

Interpreting Resiliency: An Examination of the Use of Resiliency Strategies within
the Supply Chain and Consequences for the Freight Transportation System

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Abstract

**Interpreting Resiliency: An Examination of the Use of Resiliency Strategies within
the Supply Chain and Consequences for the Freight Transportation System**

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With increases in trade volumes, lengthening of supply chains due to globalization, and an increased focus on disruptions, transportation resiliency is an issue of concern within the supply chain community. Resiliency is formally defined as the ability to recover from or adjust easily to change or disruption. For this research, and within the supply chain community, resiliency also includes the ability to avoid disruptions. This research explores and evaluates resiliency efforts currently being used by importing enterprises, focusing on goods movement within the supply chain.

Through a series of interviews with personnel responsible for transportation and supply chain operations, information was gathered to understand how enterprises are attempting to improve resiliency within their supply chain in the face of increasing risks. Fifteen resiliency strategies were identified which result reduced exposure to supply chain disruptions and/or mitigate disruption impacts. This research provides a summary of existing strategies, but also presents a framework for discussing resilience in terms of enabler strategies and strategic resiliency strategies. Both enabler and strategic resiliency strategies result in the reduction of exposure to supply chain disruptions and/or the mitigation of disruption impacts. Understanding the implications of employing various resiliency strategies can assist companies in making strategic decisions which are in the best interest of a resilient and successful supply chain. The strategies used by a given company are often a reflection of the company's current exposure to risk, and therefore experience with resiliency. For example, companies with existing supply uncertainty have already implemented resiliency strategies to mitigate the impact of sourcing difficulty. The research also discusses how knowledge of these strategies can assist freight transportation system planners, designers, and managers in improving transportation system resilience for the benefit of all users.

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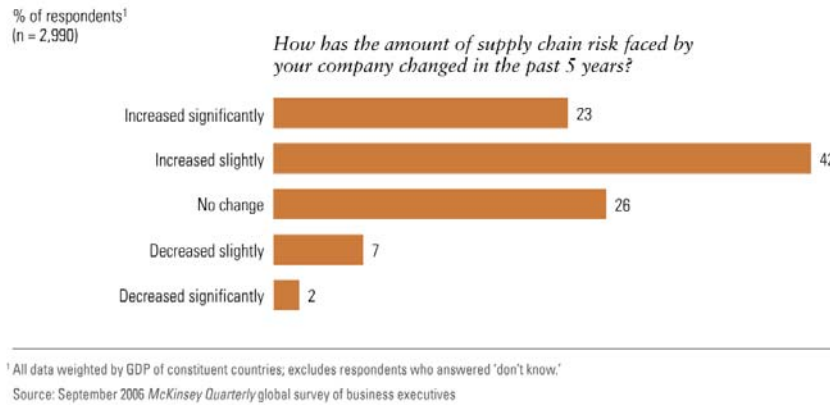
1 Introduction

As global trade volumes continue to increase and supply chains lengthen, enterprises in all sectors of the economy are facing increased likelihoods of supply chain disruptions. Vulnerabilities exist in every segment of the supply chain, including the transportation network. Recent events, such as September 11th, the West Coast ports lockout, and Hurricanes Katrina and Rita, have highlighted the potential for transportation disruption within supply chains, and the consequences of being unprepared. With the increased focus on disruptions and the continued desire to reduce cost, resiliency has become an issue of concern within the supply chain community.

Resiliency is defined as “an ability to recover from or adjust easily to misfortune or change” (Merriam-Webster 2008). Within the supply chain community, resiliency also includes the ability to avoid or reduce exposure to disruptions. For the purposes of this research, a **resiliency strategy** is defined as a tactic used to reduce the occurrence of or mitigate the effects of disruptions, allowing a supply chain to maintain or return to normal operating conditions. These concepts and definitions, as well as other terms used often within this research, will be covered in more detail within Section 4.

A growing, global economy means increased exposure to risk and potential for disruption within the supply chain. As more goods are moved, there are more opportunities for disruptions to occur. International trade is projected to grow with the values of U.S. imports and exports forecasted to increase from the equivalent of 28% of the U.S. Gross Domestic Product (GDP) in 2006 to 37% by 2015 and to 60% by 2030 (Cambridge Systematics 2008). Additionally, growth in nations such as China and India, who are predicted to be the world’s first and third largest economies (respectively) by 2050, will mean increased exports from these countries as well as an increased consumer population demanding imports (American Association of State Highway and Transportation Officials 2007).

There is evidence of an increased risk, or at least an increased perception of risk, faced by supply chains, which often leads to increased action to mitigate risk. According to a 2006 survey by *The McKinsey Quarterly* of 3,172 worldwide executives spanning a broad range of industries, nearly 2/3s reported to be facing “increasing risks to their ability to supply their customers with goods and services cost effectively.” Many of these executives believe that supply chain risk is increasing, as seen in Figure 1-1. Additionally, many of these executives also believe their enterprises are currently doing a relatively poor job of mitigating supply chain risks (Muthukrishnan and Schulman 2006).



**Figure 1-1: Executive Response to Changing Supply Chain Risk
(Muthukrishnan and Schulman 2006)**

Supply chain disruptions, especially small ones, are inevitable and often unavoidable. If resiliency plans are not incorporated into supply chain operations, the consequences include unreliable and unpredictable deliveries, and increased costs. In the current competitive environment, individual enterprises, or business firms, may be at risk to lose market share to other enterprises that are more prepared.

1.1 Importance of Resiliency

Resiliency within supply chains is not a new concept for importing enterprises, but recent trends in trade and supply chain operations have made resiliency more important, especially when considering transportation disruptions. Supply chains are becoming more complex as they are lengthened and leaned, and most supply chains are a dynamic network that is ever-changing (Christopher and Peck 2004). Global supply chains mean longer transport distances and more participants, which leads to more opportunities for disruptions (Sheffi 2005). For example, when sourcing or labor moves abroad, another mode of transportation, either water or air, is often introduced to the supply chain, and the length of the supply chain is increased, introducing new potentials for disruption. Also, disruptions abroad now have as much capacity to effect supply chains as domestic disruptions. New languages, currency, and cultural traditions add complexity to supply chain operations. In addition, customs and security regulations must be met to move goods into or out of the country. These factors associated with lengthening the supply chain lead to an increased potential of disruptions to the goods movement system.

Lean operations, instituted as a means of reducing logistics cost, leave little slack in the system to handle unforeseen problems. In a lean system there is less safety stock to cope with disruptions and a minor disruption has the potential of shutting down the entire supply chain (Sheffi 2005). Enterprises which operate on a Just-in-Time (JIT) strategy, where supplies or components arrive at the exact time they are needed instead of being held in inventory, are also extremely vulnerable to transportation disruptions. For example, when trucks carrying vital components were delayed at the borders following the September 11th attacks, the Ford Motor Company had to halt production along several assembly lines. Because the Ford Motor Company was operating on such tight margins, they could not rebound when border delays resulted in late components, and, as a result, could not meet production targets (Sheffi 2005).

With increasing of global competition, profit margins are reduced and lean operations are required to compete. However, this leaves enterprises exposed to disruptions. This is especially true in a commodity market and resiliency frequently becomes a competitive advantage (Sheffi 2005). One often used example, by Sheffi and others, of resiliency providing a competitive advantage is that of the fire at the Phillips semiconductor plant in 2000 which affected the production of a critical component used to manufacture cellphones. The plant was a major supplier to two large enterprises, Nokia and Erikson, who reacted to the situation in different ways. Nokia was proactive in securing alternative suppliers and in the six months following the disruption increased their market share. Erikson reacted in a less urgent manner and was unable to obtain replacement components. Ultimately, Erikson's failure to react to the disruption in a timely matter and the lack of resiliency in their supply chain resulted in their eventual departure from the market. The resiliency within Nokia's supply chain provided the enterprise with a competitive advantage when a disruption affected both their and their competitor's operations.

In recent years several high-profile disruptions have occurred. The largest of these, September 11th, halted air traffic, closed borders, and dramatically increased public awareness of terrorist disruptions. September 11th also contributed to a significant economic downturn. Smaller disruptions, such as the West Coast Port Lockout in 2002, provided insight into the consequences of numerous, simultaneous port closures. Events such as these have resulted in an increased awareness of the likelihood and the potential impacts of disruptions, and have ultimately increased the focus on resiliency within supply chains.

1.2 Objectives

This research structures the discussion of resiliency and provides a common language with which to discuss the concept. The research also aims to understand how enterprises are attempting to improve the resiliency within their supply chain in the face of increasing risks. Questions which this research addresses include:

1. How do enterprises perceive resiliency?
2. What resiliency strategies, with respect to goods movement, are enterprises currently using?
3. How do these enterprises perceive that these strategies are improving resiliency?
4. How successful are these strategies at making supply chains more resilient?
5. What relationships exist among resiliency strategies?
6. How do strategies used relate to an enterprise's current operating conditions?
7. How does enterprise resiliency relate to transportation system resiliency?

1.3 Contribution

In the existing literature, resiliency is often discussed in nebulous terms, typically focusing on the overall concept of resiliency, past resiliency successes and failures, and generalized frameworks and flowcharts. Absent is the discussion of how enterprises are currently integrating resiliency strategies into supply chain and goods movement policies. This research explores and evaluates resiliency efforts, focusing on the goods movement within the supply chain, currently being used in practice by importing enterprises. Additionally, the information gathered in this research may be utilized to improve resiliency within freight transportation systems.

This research presents a framework for discussing resiliency in terms of enabler and resiliency strategies. Enabler strategies, which enable an enterprise to improve resiliency, are the nebulous concepts often associated with resiliency such as flexibility and communication. The resiliency strategies are specific actions that can have a measurable impact on an enterprise's ability to tolerate disruptions. Understanding the implications of employing various resiliency strategies can assist enterprises in making strategic decisions which are in the best interest of a resilient and successful supply chain. Relationships between the strategies are revealed, highlighting the importance of enablers as a means of promoting the success of many other reported resiliency strategies. Also explored is the idea that the strategies used by a given enterprise are often a reflection of the enterprise's current exposure to risk, and experience with resiliency is often due to circumstances

other than a desire to improve resiliency. Examination of resiliency strategies as a means to reduce exposure to supply chain disruptions has shown that the use of these strategies helps spread the risk of disruptions, either geographically, temporally, or across personnel. In addition to improving resiliency, many identified strategies can provide an added value to supply chains, improving operations and efficiency on a daily basis. Additionally, the information gathered in this research may be utilized to improve resiliency within freight transportation systems as the enterprise and its behavior are key elements of the transportation system.

2 Literature Review

Literature regarding the management of supply chain disruptions has become increasingly more prevalent as the threat of disruptions has become more visible. Sources of information on the topic either take a widespread approach to examining supply chain resiliency, or focus on narrow topics such as supply and demand, developing relationships, physical and digital security, or organizational culture.

2.1 Supply Chain Resiliency

Sheffi's book, *The Resilient Enterprise* (2005), is a comprehensive overview of the changing focus of supply chains in a post-September 11th world. He explains the importance of resiliency in the wake of increasing disruptions and explores potential vulnerabilities in supply chains. Sheffi introduces ways to decrease vulnerability and increase flexibility (as a means of increasing resiliency) through improved supplier relationships, communication, collaborative security efforts, and flexible production operations. The book highlights the importance of creating a resilient supply chain to sustain a competitive advantage in the global business economy.

Pickett (2003) examined numerous past disruptions, including earthquakes, hurricanes, floods, accidents, labor strikes, and terrorist attacks, to understand the impact they had on supply chains. The study of these past events yielded lessons regarding preparation and reactions to future disruptions. Pickett's work includes several case studies of transportation/distribution disruptions due to events such as labor strikes and terrorist attacks. Based on the examination of past events, Pickett provides recommendations to strengthen supply chains, minimize disruptions, and maximize resiliency, including building a resilient culture, understanding the risks to sole-sourcing, using buffer stock, implementing enterprise standards, and insuring wisely.

Christopher and Peck (2004) note that research efforts into supply chain vulnerability were initiated in the United Kingdom prior to the United States' deep interest in the area after September 11th. Disruptions such as the UK fuel protests in September of 2000 and the Foot and Mouth Disease outbreak in February, 2001 led to an increased interest in the subject. Their work examines supply chain risks, classifying risks into five categories: process risks and controls risks (both internal to individual enterprises), demand risks and supply risks (external to individual enterprises but internal to

the supply chain), and environmental risks (external to the supply chain). Christopher and Peck also suggest ways to create a resilient supply chain through supply chain risk management efforts such as re-engineering the supply chain to value resiliency, increasing collaboration between supply chain partners, focusing on agility, and developing a culture which embraces the risk management concept.

2.2 Supply and Demand Disruptions

Focusing on two of the five categories of risk mentioned above, supply and demand disruptions, Snyder and Shen (2006) discuss managing disruptions to multi-location supply chain systems. They suggest that while the underlying issue with both supply uncertainty and demand uncertainty is having too little supply to meet demand, there are significant differences between the two uncertainties and they should not be treated in the same manner. Typically both supply and demand uncertainties are present in a supply chain. The optimal disruption management strategies take into account both types of uncertainties and their interaction.

Work by Hopp and Yin (2006) includes the development of an analytical model to reduce the risk of “catastrophic” supply failures by balancing the cost of inventory and capacity protection to the cost of lost sales. An article by Tomlin (2006) looks at supply uncertainty using a mitigation and contingency framework to evaluate supply-side tactics such as sourcing mitigation, inventory mitigation, and contingency rerouting.

2.3 External Disruptions

Shifting to external disruptions, Kleindorfer and Saad (2005) developed a framework to identify sources of, assess, and mitigate external risk, such as natural disasters, economic disruptions or terrorist activity. The four main principles of the framework include identifying the nature of the risk, quantifying the risk, selection of a mitigation approach that is appropriate for the characteristics of the supply chain, and development of suitable policies and actions to contribute to on-going risk assessment. The framework is supported by examining empirical data from the chemical industry.

Rice and Caniato (2003), with The Supply Chain Response to Terrorism Project at MIT’s Center for Transportation and Logistics, focus on disruptions at all levels of the supply chain due to terrorist activities and governmental responses due to these potential threats. Through a series of interviews with firms in the United States, the report details corporate risk assessment and corporate response

to recent terror activities, namely September 11th. Firms indicated resiliency measures adopted to address potential disruptions in key failure modes, including a failure through transportation.

Resiliency tactics named include: multiple/secondary transportation modes, spot markets, collaboration with logistics providers, use of multiple distribution centers, and direct shipment.

Sarathy (2006) also looks at security and the supply chain, discussing security related risks in all levels of the supply chain from the goods themselves, facilities such as factories and warehouses, freight carriers, people, and information. He discusses governmental safety regulations, the connection between security and technology, and general suggestions for action to improve supply chain security.

There is also literature devoted to very specific aspects of security such as the Customs-Trade Partnership Against Terrorism (C-TPAT). Bakshi and Gans (2007) explore the trade-offs between the cost of firm compliance and the reduction of inspections and congestion at ports due to membership, as well as the trade-off between increased security due to increased inspections and the resulting port congestion and additional infrastructure costs.

2.4 Resilient Culture

Additionally, first mentioned in Sheffi's work, Benson (2005) specifically discusses the importance of organizational culture in resilient supply chains. Similar to this research, Benson's study consisted of interviews, but of security officials at enterprises in varying industries. Focusing on work infrastructure and practices, human resources practices, education, communication, and measurement systems, her research examines enterprise policies and how this impacts security and resiliency of supply chains. From the information collected in the interviews, Benson discusses the key attributes of supply chain security culture success. She concludes that enterprises can improve supply chain security and resiliency by implementing the key factors, with regards to culture, in the context of their own supply chains.

2.5 Network Structure

Finally, research exists regarding network structure and the impact of disruption on cost and flow over the network. Latora and Marchiori (2005) discuss a method of finding the critical components of an infrastructure network. These critical nodes and the links, which are fundamental to the perfect

functioning of the network, are the most important to protect from disruptions such as terrorist attacks. Snyder et al. (2006) discuss models for planning supply chain networks which are resilient to disruption. These models attempt to allow supply chain infrastructure to be designed to operate efficiently and at low-cost both during times of normal and disrupted operations.

2.6 The Value of Resiliency

According to Sheffi, quantifying the importance of resiliency is difficult. Because the range of disruption situations is endless and it is difficult to calculate costs avoided, there is no simple way to give value to resiliency efforts. Resiliency efforts also often provide secondary benefits to the enterprise and supply chain such as an increased ability to react to changing markets and supply/demand volatility, which are also difficult to quantify. Flexible operations, common in resilient supply chains, often lead to increased sales, reduced costs, and increased competitive advantage (Sheffi 2005).

Although it is difficult to obtain exact figures, there is evidence of the magnitude of economic costs associated with supply chain disruptions when examining past events. The West Coast Ports Lockout in the fall of 2002 was estimated to cause \$1 billion to \$2 billion of economic damages a day. The ten day lockout also resulted in a month long backlog of goods at the affected ports (Wian 2002). The SQL Slammer Virus, which infected almost 750,000 computers in just ten minutes in 2003, is estimated to have caused economic impacts within the range of \$750 million to \$1.2 billion (Sheffi 2005). Hurricanes Katrina and Rita were estimated to have caused losses of physical capital totaling between \$70 billion and \$130 billion (U.S. House of Representatives 2005).

The Center for Risk and Economic Analysis of Terrorism Events at the University of Southern California has studied the effects of a dirty bomb attack on the Ports of Los Angeles and Long Beach. This study attaches quantitative data to the impacts of a terrorist attack at the nation's busiest ports. The study identifies three shutdown scenarios: a short shutdown lasting fifteen days, a medium shutdown lasting 120 days, and a long shutdown lasting up to one year. With economic losses estimated at \$300 million, a small shutdown would result in a relatively small impact because ships would wait out the disruption and businesses could be supplied through other ports. Longer shutdowns would result in more serious impacts because of delays in delivering goods and economic "ripple effects" such as job losses and company closures. A medium shutdown would result in economic losses of \$63 billion, and a large shutdown, \$252 billion (Rosoff and von Winterfeldt 2007). With these ports importing

approximately \$305 billion worth of goods in 2006 (Bureau of Transportation Statistics 2008), the magnitude of these losses is significant.

2.7 Literature Gap

Despite the extensive amount of literature available on topics related to supply chain disruptions and resiliency, there is a gap in the literature addressing resiliency strategies commonly used in practice. Previous literature has suggested strategies which enterprises could implement to improve resiliency, while this research identifies strategies currently being using. Resiliency strategies have not been examined to determine utilization, success, or efficiency. Previous literature has not explored the relationships between strategies and within industry sectors. Additionally, this research focuses on primarily transportation related disruptions to the supply chain.

In the past, resiliency has been discussed in nebulous terms, typically focusing on the overall concept of resiliency, past resiliency successes and failures, and generalized frameworks and flowcharts to help assess risk and mitigate for it. Absent is the discussion of how enterprises perceive resiliency and by what methods are they currently integrating resiliency strategies into supply chain and goods movement policies. This research explores and evaluates resiliency efforts, focusing on the goods movement within the supply chain, currently being used in practice by importing enterprises. Additionally, the information gathered in this research may be utilized to improve resiliency within freight transportation systems.

3 Methodology

The following methodology was used to gather and interpret data regarding use of resiliency strategies by business enterprises.

3.1 Data Sources

Data, or information, collected for this thesis was gathered through eleven informational interviews conducted with personnel responsible for transportation activities and operations in enterprises spanning a broad range of industries. Industries represented include: chemical, retail, food and beverage, and manufacturing. In addition to being responsible for daily supply chain and transportation operations, many interviewees also take part in strategic decision making regarding the transportation system of their enterprise's supply chain. Interviews were conducted in person, or over the phone, and typically lasted 60 minutes. In many cases, additional questions asked after the initial interviews were asked over the phone or via email.

