example of this could be a hurricane. There is no mystery as to what is causing the disruption and if a hurricane plan exists, it may start by indicating – “First – board up all windows” or some such action. In the bottom-left box, there is a known cause, but the action is reactive rather than preplanned. Using the same hurricane example, perhaps the firm does not have a hurricane plan. In this case, the initial action is determined by the decision maker. Their first reaction may also be to board up the windows, but they may think of many other possible first actions instead.

The top-right box is where the cause is unknown but the action is preplanned. An example of this could be a consumer complaining about a certain food product. While the cause of the complaint may not be known (is there a quality issue, health hazard, packaging issue, etc.), the preplanned answer might be to lock down all product within a given date range. The bottom-right box is where both the cause is unknown as well as the action is a reaction rather than preplanned. In the above situation, perhaps there is an unknown cause to a food problem, and no preplanned action for the person discovering the issue to implement.

Examples from the interviews of all four of these can be found in Table 3.17.

<u>Action \ Cause</u>	<u>Known</u>	<u>Unknown</u>
<u>Preplanned</u>	Firm A was monitoring the strike situation of a supplier and when the firm went on strike, the prepared plan was immediately put into action.	Firm B received a call about a product defect. While the cause of the defect was not yet known, the action was to recall all products with the defect.
<u>Reactive</u>	Firm C experienced a flood that destroyed a key piece of transportation infrastructure. The cause was easy to identify, but there did not exist a plan on how to handle it.	Firm D experienced a complete failure of their shipping process during a 3PL transition. The exact cause of the failure was unknown and there was “ <i>zero type of contingency plan in place to deal with that type of crisis.</i> ”

Table 3.17: Four examples for each action / cause pair

Within the concept of the reaction are two additional factors that help determine the action that is chosen. First is the perception of the importance or severity of the disruption. The second is the level of the person that ultimately makes the initial decision.

***Perceiving the Disruption Severity: Operational and Behavioral Aspects***

As one respondent put it perfectly when we began the interview, “*I guess you know my thing is when you look at a disruption you have to look at a definition of what you mean by disruption.*”

This quotation represents the importance of clearly defining what is meant by a disruption. As was mentioned earlier, this research narrowed the focus from a generally defined disruption to a “severe” supply chain disruption. This was meant to help respondents focus in on significant

events that they would be able to discuss as well as help there to be continuity between the responses. Nevertheless, the definitions were unique to each respondent.

A brief review of published academic definitions is first in order. At its basic level, a disruption was “unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain” (Craighead et al., 2007). In Gaonkar and Viswanadham (2007), an attempt at defining disruptions in levels of severity resulted in a deviation (when a parameter such as cost or demand strays from an expected mean value), a disruption (“the structure of the supply chain system is radically transformed...”), and a disaster (“a temporary irrecoverable shutdown of the supply chain network...”). None of these definitions fully incorporate the additional components that make up a severe disruption in the eyes of a supply chain manager as listed in the next paragraphs.

The question in our interviews was stated simply as “How would you define a severe supply chain disruption?” The answers can be broken down into definitions driven by subjective operational factors, and those driven by objective behavioral factors. We will start with the operational factors. Several quotations with factors oriented toward an operational perspective are given in Table 3.18.



<u>Topic Orientation</u>	<u>Operational Quotations from Respondents</u>
Cost	<p><i>“When I’m saying severe as a division we’re over [quantity withheld] in sales so if you’re going to affect 5% of your sales because of a supply chain issue that’s severe.”</i></p>
Multiple Echelons Affected (Supplier or Customer)	<p><i>“In our business it would probably be the shut down of a distribution center. Pharmaceuticals would have fewer distribution centers because of the value of the product, so in many companies, our own until recently, one DC pretty much handled 100% of the US so a disruption to that one DC shuts the business down completely.”</i></p> <p><i>“So when I thought about this a little bit the other day I characterized severe disruptions or catastrophic, quality is always our biggest concern, protecting the trade mark, protecting the public. Then beyond that many of our solutions become, it’s just a matter of how many dollars does it take to solve.”</i></p> <p><i>“The one-off storm in the ocean you get a boat delayed or something I think you cover those fundamentally with your safety stocks and work in progress in your supply chains. The big disruptions are these month long ordeals where you really are having trouble on a specific lane of shipment.”</i></p>

Table 3.18: Operational quotations from respondents

Cost and the number of echelons affected by the disruption were two operational factors that were brought out in the definitions. The cost, however, was not in a definite number but rather was stated in terms of a percentage of sales. The echelons that were brought out were either focused on supply issues or how the disruption would ultimately affect the customers. The key point is that multiple echelons were affected, not just the focal firm.

<u>Topic Orientation</u>	<u>Behavioral Quotations from Respondents</u>
Reaction	<p><i>“You have to stop everything you’re doing to address it”</i></p> <p><i>“I mean, granted, everything is rush, everything is in a hurry. If we’re late by a couple of days you would think that the earth was going to cease to rotate on it’s axis”</i></p>
Expectation	<p><i>“So I really do think it’s built around sort of the standard deviation. And so severe interruptions that put you one or two, more than one or two standard deviations outside of the norm, probably more than one standard deviation is something that is worth mentioning.”</i></p>
Perspective	<p><i>“I once was talking to a guy I knew from [a previous employer] and he said “Well, we had the I-10 bridge went out.” Well, find another route, man. That’s not a disruption. That’s like a hindrance.”</i></p>

Table 3.19: Behavioral quotations from respondents

The next table (Table 3.19) displays three behavioral factors that were brought out during the interviews. The first is *reaction*. This simply means that a signature aspect of the disruption being severe is how the respondent either did or was ‘forced’ to react. The response is strong and immediate if the event is, indeed, a supply chain disruption. The second behavioral aspect focuses on a deviation from the standard as the key to defining a severe supply chain disruption. As one respondent mentioned, a shipment being one day late in the U.S. would qualify as a severe disruption, while in their South Africa division, 30 days late would qualify as severe, simply based on expectation. Finally, the third aspect is simply named *perspective*. Two managers can look at the exact same disruptive situation and have very different reactions. One may call it a severe disruption, while the other called it a “hindrance”.

The perceived level of severity of the disruption to the firm is strongly linked to both the speed of the reaction and the type of decision that is made. Consider the following quotation:

*“But if I said what differentiates maybe the best situations from the worst, one is I would say would be timeliness in reacting to the issue. It’s extremely important that crisis has been identified or a high risk event, I can think of examples where we moved, saw indicators, we didn’t think it was that severe and waited for 8 hours or 12 hours longer before we really moved into what I would call crisis mode...”*

In this example, the disruption was discovered, but not urgently acted upon because it was perceived as not being as severe as it truly was. Therefore, the operational and behavioral aspects of defining a severe supply chain definition need to be considered as important to guiding the initial reaction of the decision maker.

### ***Authority Level of Initial Decision Maker***

The level of the initial decision maker is also vital to the decision that gets made. The person who discovers the disruption may be a lower-level manager without much experience or authority. This type of manager may just escalate the response process to higher-echelon management by documenting the discovery. Alternatively, if upper-level managers discover the disruption, they are able to implement a product hold or other action much easier and more quickly than could a lower-level manager. In some cases, the initial action may be to simply form the response group if the root cause and appropriate first reaction is not known to the discoverer.

These two factors, the perceived importance and the authority level, are primarily involved only when no preplanned action exists. If there is a preplanned action, the level of the discoverer doesn't play as vital a role because anyone may be empowered to sound the alarm. Similarly, in a preplanned setting, the specific severity level attached to the disruption may either be ignored or postponed. For example, all valid customer complaints can initiate a reaction to stop sales of a given product until the true scope is determined. The subsequent determination of scope and cause may reveal a legitimate disruption or one in which the sales ban can be lifted.

### **Those Who Respond: the Response Team**

Response teams have several attributes that impact the decisions they make. They can be made up of just one decision maker or multiple decision makers. The decision makers in the team can have no training or lots of training, and also can have a wide range of experience levels. These were the factors initially included in the disruption management model. Of all the categories in the model, however, this one had the most added factors that were revealed as a result of the interviews and data analysis. These additional factors were the characteristics of the leader, the functional makeup of the team members, the authority makeup, the number of members of the team, the team and decision maker risk tolerance, and the stability of the group during the recovery process. It should also be noted that not every factor was observed as an issue or even documented in every interview.

### ***Leadership Characteristics in Decision Makers***

During one of the interviews, we were struck by the strong differences in answers and attitudes that the respondent was providing. One of the researchers asked the respondent to describe themselves as a leader and decision maker. After a few moments of thought, he said:

*“I am a consensus based individual...I don't pretend to know all the answers and I appreciate, I like to throw in a concept and I appreciate anybody's input to make that concept better or to tell me constructively why it won't work. It's very easy to sway me if you've introduced an argument that makes my kind of recommendation wrong... You can change my mind on things with the proper facts and data but I've been pretty successful at leading a powerful team with that open mindedness. We're all in this together... I always talk about the improvements that my team has made, thinking within our organization we've built up. If you were sitting in a room with a bunch of my associates you couldn't tell who works for whom because we approach it as a team.”*

This particular respondent also mentioned such ideas as how relationship oriented he was and how he does not perform any kind of risk management at all right now given the current firm needs. This much contrasted interview led us to ask this question of all past and future interviews. The very next interview provided the complete opposite of the spectrum. When asked the same question, the respondent answered without hesitation:

*“I aggressively search for opportunities within my organization. I am a relentless communicator of our strategy and direction, some folks would even say I was one of the best communicators within our organization, within the businesses, and within the functions. I really try to...foster collaboration and within the global logistics*

*organization one of the things that I have found is very powerful is that power of diversity and really leveraging the diversity of our global team, people from Asia, people from Europe as well as in the Americas. I am a firm believer that perpetual optimism is a force multiplier.”*

The titles of these two respondents are Director of Global Transportation Logistics and Warehousing and Executive Director for Global Logistics, respectively. Both firms represented are above \$2 billion in revenue.

The point of including these two quotations here is to directly display the very different behavior, perceptions, and characteristics that those responsible for recovering from supply chain disruptions can have. For example, one type is a warm, confident individual who is humble and open to learning. This type of individual leads, but does not appear to be overbearing. The other type is a decisive leader who almost wills his team in a specific direction. The first type does very little planning (according to the needs of the organization), while the latter is very involved in planning. These differences are why it is vital to not only understand supply chain disruptions from an operations point of view, but also a behavioral point of view.

One additional character trait that was quite stark in its implications is best described as strength of character. When a disruption occurs, will the decision maker continue to operate in the difficult situation? Consider the following two quotations. The first involves a situation in which the leader did not display any character strength during a disruption recovery, while the second involves a leader who displayed considerable character even in challenging situations.

*“I’m not sure that they didn’t deserve it [being fired], you know in some sense but at the same time it really wasn’t helping solve the issue. In some cases I think some of those people even gave up and I think that’s part of the reason that they were gone, the fight was out of them.”*

*“I have an example, when I worked for [a firm] in Brazil... and all of a sudden my supplier went bankrupt in Brazil and I had all of the molds [there], they were my molds but they were in the supplier’s facility and they went bankrupt. Before they went bankrupt all of the employees they were together, downtown protesting at the main office of the firm; they knew the situation was not good. As soon as I heard that, I took a flight from Rio to the South of Brazil, I got to the airport, I called a security firm, I got like 3 guards, one truck and another three men to help me. I went to the factory and I, hate to say it but I broke into the factory and removed my 10 molds that I had there, and they were mine, I could prove they were all mine, they all had like the tags and everything. But the fact is I had a radio with me the whole time and I had one person monitoring the employees downtown and 20 minutes before I was removing the last mold I got the message “Hey they are going there, somebody told the Police that you are there and they are going there after you, get out of there.” .... I got an award from the CEO in Brazil, I got financial rewards, all of those things but then the CEO called me the same day and said ‘Look, I gave you this award, I gave you this money but you’re never going to do this again, okay?’ I said okay, but I’m very happy about that. But it was an incident that actually went right but could have ended really wrong.”*

In summary, there are character traits that very clearly make a difference in their ability to lead, especially during severe disruptions.

### ***Training Decision Makers on Disruption Recovery***

The topic of disruption training was mentioned earlier in the readiness section. While the difference between a team that has had specific training and one that has not conceptually is valid, the reality is that of the firms that were interviewed, none really engage in formal classroom-type training. Instead, most prefer on-the-job training, which is better termed experience.

### ***Supply Chain Experience of Decision Makers***

Experience refers to the number of years that the primary decision makers have in the related areas of supply chain management. The assumption is simply that more experience would likely correspond to more disruption and severe disruption experiences. In a brief review of Table 3.1, shown earlier in the Methods section, we see that the average number of years of experience is 21, with the least being 2 years and the most being 40 years worth of experience.

As a brief example of the role that experience plays in forming the response team, consider the emphasis one decision maker puts on finding the right people:

*“But we’ve outlined what are critical skills that you usually [need] for [a] crisis, and we quickly, we being myself and two of my managers, go through and evaluate, okay what help do we need?”*



### ***Number of Decision Makers in Response Team***

The number of decision makers can make a substantial difference in the functioning of the team, especially when combined with the style of leading the team. There are four ways that teams can be led, as shown in the boxes in

Table 3.20.

	<u>Style of Decision Makers</u>	
<u>Number of Decision Makers</u>	Single, hierarchical	Single, consensus
	Multiple, hierarchical	Multiple, consensus

Table 3.20: Matrix of # of decision makers and the decision making style

Hierarchical in our frame of reference refers to a more directive type of decision communication based more on who the leader is and less on the team as a whole. Consensus, on the other hand, refers to the attempt to allow multiple viewpoints and voting ‘rights’ for all team members, although the final decision usually rests with the team leader or leaders.

Several respondents mentioned that having too many people making “final” decisions can get challenging. There can be confusion as to instructions if teams are not unified behind one leader. However, few examples of these were given. Instead, nearly all the respondents described themselves as consensus based in their leadership of response teams. The respondents did not feel that consensus based decisions were faster or more efficient. Instead, it was a method used to obtain unity and buy-in from the team members on decisions. After discussing a team’s dynamics and the length of time to come to a decision, one respondent said:

*“So you can read into that that we’re thorough, or you can read into it that we’re slow at times.”*

Several respondents noted that their style of leadership could change based on the dynamics of the team. For example:

*“[I am] generally consensus but in a time of, it depends on your team, I think if I see a team that’s sitting there in shock it’s not consensus anymore it’s here’s what your going to do and do it, start doing it. If you see a team that’s really getting it and they understand it and listening to it, alright what do you think is the best way, you know they are working towards it and you can see they are getting it, I think consensus. Number one builds a better decision but number 2 builds some ownership and makes them work on their powers too... Yeah, there are times we you’ve just got to say bull\*\*\*\*, we’re not doing that. This is what you’re doing.”*

In summary, the number and style of the decision maker(s) can influence the speed of the decisions made and the clarity of the group direction (and hence speed of implementation).

### ***Function Representation of Response Team Participants***

The functional representation refers to the job scopes and firm participants represented on a team. Within a firm, there can be transportation, purchasing, manufacturing, and other departments represented. Additionally, there can be representatives of the customer, supplier, transportation, and third-party logistics provider on a given team.

This cross-enterprise concept was exemplified in several firms. The quotation below gives one of these examples.

*We've outlined what are critical skills that you usually for a crisis, and we quickly, we being myself and two of my managers go through and evaluate, okay what help do we need? Do we need help from purchasing? We have...a check sheet that we go through what are potential critical needs. Logistics is on there, supplier quality, supplier, they have them. We've literally had [our supplier] over here working right in the room with us. But we ask the question, do we need the supplier? Do we need representatives of the transportation firm? We have a logistics group that is supported by [3PL] and [3PL]. Today I have [their] people; they are right side by side with us because the timely communication is absolutely critical. Any of our air charter activities managed by [firm]. Any time I think I need to fly something all I've got to do is really [tell them].*

Generally, the idea of having more functions involved is considered to be good. However, sometimes too many internal representatives can create challenges. In Table 3.21, one example is provided in support of each of those two viewpoints.

<u>Cross-Enterprise is Positive</u>	<u>Too Many Functions Poses Challenges</u>
<p><i>“Interviewer: Is the team cross enterprise?”</i></p> <p><i>Respondent: Yes, and let me give you some information before the best way to avoid a disruption or to mitigate or manage a disruption is you getting all the members of the chain involved early on in the process. And by the members of the chain you are having suppliers, forwarders, the carriers, the clients.”</i></p>	<p><i>“I think the severity of the issue hurts the decision making process. The more severe the worse the decisions. Yes, because the more people [functions] get involved who don’t know what they’re doing. They’re not close enough to how things work. Where it helps is the added a sense of urgency and a sense that you know we’ll get you any resource you want, but then they also tend sometimes to get involved in decisions that they shouldn’t be involved in because they don’t understand the complexity and the repercussions at sort of the ground level. What ends up happening is my boss or the President will be asking me all kinds of questions that I find to be irrelevant and then I have to then go to the people who are working on solving the problem to get them to answer questions that aren’t going to help us solve the problem, they are just going to help us understand some of the impact of the problem. To me all resources should be on solving a problem and mitigating the impact, not keeping score. You know the score is going to be the score, people who could be players are now up in the press booth keeping score and so it is a bit of a sort of an organizational drain.”</i></p>

Table 3.21: Examples of functional representation on response teams

Finally, the challenge of having multiple function is not limited to the distractions and lack of knowledge by some. It can also include the task of getting all of the decision makers aligned on the same idea.