As required by the University of Washington Human Studies Division, confidentiality of the interviewees and enterprises represented was maintained by generalizing key attributes of each enterprise. Throughout this thesis, enterprises are referred to as Enterprise A through Enterprise K, as seen in Table 3-1, which provides information on the enterprises interviewed in this study.

Table 3-1: Enterprise Descriptions

Enterprise	Industry*	Annual Sales Range (\$ billion)*	Goods Value	Perishability	Leanness	Use of Technology
A	Retail	1-10	Low/Mid	Mid	Mid	Mid
B	Retail	50-100	Low	Mid	Mid	Mid
C	Retail	1-10	Low/Mid	Mid	Low	Low
D	Retail	50-100	Low/Mid	Mid	Mid	Mid
E	Food/Beverage	1-10	Low	High	Mid	Mid
F	Food/Beverage	Not Available	Low	High	Mid	Mid
G	Chemical	0.1-0.5	Mid/High	Mid	Mid	High
H	Manufacturing	10-50	High	Low	High	High
I	Manufacturing	50-100	High	Low	High	Mid
J	Manufacturing	Not Available	Mid/High	Low	Mid	Mid
K	Manufacturing	0.1-0.5	Mid/High	Low	High	Mid

*Source: Hoovers, Inc.

Enterprises interviewed were characterized by six key attributes. Industry sectors were generalized as Chemical, Retail, Food and Beverage, and Manufacturing. Enterprises such as Enterprise D and Enterprise E operate in multiple industry sectors with the dominate sector listed in the above table. Industry sector and annual sales information was gathered from Hoovers, Inc. (<http://premium.hoovers.com>). The four remaining attributes reflect characteristics of enterprises, such as goods value, perishability (shelf-life) of goods sold by enterprises, leanness of supply chain, and use of technology within the supply chain. Characteristics of goods value and leanness of supply chains relates to an enterprises ability and willingness to hold inventory. The perishability of goods gives a sense of the importance of on-time deliveries. Relative values of attributes were based on information gathered both directly and indirectly from interviews and assigned by the author.

Enterprises local to, or with large facilities in, the Puget Sound were chosen to participate in the research due to their accessibility. Many enterprises interviewed had prior contact with the University of Washington's Civil and Environmental Engineering Department and/or the Global Trade, Transportation and Logistics program. Communication with potential interview candidates was established via these contact networks. Potential interview candidates were contacted via email to explain the nature of the project and to request an interview with either the initial contact or a more appropriate employee.

The information gathered for this research reflects a slight Northwest-centric view because all personnel interviewed are employed within the Pacific Northwest, but the local nature of the enterprises interviewed is not deemed significant to the results of the investigation. While the type and likelihood of disruption vary by location or geographic region, the disruptions themselves are unpredictable and successful resiliency strategies prepare a supply chain to react to any disruption as opposed to specific disruptions. With the exception of Enterprise F, all enterprises interviewed have a nationwide or international presence. Additionally, with the exception of Enterprise B, all enterprises interviewed are headquartered in the region and personnel interviewed are familiar with company-wide strategies. The discussions regarding resiliency during interviews focused on a national company-wide strategies and operations, and many of the resiliency strategies examined in this research are effective independent of geographic region. The nature of the strategies examined and the conclusions drawn from the interviews are independent of the fact that these enterprises have facilities located in the Pacific Northwest, and instead are more indicative of nationwide strategies.

3.2 Research Methods

Two rounds of exploratory interviews were conducted in this study. The first round of eight interviews consisted of a general discussion and twenty-one questions related to current priorities, the role of resiliency and reliability, and future challenges. The interviews were semi structured and all twenty-one questions were not necessarily asked of each interviewee. Additional questions were asked to clarify, elaborate, or engage further discussion, as necessary. Questions asked in the first round of interviews were used to refine the focus of this research and some of the questions asked in these interviews do not pertain to the final scope of this paper.

The second round of interviews were conducted in the same manner as the first round and consisted of three interviews of thirteen questions. The questions were related to transportation priorities, vulnerabilities, and supply chain resiliencies. Some questions from the first round of interviews were included in the second round. Selected questions from the second round of interviews were also asked of enterprises who participated in the first round via email. Both the first and second round interview questionnaires are provided in Appendix A.

Interviewees were contacted a final time, via email, and asked to select, off of a list of resiliency strategies compiled from interviews, the strategies which their enterprise engaged in. This was the only occasion where enterprises were asked directly about the strategies utilized. Not all enterprises responded to final request for information. The email sent to interviewees is also located in Appendix A.

Upon completion of the interviews, information gathered was reviewed and summarized. Section 5 relays information gathered from the interviews on key topics such as priorities, vulnerabilities, resiliencies, and disruption handling procedures. Section 6 describes the resiliency strategies extracted from the interviews and provides insight into the effectiveness of strategies. Section 7 explores risk management and decision analysis. Section 8 attempts to rank both strategies and enterprises according to their resiliency. Section 9 discusses the value of and relationships amongst strategies, as well as conclusion regarding spreading of risk, current operating environments, the added value of strategies, and resiliency as a nebulous concept. Finally, Section 10 explores to connection between enterprise and transportation system resiliency.

3.3 Limitations of Data Use

This research examines the current state of supply chain resiliency strategies from the prospective of enterprises making decisions regarding the movement of goods. The qualitative data collected during the above-mentioned interviews provides insight into the resiliency strategies being used by interviewed enterprises but does not provide a basis to make universal conclusions on supply chain resiliency. Despite this, the data presented is useful in understanding the response of enterprises to an increased interest in supply chain disruptions and resiliency.

Additionally, this research focused on an enterprise's perception of their resiliency in addition to their actual level of resiliency; therefore interviewees were not asked directly which resiliency strategies they did or did not employ. In some instances what an interviewee did not say provides valuable insight, such as into their level of resiliency experience. The information both provided and absent from interviews was used to draw conclusions about enterprise resiliency. This thesis does not attempt to document the entire set of strategies used across all enterprises engaged in the movement of goods, or their frequency of use, which would require a more comprehensive sample, but are interested in enterprise perceptions of effective resiliency strategies, the relationships between resiliency strategies and enabler strategies, and the relationship between resiliency strategies and other enterprise operating conditions.

Limitations of the data include:

1. A limited number of interviews which constrain the scope of results and prevent statistical analysis.
2. Interviews which reflect a Northwest-centric view.
3. Interviewees not openly asked if they engaged in specific resiliency strategies.

3.4 Human Subjects Certification

Due to the nature of data collection and per University of Washington Human Subjects Division policy, this research methodology was reviewed and granted Certification of Exemption #07-8449-X/C. Based on the Human Subjects Division's interpretation of the federal regulations, all interviewee identification must remain confidential and research involving audiotaped or videotaped procedures is prohibited.

4 Definitions

4.1 Supply Chain

As defined by Christopher and Peck (2004), a supply chain is “the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer.” Resiliency strategies may be utilized at most points along the supply chain, but this research focuses on resiliency within the goods movement segment of the supply chain. Transportation plays an integral part of the supply chain, serving as the link between nodes such as suppliers, ports, handling and distribution centers, and destinations.

4.2 Disruption

The term disruption is used extensively within this research and is defined as follows:

Disruption: an event which has the potential to cause an undesirable impact to the goods movement within a supply chain.

Supply chain disruptions can be divided into three main categories: natural disasters, accidents, and intentional attacks. Natural disasters include events such as earthquakes and hurricanes. Accidents include incidents such as fires or equipment failures. Intentional attacks include terrorism, sabotage, computer hacking and labor issues (Sheffi 2005). This research focuses on disruptions which will impact the transportation segment of the supply chain. Within this research, disruptions are considered temporary events.

4.3 Resiliency

As stated earlier, resiliency is defined as “an ability to recover from or adjust easily to misfortune or change” (Merriam-Webster 2008). Within the supply chain community, resiliency also includes the ability to avoid disruptions. For the purposes of this research, resiliency is defined as follows:

Resiliency: the ability of an enterprise to avoid or recover from a change or disruption to their supply chain, maintaining or returning to normal operating conditions.

4.4 Resiliency Strategy

This research focuses on the resiliency strategies employed by enterprises to reduce their exposure to or mitigate the impacts of disruptions to the supply chain. For the purposes of this research, resiliency strategy is defined as follows:

Resiliency Strategy: a tactic used to reduce the occurrence or mitigate the effects of disruptions, allowing a supply chain to maintain or return to normal operating conditions.

4.4.1 *Previously Suggested Resiliency Strategies*

Prior research on supply chain resiliency has offered numerous strategies to improve resiliency. Most of the literature suggests strategies which are valid but vague with regards to implementation. Strategies suggested include employing redundancy and flexibility, re-engineering the supply chain, creating a flexible culture, collaboration, and developing strong relationships.

Fundamentally, resiliency can be achieved through **redundancy**, although this strategy is considered expensive and inefficient. Redundancy involves maintaining excess capacity in anticipation of future demand. The most basic form of redundancy is through safety stock, but holding inventory ties up capital and requires managing. Holding large amounts of inventory is the opposite of what many enterprises are trying to achieve in order to develop a lean supply chain. Additionally, having extra inventory often masks other inefficiencies and does not encourage enterprises to examine and modify operational and logistical problems. Despite this, having the capacity to hold extra inventory can be useful in cases where an enterprise can foresee a disruption and can plan ahead to build inventory (Sheffi 2005). Redundancy also includes strategies such as maintaining a dedicated transportation fleet which may not always be fully utilized. (Rice and Caniato 2003).

Creating **flexibility** is a more efficient way to achieve resiliency. Flexibility consists of “creating capabilities” by restructuring existing capacities within a supply chain (Rice and Caniato 2003).

Resiliency through flexibility is more difficult to develop because it may involve fundamental changes to the enterprise. In addition, suppliers/carriers and relationships with them must also be flexible. Flexibility can be incorporated into contracts, provisions for last minute changes, and delivery options (Sheffi 2005). The recommendations given to achieve resiliency through flexibility are vague and provide enterprises with little more than general guiding principles on achieving resiliency. One reason for this may be that the resiliency needs of supply chains vary dramatically between enterprises and rarely do specific strategies universally improve resiliency to all supply chains. Similar to flexibility is the concept of creating an **agile supply chain** to respond quickly to sudden changes (Christopher and Peck 2004).

Another suggestion to improve resiliency is to **re-engineer the supply chain**. This suggestion is rather vague, but according to Christopher and Peck (2004) supply chain re-engineering includes identifying pinch points and critical paths, understanding suppliers' risks, choosing strategies with multiple options, and re-evaluating the efficiency versus redundancy quandary. While these suggestions are relevant to the topic of supply chain resiliency and do place attention on valid concerns, they do little to suggest actual approaches to be used.

A corporate **culture** which understands and encourages resiliency within the supply chain is believed to be more resilient than one which does not. Corporate culture describes the way business and decision-making is conducted within an enterprise. Resilient, or flexible, culture often consists of questioning prevailing wisdom and conventional business practices. Resilient cultures engage and encourage employees to take part in resiliency efforts (Sheffi 2005).

Collaboration with other members of the supply chain improves knowledge of the current state of the supply chain. Collaboration is important because resiliency is best achieved at the network, not enterprise, level. The major benefit of collaboration is the exchange of knowledge which decreases the uncertainty within the supply chain. Collaboration is useful at both strategic and operational levels (Christopher and Peck 2004), and could also be described simply as communication. Having **information** about an impending or current disruption allows an enterprise to react to avoid or mitigate for the disruption.

In addition to benefiting from information-sharing with partners, resiliency can also be achieved by forming **strong relationships** with partners. Relationships may help guarantee continued service in the wake of a disruption (Rice and Caniato 2003). Partners are more likely to supply aid to one another when there is a strong history or a need to solidify future business between enterprises. Building

strong relationships requires time, and often this time is focused on one partner, at the expense of building multiple relationship (Sheffi 2005).

Using **multiple distribution centers** to increase flexibility is another suggestion for increased resiliency. Having more distribution centers within a network provides opportunities to shift products in order to avoid disruptions within the distribution network. Negative aspects of this strategy include increased transportation costs and longer lead times (Rice and Caniato 2003).

Other resiliency strategies include **decentralization** of the supply chain in order to decrease risks associated with having all capabilities centralized along one link or node of the supply chain (Pickett 2003), and having **contingency plans** ready to put into action should they be needed (Knowledge@Wharton 2006). Assuming adequate capacity, the use of **spot markets** for transportation needs, where transportation services are purchased and utilized immediately, is another recommended strategy, despite paying a premium for the service (Rice and Caniato 2003).

This research examines how enterprises are currently implementing the abovementioned strategies, as well as others, in an effort to improve resiliency. By focusing on tangible actions instead of solely on general concepts, strategies can be evaluated on their ability to improve resiliency, as well as provide a means of exploring relationships amongst strategies and between strategies and enterprises. This research presents a framework for discussing and evaluating resiliency in more concrete terms.

5 Interview Responses

As previously mentioned, personnel at eleven enterprises were interviewed to gather information about the role of resiliency within enterprises. Discussions included the topics of resiliency, vulnerabilities, disruptions, and disruption procedures. A summary of responses generated regarding these topics is provided below. The interviews were designed to capture the issues forefront in the respondent's mind and therefore were exploratory in nature. Not all topics were discussed within each interview. Complete notes from the interviews are located in Appendix B. As stated previously, per University of Washington Human Subjects Division policy, audiotaping of interviews was prohibited. Notes from interviews, and subsequent discussions of responses, are paraphrased accounts of the interviews. The topics discussed below represent general themes in supply chain resiliency. The following, along with additional information discussed in the interviews, was utilized to identify and understand resiliency strategies currently used by enterprises. Information can be gained both from what the respondents said, and what they did not say, in their interviews. Further interpretation of interview responses occurs in Section 6.

5.1 Definition of Resiliency

Interview participants were asked to define resiliency in order to understand their perception of the term. Many interviewees provided what could be considered a dictionary definition of the term. Enterprise A described resiliency as being able to respond most efficiently to unforeseen issues and return to normal conditions. Enterprise B replied that resiliency was being as seamless as possible and finding a way around problems. Enterprise D defined resiliency as being able to adapt to change and to be flexible. Enterprise G defined resiliency as the ability to have constant service. Enterprise H responded that resiliencies are abilities to react if things are not going right, and specifically resiliency is how you recover without excessive cost. Enterprise K defined resiliency as the ability to respond to changes.

Other enterprises provided specific examples of resiliency within their supply chain. Enterprise C did not define resiliency and instead responded that they did not have much resiliency in their supply chain, but if needed could potentially manipulate their sourcing or use excess distribution space to improve resiliency. Enterprise F responded that they expect disruptions within their supply chain and want to act quickly to work out problems. They aim to not be overwhelmed by emotions, deal with

accurate information, and plan for the worst at the beginning. In a general sense, Enterprise F defined resiliency as getting back to normal.

Enterprise E, Enterprise I, and Enterprise J were not asked to provide definitions for resiliency.

The interviewed enterprises overall understanding of the concept of resiliency is in agreement with the definition provided earlier in Section 4.

5.2 Transportation Priorities

By gaining insight into an enterprise's transportation priorities, one can better understand an enterprise's decision making with regards to transportation strategies. Interviewees were asked about their enterprise's current transportation priorities, how they may have changed in recent years, and what was being done to meet these priorities. While resiliency was not directly mentioned as a priority by the respondents, many of the priorities mentioned are related to or dependant on resiliency.

Enterprise A's top transportation priority is on-time delivery. They consider their merchandise perishable and require goods to be at stores when and where consumers want it.

Enterprise B's priority list is extensive and includes issues such as creating a consolidated computer system for domestic transportation management, improving truck tracking for Enterprise B-owned trucks which travel from distribution centers to stores, and developing processes and systems to manage currently outsourced perishable good distributions. In addition, Enterprise B also is working to standardize process and system logistics and develop a "best practices" structure to be incorporated into operating procedures nationwide.

Enterprise C indicated that their transportation priorities included "everything," but are specified concerned with inbound freight consolidation, especially in the wake of opening a second distribution center. To meet the priorities of this fast growing enterprise, the position of Director of Global Supply Chain was created and a process improvement team has used "opportunity exploration" to look at new ways to improve the supply chain. Among other initiatives, the team is working to develop both international and national visibility tools.

Enterprise D's transportation priorities include reducing cost, having on-time service, and maximizing space within containers to move more product per load, this moving less overall loads. To meet priorities, Enterprise D is working to improve transportation system visibility, as well as technology use.

Enterprise E's transportation priorities vary by sector of business. With concern to retail goods, inventory availability is a top priority. Low cost and predictability are priorities for Enterprise E's perishable goods. Ultimately, all priorities strive to provide a supply chain which serves the customer. Due to the fast-paced growth of Enterprise E, the enterprise is focusing on scale and flexibility to meet transportation priorities. Specifically, Enterprise E is building flexible infrastructure into the enterprise and requiring flexibility from outside partners. Additionally, Enterprise E is moving day-to-day transportation operations and decisions into regional offices where there is local knowledge, and focusing on strategic decisions at the corporate level.

The transportation priorities of Enterprise F consist of being able to provide manufacturing centers with the components necessary to produce the finished product, and then getting the finished products to the customer in one piece at one time. These priorities and the way Enterprise F attempts to meet these priorities, have changed after a recent windstorm left many of their facilities without power for one week. This disruption was the impetus for development of an emergency operations team to specifically handle production and supply chain disruptions.

Enterprise G named reliability as a top transportation priority. Enterprise G uses outside vendors for all transportation needs. They require transportation vendors to be process-orientated and have processes in place that meet Enterprise G's standards, as well as have their own resiliencies. They also want vendors who are culturally aligned with Enterprise G's culture, specifically vendors who are focused on technology.

Enterprise H's top priority is service when considering outbound goods. Price, in addition to service, is also a top priority for inbound goods. To provide the expected level of service, Enterprise H has strategically located their distribution centers to be within overnight ground service to all their dealers.

The top transportation priority for Enterprise I is to successfully utilize scheduled transportation in order to reduce the need for expediting. While it is not possible to completely eliminate the need for expediting, most often due to supplier issues, Enterprise I aims to reduce carrier related issues.

Enterprise J's priority is customer service. In an industry where time is money, almost all of the products provided by Enterprise J are moved by air. The intention is to get goods to a customer in 24

hours. In a post-September 11th world, proximity to the airport has become more important with increased security.

Enterprise K identified cost as their top priority with other important priorities being safety and reliability. Safety includes both getting people and goods in and out of the facility safely, and transportation safety. In order to meet the recent priority focus on cost, Enterprise K is in the process of opening new manufacturing facilities overseas. Additionally, Enterprise K is working to improve logistics and make smarter choices regarding suppliers, such as leveraging buying power.

Many enterprises identified improving the efficiency of logistics, through means such as freight consolidation, improved utilization of scheduled transportation, on-time deliveries, and improved visibility, as a priority. Efficient logistical operations result in other common priorities of customer service and cost. While resiliency was not mentioned as a top priority, one typical byproduct of a resilient supply chain is increased operational efficiency.

5.3 Current Vulnerabilities

Vulnerabilities are inevitable in all supply chains, but an enterprise's ability to identify vulnerabilities can improve reactions to disruptions. Questions pertaining to vulnerabilities included asking what makes their enterprise's transportation vulnerable, and are specific actions are being taken to reduce vulnerabilities?

Enterprise A identified the following vulnerabilities, which may not pertain directly to transportation, but do affect it: potential for longshoreman strikes, weather, human error, terrorist events, production delays, and system errors. Vulnerability also exists in cases where Enterprise A takes control of goods only after they have arrived in the United States, resulting in a greater risk because Enterprise A has less control. For example, while Enterprise A may not bring goods into the Ports of Los Angeles and Long Beach itself, their suppliers may, making Enterprise A vulnerable to any disruptions at these ports. Enterprise A has contingency plans for most vulnerabilities, but admittedly, some plans work well and others not at all. For example, if a specific port is shut down Enterprise A has a plan to re-route to another, but if ports on the west coast are all shut down Enterprise A's plan falls apart. Enterprise A's resiliencies are lacking in the case of disruptions that impact an entire region or country. Enterprise A has attempted to identify high vulnerabilities in specific regions and focuses effort in those regions to improve resiliency.

Enterprise C identified the inability to track supply, unpredicted port spikes or congestion, and government regulations and rules as vulnerabilities within their transportation chain.

Enterprise F believes their transportation is vulnerable because of capacity and their dependence on roads and infrastructure. They work closely with several states to become a familiar face, feeling this is an advantage in times of trouble, and work to negotiate weight limits and road limitations.

Enterprise F takes part in many general committees which are influential in the transportation community.

Enterprise G acknowledged weather, driver shortages, changing Department of Transportation (DOT) regulations, and requirements for specialized trucking as transportation vulnerabilities. Despite fully outsourcing their transportation, Enterprise G stays in close contact with their vendors to understand current conditions.

Enterprise H identified carriers that do not meet performance expectation, issues at the consolidation level, and weather concerns as vulnerabilities within their transportation system. In order to reduce potential vulnerabilities, Enterprise H pays for premium services such as using priority “Z trains,” which are moved first after disruptions occur, and driving (trucking) teams. Enterprise H is willing to spend extra money to attempt to keep variability at a minimum.

Enterprise K sees their brittle supply chain and the lack of immediate resiliency in their supply chain as a vulnerability.

Enterprise B, Enterprise D, Enterprise E, Enterprise I, and Enterprise J did not provide information on vulnerabilities.

The vulnerabilities provided by enterprises varied and there is no easily identified correlation between enterprise profile and vulnerabilities. Weather was a commonly identified vulnerability, as was outside regulations.

5.4 Disruption Procedures

Understanding how disruptions are currently handled can lead to a better understanding of the current use of resiliency strategies.

At Enterprise A, an international logistics department communicates supply chain problems to affected parties. Enterprise A does not have employees overseas, but instead have agents who are exclusive to Enterprise A and may act on behalf of the enterprise. All disruptions are reported to the corporate office. Generally there is solely a notification that a good is delayed. Occasionally, when a long delay is expected, there is a switch in transportation mode from ocean to air.

Enterprise B has a “Supply Chain Crisis Management” team located at corporate headquarters to specifically address supply chain disruptions. Additionally, Enterprise B has employees on the ground, in each of the 55 countries they import from, which may improve communication to prevent and/or handle disruptions overseas.

At Enterprise C, disruptions are mitigated based on level of inventory and risk associated to the product classification. As disruptions develop, a review of inventory status and duration of impact are assessed to determine if any interaction is necessary.

Enterprise D stressed the importance of quick notification of supply chain problems. When problems occur they are handled on an “exception” basis. Parties involved assess why a disruption occurred and identify potential mitigation options. On large delays, which typically occur in the ocean leg, Enterprise D may opt to “hotleg” products to destinations. Typically Enterprise D orders around 300 containers of each individual item, so if some containers are delayed, other containers can be shifted around to different final destinations to reduce problems. Enterprise D utilizes communication to help prioritize supply chain issues. The corporate office oversees all operations, but regional employees handle issues on a daily basis.

Enterprise F makes use of a command center to handle disruptions. There is a well publicized chain of command and each member of the command center is aware of their duties. Enterprise F categorizes disruption into different levels of impact, color-coded similarly to the Transportation Security Administration (TSA) threat levels, and procedures have been developed for each level. All parties involved in the supply chain, including third party logistics companies and outside labor, are involved in discussions involving disruptions. Procedures include simplifying the distribution process during disruptions, prioritizing deliveries, and implementing alternative delivery options.

Because transportation is outsourced, Enterprise G works with their vendors to be proactive concerning supply chain disruptions. They consider transportation to be a commodity, so if their vendors cannot perform, they are replaced. When a disruption does occur, Enterprise G relies on technology, such as automated communication, to convey information on disruptions. For example,

Enterprise G utilizes automatically generated alerts of delays to proactively inform customers of problems. In the future, Enterprise G is hoping to track with radio-frequency identification (RFID).

Enterprise H and Enterprise I both monitor goods movement and deliveries, and expedite goods when needed. For both enterprises, a delay in production would cost more than the increased costs associated with expediting goods.

For Enterprise J, shipping lanes change daily based on who needs what, where, and when; therefore disruptions to the supply chain are often unique and require unique solutions. While there are plans in place for general disruptions, most are handled on an individual and fast-paced basis due to the unpredictable demands and expensive nature of the goods being handled.

Referring specifically to infrastructure failures such as port or pass closures, Enterprise K responded that disruptions are only visible to them when reported by a transportation and/or logistics provider. When disruptions occur, Enterprise K waits them out and ultimately shuts down production lines if buffer stocks are exhausted.

Disruption procedures were not discussed with Enterprise E.

The disruption procedures discussed during the interviews were the basis for resiliency strategy identification seen in the following section. Most of the actions taken by enterprises during disruptions attempt to minimize the impact of the disruptions.

6 Resiliency Strategies

6.1 Introduction

Interview questions inquired about vulnerabilities within the supply chain, resiliency within the supply chain, and procedures used to handle disruptions. From the information gathered during the interviews, fifteen resiliency strategies were identified. The strategies were both directly and indirectly identified by the enterprise representatives interviewed. If an enterprise did not report a strategy it can be assumed that (1) the enterprise does not practice the strategy, (2) the enterprise does practice the strategy but does not find it significant to their resiliency efforts, or (3) the enterprise does practice the strategy but fails to mention its use because it has become commonplace within supply chain operations.

As stated earlier, resiliency is defined as “an ability to recover from or adjust easily to misfortune or change” (Merriam-Webster 2008). Within the supply chain community, resiliency also includes the ability to avoid disruptions. For the purposes of this research, a resiliency strategy is defined as a tactic used to reduce the occurrence or mitigate the effects of disruptions, allowing a supply chain to maintain or return to normal operating conditions.

While an enterprise often cannot reduce the potential of a disruption occurring, they may be able to reduce their exposure to potential disruptions. An enterprise is able to **reduce** the potential for disruptions to impact their supply chain by taking specific actions. If an enterprise has not (or cannot) acted to avoid a disruption to their supply chain, they may be able to **mitigate** the impacts of the present disruption by taking specific actions.

The majority of strategies are characterized as **strategic**, meaning they are tactical decisions but also may be implemented on a day to day basis. Other strategies are categorized as **enablers** and do not directly improve resiliency, but instead facilitate the success of strategic resiliency strategies. These strategies enable or encourage resiliency. The resiliency strategies identified within the interview process are listed in Table 6-1.

Table 6-1: Identified Resiliency Strategies

RESILIENCY STRATEGY	CATEGORY	REPORTED BY
Relationships	Enabler	A, D, F, G, J
Use of Information and Technology	Enabler	B, D, G,H, I
Communication	Enabler	A, B, D, F, G
Flexible Culture	Enabler	A, F, H
Flexible Transportation	Strategic	A, F, G,H
C-TPAT Certification	Strategic	A, E
DC Structure, Size of Network	Strategic	D, E, H
Resilient Nature of Suppliers	Strategic	F
Expedited Freight	Strategic	A, D, H, I
Use of Multiple Ports/Carriers	Strategic	B, E, H
Employees Overseas	Strategic	B
Extra Capacity at Distribution Centers	Strategic	C
Off-Peak Deliveries	Strategic	E
Sourcing of Components Domestically	Strategic	E
Premium Transportation	Strategic	H, I, J

The explanations and evaluations of strategies below consist of a combination of perceptions gathered at interviews and research interpretations. The interview data conveys the information provided by the enterprises which lead to conclusions regarding utilized strategies.

6.2 Enablers

Enabler strategies do not directly reduce or mitigate disruptions. Instead, enablers often help identify disruptions and lead to further action or aid in response to a disruption. Four enablers were identified and are examined below.

6.2.1 Relationships

Definition:

An enterprise develops and maintains relationships with suppliers, carriers, and customers, with the belief that strong relationships will result in increased assistance and flexibility during disruptions. Relationships may be developed through activities such as retreats as well as networking and social events.

Evaluation:

As an enabler, developing strong relationships improves resiliency by making partners more likely to aid an enterprise when a disruption occurs. A strong relationship could both reduce the potential for disruptions to impact a supply chain and mitigate the impacts of a disruption that does have an effect on a supply chain. Beyond having a strong relationship, an action must be taken to avoid or mitigate the disruption. This strategy assumes that a supplier or carrier would like to assist those with whom they have a strong, and often major, business relationship with in order to continue business. The assistance often comes in the form of an additional resiliency strategy such as flexible transportation, described later. Assuming that the resiliency benefits associated with strong relationships are realized, an enterprise is able to engage in fewer strong relationships instead of many weak relationships, without compromising reliability or resiliency.

Despite this, strong relationships do not guarantee that partners can or will act in the best interests of the enterprise in the face of a disruption. Interpretations of relationships are often vague, unlike a contract which is more explicit, and partners may not have the same understanding of the relationship. Additionally, if a partner has numerous strong relationships, they may not have enough resources to satisfy all those requiring help. The size and scope of certain disruptions may also prevent partners from having the ability to assist enterprises in reducing exposure to and mitigating effects of disruptions. Employing strong relationships also may result in favoring suppliers or carriers with whom strong relationships exist over more economical suppliers or carriers.

In order to implement this strategy an enterprise must have supply chains partners who are willing to form strong relationships. Strong relationships can be developed as an efficient way to improve resiliency by most enterprises, regardless of enterprise size or type of disruption.

Logistic Benefits:

- 1) The potential for disruptions is reduced if relationships enabler additional action.
- 2) The impacts of future disruptions are more effectively mitigated if relationships enabler additional action.

Logistic Costs:

- 1) Managerial costs increase due to time and hospitality costs associated with relationships.
- 2) Transportation costs increase if carriers with which an enterprise has a strong relationship with are favored over more economical carriers.
- 3) Inventory costs increase if suppliers with which an enterprise has a strong relationship with are favored over more economical suppliers

Interview Data:

In interviews, enterprises provided information about how they employ the use of relationships into their supply chains and resiliency planning.

Enterprise A considers themselves a “relationship company,” and have good relationships with other members of their supply chain. Employees are on the ground, traveling a lot, and developing relationships with partners. They aim to make their service providers feel like they are part of the family, and most relationships are long-standing.

One aspect of Enterprise D’s mission statement is to respect vendors. Enterprise D wants both themselves and vendors to profit, be good partners, and respect commitments.

Enterprise F communicates frequently with officials in the states it most commonly transports goods through. They believe that developing relationships with people at the state level will benefit them when there is a problem because they will not be just one of many asking for help.

Enterprise G forms solid relationships with a few select vendors. The enterprise admits they may miss out on cost savings, but they feel this is worth the dependability they get from their vendors.

Enterprise J’s shipping lanes change daily based on who needs what parts at what time. Because of this, reliable carriers are necessary and a trusting relationship with their carries has been built over time.

6.2.2 Use of Information and Technology

Definition:

An enterprise gathers information, generally through increased technology, to manage disruptions. Tools such as Transportation Management Systems (or similar enterprise management software) and procurement agents may help track goods and detect potential or actual disruptions.

Evaluation:

The use of information and technology improves resiliency by gathering and presenting information regarding disruptions, which can be communicated between parties within the supply chain. This can occur by increasing the amount and level of detail of information available, making information easily accessible, providing information to all members of the supply chain, and providing information in a

time sensitive manner. Information can provide knowledge of a disruption and gives an enterprise the opportunity to act to avoid or reduce the effects of the disruption. Early detection helps stop the spread of disruption and reduce the extent of damage. As with relationships, an action must be taken beyond the gathering of information in order to improve resiliency. The implementation of information and technology can vary by between enterprises to meet each individual enterprise's resiliency needs.

Logistic Benefits:

- 1) Knowledge of the current status of the supply chain increases.
- 2) Visibility increases within supply chain.
- 3) Disruptions are more easily identified.
- 4) The potential for disruptions is reduced if gathered information enables additional action.
- 5) The impact of the present disruption is mitigated if gathered information enables additional action.
- 6) The impacts of future disruptions are more effectively mitigated if gathered information enables additional action.

Logistic Costs:

- 1) Managerial costs increase in order to implement technology systems and manage information.
- 2) Exposure to risks associated with technology systems increases

Interview Data:

In interviews, enterprises provided information about how they utilize information and technology to improve resiliency.

Enterprise B uses an automated tracking system to track goods movement and time between various checkpoints. The detailed data is captured into a reporting system, which provides visibility to the supply chain. Additionally, Enterprise B uses a domestic transportation management system which relays information about potential disruptions.

Understanding the importance of information, Enterprise D is working to use technology better, including for transportation bid optimization and to improve their transportation system visibility.

As a dot com business, Enterprise G believes its use of technology is cutting edge and helps to provide resiliency. They do not provide their own transportation but expect a similar level of technology use from their providers. When delays, such as weather-related delays, occur, Enterprise G relies on

technology for auto-alerts to keep them informed. In the future, Enterprise G hopes to track goods with RFID tags.

Enterprise H recently invested in a logistics center which has improved shipment visibility and route optimization. The logistics center tracks real-time movements of goods, keeping costs and inventories low without sacrificing service.

Enterprise I employs procurement agents, whose role is to monitor the movement of goods and anticipate disruptions. When delays occur, the procurement agents expedite parts. The information gathered, and the ability to expedite parts when needed, replaces holding inventory in this JIT system. Enterprise I is also working in implement a transportation management system to improve visibility of their transportation network, which will ultimately improve transportation reliability and decrease costs.

6.2.3 *Communication*

Definition:

An enterprise relays information, gathered previously, about supply chain status and activities, including potential or actual disruptions, to those who have the authority to take action in order to prevent or mitigate disruptions.

Evaluation:

Like the use of information and technology, communication improves resiliency by transferring knowledge regarding disruption between parties within the supply chain. Having the knowledge of a disruption gives an enterprise the opportunity to act to avoid or reduce the extent of damage. As with relationships, an action must be taken, beyond the communication in order to improve resiliency.

An enterprise must have the technology systems and information required to communicate effectively in order to implement this strategy. All supply chain partners must be willing to communicate. As an enabler requiring limited costs, communication should be utilized by all enterprises.

Logistic Benefits:

- 1) Knowledge of the current status of the supply chain increases.
- 2) Disruptions are more easily identified.
- 3) The potential for disruptions is reduced if communication enables additional action.

- 4) The impact of the present disruption is mitigated if communication enables additional action.
- 5) The impacts of future disruptions are more effectively mitigated if communication enables additional action.

Logistic Costs:

- 1) Managerial costs increase due to the costs and time required to communicate.
- 2) The potential for miscommunication increases.

Interview Data:

In interviews, enterprises provided information about how they employ communication within the supply chain.

Almost all disruptions within Enterprise A's supply chain are reported to someone at the corporate office. If there is a chance a shipment may miss an expected date, communication between affected parties occurs.

Enterprise B has a team at the corporate office that specifically addresses supply chain crisis management. They handle problems ranging from small supply chain disruptions, like due to weather, to larger disruptions such as terrorist activities. There is a hotline to call to report disruptions, which will then be passed through the proper channels at both the local and corporate levels.

Enterprise D relies on communication, in the form of quick notification, to identify disruptions. Employees around the country track the day to day goods movement activities and report to corporate headquarters. These employees in the field are used to identify problems and report important information through the proper channels. After a problem is detected, corporate personnel assess the situation and mitigate as required for the specific situation. Enterprise D believes that communication helps prioritize problems.

Enterprise F uses communication to keep all parties involved in their supply chain abreast of disruption. Communication exists not only internally at Enterprise F, but also with suppliers, third-party logistics enterprises, and outside laborers. Communication with customers is also a priority. Formalized communication involves discussing changing conditions, for example, drivers may update on status of roads, and follows a strict agenda. Update meetings, typically via conference calls, may occur as often as every two hours if needed.

Enterprise G uses communication to keep in touch with their partners and know the status of shipments.

6.2.4 Flexible Culture

Definition:

The culture of an enterprise can simply be stated as “the way we do things around here” (Sheffi 2005). Flexible culture involves developing a business environment that encourages and promotes innovative and creative ideas to improve supply chain security and resiliency practices.

Evaluation:

Key traits of enterprises with flexible culture include: extensive communication between informed employees, distributed/decentralized power, a passion for the work, and experience with disruptions (Benson 2005). Additional characteristics include: adherence to Customs-Trade Partnership Against Terrorism (C-TPAT) guidelines, making a business case for resiliency/security, and educating employees and partners. Enterprises with flexible cultures are more aware of the potential for disruptions and constantly on the watch for these disruptions. They are also more likely to implement additional resiliency strategies. Like the previous enablers, flexible culture encourages activities which reduce exposure to or mitigate the impact of disruptions.

The support of both upper management, who make strategic decisions, and long-time employees, who are often satisfied and secure with old procedures, are necessary to implement this strategy. Incorporating resiliency and flexibility into corporate culture is a feasible strategy for most enterprises.

Logistic Benefits:

- 1) Increased successful implementation of strategic resiliency strategies.
- 2) Personal investment is created among employees.
- 3) The potential for disruptions is reduced if flexible culture enables additional action.
- 4) The impacts of future disruptions are more effectively mitigated if flexible culture enables additional action.

Logistic Costs:

- 1) Managerial costs increase indirectly if new resiliency measures are implemented due to flexible culture.
- 2) Transportation costs increase indirectly if new resiliency measures are implemented due to flexible culture.

- 3) Inventory costs increase indirectly if new resiliency measures are implemented due to flexible culture.

Interview Data:

In interviews, enterprises provided information about how they employ flexibility into their corporate culture regarding supply chains and resiliency. Often interviewees did not specifically cite “culture” as a resiliency strategy but alluded to how the culture of their enterprise encourages the development of resilient strategies and operations.

Enterprise A leadership has actively supported resiliency initiatives. The CEO of Enterprise A has been onboard with security programs, such as C-TPAT, from the onset, despite the additional cost incurred.

Following a large disruption to their supply chain, Enterprise F, with the support of its upper management, developed an “Emergency Operations Team” to handle future disruptions. The team developed a plan to delegate responsibilities and specify procedures in the event of a disruption. The team’s goals are to facilitate quick action in a disruption, plan for the worst at the beginning, and not get overwhelmed by emotions. Enterprise F’s preparations were tested recently after another disruption to the supply chain occurred. They believe resiliency increased and the disruption was more successfully mitigated because of the newly introduced initiatives.

Working with a JIT environment, Enterprise H is very decisive about taking action very early if there is a chance of disruption.

6.3 Strategic Resiliency Strategies

Strategic resiliency strategies are typically part of a long term plan of action, but are implemented on a day to day, or as needed basis. Eleven strategic resiliency strategies were identified and are examined below.

6.3.1 *Flexible Transportation*

Definition:

An enterprise has the ability to make last-minute changes to transportation providers, routes or schedules in case of disruption. Depending on how transportation is provided, it may include:

1. Flexible contracts/agreements with transportation providers or making use of backup carriers (if enterprise subcontracts transportation).
2. Making use of trucking in teams, or detours. This may also include having drivers that are trained for multiple tasks and equipment that is standardized, making it easy to substitute drivers when needed (if enterprise provides own transportation).