*“...on this [disruption] it was manufacturing taking the bullets and quality group pointing the finger...Where I guess my critique would be that there was no alignment at senior levels so decisions were being made, despite being very vocal about it, it was still made and I think it should have been handled better than what it was.”*

In summary, the functions, both within the firm and cross-enterprise, represented on the team can have an impact on the decisions made and the effectiveness of the response. It should be noted that not every disruption would need the same type of team composition. That refers back to the earlier example of the respondent with the checklist. A supplier disruption may warrant a supplier representative being on the team. However, a transportation issue between the firm and the customer probably wouldn't.

### ***Authority Representation of Response Team Participants***

Another important aspect is whether or not the decision maker on the team actually has been empowered to make all the decisions that are necessary. Additionally if the proper authority has been given, the upper level managers must be willing to allow the decision maker to make the decisions. Most of the time, the final authority does lie with the leader of the response team. Sometimes, however, it does not.

Several respondents expressed frustration or techniques to deal with not having the right decision makers involved with the team. Many times the ultimate decision maker actually doesn't participate in the team. Instead, the team 'leader' will make the decision and then is forced to run it by a higher authority. Considering the level of manager that was interviewed for this research, this was very surprising. The following four quotations present various attitudes toward the proper authority and their involvement or responsibility.

<u>Quotations About Final Authorities During Decision Making</u>	
Decision makers not part of response team	<i>I don't think so; we really try to communicate all of that kind of stuff up the ladder, because I frankly have been stunned at how hands on some of the VP's are.</i>
Decision makers not wanting to hold responsibility	<i>Correct, I've been doing this a long time, I know how to shift the responsibility to the guy who really needs to have the responsibility of decision.</i>
Escalation process to higher decision makers	<i>How far it needs to be escalated and who is involved in the decision. We have an escalation process with regards to expedited [freight] which says for example if it's going to cost an additional \$500 this is the level of approval. If it's going to cost this much, at a certain point it gets to the Executives because there is a value.</i>

Table 3.22: Quotations regarding final authorities during decision making

The impact of the team leader also holding the final authority is simple; the decisions can be made and implemented much faster. All of the above quotations came from general discussions with the respondents and not during the time that they were talking about WM or OBM disruptions.

***Quantity of Response Team Participants***

Related very much to the previous two factors, the actual number of response team members has an optimal number. Too few and you may not have the experience or functions necessary represented; too large and there may be gridlock on the team.

There was one respondent that had a particularly vivid example that dealt specifically with the number of team participants rather than the other two broader issues. In this example, there was a product recall due to some product quality issues.

*“I think one of the problems with the [product] issue we had, you start getting too many people involved, everyone wants to jump in and I think that’s another thing we’ve learned is that too many people try to get involved in an issue because they feel like they have to help and they need to help. I think that’s been a big lesson learned from these situations is that we get too many cooks in kitchen... Yeah I think the other thing is again getting too many people involved, you know from some of the other issues. There were times with that [product] thing we would probably have 40 people on the phone, it’s just an unmanageable number of people. A lot of people were just listening in. We would set up different...call-in numbers because the number had gotten out so many times, people just ... knew the meeting was at a certain time during the day and people were just calling in and want to hear, want to know. We started having meetings on different, we had these 800 numbers with codes, we’d have meetings where we would give very limited access to what that code was and we would vary the times because we didn’t want other people finding out about the meetings. Because it wasn’t that we wanted to be secret about it, it’s just that we did not need to have a large group involved in this thing. We had something specific to talk about, we had a decision to make and it’s like we don’t need a cast of thousands involved in the decision. Get the right people in the meeting, get the decision made and move on. You can report back to the larger group, so I think a lot of the lessons learned from early on is that too many people were trying to [participate].”*

The issue was that too many people were trying to a part of the decision making process, and this respondent found that to be unhelpful and time consuming.

### ***Risk Orientation of Decision Makers***

The concept of risk tolerance appeared in one interview as a side comment. It was the end of the interview and we were wrapping up by reflecting on the number and types of disruptions the firm had experienced. The respondent then mentioned that the firm appeared to be rather risk seeking.

*“You know I guess we must not be risk averse considering...where we’re doing business. I mean for example Bangladesh is huge for us, Lord knows they have natural disasters all the time, and Egypt where people are on strike or Nicaragua where they are thinking of a truck strike right now. ...we obviously think we can manage through those things because somebody’s made the decision that’s where we’re going to be and it’s worth the risk.”*

After this interview, the question of whether the firm and the respondent would consider themselves to be risk seeking, neutral, or averse, became important. While this question was not tied specifically to WM or OBM disruptions, the answers are interesting. Of the respondents, only one felt that the firm was more aggressive than themselves; risk seeking for the firm and risk neutral for the respondent. Of the remaining respondents, one felt that both themselves and their firm were on the same level – both risk seekers. All of the other respondents felt that they



were more aggressive than their firms. In some situations this was with the firm being averse and the respondent neutral, and in others the firm was neutral and the respondent seeking.

Interestingly, the one that felt that they were less aggressive than the firm was the single female respondent in the interview group. Perhaps related was the fact that she also had the least amount of experience related to supply chain management. Of the rest of the respondents, we offer one of the viewpoints from a respondent with many years of experience. He considered his firm to be risk averse in all situations. For himself, he mentioned that normally he would be risk seeking, but in times of severe disruptions or crisis he becomes risk neutral. In his opinion, the firm has already somehow been compromised and that is not a time to take additional risks.

The impact of the risk orientation of the firm is not yet fully known. One can imagine that risk seeking firms and individuals may open themselves more often to disruptions occurring in the first place. Additionally, once the disruption has happened, a risk seeking decision maker may take chances in the recovery response in hopes that the situation would resolve more quickly. On the other hand, they may lead to a re-aggravation of the supply chain.

### ***Stability and Cohesiveness of Response Group***

The usual desire in forming a response group is that this group will both see the disruption through to the end and work well together during the process. However, in some cases severe disruptions, long recovery efforts, or both, can conspire to affect the stability of the group during the recovery efforts as well as their cohesiveness.

Some disruptions leave the appropriate members of the response team unable to participate. In their white paper, P&G described the affect that Hurricane Katrina had on some of their leadership as being emotionally traumatized. The priority of the leaders was to protect and help their families and P&G had to include other team members from around the country (Harrison et al. 2006). Another respondent described the possible physical loss of response team members who were considered 'lost' for a period of time after the September 11<sup>th</sup> terrorist attacks. It took some time before a full headcount was able to be made to confirm that, in their situation, no one had been lost.

In one situation regarding the membership stability, the respondent described a disruption which was especially severe in the impact it was having on the firm's ability to ship products to their customers. In the end, it would take several months of effort to restore the distribution center to the ability to ship the daily orders on time. However, in that time frame, several of the original decision makers were fired for their role in both causing the disruption through mismanagement of a project as well as being unable to adequately aid in the recovery effort. The following two quotations provide the rest of the information.

*"I think what happened was, internally supply chain had absolutely no credibility. We would have meetings and we were just getting the hell beaten out of us, and it was more like running a gauntlet...they beat on those managers and those people who were let go unmercifully. I'm not sure that they didn't deserve it, you know in some sense but at the same time it really wasn't helping solve the issue. In some cases I think some of those*

*people even gave up and I think that's part of the reason that they were gone, the fight was out of them."*

*"So at the end of the day what happened is everybody that was involved in the project was fired, that's when I came in 6 months later, but basically it was a disaster. In December the VP of Value Chain for North America he moved to another job to be let go a few months later. The Director of Logistics and Planning was fired in August, July/August, and the Director of Planning was also fired sometime in September/October. That sounds like everybody that was somehow involved was let go."*

Instability in a response group can cause challenges to the recovery effort. First, there can be confusion over the leadership if one person is suspected to be leaving soon or is recently fired and the next leader not yet appointed. Second, the decisions that had been made are called back into question as to their viability. Third, it can delay decisions and communication as team members leave and new ones come in. The bottom line is that instability can hamper and delay the recovery effort.

Lack of cohesiveness in the group can also cause challenges to the recovery effort. Something that can occur at the formation of the group, but also at any time during the recovery process is the unproductive activity of pinning the blame for a disruption or its effects on one another. Not all respondents discussed the issue of finger pointing, but those that did felt very strongly about the effect it has on the formation of the group and the recovery effort. Table 3.23 is an example of two respondents discussing the situation of finger pointing.

*“At that moment of crisis the worst you can do is blame somebody because if you give the impression that, ‘Okay, John it was you’re fault, I probably am going to fire you but meanwhile solve it’. [The you say] ‘Well okay what’s in it for me? I’m going to lose my job anyway’. If you get the feeling that we’re in this together and we’re going to solve it together and then we’re going to talk about it and maybe it’s your fault and we’ll have to deal with it. But you know you’ll be given a fair chance to explain your performance or explain the situation and you’re going to be getting some points on how well you react I think you are more motivated to try to solve it and you’re more motivated to say okay let’s work this one out and then we’ll take it from there... You don’t gain anything by blaming people. What is done is done...I can tell you if you get into the blame game you’re not going to get it fixed.”*

*“Well it should, in my opinion bring out the best in our leaders to be able to say, you know okay stop, we just want the root cause I don’t need any of the BS that surrounds it with opinions and conjecture and finger pointing. We’ll get to performance management when it becomes an issue afterwards. And the transportation issue which was really severe where the COO was involved, I felt like not necessarily that it was him leading that problem solving and making people feel comfortable that we could focus on the problem and not lose our jobs the next day.”*

Table 3.23: Two examples of the negative effects of blame in response groups

Highlighted in these two examples are the feelings that people have of being let go the next day.

This in turn affects motivation and willingness to help fight the effects of the disruption.

Additionally, the issue of blaming is looking backward at what did happen, not looking forward

to helping to solve the problem at hand. This slows down the meetings, decision making, and

probably implementation of the decisions that are made.

### ***Section Summary***

There are many factors that have been discussed in this section about the response team. All of

these serve to have an influence in the disruption management process. Among the factors,

several deal with the size and makeup of the group, the experience of the members, the

characteristics and risk orientation of the decision makers, and the stability and cohesiveness of the group during the process of recovery. Table 3.24 recounts these factors.

<u>Factor</u>	<u>Aspects Discussed</u>
Leadership Characteristics	Character traits, strength of character impact types of decisions made
Experience of Decision Maker / Team	Experience is needed for effective decision making
Number of Decision Makers	Too many can confuse the decision making process, delay decisions and implementation
Number of Team Members	Too few can lead to not enough understanding of issue, too many can delay decision making
Training of Decision Maker	Not an important issue since most of training is on-the-job rather than formalized
Functional Representation	Need for appropriate functions, whether within the firm or cross enterprise, to be involved on the response team to aid in decision making
Authority Representation	Need for authority on the team for quick decisions and implementation
Risk Orientation of Decision Maker	Risk seekers may take unnecessary chances when the firm is trying to recover
Group Stability and Cohesiveness	Delay in decisions, lack of motivation when being blamed for issues

Table 3.24: Factors involved with the response group

The next factor in the recovery section is one of the first decisions that the recovery team will have to make; if a plan exists, should it be implemented?

## **Implementing the Recovery Plan**

Recovery plans are developed for two primary reasons that have been given thus far in this research. The first is to layout the groundwork for the process of recovering from a severe disruption that can impact the firm. The goal is to make recovering occur faster and with less confusion. The second is to practice the process of developing a recovery strategy. This reason

recognizes that it is difficult to predict disruptions accurately and continuously update and keep the plan current. It also prioritizes the training and practice with thinking through a recovery than emphasizing the actual details of a planned recovery.

Part of the decision in whether to implement a plan or not may be a result of whether the root cause of the disruption has been determined. Not knowing the cause of a disruption leads toward uncertainty in selecting a plan to implement. Once the root cause of the disruption is known, the response group may revisit whether or not to implement a plan.

Interestingly, only nine of the disruptions described in the interviews used a plan in some way. Recall that Table 3.7 from the section on Readiness showed that only 4 out of the 17 firms discussed not having any plans in place. Table 3.25 below now displays how many disruption recovery efforts used no plan at all or a partial- to full-plan implementation out of the 34 disruptions discussed during the interviews (both WM and OBM). A plan partially implemented means that perhaps aspects of a plan applied to the specific severe disruption we were discussing, but not all of the aspects.

Number of Disruptions where Plan was: (out of 34)	
<u>Fully or Partially Implemented</u>	<u>No Plan Implemented</u>
5 (WM),4 (OBM)	12(WM), 13 (OBM)

Table 3.25: The use of plans in disruption recovery

Not surprisingly, the table shows that most disruptions were dealt with primarily on experience and reactions, and not with a full or even partially applicable plan. An example of a fully implemented plan is perhaps a plan for dealing with the recall of a product due to quality issues.

A partially implemented plan can be one that instructs who within the firm should be contacted to form a recovery group and an initial reaction, but not the additional steps that need to be taken. It should be added that in many cases, there is not a full plan. The full plans exist for only the most frequent possibilities of disruptions such as Hurricanes and product recalls.

## **Understanding the Available Recovery Options**

*“Protect the brand or go with alternative bottles?”*

*“Change the formulation?”*

While making decisions may be the most important task that a response team has, it is vital to know what decisions are possible to make. The above two quotations are just two examples given by the respondents of the options they feel that they have when trying to recover from disruptions.

Three factors related to the idea of ‘Options’ are important to disruption management. The first is knowledge of what the range of choices are for a disruption recovery. The second is an understanding of the financial cost of each of those options. The third is the time it would take to implement a given option, whether it is a short-term recovery option, long-term recovery option, or long-term strategic option.

These three factors had been identified after several interviews, but one specific respondent firm toward the end of the process had experienced a disruption the same week that we were scheduled to interview them. A railroad bridge had washed away in some flooding the weekend prior, offering an excellent opportunity to confirm the process that was suspected. After the

team had been assembled, they brainstormed possibilities of actions that could be taken. The two primary questions that were being asked were simply “How much does it cost” and “How long will it take”. Each of these will now be briefly discussed.

***Specific Options Available***

After the response group has formed and decided whether or not a plan is available to be / will be implemented, the group works toward discovering what options it has in dealing with the disruption. More than just brainstorming an idea, this step also includes gathering any necessary data that will later be used to make the actual decisions. Sometimes this can be difficult as we had respondents mention not having full knowledge of the options and data before needing to make decisions.

Some of the more common options that were given during the interviews are shown in Table 3.26. One of the most frequently cited options available is simply to switch or upgrade the modes that are used for transportation. This is a favorite option because in many situations, the product is available, but in a location many thousands of miles away that usually ships by boat. Bringing goods in by air or expedited truck is a relatively simple and quick way to recover from any loss or delay of product. In comparison to many other options, it may also be relatively inexpensive.

Alternate mode	Alternate supplier	Hand inspections
Formulation change	Alternate packaging	Re-route shipments
Alternate port of entry	Recall all product	Stop production
Move facilities	Outsource shipping, production, etc.	Alternate product replacement
	Prioritize customers with inventory	

Table 3.26: Examples of options used for disruption recovery



It was mentioned earlier that many of the firms have outsourced their production to a very large degree. This leaves some decision makers feeling as if they have very few choices when disruptions occur. They can lean on their outsourced third-party logistics provider to fix the issue, or they can lean on their outsourced manufacturer to hurry up and get the product to them, but, in the short term, there may be little else that can be done. One respondent was asked about the strategic options that they felt they could put in place to help with the disruptions.

*Interviewer: So, one would be more or less volume for a carrier. Are there any other strategic options you feel like you actually have when disruptions occur?*

*Respondent: No, I don't really feel like I have any other.*

Knowing all of the options is obviously critical to making correct decisions. In addition to brainstorming with team members, some respondents described more unique ways of discovering some options available to them. One mentioned discovering an option while flipping through T.V. channels at home. Another was talking to a friend at a football tailgate party and was given a mode alternative that had never been known about previously. Others recalled unique options but couldn't remember how they actually discovered them.

Many options can also be very specific to the disruption. For example, in the earlier railroad bridge example, some of the options being considered were whether to buy land across the river, build a temporary intermodal terminal, and truck the product across the river to the terminal. Another option was to use a competing railroad's bridge 15 miles away. Both of these choices entailed knowing that the land was available for the terminal and knowing that there were

interconnecting railroad tracks that would allow them to use the alternate bridge. Getting information in a correct and timely manner is critical to making informed decisions.

### ***Financial Costs of Recovery Options***

An aspect of that correct information is what the financial costs are for a given option. This is easier to calculate for some options than for others. For example, an agent can produce accurate costs to ship a product via airfreight instead of ocean freight. On the other hand, one firm interviewed described a product recall situation on a scale and scope that had never been attempted before. Due to possible health risks, the product needed to be collected from all over the world, and it was completely unknown how much that would cost.

### ***Implementation Time of Recovery Options***

Finally, the time needed to implement an option is an important piece of information needed also. Generally, the shorter the time needed the better. During one discussion of alternate suppliers, a respondent said that they needed 3-4 months to bring another supplier online. In contrast, using an alternate mode may only take days. These two examples would probably also be complementary options rather than competing options. Knowing that one takes longer than the other, a decision maker may elect to do one in the short term and one in the long term.