Evaluation:

Flexible transportation policies have the ability to help an enterprise both avoid exposure to disruptions and mitigate the impacts of disruptions. For example, faced with a weather disruption, an enterprise may choose to send freight earlier to avoid any potential weather delays, or if freight has already been delayed by weather, to run teams of drivers in order to speed delivery. In both scenarios, flexible transportation involves having the ability make changes such as moving goods sooner than planned or using more drivers in order to avoid or mitigate the impact of a disruption. Other examples of using flexible transportation to improve resiliency include using detours to avoid disruptions, and having backup carriers, such as non-union drivers, to reduce the effects of a disruption which affects primary carriers. Essentially, flexible transportation acts as a contingency plan, but having flexible plans in place to handle transportation disruptions is successful only if the carriers have the capacity to handle unexpected demand. Strong relationships and pre-existing contracts with carriers may increase the probability of a carrier having extra capacity available for an enterprise when needed. Additionally, regional disruptions can affect multiple carriers and routes; therefore there may not be any undisrupted alternative.

In order to implement this strategy, knowledge of the disruption is required. This knowledge is typically gathered via enablers such as communication, and information and technology. Additionally, existing contracts or relationships, and capacity with transportation providers are required. Because flexible transportation policies often mean paying for contingency plans which may not be utilized, this resiliency strategy is best used for legs of the supply chain where disruptions most often occur.

Logistic Benefits:

- 1) The impact of the present disruption is mitigated.
- 2) The impacts of future disruptions are more effectively mitigated.
- 3) The time to arrival of goods is reduced.

Logistic Costs:

- 1) Managerial costs increase due to last minute changes and contracts.
- 2) Transportation costs increase due to last minute changes and keeping employees on call.

- 3) Increased exposure to additional risks due to flexible transportation.

Interview Data:

In interviews, enterprises provided information about how they employ flexibility into their transportation.

Enterprise A has resiliency built into their supply chain through a system of primary partners (carriers and consolidators) and backup partners. Weakness in their system occurs when an entire region or country is affected by a disruption.

Enterprise F provides its own transportation and has specialized trucking requirements. Their drivers can be interchanged as need because all vehicles use the same equipment. When the road network is disrupted, drivers use detours to route around problem areas.

Despite fully outsourcing their transportation, Enterprise G stays in close contact with their transportation vendors to understand current issues such as weather, requirements for specialized trucking, and labor. Enterprise G expects their vendors to be proactive and to have contingency plans. For example, to address upcoming trucking union talks, plans are in place to use non-union drivers if needed.

Enterprise H subcontracts out their transportation but take a very active role in managing their carriers. Goods are often moved from the west coast to the east coast and therefore need to transit several mountain ranges. Weather is a large concern for their supply chain, and Enterprise H keeps a close eye on weather related concerns. If storms threaten to disrupt the supply chain, Enterprise H works with the suppliers and carriers to move freight ahead of schedule if possible. They encourage carriers to use teams in the winter to move freight efficiently, even when subject to lengthy detours or delays.

6.3.2 C-TPAT Certification

Definition:

An enterprise is Customs-Trade Partnership Against Terrorism (C-TPAT) certified with the belief that this status will reduce or mitigate disruptions. C-TPAT is a voluntary government-business initiative that aims to improve U.S. border security. In order to be certified an importer must meet criteria that falls

under the categories of: business partner requirements, container security, container inspection, physical access controls, personnel security, and procedure security.

Evaluation:

Based on the claimed benefits of C-TPAT compliance, which include reduced inspections and priority after a port shutdown, participation can both reduce exposure to disruptions and mitigate the effects of disruptions. Disruptions caused by inspection delays are reduced because C-TPAT certified enterprises are less likely to undergo an inspection. Impacts of disruptions such as port closures are mitigated by having priority to get freight out of the ports as soon as possible after the event. The success of this strategy is dependent on whether certified enterprises truly experience reduced disruptions and priority. According to a survey conducted of 1,240 C-TPAT certified enterprises by the University of Virginia for the U.S. Customs and Border Protection (CBP), 39% reported a decrease in inspections and 53% reported no change, despite CBP quadrupling inspection rates (American Shipper - Shippers' Newswire 2007), implying that the majority of enterprises surveyed were experiencing a decrease in inspections or a decrease in percentage of overall inspections. There is little evidence to support or dispute C-TPAT certified enterprises getting priority after port shutdowns. If priority movement is granted after a port shutdown, being C-TPAT certified could be a competitive advantage. It is inevitable that all goods would be delayed during a shutdown, but those certified would move through faster after the shutdown ended. Additionally, in theory, a certified enterprise will have a more transparent supply chain, which can improve supply chain operations. The certification of a single enterprise cannot alone reduce disruptions such as port closures, but encouraging more enterprises to comply helps reduce the likelihood of disruptions of this type. Conversely, if more enterprises are certified, less time is needed to focus on uncertified enterprises, potentially leading to increased random inspections of certified enterprises.

Becoming C-TPAT certified requires cooperation from all members of the supply chain team. Barring cost of compliance, C-TPAT certification is a viable resiliency strategy for a wide variety of enterprises. In addition to the direct benefits of compliance, the increase in supply chain visibility benefits allows for quicker notification of disruptions.

Logistics Benefits:

- 1) Visibility increases within the supply chain.
- 2) The potential for disruptions is reduced.
- 3) The impact of the present disruption is mitigated.
- 4) The impacts of future disruptions are more effectively mitigated.

Logistic Costs:

- 1) Managerial costs increase due to effort required to reach and maintain C-TPAT certification.
- 2) Transportation costs increase because C-TPAT certified carriers must also reach and maintain C-TPAT certification.
- 3) Inventory costs increase because C-TPAT certified suppliers must also reach and maintain C-TPAT certification.

Interview Data:

In interviews, enterprises provided information about why they have chosen to participate in the C-TPAT program.

Enterprise A is very involved with C-TPAT and other security measures, and are certified at C-TPAT's highest tier. They joined the program to improve resiliency and believes their status within the C-TPAT systems helps improve the security of their goods. Enterprise A also considers it part of their corporate citizenship duty to help reduce the daily effects of new security procedures. They believe the more enterprises that take part in C-TPAT, the safer our ports are overall. Enterprise A is active in the recruitment of other enterprises into the C-TPAT program not only to strengthen the overall security of our ports, but because there are no carriers which carry solely Enterprise A or C-TPAT certified goods, and Enterprise A's goods could be subject to delays and disruptions despite their certification.

Enterprise E believes their status as a C-TPAT member will provide priority after a shutdown at a port due to a security concern.

6.3.3 Distribution Center Structure, Size of Network**Definition:**

An enterprise has a network structure that has the ability to serve, on short notice, a destination/store from a different distribution center than typically served to handle product shortages due to disruptions.

Evaluation:

Having a large network allows an enterprise to avoid or mitigate the effects of disruptions by moving products around as needed with more flexibility. If final destinations (stores) are located within close proximity to several distribution centers and there is available inventory, distribution patterns can be

modified to react to potential or actual disruptions in a more timely manner. This provides an enterprise with the ability to route around problems. Figure 6-1 illustrates this.

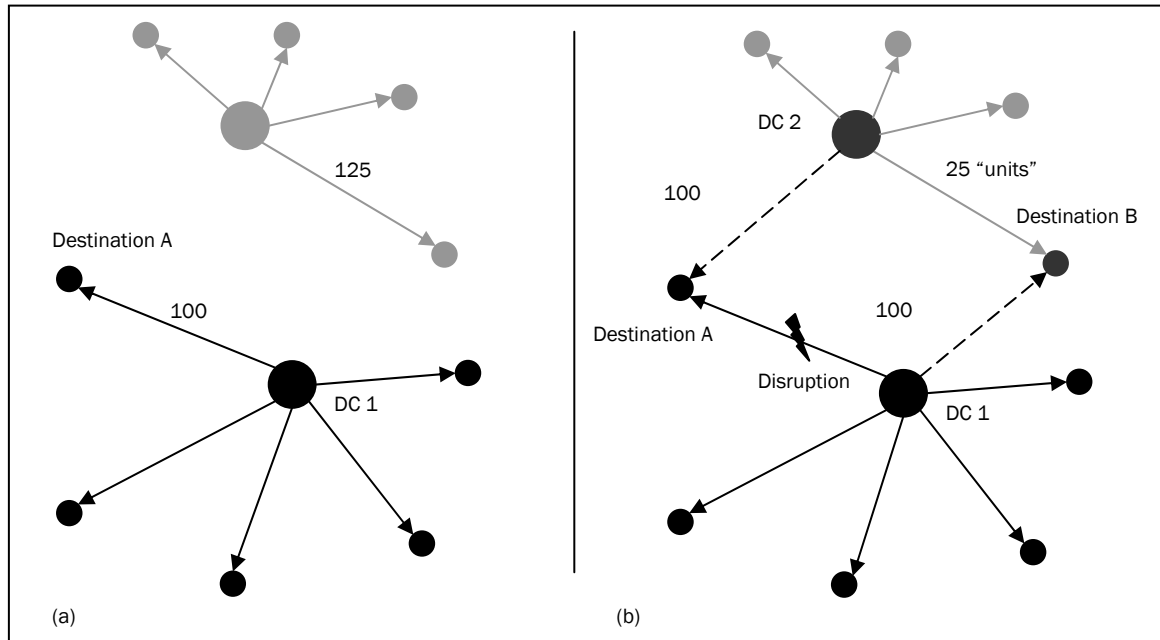


Figure 6-1: Distribution Center Network Application

In Figure 6-1(a), the 100 units of goods demanded by Destination A are typically served by DC 1. When a disruption occurs, or is expected to occur, along the goods movement path between DC 1 and Destination A, units can temporarily be rerouted so that DC 2 serves the demand of Destination A, as seen in Figure 6-1(b). The units at DC 1 typically destined for Destination A can then be used to serve the now unmet demand of Destination B. Once the disruption has been removed, goods can be routed through their normal paths. Using this strategy there may not even be any noticeable service impact at the destinations.

This resiliency strategy is best used for large enterprises that have an additional need for numerous distribution centers and have therefore reduced the distances between distribution centers and final destinations. It would not be in the best interests of an enterprise to build a large distribution center network for the sole purpose of resiliency, but instead because of a prior need for a distribution center structure which has many distribution centers located within close distances to destinations/stores. This strategy is most effective when combined with the flexible transportation strategy because last minute transportation is required to modify the distribution pattern.

Logistic Benefits:

- 1) The impact of the present disruption is mitigated.
- 2) The time to arrival of goods is reduced.

Logistic Costs:

- 1) Managerial costs increase due to the building and maintaining of a large network.
- 2) Transportation costs increase due to unexpected movement of goods to cover shortages.
- 3) Increased exposure to additional risks due to large network.

Interview Data:

In interviews, enterprises provided information about how their distribution center network improves resiliency.

Enterprise D's network is large enough that they typically order approximately 300 containers of the same item. If a number of containers are delayed, they have enough remaining containers to shift goods around and reduce problems.

Enterprise E's network layout consists of five distribution centers, which carry all of the Stock Keeping Units (SKUs) which Enterprise E sells, and approximately forty consolidated distribution centers which serve a very local area, and carry limited SKUs and perishable items. Because of the number of consolidated distribution centers and their proximity to stores, Enterprise E has the ability to move goods around if there is a breakdown, transportation or otherwise, within the supply chain. While Enterprise E believes their distribution network does improve resiliency, the structure is mostly due to the scale of the enterprise. They require millions of square feet of distribution center space and it is not feasible to provide that in one distribution center. Having consolidated distribution centers serving a local area also allows the stores to carry less inventory (and require less valuable real estate space) because merchandise can be delivered as needed with perishable deliveries that are made every day.

With its seven distribution centers, Enterprise H is able to service 95% of their dealerships with one-day ground service. In addition, as one-day service ranges have increased, 80% of dealerships have one-day ground service from two distribution centers. This allows for flexibility if there is a disruption in service from a specific distribution center.

6.3.4 Resilient Nature of Suppliers

Definition:

An enterprise does business with suppliers who are resilient independent of the enterprise.

Evaluation:

If having resilient supply chain partners encourages an enterprise to increase their own resiliency in order to improve overall supply chain resiliency, this strategy is successful and allows an enterprise to avoid or mitigate the effects of disruptions

Logistic Benefits:

- 1) Creation of a personal investment among employees.

Logistic Costs:

- 1) Managerial costs increase due to relationship with resilient partners.

Interview Data:

In interviews, enterprises provided information about how resilient suppliers improve resiliency.

Enterprise F believes that their suppliers are resilient by nature. The enterprise is a co-op where the suppliers are the owners; therefore the enterprise operations work in the favor of the suppliers. The suppliers' success is more directly related to the success of Enterprise F than in other industries.

6.3.5 Expedited Freight

Definition:

An enterprise, upon identifying a disruption, uses accelerated freight transportation to move additional freight or to speed up delivery of an existing shipment.

Evaluation:

Expediting freight mitigates the effects of a disruption by incurring transportation costs while reducing the magnitude of a disruption. If a disruption occurs within the supply chain, there can be a shift in transportation to an accelerated mode to make up for time lost in early segments of the supply chain, or a second shipment sent via accelerated mode. Due to the increased cost of expedited freight,

enterprises need to consider the value/nature of the good and what happens if it doesn't get to its destination on time. Figure 6-2 illustrates how expedited freight can be used to mitigate disruptions.

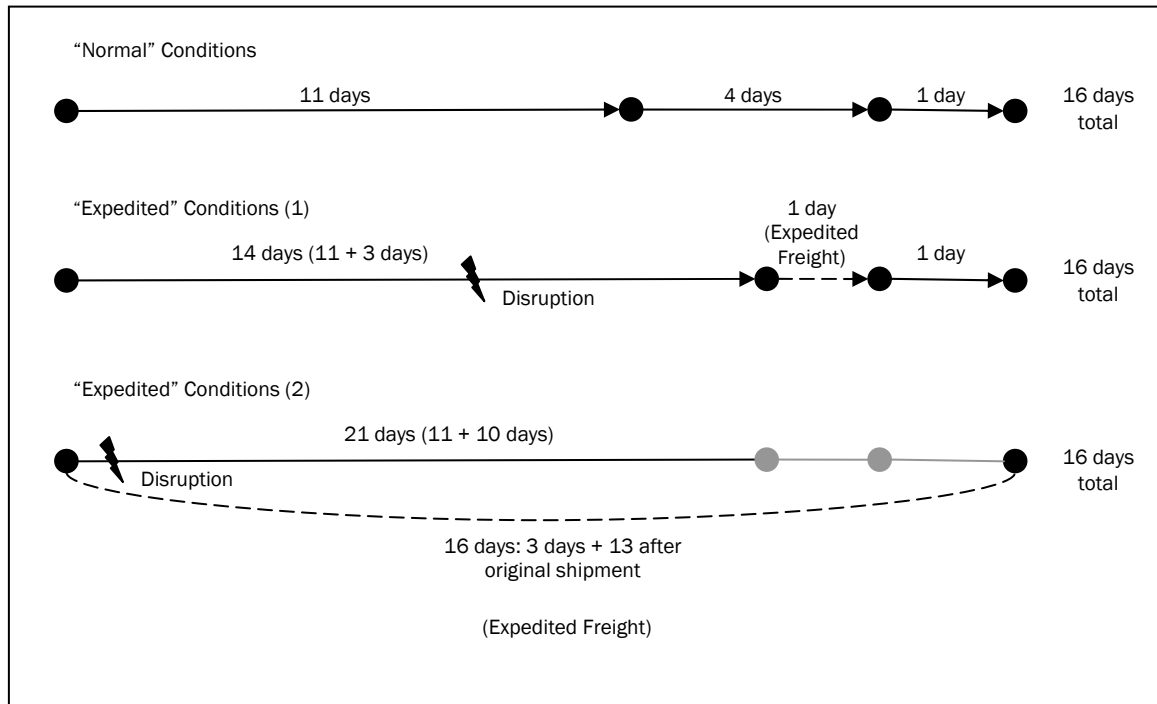


Figure 6-2: Expedited Freight Application

In this example, under "normal" conditions, goods travel through 4 nodes and 3 legs from origin to destination, with a total trip time of 16 days. In the first example of an "expedited" condition when a short disruption occurs during the first leg, accelerated transportation is utilized in the second leg of the trip to make up for time lost earlier, again with a total trip time of 16 days. In the second example of an "expedited" condition, the disruption within the first leg is expected to be long enough (10 days) to justify sending a second shipment via accelerated freight. Despite being sent significantly after the first shipment, the expedited shipment still arrives at the destination with a total trip time of 16 days.

Similar to flexible transportation, in order to implement this strategy, knowledge of the disruption is required. This knowledge is typically gathered via enablers such as communication and information and technology. Additionally, existing contracts or relationships, and capacity with transportation providers are required.

This resiliency strategy is appropriate when the costs associated with expediting the freight are less than the costs associated with a delay. Examples include when a delay in shipment arrival would

result in a factory shut-down (as is often the case in Just-In-Time manufacturing), for high-value items where the cost of lost sales is greater than the extra transportation costs, and in instances where maintaining customer satisfaction to promote future sales is important.

Logistic Benefits:

- 1) The impact of the present disruption is mitigated.
- 2) The time to arrival of goods is reduced.

Logistic Costs:

- 1) Transportation costs increase due to additional costs associated with expedited freight.
- 2) Exposure to risks associated with expedited freight increase.

Interview Data:

In interviews, enterprises provided information about how they employ expedited freight to improve resiliency.

After notification of a delay, Enterprise A may choose to shift from ocean to air transport. This most often occurs for advertised merchandise, merchandise for their large, annual sale, high-end designer goods, “hot” items (because you often do not know ahead of time if item will be a big seller), and small shipments that may actually be less expensive to ship by air.

When large delays, typically within the ocean leg, occur within Enterprise D’s supply chain, the enterprise considers the option of expediting the items to their destinations. Product buyers, who work for Enterprise D, are notified of the delay and consider using air freight to mitigate the delay caused by the disruption. The decision to air freight is dependent on the nature of the good delayed and the urgency of the delivery.

In 2006, Enterprise H spent about \$11 million in air freight to send parts that were late because of supplier or weather delays to the production plants. The value of the parts was greater than the cost of the expedited transportation. For cross country movements, Enterprise H’s recovery method is typically air transport. Their plants have no buffer and the only buffer within the production system is the transportation buffer, making it crucial to meet delivery deadlines.

Enterprise I uses supply chain management analysts to monitor delivery of parts and expedite goods when needed. They are expected to be able to anticipate disruptions and keep goods moving. With

thousands of suppliers, the need to expedite goods is expected. The costs associated with expediting are of little concern because delays on the supply chain cost millions of dollars.

6.3.6 Use of Multiple Ports/Carriers

Definition:

An enterprise imports goods through more than one port or using multiple carriers, as part of regular supply chain operations in order to avoid having a disruption affect the entire supply chain.

Evaluations:

Using multiple ports and/or carriers can both reduce exposure to and mitigate effects of some disruptions. If one assumes that the risk of disruption associated with any one port/carrier is equal to any other port/carrier, using multiple ports/carriers will lessen the chance of disruption. For example, if you are solely importing to Los Angeles/Long Beach and there is a disruption at Los Angeles/Long Beach, 100% of your goods will be delayed. If you import half your goods into Los Angeles/Long Beach and half into Baltimore and there is a disruption at Los Angeles/Long Beach, only 50% of your goods will be delayed. Figure 6-3 illustrates this.

When using one destination port and one carrier, if there is a disruption along the goods path, none of the goods arrive at the destination at the expected time. Assuming that the likelihood of a disruption along more than one path is small, when goods move via one destination port and multiple carriers, more goods are likely to reach their destination. If two carriers are used equally and a disruption occurs along one path, 50% of the goods will reach their destination on time. With three carriers, the percentage increased to 66%.

This strategy does not fully develop resiliency within the supply chain because a portion of the goods are still delayed, but it does allow for an enterprise to move a portion of their goods through the supply chain without delay and allocate the available goods to the locations where they are most critically needed. Another benefit of using multiple ports/carriers is that you develop sound relationships with multiple ports/carriers. These relationships can be utilized during disruptions to mitigate delays. For example, if you import half your goods into Los Angeles/Long Beach and half into Baltimore and there is a disruption at Los Angeles/Long Beach, you can potentially increase volumes of imports at Baltimore because a relationship already exists. This can be a competitive advantage over enterprises that do not have a previous relationship at Baltimore but would like to begin importing through there because of disruptions elsewhere.

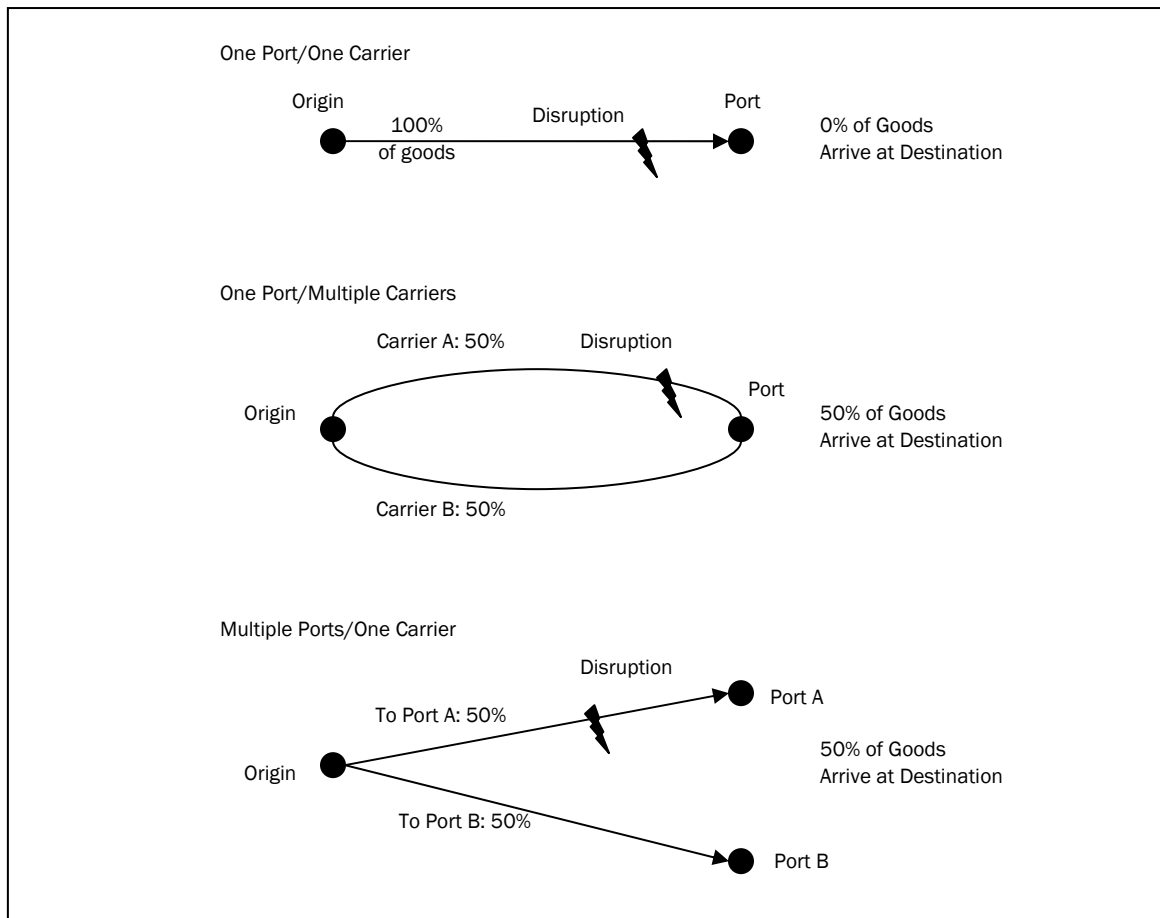


Figure 6-3: Multiple Ports and Carriers Application

In order to implement this strategy, existing relationships with multiple ports/carriers are required. This resiliency strategy is best used when an enterprise is importing a large quantity of goods that can easily be divided between multiple ports/carriers. Using multiple ports/carriers does, however, make an enterprise vulnerable to the added risks associated with importing to a second port or using a second carrier.

Logistic Benefits:

- 1) The impacts of future disruptions are more effectively mitigated because goods can be shifted around as required.
- 2) The potential of having entire shipments of goods delayed is reduced.

Logistic Costs:

- 1) Managerial costs increase due to the management of multiple relationships.
- 2) Transportation costs increase due to lost volume discounts.
- 3) There is an increased exposure to additional risks associated with the use of multiple ports/carriers.

Interview Data:

In interviews, enterprises provided information about how enterprises use multiple ports/carriers to improve resiliency.

Enterprise B does not “put all our eggs in one basket.” They use more than one vendor, steamship line and trucking line. They also bring goods into multiple ports.

Enterprise E has five main distribution centers which each import goods through a combined six different ports. If there is a disruption at one (or more) ports, or on a ship, there are still other product flows that are able to reach their destinations.

Enterprise H is evaluating new suppliers in Europe and is considering shipping four days a week, on four different shipping lines. They do not want to put a week’s worth of product on one ship and have a problem. Enterprise H wants to spread the risk. This is also true for the goods they are moving into the west coast from Asia. Previously, goods were moved through the Port of Los Angeles on one shipping line, but more recently, importing through two ports on the west coast, or with two shipping lines, has been utilized.

6.3.7 Employees Overseas**Definition:**

An enterprise locates employees overseas, in countries which are part of the supply chain, to oversee and manage operations.

Evaluation:

Assuming that direct and frequent communication is more efficient and less error prone than communication that takes place via technology (phone, e-mail, and internet), this strategy improves communication and may act as a catalyst for additional action. Locating employees overseas means they are in closer contact with the suppliers/carriers and also report directly to the enterprise. Having

early knowledge of disruptions gives an enterprise the opportunity to act to avoid or reduce the effects of the disruption.

Having employees overseas may facilitate communication between suppliers/carriers and the enterprise, but strong relationships could replace the need for a person located overseas. Similar to the previous communication and relationships strategies, having an employee overseas in itself does not make an enterprise resilient. Instead it may facilitate the notification of disruption that needs to be attended to, but is not effective without further action. Additionally, there is a presumed benefit of local knowledge that can be utilized by overseas employees.

In order to implement this strategy, there must be a willingness of partners overseas to be in close contact with an enterprise employee, as well as an adequate level of work to justify staffing an employee overseas. This strategy is best used when the expected level of communication between geographically distanced partners is not met. Overseas employees can work with new partners to get relationships off to a good start, or with partners who have reliability or trust issues, yet are still an integral part of the supply chain and cannot be replaced.

Logistic Benefits:

- 1) The impacts of future disruptions are more effectively mitigated.
- 2) Communication is more efficient due to employee proximity.
- 3) The external middleman is removed.

Logistic Costs:

- 1) Managerial costs increase due to introduction of an internal middleman.
- 2) There is an increased exposure to local risks.

Interview Data:

In interviews, enterprises provided information about how they utilize employees overseas to improve resiliency.

Enterprise B imports goods from 55 countries and has their own employees on the ground in each of these countries to manage the logistics of the supply chain.

6.3.8 *Extra Capacity at Distribution Centers*

Definition:

An enterprise scales distribution centers to have a greater capacity than required for current volumes of goods moving through the distribution center in order to increase the ability to hold inventory as needed to improve resiliency.

Evaluation:

Having extra capacity at distribution centers does not reduce exposure to or mitigate the impacts of disruptions directly. While extra capacity at a distribution center allows for holding more inventory, which increases resiliency by mitigating the impacts of a disruption, the extra capacity alone does not increase resiliency. Additionally, increasing inventory through redundancy is often inefficient.

Logistic Benefits:

- 1) The ability to carry additional inventory is increased.

Logistic Costs:

- 1) Inventory costs increase due to underutilized capacity or redundant inventory.

Interview Data:

In interviews, enterprises provided information about how they employ extra capacity at distribution centers to improve resiliency.

When building a second distribution center, Enterprise C scaled it to the same size as the existing distribution center, citing increased resiliency due to the extra capacity in both distribution centers.

6.3.9 *Off-Peak Deliveries*

Definition:

An enterprise delivers goods during off-peak hours to distribution centers or stores to avoid delivering at times when the risk of disruptions is higher (e.g. peak traffic hours).

Evaluation:

Making local, urban freight deliveries during off-peak hours reduces exposure to disruptions. When looking specifically at the segment of the supply chain consisting of the movement of goods between distribution centers and store, local congestion can be identified as a common disruption. By making deliveries during times where congestion is minimal reduces the risk of disruption or delay by the congestion.

In order to implement this strategy, a relationship must exist with carriers who are willing to deliver overnight. This strategy is best implemented when an enterprise makes small deliveries to stores in urban areas on a regular basis. Having a strong and trusting relationship with a carrier that allows you to provide access to stores without store employees present reduces the number of people required to work overnight.

Logistic Benefits:

- 1) The potential for disruptions is reduced.
- 2) In-store operations improve.

Logistic Costs:

- 1) Transportation costs increase because drivers and receivers are required to work off-peak or overnight hours.

Interview Data:

In interviews, enterprises provided information about how they use off-peak deliveries in order to improve resiliency.

Enterprise E needs to deliver perishable goods to its stores on a daily basis. There is a tight time window in which deliveries can be made without impacting store operations to both customers and employees. Many of these stores are in congested areas where deliveries are less likely to be reliably made within the tight time window, and where parking a delivery truck can be difficult because of the lack of loading docks or extended parking spots. In reaction to this, Enterprise E schedules overnight deliveries. Delivery personnel have a key to the store and unload goods without an Enterprise E employee present.

6.3.10 Sourcing of Components Domestically

Definition:

An enterprise acquires components/goods from domestic suppliers instead of from suppliers overseas, where they may be cheaper, due to a reduction in the likelihood of disruption in transit.

Evaluation:

If you assume that the longer a supply chain, the more potential for disruption, then shortening a supply chain by sourcing domestically will reduce exposure to disruptions. Sourcing a component domestically removes ocean travel, movements through two ports, and dealings with customs and border protection. These segments of the supply chain contain potentials for disruption and removing them will decrease this potential. Figure 6-4 illustrates this reduction.

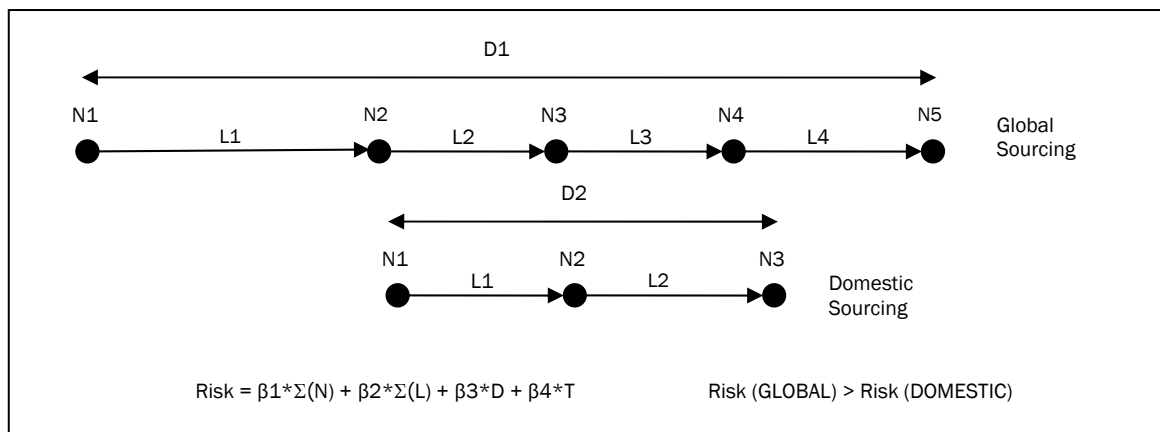


Figure 6-4: Domestic Sourcing Application

In Figure 6-4, N_x represents nodes within the supply chain such as origin/destination, ports, and distribution centers, L_x represents the links within the goods movement path, D_x represents the total distance traveled through the supply chain, and T_x represents the time required to move from origin to destination. The β -values represent the likelihood of a disruption occurring within the given node or link, or over the given distance or time. The risk of disruption is proportional to the number of nodes, the number of links, the total distance traveled, and the total time traveled. Increasing any of these within a supply chain increases the potential for disruption. Because domestic sourcing has less supply chain nodes, links, and a shorter distance of goods movement, the disruption potential, or risks associated with domestic sourcing are less than with global sourcing.

In order to implement this strategy, a domestically sourced product must exist. This resiliency strategy is most effectively for goods which are critical to the operations of an enterprise, such as a component which would stop a production line if not available or a product which would prevent sales of a focal good which had no reasonable replacement. For these goods, enterprises see the trade off of extra costs to be worth the increased reliability gained from sourcing domestically.

Logistic Benefits:

- 1) The potential for disruptions is reduced.
- 2) The time to arrival of goods is reduced.

Logistic Costs:

- 1) Inventory costs increase due to increased cost of domestic components.
- 2) Production costs may increase due to increased labor costs.

Interview Data:

In interviews, enterprises provided information about how they source domestically in order to improve resiliency.

Enterprise E sources its critical components domestically. There are numerous reasons for this, but one of the largest reasons is the reduction of the risk of not having the components when needed.

6.3.11 Premium Transportation

Definition:

An enterprise uses a more expensive mode of transportation, such as air or z-trains, assuming they offer a service which is more reliable or can move goods in a more efficient fashion.

Evaluation:

Using premium transportation both reduces exposure to and mitigates the impact of disruptions. Carriers providing premium service often offer guarantees on the level of service. In return for paying more to ship goods upon z-trains, which receive priority service, shippers are guaranteed to have their goods moved to the front of the line if there is a disruption which halts movement for a period of time, thus reducing the effects of the disruption. Premium air freight is typically managed by a third party logistics provider who works to provide a high level of service to customers by pre-qualifying carriers,

negotiating rates, and handling the details of the shipment. Pre-planned air freight often has better visibility than other modes of transportation, allowing disruptions to be spotted easily.

This strategy is best used for the movement of goods whose on-time delivery is crucial, such as in a Just-In-Time, or manufacturing environment.

Logistic Benefits:

- 1) Disruptions are more easily identified.
- 2) The impacts of future disruptions are more effectively mitigated.
- 3) The time to arrival of goods is reduced.

Logistic Costs:

- 1) Transportation costs increase due to more expensive service.
- 2) Exposure to risks associated with premium transportation increases.

Interview Data:

In interviews, enterprises provided information about how they utilize premium transportation in order to improve resiliency.

For goods moving by rail, Enterprise H spends an extra \$500 per container to move goods on Burlington Northern-Santa Fe Z-trains. If trains get stopped because of a disruption such as a derailment, the Z-trains are moved to the front of the line and move out first when the system is running again. Enterprise H thinks of this investment as an insurance policy against disruption.

Enterprise J delivers goods on an as needed basis where time is a valuable commodity. In the industry, minutes mean thousands of dollars and the intention is to get parts to customers within 24 hours. Most of the products leaving the distribution centers are moved by air. Enterprise J never transports by rail, and is very occasionally moves goods by truck. It is worth the extra money spent to transport parts via air through an enterprise like FedEx or DHL because you are assured of the reliability of the supply chain.

Enterprise I also uses premium freight because of the guarantee of delivery. There is a reason for the higher costs associated with premium freight and they expect the carrier to go to all lengths to get their goods delivered as promised. With the high cost of their goods, paying more for transportation is warranted by Enterprise I.

7 Risk Management and Decision Analysis

7.1 Risk Management

Resiliency strategies are designed to reduce exposure to disruption, reduce frequency of disruptions, mitigate the impact of disruptions, or reduce the size and severity of disruptions. Strategy implementations effect the distribution of impacts from a particular disruption, and the expected frequency of disruptions.

7.1.1 *Reducing Exposure*

When examining a strategy which is known to reduce exposure to disruptions, Figure 7-1 shows the probability distribution of the disruption exposure rate for a given disruption, both with and without implementing a resiliency strategy. In Figure 7-1, the expected value (mean) of disruption exposure is of 50 (disruptions actually exposed to) out of 100 (disruptions potentially exposed to) disruptions when the resiliency strategy is not utilized. When the strategy is utilized, the distribution is altered and pushed to the left, and the expected value of disruption exposure decreases to 25 out of 100 disruptions.

7.1.2 *Mitigating Impact*

When examining a strategy which is known to mitigate the impact of a distribution, the probability distribution impacts of a given disruption should shift towards lower impacts. For example, the probability of a given disruption causing given impacts (here, costs), with and without implementation of a resiliency strategy may follow distributions similar to that in Figure 7-2. In this example, the probability of a disruption, which will cost a given enterprise \$100,000, is 60% when the resiliency strategy is not utilized. If the strategy is utilized, the distribution shifts to the left and the probability of a given disruption, which will cost a given enterprise \$100,000, decreases to 30%. The probability of the disruption occurring does not change, but instead the expected value of the impact a given disruption decreases.