In conclusion, the important factors of the available options, their costs, and their time to implementation help decision making teams to know what decisions they can make.

## **Making the Recovery Decisions**

The final factor in the recovery response step is that of making the decision. The team was formed, the options were developed, and now the decision needs to be made. This is one of the most critical components of the disruption management process and leads most directly to the performance and effectiveness of the recovery efforts.

In the initial pre-interview model, the characteristics of the team were placed in such a manner as to emphasize the importance of these characteristics on the decisions that were made. While this is true, it was recognized that these team characteristics have an effect on the entire recovery process, which includes possibly implementing a plan, and discovering options. Hence it was discussed before these other factors.

The choices that are made, the considerations pertinent in the minds of the decision makers, and whether the choices are made individually or through consensus all are critical. The greatest black box of the decision making process is the considerations that are pertinent in the minds of decision makers. Several examples of this will be given to begin to understand this better. This section will also reiterate and / or reemphasize some of the earlier factors that play into the decisions being made.

### ***The Choices Made***

Most of the options that were given in the previous section have been chosen at one time or another as a formal recovery decision. In most recovery efforts, there are multiple decisions that are made that work together to help the firm fully recover.

Choosing an alternate mode, usually one that would expedite the shipment in some way, was the one of the most common methods of trying to recover from a disruption. Many also mentioned prioritizing their customers in some way with the inventory that was remaining. Some common traits between these two options are that they are relatively quick to implement, relatively inexpensive (compared to other options), and lend themselves to most types of disruptions.

### ***Important Factors in Decision Making***

There are many factors that are involved in the mind of the decision maker when the decision needs to be made. Some of these include the aforementioned cost and time of the option, but also involved are the way that an option will affect the reputation of the firm, the cause of the disruption, the severity of the disruption (and how quickly the decision needs to be made), the effect on the shareholders, risk orientation, and many more. Several of these will be exemplified in the paragraphs and quotations that follow.

Over- or under-reacting is one of the challenges that has been cited in previous research (Massey and Wu 2005). Evidence of overreacting and making uninformed decisions was evident also in the answers from the respondents. Two examples are:

*“We had situations early on where we have a problem - next thing you lock up a zillion square feet [of product] because there is a quality issue and then when you get into it, you know something, this is [limited to] just one batch. What are you doing, locking up the whole inventory for that?”*

*“...but with the information I saw and my experience they asked for a full inspection of half a million cases when they had such small representatives of defects and it was causing major issues with customers and cost”*

In this example, the firm discovered a quality issue in their product and proceeded to halt all sales and purchases of the product until the core issue could be found out and dealt with. There were three disruptions which specifically mentioned an overreaction on the part of a decision maker. The commonality between them is that, though different types of products, they dealt with a quality issue. Additionally, of the three two were mentioned as OBM disruptions, while the third was a description of a severe disruption outside of the ‘official’ WM and OBM disruption.

Some decisions are made without adequate information. This can be due to the criticality of a quick decision, lack of information, or misinformation that is given. As one respondent put it simply, *“I’d like to tell you that the rest of the decisions are made on an educated basis but we do make some decisions in a vacuum.”* Similar to overreacting, three firms specifically mentioned not having enough initial information by the time decisions had to be made, and all three disruptions were quality related. This is not to say that other respondents felt that they had all the knowledge that they needed or desired in order to make effective decisions. However, at first glance, there did not appear to be either the necessity to make a decision without the information or that the ramifications may have been less on a faulty decision.

For some decision makers, other factors played a minor or non-existent role, the only thought was how to help others impacted by the same disruption. One example of this was during one disaster that was affecting many firms in the U.S.A. at the same time, one of the primary decision makers had this sentiment about the impact of the disaster on their firm and products:

*“How you got them there, what the impact on sales was, on cost, didn’t matter. For a moment in time nothing mattered except we felt like we had products that could save lives, we’ve got to find a way to get them to people who needed them. Like, it was this feeling that you don’t get everyday when you’re in the supply chain wars that take place everyday. And everyday we’re battling with customers, suppliers, issues internal, political battles. For that time period nothing else mattered except getting what needed to be transported.”*

The respondent mentions very clearly that at that point in time cost was not a consideration, only speed of getting their products to people that needed them. Obviously, this type of sentiment cannot occur at every firm for not all products help save lives, but perhaps for this industry, pharmaceuticals and medical devices, it is more common in the decision making process for certain types of disruptions.

On the other side of the spectrum, some decision makers are very focused on others, namely their competition or shareholders, in their decision making process. This can take the form of looking for opportunities in the failures of the supply chain, or simply being aware of the additional ramifications of decisions. Encouragingly, none of the respondents gave examples where decisions had marginalized the recovery efforts for these reasons. In one example, one

respondent mentioned that knowing the supply disruption was affecting the entire industry changed the outlook and direction of the recovery efforts. In another example, one respondent was aware of the stakeholder's perspective on their recovery and risk mitigation efforts, but made that decision anyway.

*“One of the pieces that came out of it was that, one of the things we had to assess is, okay is this only our company, or are there other companies? Is it going to be market wide?”*

*“But that's a challenge because when I look at our inventory numbers today, we're not loved for our inventory on Wall Street. Let's put it that way.”*

The relationship orientation of a decision maker can heavily influence the type of decisions that are made. When asked a question about whether they would source product from one or multiple ports, this respondent answered:

*“Do you consciously put all your eggs in one beach port basket hoping that your relationship will help you through that? Or do you say nope, we're going to do business with 5 different ports, not really knowing what other shippers are going to do and they are going to flood all those ports where you have no relationship and it's, I mean that's where I come back to there is no rock solid contingent plan because you really don't know what's going to happen. I don't know.”*

In addition to showing some risk averseness, this respondent later decided that if given the choice, they would focus all materials through one port and rely on the relationships developed

to help avoid any possible disruptions. Good relationships can also make a decision maker less likely to move away from a specific supplier or transportation provider, even given evidence that others would take as a license to do just that.

Decisions can also be made without enough of the detail for implementation put into it. While there was only one example of this given during the interviews, we think that this may be an issue worthy of further future investigation. The issue is that decision makers can understand the scope and strategies of the supply chain, but not the specifics of implementations or how something will actually be accomplished. As the respondent articulated it:

*“One of the biggest; the challenge that I have and a lot of times is that, people have great concepts of how to handle supply chain. But, you know, I always say, okay, how is this physically going to get done? You told me, systematically. You told me, you know, who we’re going to use. But who’s going to do physically do what and how are they going to do it to make sure that it actually moves. That’s the biggest challenge. The big picture is easy. It’s the details going into it that becomes tougher.”*

The probable reason this can occur is decision makers without the correct experience or training and the response team not having the correct representatives participating. The probable implication of this is that recovery takes longer since decisions have to be fleshed out and perhaps incorrect decisions are being made since the details are not fully understood.

The situation can also occur where the decision maker has several options that ultimately get taken away leaving, ultimately, no decision to be made. Only making the best of the given



situation is the way to recover. One respondent described the challenges of implementing a start-up warehouse situation where a new third-party logistics provider was taking over for an old provider. For many reasons, the initial start-up was a failure and would take several months to recover from. It left the respondent scrambling for options. In his words:

*“Right, now I’ll tell you I did have meetings with other 3PLs here... the other people that bid on it including the incumbent that was there, in case I had to change... I was literally left with only one change opportunity and that was to go back to the incumbent, because I told [the firm] there was no way in hell you can go through another start-up. If I had the incumbent they had the systems, they know the business. I could go back there, it’ll cost you a fortune and quite frankly they are part of the reason where we are today. So we just never did it, and I also told them if you go, I’m leaving, I’m not going through this for anybody again....”*

The reality became that the decision maker felt that there was no alternative to following through with the initial start-up.

Finally, the severity of the disruption can greatly impact the decision making process. Originally for this research, the focus of severe disruptions was chosen to ensure that disruptive events could be recalled with enough detail. However, this severity also affects the speed with which decisions are made, the method within the groups by which they are made, and at times the productivity. These answers are displayed in Table 3.27.

<p><u>Interviewer: Does the severity of the disruption make a difference in the decisions?</u></p>
<p><i>“Well, obviously the sense of urgency gets to higher levels very quickly if it’s very severe. It depends if you’re trying to put in a permanent fix or if you’re trying to fight this as a fire and just get it out so you can start to work on the thing. If it’s really bad, it’s the fire fighting and that kicks in a whole different role, it’s not consensus it’s directive and you know more about putting together, here’s the plan, you’re going to do it, now execute it type of thing versus walking through it. [Decisions are made faster], we haven’t got time to talk about it, are we going to do this or not, you know, and then do it.”</i></p>
<p><i>“I think the severity of the issue hurts the decision making process. The more severe the worse the decisions. Because the more people get involved who don’t know what they’re doing. They’re not close enough to how things work. Where it helps is they added a sense of urgency and a sense that you know we’ll get you any resource you want, but then they also tended sometimes to get involved in decisions that they shouldn’t be involved in because they don’t understand the complexity and the repercussions at sort of the ground level..... And so there’s a lot of what we call gerbiling of information which is a wheel spinning thing to the extent that it’s counter productive.”</i></p>
<p><i>“Yes. The more severe, the faster and more radical decisions are taken and usually will get more support. For the better. If it is a mild disruption, people might deal with it as a regular thing until it becomes much worse...”</i></p>

Table 3.27: Examples of disruption severity affecting decision making

The key points brought out by the respondents include directive instead of consensus decisions, quicker decisions, people getting involved that don’t need to be involved, more support from all corners for the decision, and more ‘radical’ decisions being made. This last one is perhaps a reference to the risk tolerance being different during very severe disruptions.

***Decision Making – Individually or Through Consensus?***

As was mentioned in the earlier section on leadership characteristics, decisions can be made by an individual or by consensus. This was seen in the disruptions that were discussed. Also

mentioned previously was that it appears the severity of the disruption can migrate decisions that would have been made through consensus toward being made by a single decision maker.

What is not known is the impact that each type of decision making might have on the recovery as a whole or the lessons learned. More on this will be discussed in those two sections that follow, respectively.

In conclusion, the actual decisions that are made are the culmination of many factors that work together in the mind of the decision maker. As an important point, the process of decision making is not a once-for-all event. In nearly all disruption recoveries, the process of discussing the options and making a decision will become cyclical as the results of those decisions as well as updated conditions are re-analyzed. New recovery options are discussed and new decisions are made. Only when this iterative cycle is complete and the supply chain has recovered is the firm able to move on into the effectiveness and recovery metrics phase.

### ***The Performance of the Recovery***

The initial disruption management model identified the recovery performance assessment as one of the final steps, occurring after the recovery process was complete. This is the ultimate question for the process; whether the recovery process was effective or not. Measuring this performance is the topic of this section.

The initial model had included the factors of the speed of the recovery and the final cost as key metrics. While these were shown to be important, several additional metrics were also revealed.

These were the impact of the disruption on the supply chain, the impact to customers, the perception of the recovery efforts, and whether additional disruptions were prevented as a result of the efforts. These added factors can be seen in the final disruption management model (Figure 3.4).

## **The Meaning of Performance**

In the original protocol of the interview, respondents were asked to talk about the performance and recovery effectiveness of the disruption. However, unlike the term “severe disruption”, respondents were not asked to formally define the term “performance” in relation to the recovery process. At the end of the interviews, it was decided to ask that question in the follow-up emails sent to each respondent. Eight out of the eighteen responded with a definition.

Understanding this is especially crucial to future researchers who wish to test empirically propositions that come from this and other research in supply chain disruptions. It is important because we will need to operationalize performance correctly.

Table 3.28 shows all eight of the replies given. Some respondents were able to separate and offer a distinction between the performance of the process of recovery (how the teams performed, decisions were made, etc.) and the performance of the business recovery (cost impact, etc.). These distinctions are included in the table.

<u>Definition of recovery performance</u>
<p><i>“We have no measurement or definition. We are reactionary, then we look at what happened, beat it to death, and point fingers for a few months.”</i></p>
<p><i>“Keeping the business flowing with as minimal impact as possible.”</i></p> <p><u>Process of recovery:</u> <i>“Speed at which you have recovered, overall financial impact.”</i></p> <p><u>Business recovery:</u> <i>“Keeping the customers happy with products (sales continue; supply chain functions transparently).”</i></p>
<p><u>Process of recovery:</u> <i>“Did they follow the guidelines, don’t always perform post-mortem. How do they score against the process they have already developed.”</i></p> <p><u>Business recovery:</u> <i>“Stopped throwing money at situation, restored to pre-disruption performance levels (fill rate, quality, cycle time, etc). Measure of speed - how fast it can happen.”</i></p>
<p><i>“Speed to get back on track.”</i></p> <p><u>Process of recovery:</u> <i>“‘Casualties’ avoided”</i></p> <p><u>Business recovery:</u> <i>“Total financial impact and time to get back to the level before the disruption from a service and financial level stand point.”</i></p>
<p><u>Process of recovery:</u> <i>“Good teams (well integrated talented teams) will always see opportunities in the disruptions. Not so good teams will only assign blame on disruptions.”</i></p> <p><u>Business recovery:</u> <i>“Best measure is customer service. Was the disruption noted by our clients? If so, how fast did we recover our customer service levels?”</i></p>
<p><u>Process of recovery:</u> <i>“Generally by how quickly we mobilize to form our team, how quickly and how well we communicate internally and feedback from customers on our information sharing/communication.”</i></p> <p><u>Business recovery:</u> <i>“Generally by our customer service levels - how quickly we return to normal business and no longer impact our customers.”</i></p>

*“Performance would be how quickly a team (forwarder & client in our case) identify and comprehend the situation and the options available and subsequently initiate resolution.”*

Process of recovery: *“Using the pre-disruption performance as the basis for measurement, how quickly the team are able to identify the issues and resolutions, then how effectively the resolutions are implemented.”*

Business recovery: *“Using the pre-disruption performance as the general barometer, how quickly the team are able to provide full service to our customer base as well as return to normal inbounding from our supply base as part of the resolution implementation.”*

*“The execution of the recovery plan and daily (if not 2x daily) measurement of effectiveness to allow for mid-course adjustments.”*

Process of recovery: *“Truck fill rate, % loads covered, output, on-time, spend, etc. and informally evaluate effectiveness of team assembled to fix the issues.”*

Business recovery: *“Sales & cost data in relation to recovery plan assumptions”*

Table 3.28: Definitions of recovery performance

As can be seen in the table, one respondent felt that they did not adequately have definitions and that this led to issues of blaming one another after the disruption was dealt with. One of the most common points brought out was the speed with which the firm was able to return to pre-disruption service levels and costs. A couple did mention the financial impact of the disruption. Most mentioned, though, that the most important factor was customer service. What goes on internally is not nearly as important as maintaining customer satisfaction and service levels. There were some additional metrics mentioned such as fill rates, % loads covered, quality, avoiding ‘casualties’ within the firm, not blaming one another, internal and external communication, and implementation effectiveness.

In putting a more formal definition of recovery performance together, we offer the following: the avoidance of a customer service impact or the speed at which customer service has been restored to pre-disruption levels while minimizing cost. While other factors were listed, some of the metrics are very specific to either a type of disruption or firm supply chain design. For example, a quality metric applies better to a quality issue than it does to a disruption caused by a hurricane.

In the disruption management model, the idea is that factors that occur in the decision making process have an impact on the performance of the recovery process. Several of these measurement methods follow with some possible results of impacting factors.

## **Measuring the Recovery Performance**

Recovery speed, financial impact, and customer impact were the most common methods to measure recovery success. Three additional factors were the impact on the broader supply chain, the perceived impact success of the management process, and whether future disruptions were prevented (such as the bullwhip). All of these will be discussed in this section.

### ***Recovery Speed***

Some disruptions take only a few days to resolve while others can take months to resolve. As a factor of importance, the speed of recovery has been discussed and shown earlier. However, two additional tables can offer additional insight into the factors that may affect the speed of recovery.

We can look at the average length of recovery time by WM and OBM disruptions as well as the Top-10 longest disruptions from the data. However, it must first be mentioned that there are accurate data points for only 19 of the 34 disruptions. Information either wasn't or couldn't be given for the other 15 disruptions. We must therefore tread carefully when interpreting the data in the tables.

Table 3.29 shows the average length of recovery time for WM and OBM disruptions. Out of the nineteen data points, ten were for WM disruptions, and the other nine for OBM disruptions. As can be seen, the length of the recovery process was nearly two months longer for OBM disruptions than WM.

	<u>WM</u>	<u>OBM</u>
Avg. Length of Recovery	6.65 weeks	14.58 weeks

Table 3.29: Recovery time by WM or OBM disruptions

The next table, Table 3.30, displays the top ten disruptions (out of the nineteen data points) by the length of time it took to recover. As can be seen, nine out of the ten were man-made external issues. The top three were also OBM disruptions, and OBM represented six out of the ten disruptions.



<b><u>Rank</u></b>	<b><u>Disruption Category</u></b>	<b><u>Cause</u></b>	<b><u>Weeks to recover</u></b>	<b><u>WM or OBM</u></b>
1	Man-made External	Supplier quality	43	OBM
2	Man-made External	3PL warehouse start-up	34	OBM
3	Man-made Internal	Product recall	26	OBM
4	Man-made External	Customs delay	17	WM
5	Man-made External	Labor strike	15	WM
6	Man-made External	3PL merger	13	OBM
7	Man-made External	Supply chain coordination	13	WM
8	Man-made External	Demand spike	12	OBM
9	Man-made External	Transportation availability	10	OBM
10	Man-made External	Supplier quality	7	WM

Table 3.30: Top-10 disruption events by weeks to recover

It should be included that if a respondent replied with a range of recovery, the range was averaged for calculation purposes. For example, if 2-4 weeks was given as a recovery time, the average of 3 weeks was used.

### ***Financial Impact of the Disruption***

In our cost driven supply chains, it was very surprising to discover that many respondents had difficulty providing a cost or financial impact to the firm as a result of disruptions. Only a few of the disruptions had even a ballpark price tag associated with the disruption.

Two examples of common responses are given. Both of these examples were well-managed disruptions in the opinion of the respondents. One was able to estimate the cost, and one was not.

*“That might have been \$2-300,000 and then the rest would have to be calculated in lost sales and I don’t [know that].”*

*“And that had the potential to be a serious disruption for us, but we were able to keep it managed. You know there was a level of difficulty, there was certainly a penalty level of added freight costs and added labor costs around it, but it was handled pretty well because we pulled the right management team together and we overcame some traditional barriers or roadblocks.”*

The first quotation was able to mention a price but also mentions that there were probably lost sales. However, this was difficult for the respondent to measure. The second quotation was unable to provide an estimate, but did provide where the costs would likely come from: freight costs and labor costs. Most respondents agreed that those are the most likely candidates for disruption costs, although others were mentioned such as recall costs, replacement costs, and inventory expiration costs.

Table 3.31 shows the known recovery costs by the category of disruption, as well as whether a plan was implemented with this specific disruption. It is interesting to note that a much higher percentage of the man-made internal disruptions had a more accurate cost associated with it. Recall from Table 3.5 that there were only five man-made internal disruptions. Four of them are listed below with associated costs. They also seem to be of a higher cost, although it is too small of an observation set to confirm that.

<u>Disruption Category</u>	<u>Plan Implemented?</u>	<u>Financial Impact</u>
<i>Natural Disaster</i>		
Hurricane recovery	No	\$10 million
Heavy snowfall	No	\$0
<i>Man-made External</i>		
Terrorism	Partial	Tens of millions
3PL transition	No	\$3-7 million
Supply shortage	No	\$1 million
Port strike	No	> \$300,000
Transportation, customs delay	No	< \$100,000
Supplier delay	No	> \$60,000
Shipping delays	No	\$0
<i>Man-made Internal</i>		
New product development	Partial	\$100 million
Product recall	No	\$50-60 million
Product recall	Yes	\$5 million
Plant quality	No	\$2 million

Table 3.31: Recovery costs by category of disruption

It is difficult to draw any conclusions from the implementation of a plan on the cost since only three examples are in the table. Generally, the internal disruptions may cost more and are more likely to have been planned for in the first place.

### ***Customer Impact of the Disruption***

As mentioned earlier, one of the greatest factors to be measured in the performance category is the impact the disruption had to customers. In the discussion about why some disruptions were well managed and some were not, one respondent said simply that the customers never knew a disruption had occurred and that that was the difference.

Besides the strain put on the customer service level, a couple of respondents mentioned having to physically pay the customers either for damages (more common when a supply delay shut down a manufacturing line) or even to take the product. For example:

*“Luckily our customer took the goods, even though they were late, but we ended up having to pay a lot of money for them to do that. So we didn’t lose the customer, but we did lose a considerable amount of money; \$60-70,000 range.”*

### ***Supply Chain Impact of the Disruption***

Normally, the focus of the impact external to the firm is on customers. However, the effectiveness of disruption recovery can also be linked to the greater supply chain. Suppliers are impacted by the ability of a firm to restore normal operations. The supplier may also have a financial impact to calculate. This is the primary thrust of the discussions in academia behind total supply chain cost (though these are not specifically focused on the impact of disruptions to this).

The firm’s internal supply chain may have been realigned as a result of the recovery process with a new or relocated distribution center. Transportation carriers may have had an opportunity to work with a firm never before worked with as a result of the firm scrambling for transportation needs. This in turn can affect the relationships of the supply chain. All of these can be additional, although harder to calculate, effectiveness measurements.

### ***Additional Disruptions Prevented***

A final measure of the performance of the recovery process is whether additional disruptions were prevented. This is not the same as preventing future disruptions (see learning or readiness). Instead, this refers to not allowing the disruption to also trigger such things as the bullwhip effect or supply bubbles in the supply chain, which can give a firm the idea that it is out of the disruption when in fact the supply shortage may be coming back down the supply chain again.

Two respondents mentioned these additional disruptions. One mentioned the bullwhip in the manner of overreacting to a shortage of supply and placing more orders than were necessary. The other mentioned the supply issue in the manner of a ‘bubble’ in the supply chain that gets forgotten about.

*“There is a period of time in the global supply chain and you know we’re in this global economy that there is this bubble and ripple effect that companies have to deal with, mitigation efforts, sometimes months after the initial incident. Keeping that momentum up and keeping that in front of the organization so that they understand when it’s coming. You know we could be having an issue on that US to Europe lane or US to Asian lanes or vice versa and you’ve got to keep that out in front of your commercial folks and in front of the business folks that we haven’t even see the impact yet and you have people saying, hey why are you having issues, I thought you solved that problem. Well we did solve it but we fixed it two months ago there is still this gap that’s moving through the big pipeline, right.”*

Preventing an additional disruption with the decisions that are made is an important part of the recovery process.

### ***Recovery Perception: Management of the Disruption and Final Disruption Impact***

Many decision makers can look at the same disruption and recovery effort and some will label them as well managed events and others will label them as poorly managed. These perception differences were first shown in how the severity of a disruption can be interpreted differently. Similarly, there are factors that impact the perception about the management (WM or OBM) and impact (low or high impact) of the disruption and subsequent recovery effort. This perception may then impact the remaining step, learning, to be discussed later. We first discuss what some of the factors were that influenced the respondent to perceive the disruption recovery effort to be well managed (WM) or had the opportunity to be better managed (OBM).

In nearly all of the interviews, when asked to describe why the two disruptions mentioned were classified they way they were, it was summarized in either one or possibly two issues. Despite there being many factors that were brought up by all of the respondents put together, it came down to a very small set of factors for any one person. The most important themes of actually managing the severe disruption focus on the visibility the decision makers have of the disruption as well as the interactions and make up of the people involved in the process. Another factor was revealed from two respondents who specifically had trouble identifying one disruption in each category.

The most common answer had some commonality with the degree of visibility the decision maker had to the disruption. In some cases, it was anticipating the disruption, in others it was seeing what was occurring once the disruption had begun. Below are several quotations on the factor of visibility (Table 3.32).

<i>“I think it gets down to the reactive mode versus the proactive mode.”</i>
<i>“Interviewer: Now, why did you coin this as one that was not well managed? Respondent: Because I don’t think anybody gave a lot of thought to this potentially happening.”</i>
<i>“...and the reason why I think it was managed well was, we had some level of world visibility to it and took mitigating actions ahead of time”</i>
<i>“And to me, the biggest reason why they are much harder to tackle is because they are harder to find.”</i>
<i>“But if I said what differentiates maybe the best situations from the worst, one is I would say would be timeliness in reacting to the issue. I can think of examples where we moved, saw indicators, we didn’t think it was that severe and waited for 8 hours or 12 hours longer before we really moved into what I would call crisis mode, so I would say timeliness is one.”</i>

Table 3.32: Quotations focusing on different aspects of disruption visibility

The factors start with being able to anticipate the disruption. One aspect under the umbrella issue of visibility is whether the decision maker felt completely reactive or whether they had had the chance to be proactive with the disruption. This is really pre-disruption visibility and whether the decision maker can even imagine that type of disruption occurring. The next aspect

is if the disruption potential was seen, was anything done to try to prevent the disruption from occurring. A well managed disruption usually had some mitigation planning tied to it.

Some respondents struggled to even find the disruption occurring within their supply chain. Another described that even when it was found, inability to see clearly what was going on prevented the decision makers from acting quickly and decisively. Part of this challenge is really in understanding what the root cause of the disruption is. Perhaps part of the result can be seen, but since the root remains hidden, the decisions are slow or incorrect. This can also lead to other issues, as described in the quotation below:

*“If you have a quality issue and your product quality, let’s just say, out of control because you can’t even define what the issue is. You know what the symptom is, but you ... have difficulty attributing what the root cause is. In some cases you end up with finger pointing internally between organizations or it’s an engineering or it’s a supplier issue, right, the supplier is out of spec or the supplier is bringing the part to print, and those kinds of things, there is a lot of delay there while people are trying to understand what the root cause is and it requires a committee to solve it, to me that’s where we’ve had bigger problems. And the problems are of longer duration because for us we need to get, before we can, like I think some of your questions talk about this, but you need a committee that almost goes end to end on a problem like that, right, not a committee but you need a team.”*



The challenge was to find the root, but the issue in this not well-managed disruption resulted in finger pointing between the decision makers and ultimately the wrong people being involved and too many of them at that.

One final aspect of visibility involves not just the manufacturing firm finding it, but then being able to hide it from the customers. This was deemed to be a well-managed disruption.

*“Well I think because we were able to, we had these multiple disruptions, we had the inspection piece going on, we had, tried to move the inventory around you know and we did that during a very busy time for us with a lot of unknowns and you know it’s very cross functional. I think the success is we didn’t disrupt the supply for the most part, you know we kept the product on the shelf during the busiest time of the year for [the product] and you know for the most part the consumer was completely oblivious to what was going on.”*

Interpersonal factors were heavily involved in a decision maker’s perspective. Already mentioned previously was the negative finger pointing. Other aspects include who was on the recovery team, how many people were on the team, the experience of the team, and the communication between members of the team. These are shown in the two quotations in Table 3.33.

Interestingly, two respondents had initial difficulty describing two different types of disruptions in the way that they were managed. One had difficulty finding any disruption that had been well

managed, while another was hard pressed to describe any disruption that had been poorly managed.

Table 3.34 shows the two perspectives next to one another.

<p><i>“...this gets a little bit into managing crisis, is having the appropriate <u>number of people</u> and the <u>right skill sets</u> to deal with whatever the crisis is.”</i></p>
<p><i>“Absolutely like I said in the beginning, they both boil down to communication and it really just comes down to how effectively we <u>communicated</u> throughout those processes”</i></p>

Table 3.33: Responses directed toward interpersonal aspects of the response team

<u>Both poorly managed</u>	<u>Both well managed</u>
<p><i>“I’m struggling to think, we put in, this is my challenge, I’m struggling to think of when we put in a contingency plan that went real well or that went better than what other shippers that I’ve talked to and I’m struggling to come up with an example.”</i></p>	<p><i>“Both of them went relatively well, you know there wasn’t any that I’d say gosh that was a disaster”, [from a management point of view.]</i></p>

Table 3.34: Initial responses that were both the same from a well- or not well-managed viewpoint

While this difficulty only happened in two of the eighteen interviews, we were able to perhaps find the common factor between the two perspectives. After discussing the two disruptions, the following insight was gained from the respondent who had the initial difficulty finding a disruption that was not well managed:

*Interviewer: “Right, both your examples affected the whole industry which makes a difference as well.”*

*Respondent: “And that’s another piece that you’re not, it’s not like you’re losing to competition on it”*

An important point can be made from these two respondents. More than other respondents, these two respondents made reference to peers or competitors when thinking about their disruptions. One thought that their firm managed worse than what other people had done, and the other felt that since the two disruptions brought up were both industry-wide, and that they had responded appropriately, that both were well managed. This factor needs to be studied and found in more examples, however, to build confidence in this result.

Initially, this differentiation between types of disruptions response effectiveness was inserted as part of the CIT (Critical Incident Technique). This focus on critical incidents provided an aid to remembering events. However, this differentiation is important from another aspect. When dealing with relationships in the supply chain, decision making after disruptions have occurred, and the performance of a recovery team, the behavioral viewpoint held by the decision makers may hold ramifications for those and other factors. There is not one common theme that identifies whether a disruption should be classified as well managed or not well managed, though the primary factors revolved around visibility and the make-up and interpersonal relationships of the recovery team.

Similar to the management effectiveness perception, the perception of low vs. high impact disruptions is also likely to have an influence on how the decision maker learns from the disruption and whether changes to other factors are made in anticipation of future disruptions.

For example, if a \$10 million disruption is considered to have been low-impact, the decision maker may not be interested in investing resources into planning for future disruptions. On the other side, a decision maker looking at the event as high-impact may do just that and pour resources into developing a future plan.

This perception is also, again, why some disruptions were labeled as well managed and others not. As one example of these perceptive differences, consider

Table 3.35 which lists WM and OBM disruptions, the associated costs (if known), and a brief description of the disruption.

<b><u>WM</u></b>		<b><u>OBM</u></b>	
<u>Cost</u>	<u>Description</u>	<u>Cost</u>	<u>Description</u>
\$10 million	Katrina recovery, switching to alt. modes	\$100 million	Quality issue with product
\$1 million	Supply shortage, premium transportation	\$50-60 million	Product quality
< \$100,000	Transportation delay to customer line	Tens of millions	Indirect terrorism to plant
> \$300,000	Port strike recovery	\$3-7 million	3PL start-up
> \$60,000	Supply delay (transportation cause)	\$5 million	Product recall
		\$2 million	Plant / product quality – politics played into it
		\$0	Snowfall delayed shipments, costs transferred to transportation firms
		\$0	Shipping delays

Table 3.35: Costs associated with WM and OBM disruptions

At first glance, it would appear that the more costly disruptions were also the ones more likely to be classified as OBM disruptions, however, the two disruptions that were known to be of negligible cost or \$0 were also both OBM disruptions. Other factors are likely also important.

We end this section with the example of the 3PL start-up that displays one of these other likely factors. Though there were heavy costs associated with it (\$3-7 million), the respondent perceived that that was not the most important impact aspect.

*“The most important thing in my opinion was not the financial impact, of course there was a financial impact but the most important thing for me is the fact that the value chain totally lost its credibility with the business, completely lost it because it was seen as a value chain disruption. It was seen as something that value chain didn’t manage properly and it was seen as something that took a long time for value chain to fix. In my opinion the worst damage was the fact that the value chain credibility was heavily impacted and I can say that it took at least one year, or one year and a half to bring it back to where it should be. So it meant that we needed at least one year of good results after that to regain some type of credibility with the business.”*

In summary, visibility of a disruption and the functioning of the team have a great impact on disruptions that were well managed and those that weren’t. The perceived impact of the disruption also not only has an impact on this management determination (WM or OBM), it also may impact the learning that the firm does after disruptions.

### ***Learning from the Disruption and Recovery Process***

*“Every time we activate the crisis room part of our process is to do a debrief after it’s all done to capture lessons learned. What could we have done better, where did we make decisions that in the end didn’t result in the actions we needed or the prevention we*

*intended to have. So, I can't think of a crisis yet that we couldn't have done better on, that there aren't areas for improvement."*

*Interviewer: "What did you learn from it? How did you incorporate your experience from that incident?"*

*Respondent: "We didn't do a thing."*

These two quotations represent the two most common responses to the end of the recovery process – either a debriefing afterwards to garner lessons learned, or not doing anything at all. If there is a formal debrief, another factor that is involved is whether or not any further changes are made. This would be the time that a future risk plan is put into place, perhaps long-term supply chain design changes, and others.

This section will take the learning step initially included in the disruption management model and add two specific factors. They are the formal learning process and whether any changes are made, as the final step in the disruption management process. These additions can be seen in the final disruption management model (Figure 3.4).

### ***Formal Learning Process***

A formal learning process simply means that after the disruption recovery is deemed to be at an end the decision maker, either with or without the team, they attempt to glean items that can be learned about the cause of the disruption or process. This process can range from being non-

existent, to slight learning or communication, to full implementation of learning items. Consider the following three levels of learning in Table 3.36.

<u>Learning Level</u>	<u>Example</u>
None	<i>“That’s something, like I said that’s something we can do a lot better. We just we tend to just move onto the next problem.”</i>
Slight / Some	<i>“...as well as communicating within our own group. So there were a lot of people who had a little chit chat. Now is there a written plan in process, not to my knowledge.”</i>
Fully implemented	<i>“So we’ve used proactive monitoring capabilities to help avoid some of those and there have been times where a certain amount of cargo has been jammed in a system like UPS’ and we’ve been able to get quicker access to where our product was. So I think both we and UPS learned from that significant disruption. Now they have what they call intercept.”</i>

Table 3.36: Examples of the level of learning

Most of the firms that were interviewed do learn from the disruption. Table 3.37 displays these by WM and OBM disruptions. There were only three firms that did not mention having a learning process or debrief at all, and there was no difference in the type of disruption. There were a couple of situations where there was a learning point taken from the disruption, but due to lack of funding the solution was not able to be implemented. These were excluded from the table. There were also two situations in which it was unable to be determined whether learning had occurred or not. These also were excluded.