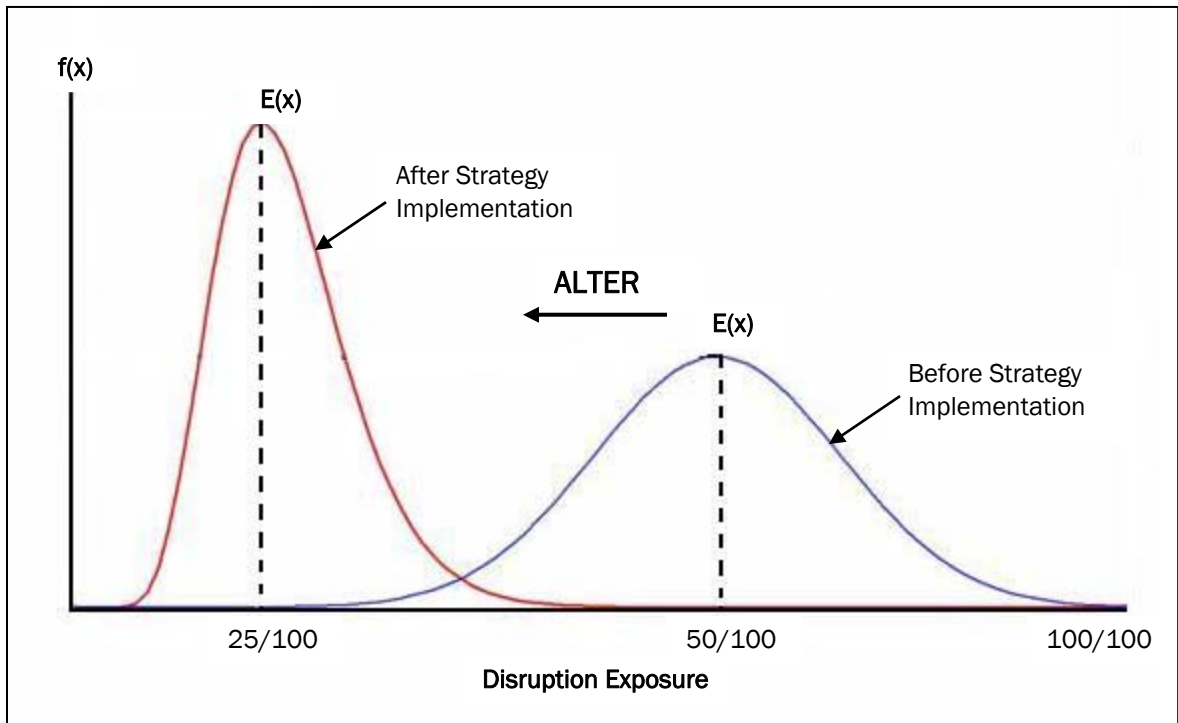


Figure 7-1: Probability Distribution – Reducing Exposure

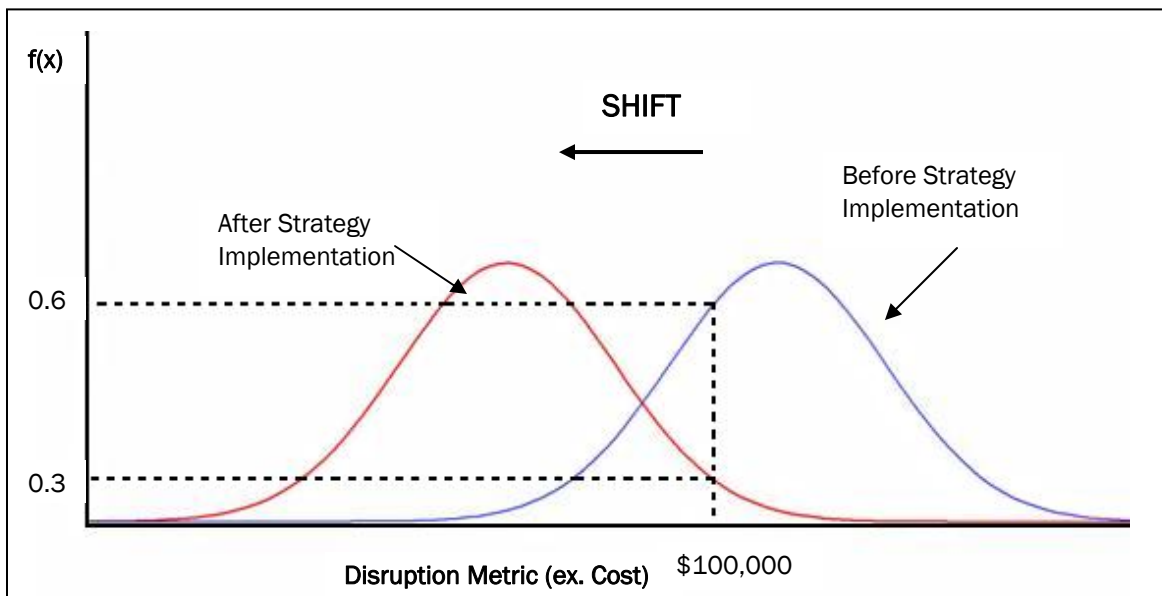


Figure 7-2: Probability Distribution – Mitigating Impact

7.2 Decision Analysis

In order to determine whether an enterprise should undertake a resiliency strategy, the expected value to the company from undertaking the strategy should be calculated. For a given strategy, an enterprise has to ability to choose whether or not to utilize the strategy. Looking at a single strategy and Figure 7-2 as an example of the probability of a \$100,000 disruption, with and without the use of a resiliency strategy, the expected value of the strategy can be determined as done in Figure 7-3.

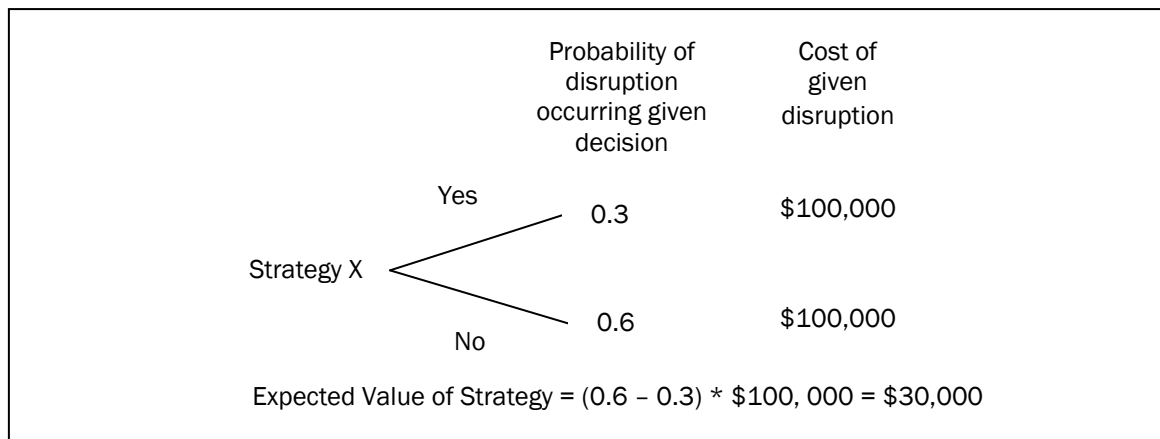


Figure 7-3: Expected Value of a Single Strategy

Choosing to utilize the given strategy results in a probability of disruption decrease of 30%, which for a \$100,000 disruption translates into a \$30,000 strategy value. An enterprise should implement the given strategy if the costs associated with implementation are less than \$30,000. This does not guarantee the enterprise will be successfully resilient in the face of the given disruption, but they will be making a good decision given the information available.

In many cases, strategies are related and dependant on one another. Figure 7-4 illustrates this relationship and how it impacts the expected value of a strategy. The expected value of the second strategy (Strategy Y) is dependant of the implementation of the first strategy (Strategy X). The benefits of strategies X and Y are not independent. This may also be true of the overall benefits of strategies, as one strategy will likely have an impact on the probability distributions of several disruptions.

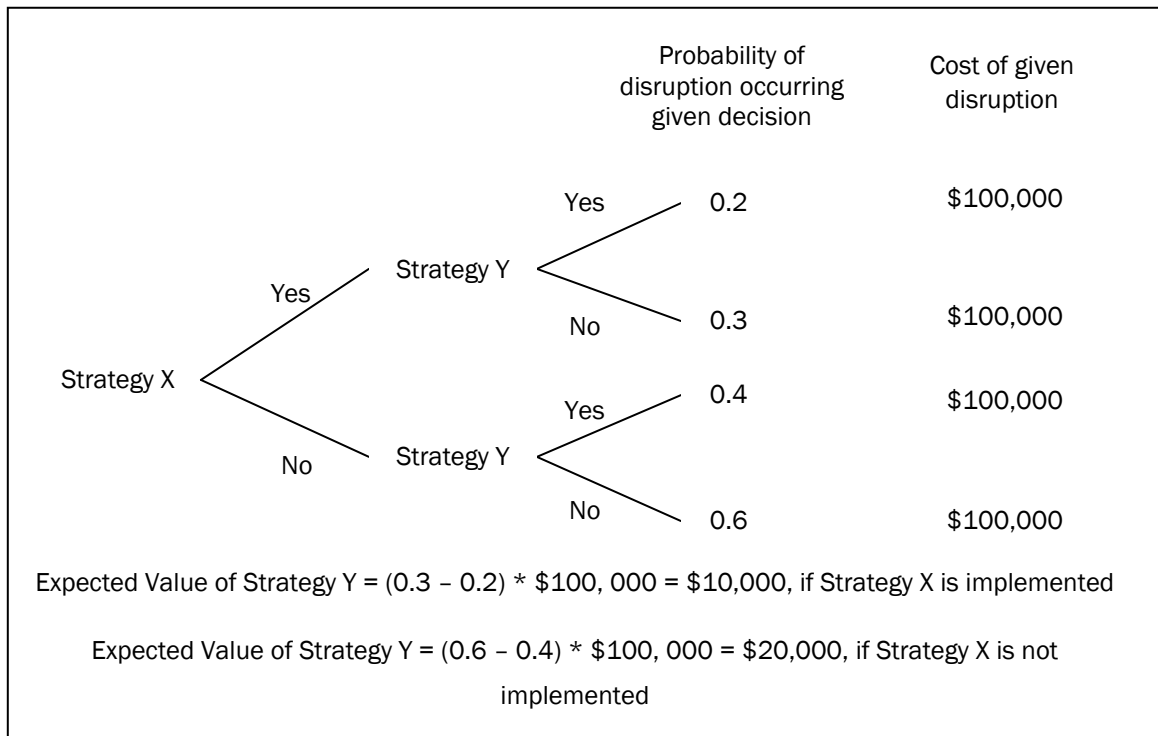


Figure 7-4: Expected Value of Multiple Strategies

7.3 Challenges with Risk Management and Decision Analysis

While, in theory, the framework presented above can assist an enterprise in selecting resiliency strategies which are best suited for their supply chain, gathering the information required to utilize this framework is difficult. Determining the probability distributions for any number of disruptions requires a great deal of information regarding supply chain operations and potential reactions, much of which is not known. That said, the framework can realistically be used to identify thresholds, which may be more practical. For example, given an investment level, a risk level can be identified for which the investment pays off.

8 Measuring Resiliency

8.1 Ranking Strategies

As a means of comparing the effectiveness of enterprises, there was an attempt to rank strategies according to their ability to increase supply chain resiliency. Realizing that no two enterprises operate under the same business strategy, it was difficult to rank the strategies in an absolute fashion. The costs and values of each strategy vary from enterprise to enterprise. Certain strategies can be looked upon favorably for increasing resiliency at minimal cost and can be utilized by most enterprises. These include building relationships, communication, and flexible culture, which all incur modest costs. Using information to understand, predict, and identify disruptions can improve resiliency within any supply chain, and the level of detail of information and the means of gathering it can vary between enterprises depending on their needs and financial capacities. Other strategies, such as distribution center structure, expedited freight, and domestic sourcing are more expensive to implement but if already integrated into business strategy, are effective at improving resiliency. All strategies identified, are able to efficiently improve resiliency if implemented correctly.

Resiliency efforts can be evaluated independent of the actual disruption. The possibilities of disruptions are endless and a given disruption can affect a supply chain in many ways, making it impractical and nearly impossible to plan for a specific disruption, let alone many specific disruptions. The complexity of this task was illustrated in Section 7. Instead, the value of a resiliency strategy can be examined by looking at its ability to reduce exposure to or mitigate a disruption at different positions within the supply chain. The goods movement within the supply chain can be divided into six generalized segments, foreign transportation/distribution center, foreign port, overseas travel (air/water), U.S. port, U.S. distribution center, and domestic transportation, and each resiliency strategy can be associated with reducing disruptions one or more segments. Slight modifications to the supply chains segments above can account for alternative good movement paths into the United States, such as entry by land ports. Table 8-1 relates resiliency strategies to the goods movement segments they impact. The segments which are affected by a given strategy are shaded. Not all supply chains use all segments. For example, an enterprise which does not import products from overseas is not affected by foreign transportation or ports, overseas travel, or domestic ports. Other enterprises may not make use of domestic distribution centers.

Table 8-1: Strategies Impacting Goods Movement Segments of the Supply Chain

Strategy	Foreign Transportation/ DC	Foreign Port	Overseas Travel (Air/Water)	U.S. Port	Distribution Center	Domestic Transportation
Relationships						
Information and Technology						
Communication						
Flexible Culture						
Flexible Transportation						
C-TPAT Certification						
DC Structure, Size of Network						
Resilient Nature of Suppliers						
Expedited Freight						
Use of Multiple Ports/Carriers						
Employees Overseas						
Extra Capacity at DC						
Off-Peak Deliveries						
Domestic Sourcing						
Premium Transportation						

As seen in Table 8-1, strategies such as relationships, the use of information and technology, communication, flexible culture, flexible transportation, expedited freight, and premium transportation can improve resiliency over the entire supply chain. Other strategies, such as C-TPAT certification, employees overseas, and off-peak deliveries, may only impact one or two segments of the goods movement. The number of segments impacted is not necessarily indicative of the overall value of the strategy. Strategies which can be employed in multiple segments of the supply chain are valuable because they can be utilized in numerous disruption situations, but strategies which are segment specific meet specific resiliency needs.

8.2 Ranking Enterprises

While it is difficult to rank the individual strategies on their ability to improve resiliency, one possible method of ranking enterprises interviewed involves ranking according to the number of strategies

Table 8-2: Enterprise Reported Strategies

[illegible]

Merging Table 8-1 with Table 8-2 provides a means of ranking enterprises in order of their overall, expected resiliency. Points can be assigned to each enterprise based on the number of strategies reported, and the number of segments which these strategies impact. For example, if an enterprise reported the use of information and technology as a resiliency strategy, they would receive six points because this strategy impacts all six segments of the goods movement within the supply chain. If an enterprise reported off-peak deliveries, they would only receive one point because this strategy only impacts the transportation in the U.S. segment of the goods movement. Because the goal of the ranking is to evaluate an enterprise's resiliency prior to an actual disruption, an enterprise can receive points for a strategy which is in place but may not have yet been used in practice. As mentioned previously, this method does penalize enterprises, such as Enterprise F, which operate a domestic supply chain. Table 8-3 shows the results of this method of ranking where the maximum value is 59.

Table 8-3: Enterprise Resiliency Rankings

Enterprise	Foreign Transportation/ DC	Foreign Port	Overseas Travel (Air/Water)	U.S. Port	Distribution Center	Domestic Transportation	Total	% of Total	Rank (by %)
A	7	6	7	9	9	8	46	78	7
B	10	9	9	11	9	9	59	100	1
C	8	7	8	10	9	8	50	85	5
D									
E	8	7	7	9	8	8	47	80	6
F	7	6	6	8	7	7	42	88*	4
G									
H	10	9	9	11	9	9	57	97	3
I	10	9	9	11	9	9	59	100	1
J									

* Out of a total of 48 possible points for a domestic supply chain.

There is a wide range of resiliency scores. Enterprise B received a “perfect score” of 59 based on the strategy selection which occurred post-interview. Another enterprise, Enterprise I, also indicated that their enterprise utilized all of the strategies named. The respondent commented that Enterprise I utilizes all of the strategies named but they are not standardized throughout the organizations or divisions within the enterprise. This conclusion is consistent with information gathered in the interview. For an enterprise such as Enterprise I, where there are numerous, separate supply chains within one organization, it may be best to examine supply chains individually. As expected, Enterprise F would be ranked last if based on total points earned due to the enterprise's shorter supply chain. It was determined that Enterprise F was unable to earn eleven additional points because of the enterprises shortened supply chain. Enterprise F's 42 out of 48 possible points, or 87.5%, is

equivalent 52 points out of the entire 59 points, which then allows the enterprise to compare easily to others.

Looking across the table, the points awarded to each enterprise are relatively constant across supply chain segments, although generally, more points are awarded in the latter half of the supply chain segments. Reasons for this may include the relative ease of implementing strategies in close proximity to decision makers, and the more crucial need to respond to disruptions quickly due to the close proximity to final destination.

8.3 Discussion

While the method above provides an adequate ranking method to determine the relative resiliency of an enterprise, it has its shortcomings. The evaluation is a self-assessment as the enterprises themselves identified the strategies used without a formal assessment of to what degree enterprises are truly using strategies to improve resiliency. Enterprises were asked which strategies they used “to improve resiliency,” but responses could easily include operating procedures which are primarily used for means other than improving resiliency. If this ranking is to be used by the enterprises to compare themselves to others with the intent to continue to improve resiliency, the results provided can achieve this goal. Perhaps the best way to use the information provided is to compare enterprises within given industries to determine if a given enterprise is more or less resilient than other enterprises within the same industry. If the intent of the ranking is to compare enterprises for use by an outside entity, an independent assessment of the strategies which an enterprise uses would be useful to provide more accurate results. This ranking is currently based on a group of resiliency strategies which is not all-inclusive. Additional strategies may be added to the ranking, but must be evaluated over all enterprises to provide a valid comparison.

Currently, the strategies are equally weighted in the ranking, although the method of ranking does reward strategies which can be implemented over numerous segments of the supply chain. If strategies were to be weighted, the enabling strategies should be weighted less than the other resiliency strategies because they do not allow for resiliency directly. Because all companies, with the exception of Enterprise E, listed all four enablers as strategies used, weighting these strategies less makes little difference to the overall ranking.

This method of ranking is not the only possible way to rank enterprises based on their level of resiliency within the supply chain. Enterprises could also be ranked based on amount spent on resiliency efforts, cost savings due to resiliency efforts, and types of disruptions accounted for, among

other thing. The limiting factor regarding a ranking of enterprises is the amount of information available. Often, gathering information related to resiliency and resiliency efforts is difficult and complex, as seen in Section 7. With the current information available from the interviews about the utilization of resiliency strategies, and limited information regarding other considerations, the above ranking is one of the most complete ranking possible. Additional information, which potentially could take a great effort to obtain, would improve the methods of ranking available.

Based on interview conversations and the concept of disruption experience, described in Section 9, there were both expected and unexpected results. Enterprises which operate with a JIT strategy, such as Enterprise I and Enterprise H, are ranked high, as expected due the severe consequences associated with a supply chain which operates with limited or no inventory. Given their awareness and insight into supply chain resiliency, it was expected that Enterprise E would have ranked higher among enterprises. This is likely related to the weaknesses associated with self-assessment. For example, while they did not report using information and technology as an enabling strategy, Enterprise E may in fact use information and technology more than an enterprise, such as Enterprise C, who did respond as utilizing the strategy, and was ranked higher than Enterprise E despite appearing to have limited experience with resiliency and disruption management.

9 Discussion

9.1 Outcomes

As stated earlier, there are two distinct outcomes to the implementation of resiliency strategies: (1) the reduction of exposure to or frequency of disruptions and (2) the mitigation of the impacts, or size and severity, of disruptions. Like many of those previously examined, strategies can also both reduce and mitigate, depending on the circumstances of the disruption. In most cases, it would be preferable to reduce exposure to a disruption than to mitigate the impacts of one. Figure 9-1 summarizes the strategies and possible outcomes of their use.

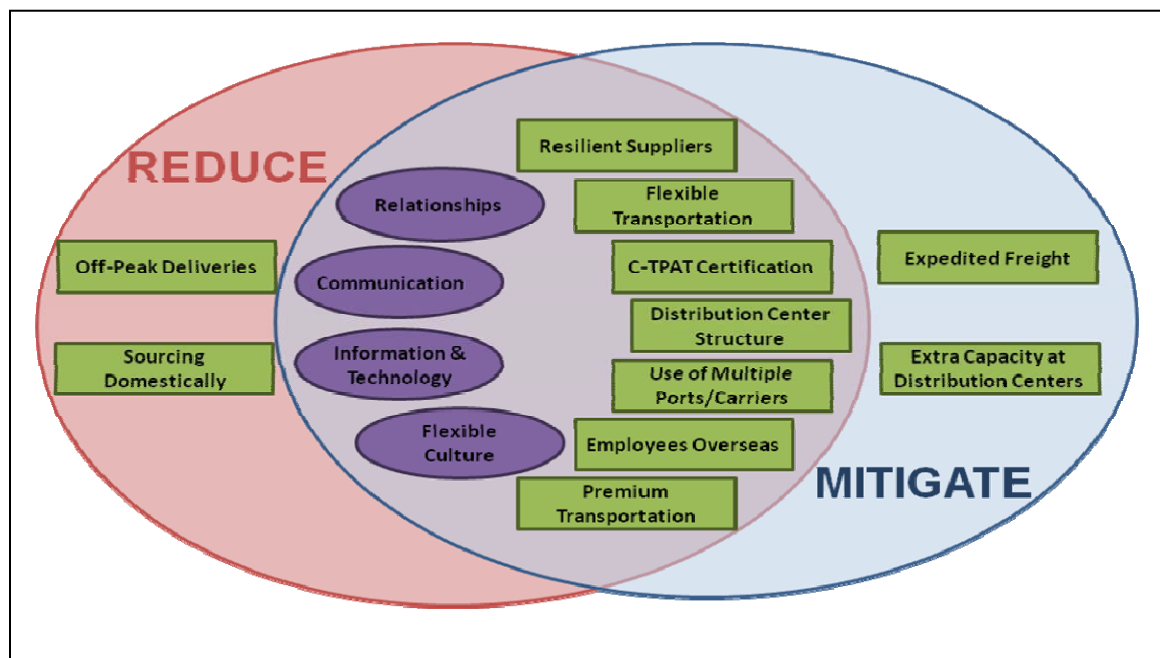


Figure 9-1: Resiliency Strategy Outcomes

The distinction between reduction and mitigation, as identified in Section 7, is most clearly seen temporally. Reduction is proactive and action is taken prior to the disruption physically affecting the supply chain. While often the disruption cannot be prevented, the supply chain operates such that despite the disruption, operations are not disturbed. Mitigation is reactive and occurs when exposure to the disruption cannot be avoided. The supply chain is affected by the disruption and the resiliency strategy serves as a means of returning the supply chain to previous, or normal, operations.