	<u>WM</u>	<u>OBM</u>
Formal Learning	11	12
No Learning	4	3

\*out of 34 disruptions

Table 3.37: Learning processes by disruption type

In summary, learning seems to be a process that firms employ no matter how the disruption went. Only one example showed otherwise.

### ***Changes Made to Handle Future Disruptions***

Most firms employed a formalized learning process after the severe supply chain disruption. There were many examples of changes made as a result of the learning process. Some were simple, such as IT fixes that could flag issues, while others were much more consuming, such as a new warehouse being built. Several of these are shown in Table 3.38.

The disruption often acts as the spur that the decision makers needed to be able to push through changes that were needed. Some decision makers had ideas that had to wait until a disruption occurred so that they could point to it as the ‘I told you so’ occurrence. Others merely discovered the changes that needed to be made only after the disruption.



<u>Changes Made</u>	<u>Example</u>
Capital investment in manufacturing	<i>“I think technically what good came out of it was they decided to invest some capital to prevent this thing from happening again, but frankly I don’t think we learned from that how to make good objective decisions with the data.”</i>
Hire a foreign language expert	<i>“Yeah visibility was one; second was language, you know since this happened in Mexico a lot of the communication we were getting was in Spanish and I do not have someone on my team that speaks Spanish, so one of the things, one of the corrective actions there is we now have a person on our team who can speak Spanish fluently.”</i>
Building a consolidated warehouse	<i>“Well I’ll tell you, what it did do, it took a disaster to finally build the new warehouse that we got and this was the disaster because I remember sitting down and people were asking me, the executive committee said, well first of all I said you guys are asking me to ship out of a completely ineffective warehouse. You’ve been lucky, you’ve delayed this for years, now you’ve got facilities all over [the city], you’re now in four buildings, quite frankly you’re inefficient as hell, your customers want to go a different directions with combined orders from combined businesses but you can’t do it effectively with this. It’s time to get your warehouse that you wanted to build about 4 years ago. Bring those prints back in and get the work in. That’s how we got started on the warehouse and consolidated it into where we are today. “</i>
New co-packer qualification process	<i>“It ended up being; I think we learned a lot on the co-packer qualification piece. We qualified them on the formula, but we didn’t qualify them or ensure that they could deliver on the packaging.”</i>
Adding inventory	<i>“If you see a market that’s starting to look like it’s potentially a risk for this kind of disturbance, raise the flag and then we will take those potential issues, talk about them, maybe decide we’re going to add a couple of weeks of raw material inventory; we’d add inventory in those cases.”</i>

Table 3.38: Examples of changes firms made after disruptions

Additionally, the occurrence of a disruption is the strongest impetus for many firms to create risk plans for similar events. For example:

*“And after Katrina now we have a formal hurricane plan and every time we go into hurricane season we kind of go through the steps of that plan again, so we learned.”*

Specifically, September 11<sup>th</sup> and Hurricane Katrina motivated many firms to formalize risk and business continuity plans that had been either non-existent or incomplete.

In summary, while some firms do not debrief and take the opportunity to learn from disruption recovery processes, most do. They also employ changes that are very specific to that disruption and that firm.

### ***Conclusion and Contribution - Theoretical Model***

We have discussed many factors that are a part of the disruption management process, many of them realized as a result of the data analysis from the interview data that were collected. The original model, shown in Figure 3.3, was developed based on the literature and prior to the interviews. The protocol and questions used in the interview were derived from the model.

As a part of the data analysis process, the model built was sent to all respondents for their review and comments. Nine out of eighteen replied with their thoughts about the updated model. While some felt that the process model was appropriate, others included comments with possible missing factors. Their comments, if appropriate, have been added to the model or integrated into

the results section. The updated and final disruption management model is presented in Figure 3.4.

As just one example of the feedback that was received, one respondent added to the possible changes that can be made as a result of the learning process. He describes that at a previous employer, the September 11<sup>th</sup> attacks had caused the firm to reevaluate their insurance strategies.

*“Also under the last silo “learning” on the same [model]. We had legal, risk management and finance involved after major events to assess whether or not our insurance strategies made sense as well as our ability to reduce the aftermath risk of insurance seized products flooding the grey market. In the case of [a previous employer] and 9/11, many entire server banks were deemed total losses, just to be resold on the reduced or grey market. Customers were purchasing million dollar systems for a dime on the dollar. Sales plummeted. It was a major consideration moving forward and a substantial learning nobody anticipated prior.”*

The disruption management model is shown below in Figure 3.4.

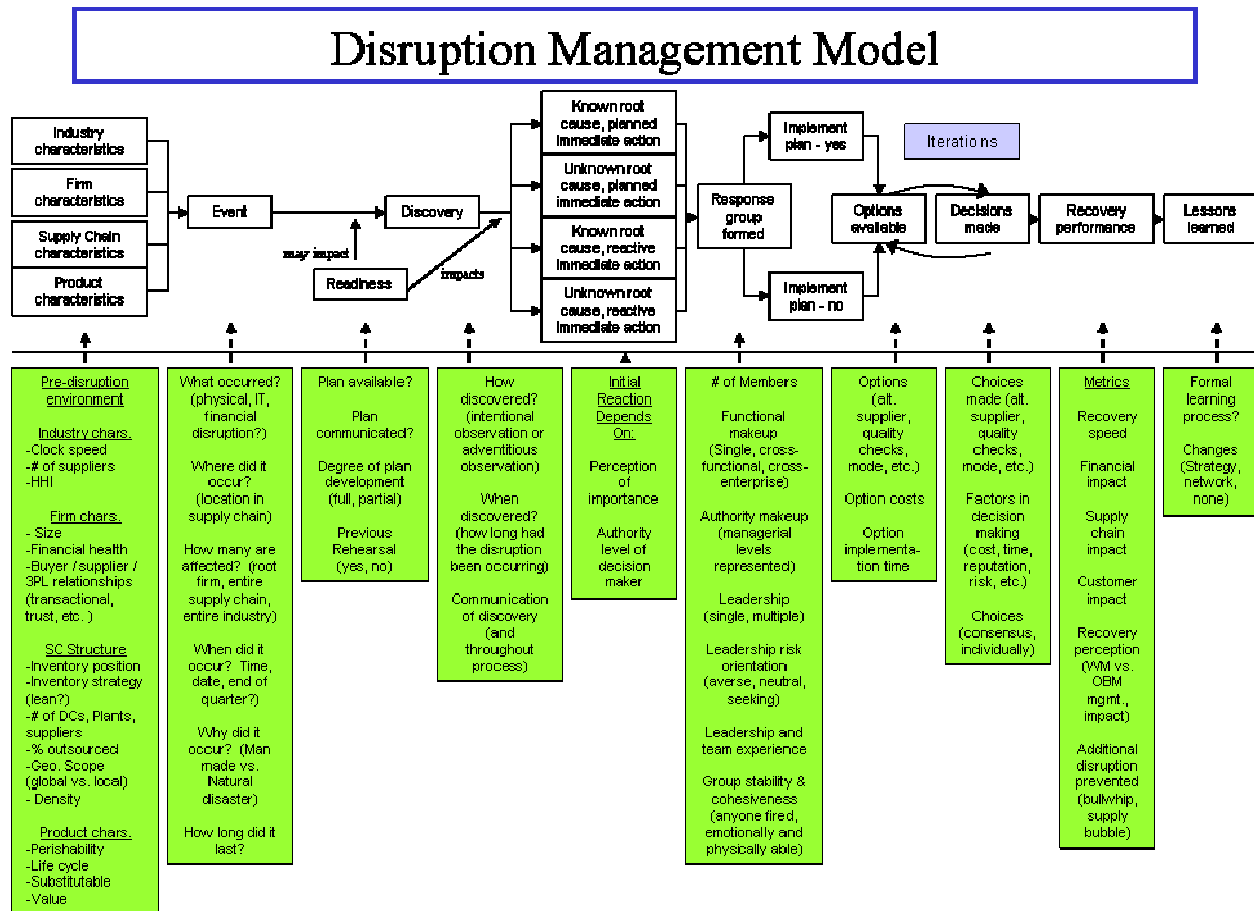


Figure 3.4: Final disruption management model

The factors discussed in each of the results sections have been included in the model. Additions came to most factors, but especially in expanding the number of pre-existing conditions, response group characteristics, and the addition of the initial reaction step. Arrows coming from the category of readiness reflect what was mentioned earlier, that readiness will impact the initial reaction and may impact the discovery of the disruption.

The locations of the factors in the process model do not have implications on the time of occurrence between factors. For example, a hurricane may be discovered, communicated, and

the response group formed all in the same day. However, the decision making process of vetting the available options, making decisions, and repeating the process until the disruption is recovered from may take many days or even months.

Finally, as was mentioned in the section discussing the plan implementation, that decision may rest with whether the root cause of the disruption is known by that point. If, after iterations of making decisions, the root cause becomes known, the response team may revisit whether, if a plan exists, to implement the plan. The process then continues with vetting the options and making decisions as shown in the model. This possible iteration cycle does not occur in the majority of firms during their recovery process and has not been visibly depicted in the final disruption management model.

This concludes the results section. We now turn our attention to using the results presented to begin building propositions that are testable empirically in future research.

## **Section 3.5: Discussion and Propositions**

The task of this research has been to understand the phenomenon of decisions and decision making as a result of severe supply chain disruptions. In order to do this, a data set has been created from structured interviews that build a theoretical foundation for understanding and analysis which culminated in the disruption management model. On this foundation, propositions can be built that are testable empirically. That is the purpose of this final section for Chapter 3, to proffer the propositions.

The analysis has found the disruption management model to be very complex with many factors impacting the key steps of readiness, discovery, response, effectiveness, and learning. Specifically, the black box of response has been expanded to include the initial reaction, the formation and dynamics of the response group, the possible implementation of a disruption recovery plan, the options available to decision makers, and the decisions that are actually made. This model will open up many avenues for additional research in the already growing field of disruption management.

While some of the factors involved were predicted and known, such as the size of the firm, supply chain structure of the firm, whether they had been involved in risk planning, the experience of the decision maker, and a few others, many additional factors were discovered that have an important impact on decision making. The results of the interviews showed some very distinct differences between disruptions that were considered well managed (WM) and those that had the opportunity to be better managed (OBM).

One clear difference was shown to be the type of disruption that was later to be considered WM. No WM disruption fell into the man-made internal category; they were either natural disasters or man-made external. A reason for this could be that internal disruptions already have the label as being someone's fault, which can lead to problems later in the response group should the blame game be played. It could also be that internal disruptions don't initially have the same sense of urgency as natural disasters and hence may not get the same teamwork, escalation, or resources put to it.

Another difference suggested by the data was that OBM disruptions take much longer to recover from. The average difference was nearly two months, which is a very large amount of time where costs and customer service are concerned. The extra amount of time could be caused by several factors during the process such as delayed discovery compared to natural disasters, infighting during decision making, or perhaps lack of preparation. This last thought is loosely supported by the fact that where a full plan existed (five disruptions), four of those were categorized as WM.

Disruption recovery plans were revealed to be considered more valuable as processes to be learned rather than steps to be followed. Similarly, formal disruption recovery training given to decision makers was non-existent, but four firms were known to engage in rehearsals for disruptions. These four firms were also in the top 50% of the firms according to size (as measured by total sales). Recovery plans also faced the challenge of being effectively communicated throughout the organization, as occurred with one firm who actually had a plan which was not implemented because of lack of communication.

Communication is an important aspect throughout the disruption management process. Besides conveying the existence of recovery plans, effective communication is needed to discover the disruption from external sources, to convey that discovery to appropriate decision makers within the organization, to facilitate the decision making process within a response group, to spread the instructions and implementation actions from decisions that have been made, and finally to inform the firm of the points that were learned from the disruption recovery process. Without effective communication, delays occur that can exacerbate the severity of the disruption at the most, and delay the full recovery and minimize costs at the least. Lack of communication can also influence the types and number of options that decision makers are made aware of before needing to make decisions.

The types of decisions that were available to decision makers were revealed by the data analysis to include many more that are common to purchasing, transportation, and logistics functions, and less to manufacturing functions. This is due to the fact that outsourcing has taken hold to such a degree that many firms that were manufacturers of nearly 100% of their goods sold in previous years have become brand managers, manufacturing a much smaller percentage of goods sold, in recent years. These options include more of paying for premium transportation, alternate ports of entry, and switching suppliers. This trend has also elevated the role that these carriers and third-party logistics providers (3PL) have; and along with that the strength of relationships in the supply chain. Many times in the interviews, the cause or the solution heavily involved a 3PL.

Fortunately, the analysis showed that most firms learn from the disruptions. Whether the disruption went well or was poorly managed, there are formal learning processes in place. The



range of what is learned is very specific to the firm, the disruption type, and many other factors as very few of the firms displayed similar learning points.

Finally, there is still much to be understood on the topic of understanding the decision makers and the groups they lead. The experience, authority makeup, functional makeup, risk orientation, stability, and simple number of people and decision makers were all cited for their importance. For example, nearly all of the managers were self-described as being more risk-oriented than the firms that employed them. The number of people on the team, if it got too large, also detracted from the purpose and functioning of the team and delayed recovery.

It is relevant to make a few comments on the well known limitations of this research methodology before proceeding to the propositions. In comparison to more representative data sets such as those from secondary databases and surveys, the nature of interviews is to provide depth, not breadth with statistical significance. Analysis from interview data is based on a much smaller sample size of eighteen interviews from seventeen firms representing multiple industries. However, the interview approach allowed for topical exploration in much greater depth than would ordinarily occur as a result of a survey instrument.

Finally, as there was limited theory or literature in disruption from which to draw upon, the study is exploratory in nature. There may be some bias in the data sample as the managers interviewed represented transportation, logistics, and supply chain functions rather than marketing, production, or customer service. Similar limitations to these can be found in other qualitative and grounded theory research such as Flint et al. (2002) and Pagell (2004).

## ***Contribution – Propositions***

The purpose of this research was to understand how and why decisions are made in recovery processes. Some pre-response conditions such as the industry, firm, and supply chain structural characteristics have an influence on how the recovery can take place. The event itself, readiness for it, and its discovery also play crucial roles in the recovery process.

The response itself focuses on the reaction of the firm upon discovery of the disruption, the formation and dynamics of the group that is formed to deal with it, and the options and decisions that the group has to make. Lastly, the post-response steps of recovery performance analysis and the learning with any strategy changes that occur from the disruption set the stage for how the firm may react or deal with disruptions in the future. This section will loosely follow this line of thought with pre-disruption, disruption recovery, and post-disruption propositions.

The complexity of the disruption management model is exciting from the point of view that there is much to learn. This also means that there could be a multitude of propositions formulated and put forth. However, we will limit the propositions here to those that are perhaps more strongly supported and / or important. Additionally, the flow of the propositions will be to start with propositions from the left side of the process model and more toward the right side.

## **Propositions**

It was shown that firms had various levels of readiness for severe disruptions. Readiness is put in place by firms in hopes of increasing their performance in recovering from a disruption. A

common way of doing this is by developing a plan or process to use when disruptions occur. Some are more fully developed than others. A greater degree of readiness occurs when the plan is communicated well throughout the organization. Some firms take a final readiness step by rehearsing the plan they have developed. The more of these steps a firm takes; it can be argued that the more a firm is prepared for a disruption. Firms can likely be compared to one another on a 'readiness scale'.

One of the many pre-disruption environmental factors that appear to have a significant effect on the level of a firm's readiness is its size. Larger firms have a greater amount of resources available to them both to dedicate to risk management / disruption planning as well as rehearsing for severe disruptions. While firms large and small can develop risk plans, only larger firms actively rehearse, presumably due to additional resources. From Table 3.39, it is shown that the four firms that mentioned rehearsing were in the top half of all firms in the dataset by firm size, including the largest two.

Additionally, one respondent mentioned that they just did not have the resources to spend on maintaining many of their plans, let alone spending time and resources on rehearsing.

*"...I was like wow, who's got the resources for that [rehearsing]? We'd have to take a weekend to rehearse because everyone's got jobs to do. And maybe it's just a different operational methodology. We happen to be in a very low margin business that doesn't have high growth, right and so you look at it and you [see] everybody's ... got ... real, core, day to day jobs."*

Firm	Industry	Size (Sales)**	Rehearsal?
A	Automotive	\$10+	Yes
B	Pharmaceutical	\$10+	Yes
C	Chemical	\$10+	No
D	Agricultural Equipment	\$10+	No
E	Food and Beverage	\$10+	No
F	Consumer Products	\$2 - \$10	Yes
G	Apparel	\$2 - \$10	No
H	Cosmetics	\$2 - \$10	Yes
I	Consumer Durables	\$2 - \$10	No
J	Paper	\$2 - \$10	No
K*	Chemical	\$2 - \$10	No
L	Construction	\$2 - \$10	No
M	Hi-tech	< \$2	No
N	Hi-tech	< \$2	No
O	Food and Beverage	< \$2	No
P	Healthcare	< \$2	No
Q	Home Building Supplies	< \$2	No

\*Firm that provided multiple respondents

\*\* In billions of dollars

Table 3.39: Firm size matched with whether they perform disruption rehearsals

This supporting information leads to the first proposition:

*Proposition 1: Pre-disruption environment factors, such as firm size, impact the level of firm readiness.*

Supply chain relationships play an instrumental role in the recovery efforts of the firm. One firm, for example, described having representatives from the supplier, 3PL, and air charter transportation companies in the firm's war room during a recent severe disruption at a supplier.

As a general statement, inclusion of supply chain members in a recovery effort either leads to or

results from strong relationships. Without these strong relationships, it would be difficult to have a well-functioning team composed of various supply chain members.

As described earlier, many firms rely on 3PLs and other freight forwarders to help with their global freight movement. All of the firms interviewed had outsourced at least some of their transportation needs. During severe disruptions, sometimes one of the only options a firm can have is to communicate, push, and lean on the outsourced transportation provider. Without relationships, this would be very difficult. For example, consider the firm that was not interested in developing relationships with their carriers before Hurricane Katrina.

*“We were given some advice to nurture the carriers and I remember joking at the time that I just can’t embrace the word nurture when it comes to a motor carrier, you know that’s a little too mushy for me.”*

During the Katrina disruption, this firm frequently ran into challenges of moving their freight and the disruption ended up costing them \$10 million, which was one of the most costly disruptions based on results displayed in Table 3.31. As a part of their lessons learned, they added an annual meeting with all carriers to nurture these relationships.

As a final statement, it can sometimes be the lack of relationship that causes the disruption in the first place. One respondent discussed low relationships with motor carriers as resulting in dropped loads during harvest season. Farms are willing to pay more money per load, but the loads only last for one month. The respondent, on the other hand, has loads all year round, but

for a lower price. He is working hard to develop his relationships in order to minimize the dropped loads at times during the year.

Therefore, in light of these examples, we offer a proposition regarding relationships and recovery performance:

*Proposition 2a: Firms with strong supply chain relationships in place prior to a supply chain disruption are more likely to have increased recovery performance.*

*Proposition 2b: Firms with strong supply chain relationships experience fewer disruptions than those with worse relationships.*

The next few propositions will involve more of the factors discovered within the disruption recovery phase of the disruption management process.

According to the interview results, readiness appears to have an effect on several aspects of recovery, namely the speed of discovery of a disruption, the speed of the initial reaction, the speed of recovery decision-making, and the speed of total recovery. First, the proactive mindset that leads a firm to prepare in the first place can also lead to a proactive posture in discovering a disruption. For example, one respondent on the upper end of a readiness scale proactively monitored labor contracts and was able to know immediately when a strike was set to occur because of the monitoring. Additionally, these firms are more likely to develop IT monitoring and other means of discovering disruptions sooner. There are some disruptions that are

unpredictable, but in general, a firm that prepares seems able to discover disruptions more quickly than those who do not.

An important aspect of a recovery plan is the identification in the plan of the person to contact and an identification of the first response to a disruption. This makes the actions of the person discovering the disruption more defined and predictable. It also allows for quicker communication when they know what team is to be put in place and how to do it. This was evidenced by one respondent who carries a list of contacts and phone numbers on him at all times in case of disruption. Table 3.7 showed that there were four firms that did not have any risk plans in place (low end of a readiness scale). Of these four firms and the eight disruptions they discussed (two per firm), two of the disruptions had been occurring for one week before they were finally communicated to the person with the ability to take action. By contrast, none of the four firms that actively rehearse (high end of a readiness scale) had a discovery followed by more than one day in communication time. Therefore, recovery planning is likely to increase the speed and consistency of the initial reaction to discovering a severe disruption.

As was mentioned previously, one respondent felt that having mock disruptions and rehearsals had immense value as the response team learned to be calm and collected during actual disruptions. There is a natural tendency to be excitable and make rash decisions. However, calmness allows for decisions to be made more clearly and decisively, with fewer changes by decision makers. The plan often outlines how a disruption should be dealt with, thereby also speeding the brainstorming and option-generating session. Many of the options are already known and can therefore be decided upon more quickly.

Finally, readiness seems able to affect the performance of the recovery. Recall from Table 3.10 that of the five disruptions where a plan existed for the recovery effort, four out of the five were considered to be well managed by the respondents. These well-managed disruptions can have lower total costs and quicker recovery times. These quicker recovery times for well managed disruptions can also be seen from Table 3.30, where 6 out of the top 10 longest recovery times were for OBM disruptions; as well as the top 3. As a result of these supporting details, the following are proposed:

*Proposition 3a: Firms with greater readiness to respond to a supply chain disruption are more likely to have faster discovery of a disruption than are firms with lesser readiness.*

*Proposition 3b: Firms with greater readiness to respond to a supply chain disruption are more likely to have a faster initial reaction to it than are firms with lesser readiness.*

*Proposition 3c: Firms with greater readiness to respond to a supply chain disruption are more likely to have greater decision-making speed than are firms with lesser readiness.*

*Proposition 3d: Firms with greater readiness to respond to a supply chain disruption are more likely to have greater recovery performance than are firms with lesser readiness.*



The severe disruptions that were given as examples by the respondents were placed into three categories. There were natural disasters, man-made internal disruptions, and man-made external disruptions. Additionally, these were sorted by being well-managed or as managed with the opportunity for improvement and displayed in Table 3.5. As shown from that table, none of the well-managed disruptions fell into the man-made internal category. Instead, all of the internal disruptions were considered to be OBM by the respondents.

There seemed to be several reasons for this. Among them there was finger pointing among team members, lack of clarity among leadership, lack of planning or quick response, delay among communicating the disruption, and people involved that were not appropriate for the response. In other words, a response team often was created that was not cohesive, but rather dysfunctional.

Two quotes taken from these disruptions provide examples of dysfunctional groups. The first describes the lack of cohesiveness that can arise in a group:

*“We are reactionary, then we look at what happened, beat it to death, and point fingers for a few months.”*

The second quote discusses the instability that can occur in response groups:

*“We would have meetings and we were just getting the hell beaten out of us, and it was more like running a gauntlet...they beat on those managers and those people who were let go unmercifully...So at the end of the day what happened is everybody that was involved in the project was fired, that’s when I came in 6 months later, but basically it was a disaster... everybody that was somehow involved was let go.”*

Based on this information, the following proposition is offered:

*Proposition 4: Firms responding to man-made internal disruptions more frequently establish and recover with a dysfunctional response group compared to firms responding to a natural disasters and man-made external disruptions.*

It is important for firms to recover as quickly as possible from severe disruptions. Some of the disruptions were recovered from in less than a week. As shown in Table 3.30, others took up to 43 weeks (about 10 months). Table 3.30 shows the ten disruptions that took the longest to recover from. Of the ten longest recovery times, nine of the disruptions were categorized as man-made external disruptions. The other disruption was a man-made internal disruption. Possible reasons for this strong correlation could be that external disruptions involve circumstances outside the control of the firm. For example, if a supplier is having a quality problem, there is only so much a firm can do to help its supplier.

There could also be a possibility that response teams are slower to involve and communicate with external supply chain members. Internal disruptions have presumably less communication barriers. While the exact reason still needs to be discovered, it is suggested that:

*Proposition 5: Firms responding to man-made external supply chain disruptions have a longer recovery process time than do firm responding to natural disasters or man-made internal disruptions.*

Implied but unspecified to this point is the notion that faster discovery of a disruption is better than slower discovery. Many respondents from our dataset as well as from others (Blackhurst et al. 2005) have discussed the need for quick visibility of a disruption. The visibility into the disruption allows the response team to form and decisions to be made in hopes of mitigating further damage. This indicates that the sooner discovery can occur, the better the recovery performance can be. A ready example of this is the disruption that was generated by improper paperwork at the U.S. – Mexico border for a shipment of product. The discovery should have happened a week earlier, but was not caught and ended up costing the company in the form of payments to customers to accept the delayed product.

There were nineteen disruptions where the recovery time was known and given by the respondents. These were matched up with the time it took for the discovery to occur. Three discovery timeframes were used, namely those discovered the same day it occurred, within one week of occurrence, or within weeks (or, more than one week). Table 3.40 shows that many of the disruptions that took one week or longer to discover were far more likely to take longer for a recovery. This is shown by looking at the upper half of the table. Four of the top nine disruptions in terms of length were discovered the same day, so it is possible to have a quickly discovered disruption that takes a long time to recover from. Similarly, eight of the ten disruptions that took the shortest amount of time to recover from were discovered the same day as the occurrence.

<u>Group</u>	<u>Recovery in weeks</u>	<u>Discovery</u>
1	43	Weeks
1	34	Same day
1	26	Weeks
1	17	Same day
1	15	Same day
1	13	Weeks
1	13	Weeks
1	12	1 week
1	10	Same day
2	7	Same day
2	6	1 week
2	3	Same day
2	2	Same day
2	2	Same day
2	2	1 week
2	2	Same day
2	1	Same day
2	1	Same day
2	0	Same day

Table 3.40: Discovery of disruption matched up with recovery time

However, there is also the challenge of knowing the cause of the disruption at the time of discovery. With some types of disruptions, this is simultaneous. Hurricane Katrina was a simultaneous discovery of the disruption and the cause (natural disaster). There are many disruptions where this may not be the case. In the example of one product recall, it was known that the product was defective through the manufacturing process, but it was not known for several weeks where in the manufacturing process the disruption was occurring. In these cases, decisions are being made without full knowledge of whether the decisions will in fact help recover from the disruption.

Therefore, it is postulated that:

*Proposition 6: Faster discovery of a supply chain disruption, including identification of its root cause, leads to shorter recovery times.*

During the fifth interview that was conducted, one of the researchers began to draw Figure 3.5. The respondent was discussing how a disruption which was only moderate in its severity had resulted in a much greater financial impact due to finger pointing within the response team, disagreement among team members, and strong overreaction in some of the response decisions that had been made. While this is nothing new with other respondents describing similar issues at times, the team dysfunction was stark contrast to the previous interview (the fourth interview) where the severity had been much greater but the team worked with high efficiency and unified purpose.

Severity is a very understandable term, but measuring it practically is difficult. Severity needs to be measured both by operational (such as cost, duration, and other effects on the firm) and behavioral (such as perception, decision maker reaction) measures to be thoroughly understood. Part of this is reflected in the idea that the same disruption can be perceived to be severe by one decision maker and mundane by another decision maker. All respondents were asked to discuss whether, in their opinion, the severity of a disruption affected the decision making process. One respondent mentioned the following:

*“Yes. The more severe, the fastest and more radical decisions are taken and usually will get more support. [That is] for the better. If it is a mild disruption, people might deal with it as a regular thing until it becomes much worse...”*

In reviewing the complete data set of disruptions that were given by the respondents, the pattern emerged that the severity not only affects the factors listed in the previous proposition, but that the final outcome of recovery performance can also be impacted by severity. This can likely occur in a u-shaped pattern. For disruptions that are not very severe, a team is formed and is able to deal with the disruption effectively. For extremely severe disruptions, the response team moves more into a survival mode with unity behind the decisions because there is no time for questioning or slowness in implementation. However, for initially moderate disruptions, other team or firm dynamics are allowed to play a role because the disruption is severe enough to gain firm-wide recognition of the problem, but not severe enough to force quickness in decisions and strong unity behind those decisions.

This can possibly lead to over- or under-reaction among decision makers due to political reasons (trying to blame-shift or keep a job), increased costs and recovery time than what should have been needed, and a feeling that the disruption has not been well managed. This effect is likely exacerbated with man-made internal disruptions where the fault lies with someone within the company. See Figure 3.5 for a visual representation of this.

*Proposition 7: The severity of a disruption has an impact on recovery performance with less severe and very severe disruptions having better recovery performance than do recoveries from moderately severe disruptions.*

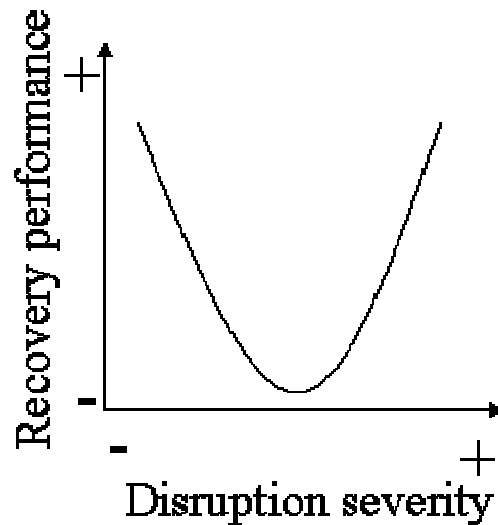


Figure 3.5: Relationship between disruption severity and recovery performance

The learning process can be thought of as composed of multiple aspects. Two of those are whether the learning process is formalized and also whether any strategic changes take place as a result of the process. The next several propositions deal with these two aspects.

A formalized learning process means that it is customary following a disruption recovery to have the team or appropriate persons discuss what went wrong and what could be done better next time. This may include the decision to create future response plans for disruptions

One result of the interviews was the observation that although most firms go through the learning process, not all do. There was virtually no difference between whether the firm learned after

WM or OBM disruptions, as was shown in Table 3.37. There also did not seem to be a difference of learning dependent on disruption recovery performance, as shown in Table 3.41. Whether the severe disruption ended by taking many weeks or few weeks, the learning process could occur after both.

<u>Recovery in weeks</u>	<u>Learning Process?</u>
43	Yes
34	Yes
34	Yes
26	Yes
17	No
15	Yes
13	Yes
13	Yes
12	Yes
10	Yes
7	Yes
6	Yes
3	No
2	Yes
2	No
2	No
2	No
1	Yes
1	Yes
0	Yes

Table 3.41: Disruption recovery and a formalized learning process

Instead, the learning process seems to be predetermined to occur or not planned at all. The respondents usually included statements such as “this is what we always do” or “we always debrief”. This predetermination seems more dependent on the culture of the company or the desired protocol of the decision maker that will be involved, regardless of the type or severity of the disruption. Therefore, we propose the following:



*Proposition 8: The learning process is preplanned by the decision maker to occur or not to occur and is not the result of the disruption itself.*

One of the most important questions to answer is to determine which factors might lead to strategic changes. Most of the firms interviewed conducted a learning assessment after the disruption was recovered from. Table 3.37 showed that out of 30 disruptions, learning took place in 23 of those situations. However, learning does not always indicate that a strategic change also took place. According to Hofer & Schendel (1978), strategic change can be defined as “changes in the content of a firm’s strategy as defined by its scope, resource deployments, competitive advantages, and synergy”. By this definition, there needs to be substantial resources deployed to enact the change. This is important to help define which firms in this data set enacted an actual strategy change as a result of the disruption. For example, one firm programmed their IT system after one disruption to flag orders of a certain size in order to more quickly identify demand spikes. This would not be considered a strategic change.

After analysis, three of the disruptions led to substantial strategy changes. These are listed in Table 3.42, along with some additional data.

Firm	Strategic Change Made	Firm size (out of 17; the 17 <sup>th</sup> firm is the smallest)	Disruption type	Disruption cost	Risk plan in place for disruption type?	Rehearsals for any kind of disruption?
A	Move from multiple warehouses down to one warehouse	11	Man-made external	\$3-7 million	No	No
B	Stop treating motor carriers as commodity, build relationships instead and allow longer contracts	14	Natural disaster	\$10 million	No	No
C	Move from a single-supplier model to multiple suppliers for key components	10	Man-made external	Unknown	No	No

Table 3.42: Additional information related to three firms that made strategic changes

In the strategic change literature, there has traditionally been much focus on firm size and the pace of strategic change in the company. Generally, it has been found that structural inertia in large firms leads them to be slower in their pace of change (Amburgey et al. 1993). This is most likely the same situation with regards to changes after disruptions. In looking at the two initial examples at the beginning of the research involving Toyota and Ford (both large firms), we saw that two earthquakes were not enough for Toyota to change its strategy, but multiple recalls due to engineering and supplier related problems were enough for Ford to change its strategy of outsourcing.

Looking at Table 3.42 reveals another possible supporting point with regards to strategic changes. The first is that of the firms that made strategic changes that required significant financial and time investments (moving from single to multiple suppliers, building a new warehouse, and viewing and managing carriers as an investment rather than a commodity), they

were all in the lower 50% with regards to firm size in our dataset. Previous literature and preliminary results from our dataset, then, lead us to the following proposition:

*Proposition 9: Larger firms will have fewer strategic changes in their response to individual supply chain disruptions than will smaller firms.*

Of the same three significant strategic changes listed in Table 3.42 (moving from single to multiple suppliers, building a new warehouse, and viewing and managing carriers as an investment rather than a commodity), two were man-made external disruptions and one was a natural disaster. None were man-made internal disruptions. This could be a result from the idea that man-made internal disruptions are viewed as the fault of a person rather than the fault of a strategy. Therefore, man-made internal disruptions will result in learning, but not large strategy changes.

*Proposition 10: Firms facing man-made internal supply chain disruptions are less likely to introduce strategic changes in their response to the disruption than are firms facing natural disasters or man-made external disruptions.*

Referring back to Table 3.31 which shows the relative costs of disruptions, it is shown that the two disruptions that resulted in strategic changes and whose costs are known were the most costly natural disaster and the second-most costly man-made external disruption respectively. This seems to indicate that the perceived severity of these disruptions to the smaller firms is great

and causes the reaction of needing to find and change some strategies. This leads to the following proposition:

*Proposition 11: The greater the severity of the disruption, the more likely the firm is to introduce strategic changes in their response to the disruption.*

Finally, disruption plans are intended to help plan out before the disruption what the response is supposed to be. As a result, the recovery process likely takes on a more predictable structure. The learning process after such disruptions is likely to reveal opportunities to learn from, but probably not along the lines of major strategic changes. In principle, firms that created the plans had likely thought about their strategies in place at the time of the planning and were therefore not ‘surprised’ into a strategic change.