Initially it was believed that strategies could be categorized as either strategic, implying long-term, or operational, implying short-term. It was suspected that long-term strategies typically reduced the likelihood of a disruption and short-term strategies reduce disruption severity. Further examination concluded that all of the strategies could be considered strategic decisions although many were employed operationally. For example, a decision to use multiple ports to import goods is made at a strategic level, as is the decision to allow goods movement to shift between ports as necessary and as capacity allows. However, the decision to actually shift goods from one port to another is made on an operational basis as events develop. Likewise, it is a strategic decision to allow for expedited freight transportation to be used when needed, but the decision to send goods via an expedited service is made on a day-to-day basis.

9.2 Spreading Risk

Ideally, members of a supply chain would eliminate all sources of disruption if possible. Unfortunately, disruptions such as natural disasters and intentional attacks cannot be controlled by enterprises within the supply chain. Instead, as stated earlier, enterprises attempt to reduce their supply chain's exposure to disruption. In doing so, resiliency strategies spread the risk of a disruption temporally, geographically, or across people. Table 9-1 identifies how resiliency strategies spread the risk of disruption. Explanations follow.

Table 9-1: Spreading Risk Through Resiliency Strategies

Strategies	Temporally	Geographically	Across People
Relationships			
Information and Technology			
Communication			
Flexible Culture			
Flexible Transportation			
C-TPAT Certification			
DC Structure, Size of Network			
Resilient Nature of Suppliers			
Expedited Freight			
Use of Multiple Ports/Carriers			
Employees Overseas			
Extra Capacity at DC			
Off-Peak Deliveries			
Domestic Sourcing			
Premium Transportation			

The strategic resiliency strategies of flexible transportation, expedited freight, and off-peak deliveries spread the risk of disruption over time. Flexible transportation policies allow for goods to be shipped ahead or behind schedule in order to avoid potential disruptions. For example, when there is knowledge of an impending snowstorm, an enterprise may choose to send an available shipment of goods in advance of a previous delivery date to avoid risking a pass or other road closure. Expedited freight reduces the time needed to transport goods along the supply chain. The concept off-peak deliveries relies on the fact that deliveries made overnight are less likely to be disrupted by congestion or other urban disturbances.

Many strategic resiliency strategies, including flexible transportation, distribution center structure, the use of multiple ports, extra capacity at distribution centers, and sourcing components domestically, spread risk geographically. These strategies are based on the assumptions that disruptions will not occur simultaneously in multiple geographically separated locations, and that the geographic length of a supply chain is directly related to the potential risk of disruptions to that supply chain. While often true, disruptions may affect large geographic areas making them virtually unavoidable. Additionally, a supply chain, regardless of how short, will never be completely free of the threat of disruptions. Flexible transportation, distribution center structure, the use of multiple ports, and extra capacity at distribution centers allow for goods to be moved around areas of disruptions through areas not currently experiencing disruptions. Sourcing domestically reduces the distance goods travel and removes aspects of the supply chain such as border crossings, which also hold a potential for disruption.

Strategic resiliency strategies, including include flexible transportation, C-TPAT certification, resilient suppliers, use of multiple carriers, employees overseas, and premium transportation, in addition to the four enablers may spread risk across personnel. Spreading risk across personnel entails involving more people into the supply chain, and informing and empowering multiple people within the supply chain to react to potential disruptions. Flexible transportation, resilient suppliers, and use of multiple carriers spread the risk of disruptions across more people within the supply chain. Similar to assumptions made regarding geography, it can also be assumed that non-geographically related disruptions will not occur simultaneously to multiple carriers. Premium transportation shifts the risk to the premium transportation providers who guarantee service. The enablers of relationships, use of information and technology, communication, and flexible culture, in addition to C-TPAT certification and employees overseas spread risk across personnel by decentralizing. By decentralizing, people are given the authority to respond quickly to problems, often being able to avoid a disruption instead of having to later mitigate the impacts of one.

9.3 The Value of Enablers

Enablers (relationships, use of information and technology, communication, and flexible culture) were the most commonly cited resiliency strategies. Reasons for this may include the low cost of utilizing such strategies, as well as the additional benefits associated with these strategies such as improved operations, and increased sales and efficiency. Examining the relationships between strategies, it is evident that enablers contribute to the successful utilization of other resiliency strategies. The strategies of relationships, use of information and technology, communication, and flexible culture are associated with numerous strategic resiliency strategies, in addition to being related to one another, as seen in Figure 9-2 through Figure 9-5.

Relationships exist among strategic resiliency strategies as well. For example, flexible transportation and a flexible transportation policy allow for the use of expedited freight when necessary, ensure the success of using multiple port and carriers, ease the coordination off-peak deliveries, and allows for the use of premium transportation when appropriate. Figure 9-6 illustrates these relationships.

Explanations of all relationships between strategies can be found in Appendix C.

The enabler strategies are vague in nature, but can be applied to all business models and, as seen previously in Figure 9-2 through Figure 9-5, enable many other resiliency strategies. One enterprise, Enterprise E, did not specifically mention the use of enablers during their interview, but it can safely be assumed that enablers are most likely being used to facilitate other strategies. Enterprise E makes use of off-peak deliveries to distribute perishable items daily to stores in urban areas. Delivery drivers, who do not work directly for Enterprise E, are provided with keys to enter stores unattended overnight. This action is possible because of a flexible culture which encourages thinking outside of the norm, a solid relationship with a delivery carrier, and extensive communication between Enterprise E and the delivery carrier. This one strategic resiliency strategy requires three unmentioned enablers to guarantee its success. A potential reason for not indicating the use of these strategies is that many daily operational tasks, where the importance and use of the enablers may be most evident, are outsourced. Additionally, the environment at Enterprise E may be taken for granted, and utilization of enablers may be understood as expected actions and not solely for resiliency purposes.

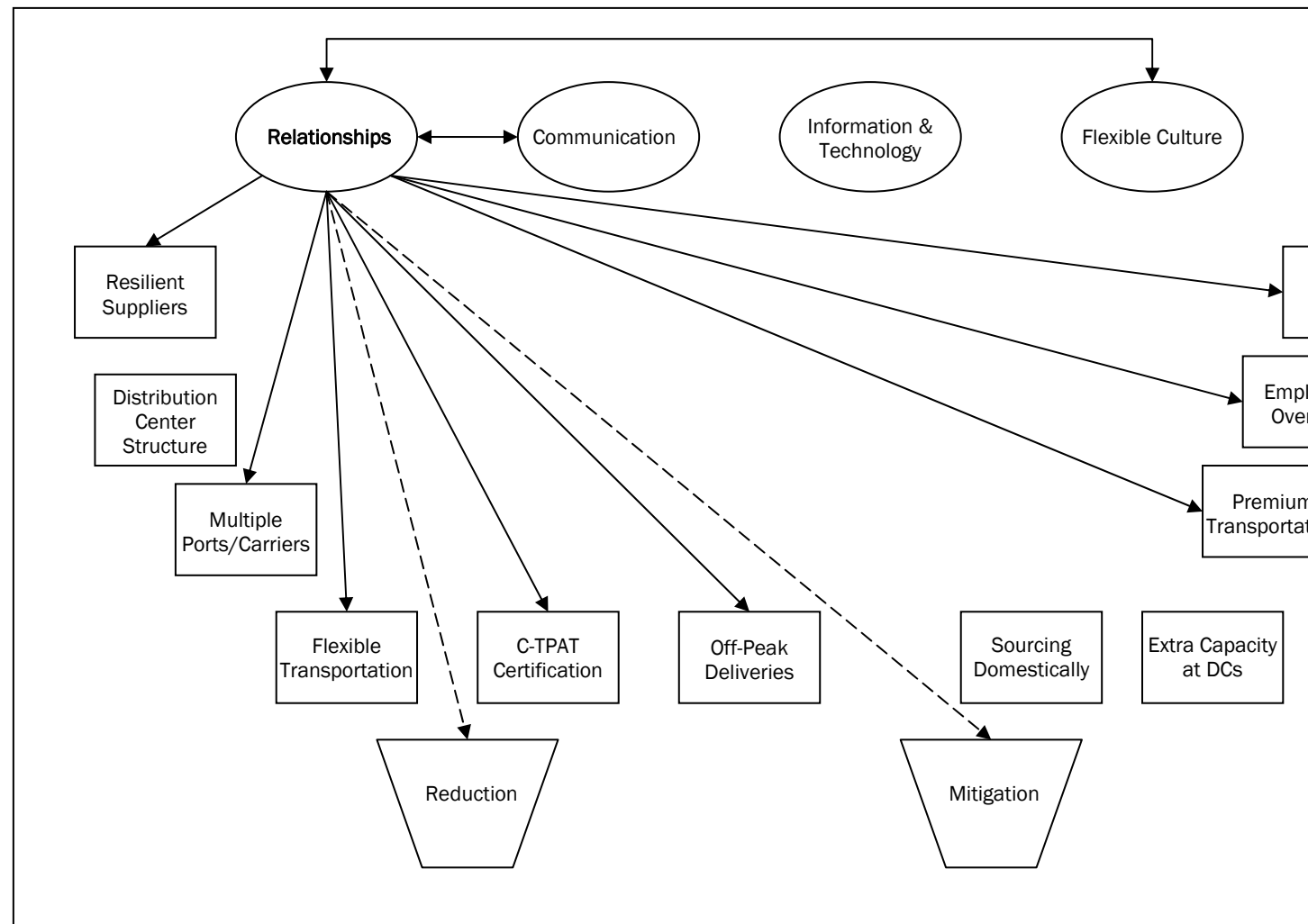


Figure 9-2: Relationships between Enabler "Relationships" and Resiliency Strategies

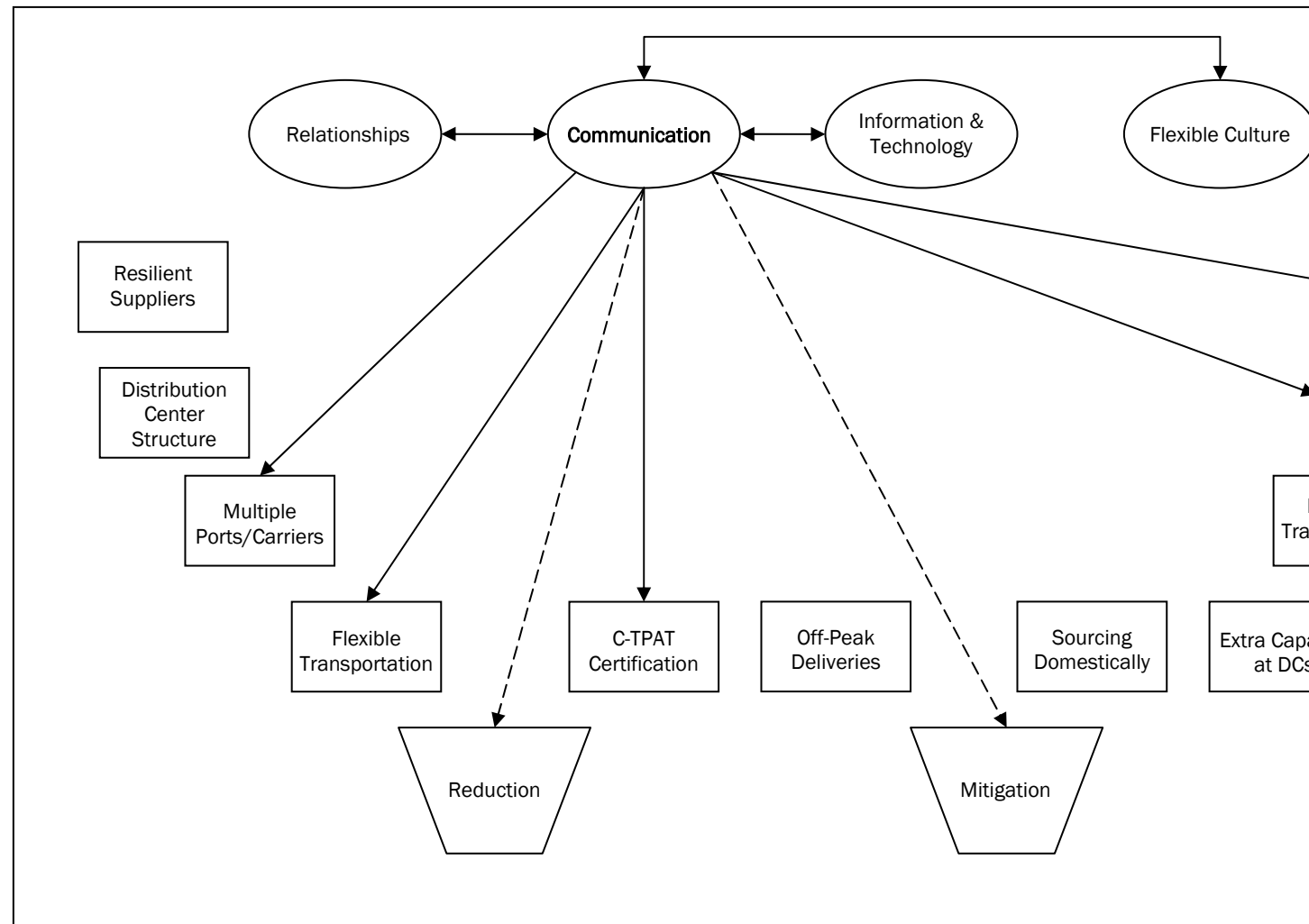


Figure 9-3: Relationships between Enabler “Communication” and Resiliency Strategies

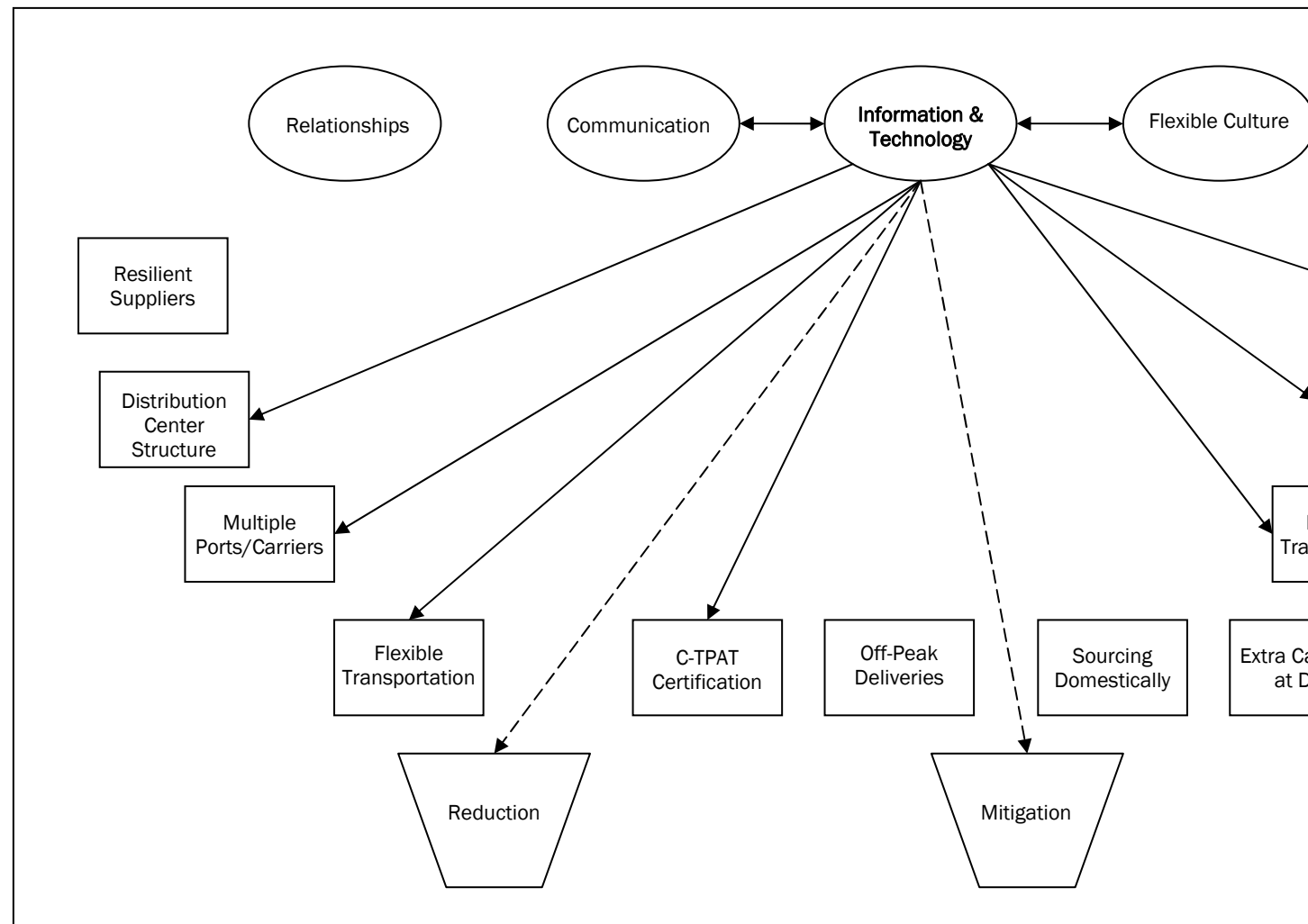


Figure 9-4: Relationships between Enabler “Information & Technology” and Resiliency Strategies