Support for this idea comes from Table 3.42 which shows the three firms that did make strategy changes as a result of the learning process. It can be seen that none of the three firms had a plan in place for the type of disruption that occurred to them, nor do they actively rehearse for any type of disruption. We therefore proffer that:

*Proposition 12: Firms having a disruption response plan in place prior to a disruption have fewer supply chain strategy changes in the recovery and learning phases than do firms with no disruption response plans.*

## **Chapter 4: Conclusion**

This research started by discussing two severe disruptions that had affected two large automakers in the past decade. One automaker explicitly said that as a part of their recovery process they would temporarily shut down some plants, but not change their supply strategy. The other automaker had spent years outsourcing parts development and supply and, as the result of their supply disruptions, made the strategic decision to insource some of the engineering processes. Though the disruptions were different, they both offered insight into the types of decisions that are made after severe disruptions.

In a broad discussion about supply chain disruptions, many gaps were identified that exist in the literature. One was the need for an overarching framework, which resulted in the work that was done for Chapter 2. Another gap identified was the need for more understanding into the decision making factors and processes that occur as firms recover from severe supply chain disruptions. The research in Chapter 3 begins to fill this gap. Summaries of the two parts to this research are now given, followed by the important managerial implications of both. Limitations to this research will also be discussed as well as future research opportunities based on this research.

### ***Summary of Chapter 2***

In Chapter 2, the literature associated with risk management, supply chain disruptions, supply chain security, business continuity planning, crisis management, supply chain sustainability, and supply chain resilience was presented and summarized. It was shown that some of these terms

overlap in their meanings. These were then presented in the format of a framework for better understanding how the concepts fit together. The framework not only displays what has been done in the broad area of supply chain risk and disruptions, but also revealed areas of opportunity for future research.

### ***Summary of Chapter 3***

Chapter 3 began with a brief review of the concepts and factors in the literature that were known or assumed to be important in the disruption management process that includes post-disruption decision making and recovery. These factors were displayed in the initial disruption management model (Figure 3.3).

Lack of theory in this area led to the necessity of using the grounded theory methodology of qualitative data analysis to help build theory upon which propositions could be developed. Eighteen interviews were held using a structured interview protocol in order to gather the necessary data. These data were then analyzed for relationships among the known factors as well as for any revelation of new factors and concepts. These were added to the original model and led to an updated disruption management process model (Figure 3.4).

Finally, several propositions were given based upon the factors from the disruption management model. The directions of the relationships proposed were supported by the results and implications of the data analysis. These propositions can be tested empirically in future research.

## ***Managerial Implications***

In addition to providing a strong theoretical base for academics and future research, this research offers some excellent managerial insights and has implications for their disruption recovery process. Chapter 2 offers a strong framework for managers to have common terminology and framing when they discuss business continuity planning, risk management, and disruption recovery. It also offers a template for future investigation when helping their firm develop these capacities. Though it does not provide the specific details, it provides the initial starting point from which to acquire additional materials. For example, a firm may realize that it does a good job of managing disruption recovery, but needs to further develop its BCP process. The next step could then be to reference a handbook on BCP (Hiles 2007).

Similarly, the disruption management process can provide excellent insight into factors that many managers had not considered before. For example, one supply chain manager emailed the following as a response to the interview and materials that had been sent to him:

*“This has been very stimulating and enjoyable. It has forced me to review my current strategies and understand the weaknesses and strengths.”*

Many managers will likely take the factors and, similarly, begin to pay attention to and review their own practices as well as details when future severe disruptions occur to them.

The research also begins to quantify the usefulness of risk plans and how different disruptions are viewed and should be handled differently. It is extremely helpful for the managers to be able

to identify some of the causes of failure, especially referring to the initial reaction and the cohesiveness of the response group.

Finally, the process model offers a best-practices look at disruption management. For example, the checklist mentioned by one respondent is a simple, effective approach to ensuring that the right resources are brought in to help manage a disruption. It is likely that many others will adopt a similar approach.

### ***Research Limitations***

As with all research, this research is not without its limitations. Starting with the framework built in Chapter 2, one of the major limitations is that it has not been confirmed using appropriate qualitative methods. It was developed based on the literature base available, but in order to strengthen the case and determine if any pieces are missing, it should be confirmed by process with academic researchers as well as supply chain managers and firm business continuity planners.

Some of the limitations for the grounded theory methodology (Chapter 3) have already been provided, but will be re-presented here. In comparison to more representative data sets such as those from secondary databases, surveys, and simulations, the nature of interviews is to provide depth, and not breadth that would be associated with providing statistical significance. Analysis from interview data is based on a much smaller sample size (here, eighteen interviews from seventeen firms) representing multiple industries. Another limitation is that propositional evidence is weighted primarily on these interviews for data, and much less on documentation



from firms and the observations of the researchers, as has been recommended in case studies. In some cases, factors can be revealed if even one firm reveals it, much less all eighteen. None of these propositions have been empirically tested for significance.

There was limited theory or literature on the topic of disruptions from which to draw upon, and the study is to be considered exploratory in nature as a result. There may be some bias in the data sample as the managers interviewed represented transportation, logistics, and supply chain functions rather than marketing, production, or customer service. Similar limitations to these can be found in other qualitative and grounded theory research such as Flint et al. (2002) and Pagell (2004).

### ***Future Research Opportunities***

The Supply Chain Disruption Management Framework and Disruption Management Process Model have areas of interest that have not been able to be explored in this research, leaving multiple areas for future research.

Starting with the framework, there are three additional areas (aside from the literature gap covered in Chapter 3 of this research) that have less literature devoted to understanding them. The first is understanding of the decision making process, and its operational and behavioral factors. Some literature, such as Manuj and Mentzer (2008b), has begun to explore decision maker behavior and traits, but is still at the qualitative and exploratory stage. A second area of future research is the impact on risk that disruptions and firm strategies have. Normally, we look at the effect that firm risk has on the strategy selection or other actions, but far less on how they

in turn affect risk. Finally, confirmation of the framework needs to be tested through qualitative means and any terms or concepts that have yet to be discovered need to be added.

Similarly, there are multiple directions and opportunities for research using the disruption management model. The focus of this research was on the recovery and decision making process, however, as evident from the propositions, many additional factors included in the model have relationship between one another that can be put forth as propositions. Another opportunity is for areas that were lightly touched upon, such as how disruptions affect and impact relationship in the supply chain, to be investigated more thoroughly through qualitative means. Finally, for all of the propositions that were included in this research, it is important to empirically test them. This can be done with secondary data, by conducting a survey, and conduct experiments of situations that could be difficult to study as the events occur.

### ***Final Conclusion***

This research has built a framework for understanding the concepts surrounding supply chain risk and disruptions as well as a disruption management model offering insights on the factors that play a role in the post-disruption recovery and decision making process.

## Chapter 5: Appendices

### *Appendix A: Graphical Representation of the Scope of the Supply Chain*



Figure A.1: A supply chain management map of logistics, marketing, and manufacturing (Mentzer et al. 2006)

## ***Appendix B: Example of Letter Used to Recruit Interview Candidates***

Dear XXX,

Your name was given to me by [reference]. I am a student at the University of Maryland, where I am currently finishing my Ph.D. and dissertation.

The topic of my research is Disruptions in the Supply Chain (and, more importantly, how companies adjust/react to the disruptions). The research originates from the observation that given similar disruptions, firms can make very different recovery and supply chain strategy decisions. The goal is to help build better disruption management processes (recovery strategies and performance).

Would you be interested / available for an interview on this topic? Specific questions would revolve around what disruptions you face, how they are dealt with, how the strategy choices might then be changed in response to disruptions, and what the performance of decisions has been.

The interview would last 60-90 minutes and remain confidential. Specifically, I am thinking of the time frame between [date range] where we could conduct an interview. However, another week could easily be scheduled, either in person or over the phone.

If you know of any additional persons who might be interested / available, please feel free to pass this email on.

Thanks for your help. Please don't hesitate to call me on my cell below with any questions.

Best regards,  
John

**John R. Macdonald**

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-

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## ***Appendix C: Interview Protocol and Questions***

### Interview Protocol and Questions

#### *Introduction*

- Introductions of interviewer and interviewee
- Overview of study: Severe supply chain disruptions can have a costly impact on companies. Organizations have many ways of dealing with disruptions. I am interested in how your organization deals with them. The goal of this research project is to help organizations grow in their resiliency to severe disruptions.
- Permission to record audio of conversation

#### *Demographics*

- Title and position of interviewee
- Brief job history
- Brief background on organization / industry

#### *Interview Questions - General*

- *Supply Chain*: Briefly describe your supply chain
- *Definition*: What is a severe disruption to your company?
  - a. The worst crisis you can imagine for your organization is...?

#### *Interview Questions – Critical Incident Technique*

*Additional Comment*: I would like you to answer the next questions for both a severe disruption that was well managed and one that left room for improved management.

- Describe a recent severe disruption you / your organization has experienced.
- How did the disruption affect (impact) your organization?
- How and when was the disruption discovered?
  - a. “I knew we were in a crisis because...”
  - b. While the disruption was occurring, what decisions were made and how were they made?
- What did your organization do to stop / mitigate / reduce the disruption’s effect?
  - a. Did you refer to a previous plan?
  - b. Who was responsible for recovery from it?
- How were final decisions made? Individual, team, other?
- Did the disruption affect your internal / external supply chain relationships? (3PL, B, S)
- After the disruption was ‘over’, and initial recovery was done, what, if any, decisions were made? (about strategies, performance, future prevention, etc)

#### *Interview Questions - General*

- *Disruptions*: Briefly describe any additional severe disruptions your organization has faced.

- *Strategic options:* When severe disruptions occur, what strategic options (levers) are available to you to recover from them?
  - a. Of these strategies, what is the current strategy of your organization?
- *Manager Characteristics:*
  - a. Have you ever received training in dealing with these disruptions?
  - b. How is your disruption decision making performance evaluated?
- *Readiness:*
  - a. Discovery of severe disruptions triggers what actions?
  - b. Do you have risk plans in place? What types?
    - i. Have you referred to previously designed risk plans? Was that useful?
    - ii. Had you rehearsed any of these plans?
    - iii. Did the severe disruption 'behave' as expected?
- *Responses:* How does the disruption severity affect decision making?

*Unplanned/Floating Prompts*

- Can you describe that?
- Please explain that in more detail.
- Are there instances when it doesn't happen that way?
- Can you give an example or two?
- Tell me more.

## Appendix D: Informed Consent Form for Interviewees

### INFORMED CONSENT FORM

Project Title	<b><i>Supply Chain Disruption Decision Making</i></b>
<b>Purpose (Why is this research being done?)</b>	<i>This is a research project being conducted by Tom Corsi and John Macdonald at the University of Maryland, College Park. The purpose of this research is to understand the factors that are included in the decision making process after a supply chain disruption and what the strategic and performance implications of these decisions are.</i>
<b>Procedures (What you will be asked to do)</b>	<i>The procedure involves one session in which you will be asked to discuss disruptions your company has faced, the factors involved, the decisions made to recover, and the strategy and performance results. There may be a short follow up session to verify the resulting model with a few short questions.</i>
<b>Confidentiality</b>	<i>We will do our best to keep your personal information confidential. To protect your confidentiality, your interview will be given a coded identifier, and only the researcher will have access to the identification key. Any report or article about this research project, your identity will be protected to the maximum extent possible. Your information may be shared with representatives of the University of Maryland, College Park or governmental authorities if you or someone else is in danger or if we are required to do so by law.</i>
<b>Risks</b>	<i>There are no known risks associated with participating in this research project.</i>
<b>Benefits &amp; Ability to Ask Questions</b>	<i>The research is not designed to help you personally, but to help the investigator learn more about decision making and the effect of supply chain disruptions. However, you will receive an executive summary of the results which will hopefully help you deal with the disruptions you face through enhanced decision making. You are free to ask questions at any time.</i>
<b>Freedom to Withdraw</b>	<i>Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop at any time.</i>
<b>Contact Information for Questions</b>	<p><i>This research is being conducted by Tom Corsi and John Macdonald in the Department of Logistics, Business, and Public Policy at the University of Maryland, College Park. If you have any questions about the research study itself, please contact:</i></p> <p><i>Tom Corsi; 301-405-2197; tcorsi@rhsmith.umd.edu OR</i>  <i>John Macdonald; 515-450-8953; jmacdona@umd.edu</i></p> <p>If you have questions about your rights as a research subject or wish to report a research-related injury, please contact:</p> <p><b>Institutional Review Board Office,</b>  <b>University of Maryland, College Park, Maryland, 20742</b>  <b>(e-mail) <a href="mailto:irb@deans.umd.edu">irb@deans.umd.edu</a>; (telephone) 301-405-0678</b></p> <p><i>This research has been reviewed according to the University of Maryland, College</i></p>

	<i>Park IRB procedures for research involving human subjects.</i>
<b>Statement of Age and Consent</b>	<i>Your signature indicates that: you are at least 18 years of age; the research has been explained to you; your questions have been fully answered; and you freely and voluntarily choose to participate in this research project.</i>
<b>Name of Interviewee</b>	
<b>Signature of Interviewee</b>	
<b>Date</b>	



## Chapter 6: Bibliography

Ahituv, N., Igarria, M. and Sella, A. (1998). "The effects of time pressure and completeness of information on decision making." Journal of Management Information Systems **15**(2): 153-172.

Alexander, D. E. (2004). "Cognitive Mapping as an Emergency Management Training Exercise." Journal of Contingencies and Crisis Management **12**(4): 150-159.

Amburgey, T. L., Kelly, D. and Barnett, W. P. (1993). "Resetting the Clock: The Dynamics of Organizational Change and Failure." Administrative Science Quarterly **38**: 51-73.

Barnes, J. C. (2001). A Guide to Business Continuity Planning. New York, NY, John Wiley & Sons.

Barton, L. (2008). Crisis Leadership Now. New York, NY, McGraw-Hill.

Bendoly, E., Donohue, K. and Schultz, K. L. (2006). "Behavior in operations management: Assessing recent findings and revisiting old assumptions." Journal of Operations Management **24**: 737-752.

Benyoucef, M. and Forzley, S. (2007). "Business Continuity Planning and Supply Chain Management." Supply Chain Forum: An International Journal **8**(15).

Blackhurst, J., Craighead, C. W., Elkins, D. and Handfield, R. B. (2005). "An empirically derived agenda of critical research issues for managing supply-chain disruptions." International Journal of Production Research **43**(19): 4067-4081.

Boyson, S. and Han, C. (2007). Eras of enterprise globalisation: from vertical integration to virtualisation and beyond. Multinational Corporations and the Emerging Network Economy in Asia and the Pacific. J. J. Palacios. Oxford, U.K., Routledge.

Brindley, C., Ed. (2004). Supply Chain Risk. Burlington, VT, Ashgate Publishing Company.

Brindley, C. and Ritchie, B. (2004). Introduction. Supply Chain Risk. C. Brindley. Burlington, VT, Ashgate Publishing Company.

Cantor, D. E. and Macdonald, J. R. (2008). "Decision Making in the Supply Chain: Examining Problem Solving Approaches and Information Availability." Working Paper.

Chapman, P., Christopher, M., Juttner, U., Peck, H. and Wilding, R. (2002). "Identifying and Managing Supply Chain Vulnerability." Logistics and Transportation Focus **4**(4): 59-64.

Child, J. (1972). "Organizational structure, environment and performance: the role of strategic choice." Sociology **6**: 1-22.

Chopra, S. and Sodhi, M. (2004). "Managing risk to avoid supply-chain breakdown." MIT Sloan Management Review **46**(1): 53-61.

Chozick, A., A Key Strategy of Japan's Car Makers Backfires. *The Wall Street Journal*. 2007a, July 20, B1

Chozick, A., Toyota Sticks by 'Just in Time' Strategy After Quake. *The Wall Street Journal*. 2007b, July 24, A2

Christopher, M. and Lee, H. (2004). "Mitigaing supply chain risk through improved confidence." International Journal of Physical Distribution and Logistics Management **34**(5): 388-396.

Closs, D. J., Jacobs, M. A., Swink, M. and Webb, G. S. (2008). "Toward a theory of competencies for the management of product complexity: Six case studies." Journal of Operations Management **26**(5): 590-610.

Connelly, T. J. (1997). "The rational irrational behavior hypothesis." Journal of Financial Planning **10**(2): 32-34.

Cooke, J. A. (2002). "Brave New World." Logistics Management Distribution Report **41**(1): 31-34.

Corbin, J. and Strauss, A. (2008). Basics of Qualitative Research. Thousand Oaks, CA, Sage Publications.

Council of Supply Chain Management Professionals. (2008). Retrieved Feb 6, 2008, from <http://www.cscmp.org>.

Cousins, P., Lamming, R. and Bowen, F. (2007). The Role of Risk in Environment-Related Supplier Initiatives. Executive Briefing 2007-08, The University of Manchester.

Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J. and Handfield, R. B. (2007). "The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities." Decision Sciences **38**(1): 131-156.

Croson, R. and Donohue, K. (2003). "Impact of POS Data Sharing on Supply Chain Management: An Experimental Study." Production and Operations Management **12**(1): 1-11.

Croson, R. and Donohue, K. (2006). "Behavioral Causes of the Bullwhip Effect and the Observed Value of Inventory Information." Management Science **52**(3): 323-336.

Datta, P. P., Christopher, M. and Allen, P. (2007). "Agent-based modelling of complex production / distribution systems to improve resilience." International Journal of Logistics: Research and Applications **10**(3): 187-203.

de Courson, R. (2007, July 19). "Japan Quake Reveals Fragility of Modern Industrial Systems." Terradaily.com Retrieved August 31, 2007, from [http://www.terraily.com/reports/Japan\\_Quake\\_Reveals\\_Fragility\\_Of\\_Modern\\_Industrial\\_Systems.htm](http://www.terraily.com/reports/Japan_Quake_Reveals_Fragility_Of_Modern_Industrial_Systems.htm).

Doherty, N. A. (2000). Integrated Risk Management - Techniques and Strategies for Managing Corporate Risk. New York, NY, McGraw-Hill.

Dowling, R. G. and Staelin, R. (1994). "A model of perceived risk and intended risk-handling." Journal of Consumer Research **21**(1): 119-125.

Drabek, T. E. and Hoetmer, G. J., Eds. (1991). Emergency Management: Principles and Practice for Local Government. Washington, D.C., ICMA.

Dubrovski, D. (2004). "Peculiarities of managing a company in crisis." Total Quality Management **15**(9): 1199-1207.

Eisenhardt, K. M. (1989). "Agency Theory: An Assessment and Review." Academy of Management Review **14**(1): 57-74.

Ellram, L. M., Tate, W. L. and Billington, C. (2008). "Offshore outsourcing of professional services: A transaction cost economics perspective." Journal of Operations Management **2008**(2): 148-163.

Eyefortransport. (2006, July). "Cargo and supply chain security trends." from <http://www.eyefortransport.com/cargosecurity2006>.

Faisal, M. N., Banwet, D. K. and Shankar, R. (2006). "Supply chain risk mitigation: modeling the enablers." Business Process Management Journal **12**(4): 535-552.

Fine, C. H. (1998). Clockspeed: Winning industry control in the age of temporary advantage. Readin, MA, Perseus Books.

Flanagan, J. (1954). "The critical incident technique." Psychological Bulletin **51**: 327-359.

Flint, D. J., Woodruff, R. B. and Gardial, S. F. (2002). "Exploring the phenomenon of customers' desired value change in a business-to-business context." Journal of Marketing **66**(4): 102-117.

Gaonkar, R. S. and Viswanadham, N. (2007). "Analytical framework for the management of risk in supply chains." IEEE Transactions on Automation Science and Engineering **4**(2): 265-273.

Gaudenzi, B. and Borghesi, A. (2006). "Managing risks in the supply chain using the AHP method." The International Journal of Logistics Management **17**(1): 114-136.

Gilbert, G. A. and Gips, M. A. (2000). "Supply side contingency planning." Security Management **44**(3): 70-73.

- Glaser, B. G. (1998). Doing Grounded Theory: Issues and Discussions. Mill Valley, CA, Sociology Press.
- Glaser, B. G. and Strauss, A. L. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. Chicago, IL, Aldine Publishing Group.
- Hale, J. E., Hale, D. P. and Dulek, R. E. (2006). "Decision Processes During Crisis Response: An Exploratory Investigation." Journal of Managerial Issues **18**(3): 301-320.
- Handfield, R. B. and McCormack, K., Eds. (2008). Supply Chain Risk Management: Minimizing Disruptions in Global Sourcing. Resource Management. Boca Raton, FL, Taylor and Francis Group, LLC.
- Handfield, R. B. and Nichols, E. (1999). Introduction to Supply Chain Management. Upper Saddle River, NJ, Prentice-Hall.
- Harl, N. E. (2002). U.S. Agriculture, Food Production is Threatened by Bioterrorism Attacks. Ag Lender. **April**: 10-11.
- Harrison, K., Malseed, C., Busch, G., Wunderle, D., Adair, T. M. and Zimmer, E. (2006). Forces of Business and Forces of Nature - Building an Agile Supply Network. Supply Chain Executive Conference, Scottsdale, Arizona.
- Heath, R. (2007). A crisis management perspective of business continuity. The Definitive Handbook of Business Continuity Management. A. Hiles. West Sussex, UK, John Wiley & Sons Ltd.
- Hendricks, K. B. and Singhal, V. R. (2003). "The effect of supply chain glitches on shareholder wealth." Journal of Operations Management **21**: 501-522.
- Hendricks, K. B. and Singhal, V. R. (2005a). "Association between supply chain glitches and operating performance." Management Science **51**(5): 695-711.
- Hendricks, K. B. and Singhal, V. R. (2005b). "An empirical analysis of the effect of supply chain disruptions on long run stock price performance and equity risk of the firm." Production and Operations Management **14**(1): 35-52.
- Herman, M. L. and Oliver, B. B. (2002). "A Primer for Crisis Management." Risk Management **49**(1): 48-53.
- Hiles, A., Ed. (2007). The Definitive Handbook of Business Continuity Management. West Sussex, UK, John Wiley & Sons Ltd.
- Hiles, A. and Barnes, P. (2001). The Definitive Handbook of Business Continuity Management. Chichester, John Wiley & Sons.

- Hofer, C. W. and Schendel, D. (1978). Strategy Formulation: Analytical Concepts. St. Paul, MN, West.
- Johnson, M. E. (2001). "Learning from Toys: Lessons in Managing Supply Chain Risk from the Toy Industry." California Management Review **43**(3): 106-124.
- Juttner, U., Peck, H. and Christopher, M. (2002). Supply Chain Risk Management: Outlining an Agenda for Future Research. Logistics Research Network 7th Annual Conference.
- Juttner, U., Peck, H. and Christopher, M. (2003). "Supply Chain Risk Management: Outlining an Agenda for Future Research." International Journal of Logistics: Research and Applications **6**(4): 197-210.
- Kleindorfer, P. and Saad, G. (2005). "Managing disruption risks in supply chains." Production and Operations Management **14**(1): 53-68.
- Kleindorfer, P. R., Singhal, K. and Van Wassenhove, L. N. (2005). "Sustainable Operations Management." Production and Operations Management **14**(4): 482-492.
- Knight, F. (1921). Risk, Uncertainty and Profit. New York, NY, Harper & Row.
- Koch, C. (2002). Hershey's Bittersweet Lesson. CIO.
- Lee, H. and Tang, C. S. (1998). "Variability reduction through operations reversal." Management Science **44**: 162-173.
- Lee, H. L. (2004). "The triple-A supply chain." Harvard Business Review **October**: 102-112.
- Levy, D. (1995). "International sourcing and supply chain stability." Journal of International Business Studies **26**: 343-360.
- Linton, J. D., Klassen, R. D. and Jayaraman, V. (2007). "Sustainable supply chains: An introduction." Journal of Operations Management **25**: 1075-1082.
- Machalaba, D. and Kim, Q., West Coast Docks are shut down after series of work disruptions. Wall Street Journal. (Eastern Edition), 2002, 30 September, A2
- Manuj, I. and Mentzer, J. T. (2008a). "Global Supply Chain Risk Management." Journal of Business Logistics **Forthcoming**.
- Manuj, I. and Mentzer, J. T. (2008b). "Global supply chain risk management strategies." International Journal of Physical Distribution and Logistics Management **38**(3): 192-223.
- Massey, C. and Wu, G. (2005). "Detecting regime shifts: The causes of under- and overreaction." Management Science **51**(6): 932-947.

McKinnon, A. (2006). "Life Without Trucks: The Impact of a Temporary Disruption of Road Freight Transport on a National Economy." Journal of Business Logistics **27**(2): 227-250.

Melnyk, S. A., Zsidisin, G. A. and Ragatz, G. L. (2005). The Plan Before the Storm. APICS Magazine. **November/December**: 32-35.

Mentzer, J. T., Min, S. and Bobbitt, L. M. (2004). "Toward a unified theory of logistics." International Journal of Physical Distribution and Logistics Management **34**(7/8): 606-627.

Mentzer, J. T., Stank, T. P. and Esper, T. L. (2006). "Supply Chain Management and its Relationship to Logistics, Marketing, Manufacturing, and Operations Management." Working Paper.

Merriam-Webster (2008). Merriam-Webster Dictionary. Springfield, MA, Merriam-Webster, Inc.

Mintzberg, H., Raisinghani, D. and Theoret, A. (1976). "The structure of "unstructured" decision processes." Administrative Science Quarterly **21**(2): 246-275.

Mitchell, V. W. (1995). "Organizational risk perception and reduction: a literature review." British Journal of Management **6**: 115-133.

Mitroff, L. and Alpaslan, M. (2003). "Preparing for Evil." Harvard Business Review **April**: 109-115.

Morton, R. (2002). "Hope for the best, plan for the worst." Transportation and Distribution **43**(4): 51-54.

Murphy, J. (2006). Managing Supply Chain Risk: Building in Resilience and Preparing for Disruption. White Paper, WisdomNet Inc.

Murphy, T. (2003). Insourcing. Ward's Auto World: 44-48.

Musson, M. (2001). Business continuity strategies for manufacturing and logistics. The Definitive Handbook of Business Continuity Management. A. Hiles and P. Barnes. Chichester, John Wiley & Sons: 163-169.

Naglewski, K. (2006). "Are you ready to make effective decisions when disaster strikes? Strategies for crisis decision-making." The Journal of Private Equity **9**(2): 45-51.

Nagurney, A. and Matsypura, D. (2005). "Global supply chain network dynamics with multicriteria decision-making under risk and uncertainty." Transportation Research: Part E **41**: 585-612.

- Norrman, A. and Jansson, U. (2004). "Ericsson's proactive supply chain risk management." International Journal of Physical Distribution and Logistics Management **34**(5): 434-456.
- Norrman, A. and Lindroth, R. (2002). Supply Chain Risk Management: Purchasers' vs. Planners' Views on Sharing Capacity Investment Risks in the Telecom Industry. 11th Annual IPSERA Conference, Twente University.
- Norrman, A. and Lindroth, R. (2004). Categorization of Supply Chain Risk and Risk Management. Supply Chain Risk. C. Brindley. Burlington, VT, Ashgate Publishing Company.
- Ogden, J. A., Peterson, K. J., Carter, J. R. and Monczka, R. M. (2005). "Supply management strategies for the future: A Delphi study." Journal of Supply Chain Management **41**(3): 29-48.
- Pagell, M. (2004). "Understanding the factors that enable and inhibit the integration of operations, purchasing and logistics." Journal of Operations Management **22**: 459-487.
- Paulsson, U. (2004). Supply Chain Risk Management. Supply Chain Risk. C. Brindley. Burlington, VT, Ashgate Publishing Company.
- Pearson, C. M. and Clair, J. A. (1998). "Reframing Crisis Management." Academy of Management Review **23**: 59-76.
- Peck, H. (2005). "Drivers of supply chain vulnerability: an integrated framework." International Journal of Physical Distribution and Logistics Management **35**(3/4): 210-232.
- Rice, J. and Caniato, F. (2003). "Building a secure and resilient supply chain." Supply Chain Management Review **7**(5): 22-30.
- Ritchie, R. L. and Marshall, D. V. (1993). Business Risk Management. London, U.K., Chapman and Hall.
- Russell, D. M. and Saldanha, J. P. (2003). "Five tenets of Security-Aware Logistics and Supply Chain Operations." Transportation Journal **2003**(Summer): 44-54.
- Sarathy, R. (2006). "Security and the global supply chain." Transportation Journal **45**(4): 28-51.
- Savage, M. (2002). "Business continuity planning." Work Study **51**(5): 254-261.
- Schultz, K. L., Juran, D. C. and Boudreau, J. W. (1999). "The Effects of Low Inventory on the Development of Productivity Norms." Management Science **45**(12): 1664-1678.
- Schultz, K. L., McClain, J. O., Robinson, L. W. and Thomas, L. J. (2007). "The Use of Framing in Inventory Decisions." Working paper.
- Schultz, K. L., McClain, J. O. and Thomas, L. J. (2003). "Overcoming the dark side of worker flexibility." Journal of Operations Management **21**: 81-92.

Sheffi, Y. (2001). "Supply Chain Management under the Threat of International Terrorism." International Journal of Logistics Management **12**(2): 1 - 11.

Sheffi, Y. (2005). The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage. Cambridge, MA, The MIT Press.

Sheffi, Y. and Rice, J. (2005). "A supply chain view of the resilient enterprise." MIT Sloan Management Review **47**(1): 41-48.

Shockley, J. and Ellis, S. (2007). Measuring the Supply Risk Construct: An Exploratory Study. Decision Sciences Institute. Phoenix, AZ.

Sitkin, S. B. and Pablo, A. L. (1992). "Reconceptualizing the determinants of risk behaviour." Academy of Management Review **17**(1): 9-38.

Smith, D. (2005). "Business (not) as usual: crisis management, service recovery and the vulnerability of organizations." The Journal of Services Marketing **19**(5): 309-320.

Smith, K. G. and Hitt, M. (2005). Learning how to develop theory from the masters. Great Minds in Management. K. G. Smith and M. Hitt. London, Oxford: 572-588.

Sniezek, J. A., Wilkins, D. C., Wadlington, P. L. and Baumann, M. R. (2002). "Training for Crisis Decision-Making: Psychological Issues and Computer-Based Solutions." Journal of Management Information Systems **18**(4): 147-168.

Storey, J., Emberson, C., Godsell, J. and Harrison, A. (2006). "Supply chain management: Theory, practice and future challenges." International Journal of Operations & Production Management **26**(7): 754-774.

Svensson, G. (2000). "A conceptual framework for the analysis of vulnerability in supply chains." International Journal of Physical Distribution and Logistics Management **30**(9): 731.

Svensson, G. (2002). "A conceptual framework of vulnerability in firms' inbound and outbound logistics flows." International Journal of Physical Distribution and Logistics Management **32**(1/2): 110-134.

Tang, C. S. (2006a). "Perspectives in supply chain risk management." International Journal of Production Economics **103**(2): 451-488.

Tang, C. S. (2006b). "Robust strategies for mitigating supply chain disruptions." International Journal of Logistics: Research and Applications **9**(1): 33-45.

Thibault, M., Brooks, M. R. and Button, K. J. (2006). "The Response of the U.S. Maritime Industry to the New Container Security Initiatives." Transportation Journal **45**(1): 5-16.



- Tomlin, B. (2006). "On the Value of Mitigation and Contingency Strategies for Managing Supply Chain Disruption Risks." Management Science **52**(5): 639-657.
- Twelker, P. A. (2004). "The Critical Incident Technique: A Manual for Its Planning and Implementation." Retrieved March 12, 2008, from [http://www.tiu.edu/psychology/Twelker/critical\\_incident\\_technique.htm](http://www.tiu.edu/psychology/Twelker/critical_incident_technique.htm).
- Vachon, S. and Klassen, R. D. (2002). "An Exploratory Investigation of the Effects of Supply Chain Complexity on Delivery Performance." IEEE Transactions on Engineering Management **49**(3): 218-230.
- Waters, D. (2007). Supply Chain Risk Management: Vulnerability and Resilience in Logistics. Philadelphia, PA, Kogan Page.
- Working Paper (2007). "The role of strategic security." Working Paper.
- Wu, D. Y. and Katok, E. (2006). "Learning, Communication, and the Bullwhip Effect." Journal of Operations Management.
- Wu, T. and Blackhurst, J. (2005). "A modeling methodology for supply chain synthesis and disruption analysis." International Journal of Knowledge-based and Intelligent Engineering Systems **9**: 93-105.
- Wu, T., Blackhurst, J. and Chidambaram, V. (2006). "A model for inbound supply risk analysis." Computers in Industry **57**: 350-365.
- Wu, T., Blackhurst, J. and O'Grady, P. (2007). "Methodology for supply chain disruption analysis." International Journal of Production Research **45**(7): 1665-1682.
- Yin, R. K. (2003). Case Study Research: Design and Methods. Newbury Park, Sage.
- Zinn, W., Knemeyer, A. M. and Eroglu, C. (2006). "Managing the Risk of Catastrophic Events in Supply Chains." Working Paper.
- Zsidisin, G. A. (2003). "Managerial Perceptions of Supply Risk." Journal of Supply Chain Management **39**(1): 14-25.
- Zsidisin, G. A. and Ellram, L. M. (2003). "An Agency Theory Investigation of Supply Risk Management." Journal of Supply Chain Management **39**(3): 15-27.
- Zsidisin, G. A., Ellram, L. M., Carter, J. R. and Cavinato, J. L. (2004). "An analysis of supply risk assessment techniques." International Journal of Physical Distribution and Logistics Management **34**(5): 397-413.

Zsidisin, G. A., Melnyk, S. A. and Ragatz, G. L. (2005). "An institutional theory perspective of business continuity planning for purchasing and supply management." International Journal of Production Research **43**(16): 3401-3420.

Zsidisin, G. A. and Smith, M. E. (2005). "Managing Supply Risk with Early Supplier Involvement: A Case Study and Research Propositions." Journal of Supply Chain Management **41**(4): 44-57.