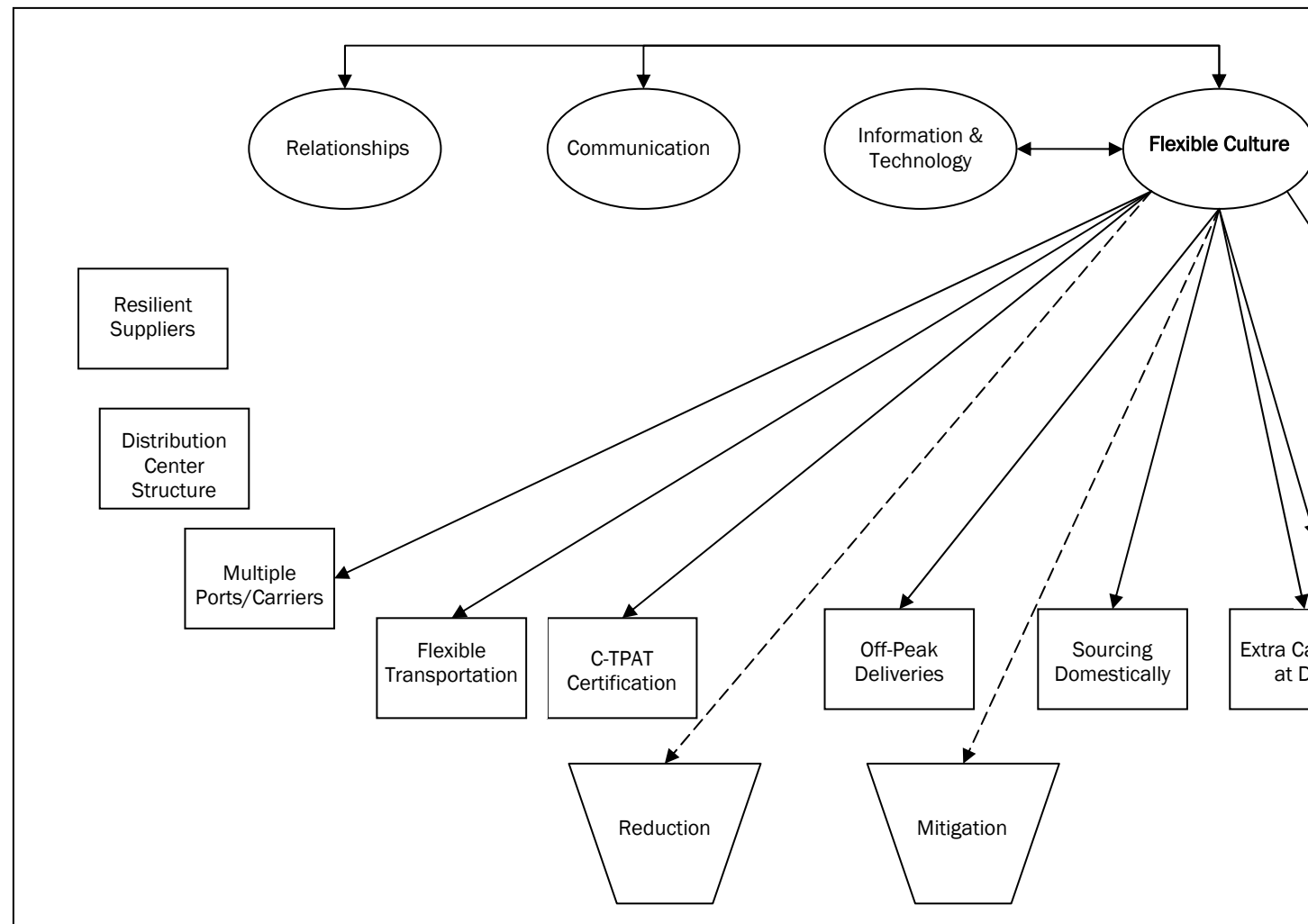


Figure 9-5: Relationships between Enabler “Flexible Culture” and Resiliency Strategies

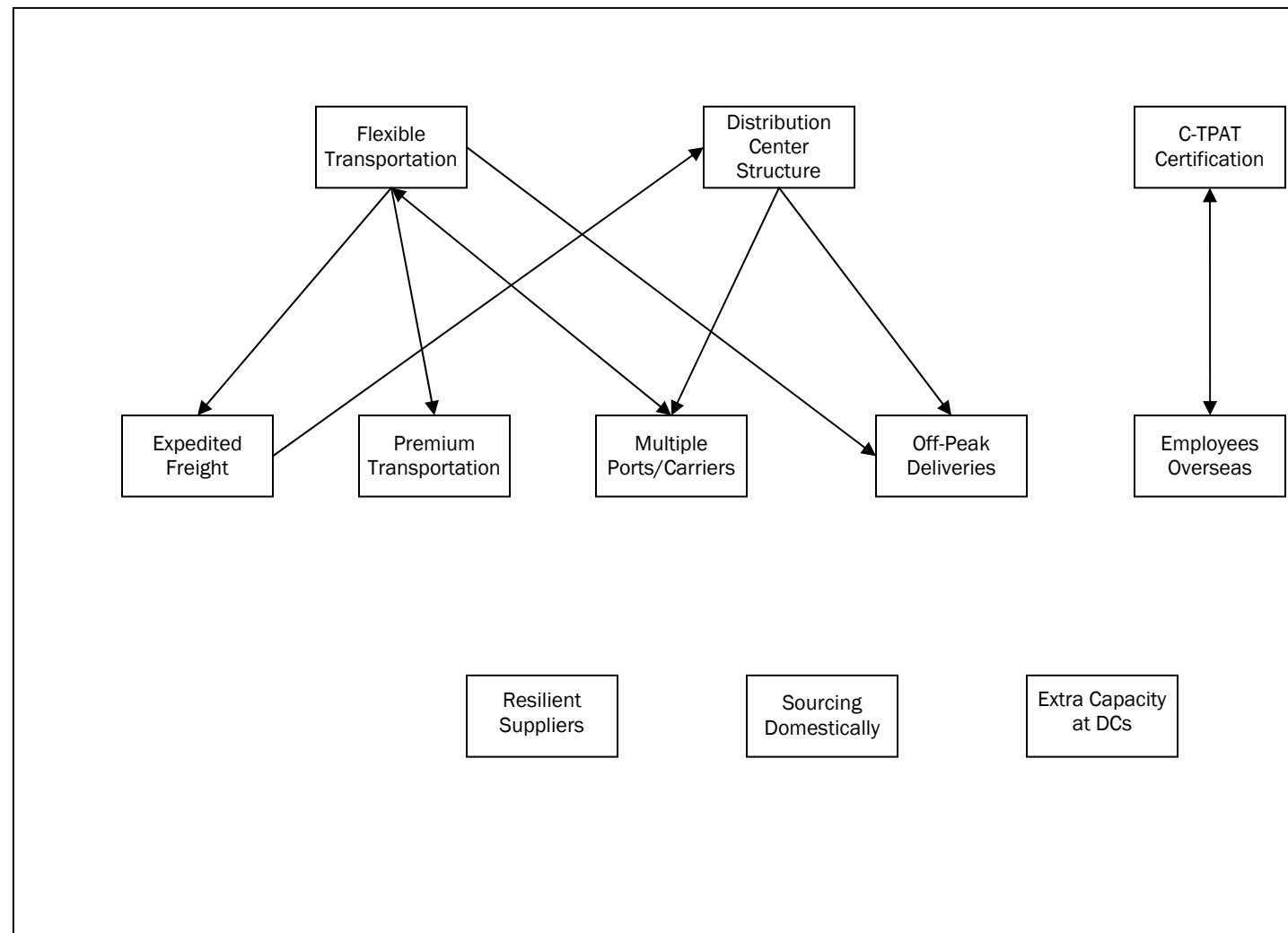


Figure 9-6: Relationships Between Strategic Resiliency Strategies

Most enterprises are assumed employ enablers to some degree, whether intentional or not. As mentioned earlier, strategies like communication, relationships, and information and technology are integral to daily business operations and are able to provide resiliency benefits even if not fully realized as such. When utilized to their fullest potential, these strategies enable a multitude of additional strategies, improving their potential for success.

9.4 Relationship to Current Operating Environment

The enterprises interviewed can be divided into three general business sector categories: manufacturing, retail, and food/beverage. The strategies reported by these enterprises were examined to determine if there are relationships between strategies used, and business sector. Examining strategies utilized by each enterprise, the resiliency strategies used do not appear to be linked to the specific nature of the business but more so to the maturity and natural likelihood for disruptions within the supply chain for a given industry. Enablers are the easiest, least cost-prohibitive strategies, and also provide many other benefits to company operations; therefore are often the first strategies implemented by an enterprise when trying to improve resiliency. As a supply chain develops and matures, it responds to frequent problems which occur due to the operating environment the enterprise is works in. These responses often double as resiliency strategies that can handle transportation disruptions. An enterprise may not directly identify certain strategies, such as enablers, when discussing resiliency efforts because these strategies have become commonplace to operations. The strategies reported are often a reflection of the mature of an enterprises experience with resiliency. Unlike Table 8-2, Table 9-2 summarizes only the strategies indicated by enterprises directly during interviews. This provided a better understanding of what strategies are the focus of resiliency efforts within the enterprise

Enterprise A, Enterprise B and Enterprise D are classified as retailers, and while all three make use of enablers, other strategies mentioned vary widely. Within the retail sector there is the most diversity of businesses and business models, meaning each supply chain has different resiliency needs. These enterprises interviewed do not operate supply chains which are exceptionally lean or exceptionally volatile. Retailers are more likely to hold higher levels of inventory which can be used to respond to small disruptions. Resiliency is not forced as a concern for these enterprises. Instead, these enterprises understand, in the general sense, that resiliency can benefit a supply chain, and have chosen to explore how resiliency can best be implemented into their own supply chains to address their specific needs.

Table 9-2: Interview Reported Strategies

	A	B	C	D	E	F	G	H	I	J
Relationships										
Information and Technology										
Communication										
Flexible Culture										
Flexible Transportation										
C-TPAT Certification										
DC Structure, Size of Network										
Resilient Nature of Suppliers										
Expedited Freight										
Use of Multiple Ports/Carriers										
Employees Overseas										
Extra Capacity at DC										
Off-Peak Deliveries										
Domestic Sourcing										
Premium Transportation										

Enterprises such as Enterprise C and Enterprise K have not suffered from disruptions and have few to no resiliency strategies to speak of. The rapid and recent growth of Enterprise C has left its supply chain scrambling to catch up. Due to the lack of previous disruptions, future disruptions do not appear to be a large threat. Enterprise C has chosen to focus on expanding and increasing the efficiencies of their supply chain without considering the importance of resiliency. Additionally, due to the lower costs of goods produced, Enterprise C can afford to hold more inventory than enterprises with higher costs goods such as Enterprise I and Enterprise H. Enterprise K is not mentioned in Table 9-2 due to their lack of use of resiliency strategies. Self-admittedly, Enterprise K has a brittle supply chain with no immediate resiliencies because they have been fortunate to yet experience any major problems due to disruptions within the supply chain.

The products provided by Enterprise E can be loosely classified as commodities which are consumed upon purchase. Additionally, a small number of components are used to make a limited number of products, and if any of these critical components are delayed, the products themselves cannot be

produced. As with other commodities, if Enterprise E cannot deliver their products another enterprise is waiting and able to provide a very similar one, costing Enterprise E business and possibly damaging their reputation. Also, because these critical components are perishable, subject to quality standards, and there is limited storage space in Enterprise E's facilities, deliveries are made on a near daily basis. The frequent delivery required for perishable, typically food, products means more exposure to disruption due to more overall time in transit. Enterprise E has developed a mature resiliency approach due to the severe consequences of disruption and high competition associated their supply chain and operations. The strategies employed by Enterprise E, such a sourcing many critical components domestically and making off-peak deliveries, display this experience.

Enterprise F also produces food products, but displays less resiliency experience than Enterprise E due to previous lack of experience with disruptions. Having a domestic supply chain reduces the potential for disruption, as previously mentioned, and may be a reason for Enterprise F's lack of experience with disruptions. A recent weather disruption, and subsequent breakdown within the supply chain, encouraged Enterprise F to evaluate and improve their resiliency procedures. As a relative newcomer to the area of resiliency, Enterprise F is beginning to integrate more general resiliency strategies such as communication, relationships, and flexibility into the supply chain. When faced with a second weather disruption a year after the first, Enterprise F utilized recently established strategies and believes their supply chain response improved due to the strategies in place. One can expect that as Enterprise F continues to explore and understand the importance of resiliency within their supply chain, the strategies they chose to implement will be similar those of Enterprise E. Enterprise F's actions align with previous research asserting that enterprises that have experienced a previous disruption are more likely to be proactive in an attempt to improve resiliency (Rice and Caniato 2003).

The large manufacturing enterprises use similar strategies, such as use of information and technology, expedited freight, and premium transportation, but they do not employ these strategies solely for the sake of transportation resiliency. Both Enterprise H and Enterprise I manufacture expensive products using a JIT strategy, meaning the precise delivery of goods is essential to being able to operate with minimal inventory. JIT is foremost an inventory strategy, and its success hinges on the ability to operate with low volumes of inventory and still keep assembly lines moving. By removing safety stock, a supply chain is automatically less resilient and depends more on the reliability of other aspects of the supply chain like the transportation network. A JIT supply chain needs to actively increase resiliency and ability to respond to delays, potential and actual, in order to be successful. Given the size and value of the good produced by both these enterprises, the extra expenditures required to implement information technology systems and use expedited and premium freight are

inconsequential to the costs of holding increased inventory and potential assembly delays. Enterprise J does not operate as a JIT supply chain but provides service to enterprises who value expedited service very highly. As with Enterprise H and Enterprise I, whose manufactured goods cost in the hundred thousands and hundred millions of dollars respectively, the cost of transportation for Enterprise J is negligible when concerned to the cost of customers' delays of business due to delayed goods. Similar to Enterprise J, Enterprise G provides products to enterprises that operate JIT and therefore value high levels of service. Higher values goods incur high inventory costs and therefore it is most efficient to produce finished goods to be sold as quickly as possible.

A supply chain which operates with a JIT strategy can be considered mature due to concerns beyond solely ensuring that goods arrive at the destination as expected. Enterprises using JIT have made the decision to improve efficiencies to an already established supply chain, thus reducing supply chain costs. Disruptions are more consequential within these supply chains, and therefore resiliency efforts are more established. The strategies most commonly reported by these enterprises are the most appropriate and effective means of establishing resiliency given the requirements of a JIT, large, manufacturing supply chain.

9.5 Resiliency as a Nebulous Concept

As mentioned earlier, resiliency has been discussed in nebulous terms in the past. One of the aims of this research was to present a framework for discussing resiliency in more specific terms, which was accomplished using concepts such as enablers and strategies. While evaluating resiliency strategies and understanding enterprise implementation, it became clear that there was a need for the nebulous discussion. Given the multitude of disruption possibilities and supply chain structures both between and within enterprises, it is difficult to discuss resiliency in absolute terms. It is impossible to develop a prescribed plan to improve resiliency in supply chains as a whole and strategies are not universal. Resiliency is best explored at the individual enterprise level, and therefore, when discussed in general terms, a rather vague concept.

9.6 Adding to Supply Chain Strength

In addition to improving resiliency, these strategies may also be able to add value to the supply chain in other ways. Several of these strategies, including use of information and technology, communication, and C-TPAT certification increase visibility in the supply chain, as well as impact other

supply chain concerns such as insurance rates. With respect to resiliency, these strategies allow enterprises to identify disruptions earlier. Increased visibility also allows enterprises to identify inefficiencies within the supply chain, and could potentially lead to a reduction of inventory due to increased knowledge of goods flow.

As stated earlier, more volatile supply chains with existing disruption experience such as supply and demand fluctuations are often more mature, resiliently speaking. To complete the circle, supply chains which employ resiliency strategies become more capable of handling other disruptions such as supply and demand fluctuations. An enterprise who aims to be resilient to large scale disruptions typically increases their resiliency to daily vulnerabilities (Sheffi 2005). For example, a flexible transportation strategy not only allows for changes to contracts of scheduling due to events such as closed ports and large weather events, but also for last-minute order changes or congestion.

10 Relevance to Transportation System

The enterprise view of supply chain resiliency cannot be isolated from the resiliency of the transportation system which includes the physical infrastructure, government policy and regulations, and all transportation system users (such as private vehicles, commercial fleets, and public transportation vehicles). An enterprise could have extensive resiliency plans in place, but most often requires assistance in the form of information or infrastructure to successfully implement the plans. Supply chains are dependent on both public and private infrastructure, and often enterprises rely on governmental agency policies and regulations in order to move goods efficiently.

10.1 Infrastructure

Much of the infrastructure which goods move on is designed, built, and managed by a Department of Transportation (DOT), whether it be at the city, state, or federal level. Additional goods are moved on private infrastructure, such as rail, which is managed by private agencies. During normal conditions, enterprises know what to expect from and how to best use the infrastructure, due to experience. During a disruption, an enterprise's level of resiliency may depend on understanding how the infrastructure has been affected, what alternatives have been provided, and how other users respond. Additionally, if the agencies maintaining the infrastructure understand how enterprises use the infrastructure to move goods, they can make better decisions on how to handle disruptions in order to minimize impacts on users.

From the strategies identified during the interviews the following conclusions can be made about the impact of these strategies on the transportation system. Broadly speaking, the transportation system benefits from efficient freight operations, as fewer vehicle miles and vehicle hours are spent producing the same good. Less infrastructure capacity is required to perform the same work of moving goods from origin to destination. The impacts of the use of the identified strategies on the transportation system are examined in detail below:

- Developing **relationships** with the agencies or personnel who manage the components of the transportation system helps facilitate communication and information sharing between the enterprise and the transportation system. With better information about user behavior, the agency can make better investment decisions regarding system operation and improvement.

- The **information** gathered by enterprises through technology, and shared with the agency through **communication**, allows the agency to managing the transportation system more effectively
- If an enterprise maintains a **flexible transportation policy**, the managing agencies can rely on the enterprise having the ability to reroute around problem areas if given proper notice, relieving the stress or demand to these areas during a disruption.
- When enterprise becomes **C-TPAT certified**, it helps to facilitates security procedures within the port, assisting the port managing agency in improving the efficiency of the safe movement of cargo through the port.
- Having a wide-spread **distribution center structure** spreads the transportation demands of the enterprise over the infrastructure, lessening the burden on any one region or segment of the transportation system. Using **multiple ports or carriers** also achieves this end.
- When an enterprise **delivers during off-peak hours**, it is utilizing the infrastructure at a time when there is typically excess capacity and reducing demand on the transportation system during peak flow periods. This allows the transportation system to provide better service to other users.
- An enterprise which **sources domestically** may increase the demand for domestic transportation, but lessens the burden on U.S. points of entries such as ports. The net effect depends on the relationship between current demand and capacity of these system elements.
- Some forms of **premium transportation**, such as previously mentioned z-trains, demand a higher level of service from the managing agencies in the event of a disruption.

In general, the use of resiliency strategies by enterprises also increases the resiliency of the transportation system. It is expected that many enterprises will adopt additional resiliency strategies, and that overall these will improve the level of communication between parties active in the transportation system, and help spread demand for the transportation infrastructure across time and space.

10.2 Government Regulations

Enterprises expressed some concern regarding government response to disruptions. Historically there have been cases when government response to disruptions had a greater impact on supply chains than the disruption itself. For example, the closure of U.S. airspace and delays at the borders

immediately following the attacks on September 11th were more disruptive to supply chains than the actual attacks themselves (Rice and Caniato 2003). With regards to both large-scale and daily disruptions, the policies of the federal, state and local governments impact an enterprise's ability to move goods. These policies include federal policies such as C-TPAT and the Container Security Initiative (CSI), and local policies such as hazard mitigation plans. From the enterprise's perspective, it is important to understand and anticipate government reactions to disruptions in order to improve resiliency. The most successful government policies are the product of an interaction between the enterprises and agencies because are most successful when embraced by industry and therefore require industry input.

In the interviews conducted, several enterprises voiced concerns regarding interactions with governmental agencies. Enterprise A, Enterprise D, Enterprise E and Enterprise J identified security measures such as the Customs and Border Protection's (CBP) 10+2 initiative and the Transportation Worker Identification Credential (TWIC) program as potential transportation challenges. Enterprise J commented that since September 11th, the Department of Homeland Security and the Transportation Security Administration have made commerce more difficult. Enterprise E remarked that they understood the purpose of such initiatives but felt they were difficult to comply with. Enterprise H identified border controls, especially at the southern border, as an issue. Being required to switch trucks, and often carriers, at the border introduces more room for disruption or incident within the supply chain. These initiatives have been put into place to deter disruptions and protect trade, but they also introduce challenges to supply chains.

With regards to both infrastructure and policy, successful interactions between the private and public sector require communication and information exchange (both enablers) to occur before, during, and after the disruption. In order to effectively accomplish this exchange, relationships (another enabler) must be developed between the two entities. The fourth enabler, flexible culture, is also an important trait for an agency to embody in order to best react to disruptions and interact with enterprises moving goods. In general, resiliency strategies impact the transportation system by spreading demand. Enterprise resiliency and systems resiliency are not stand alone concepts and interactions between the two are necessary for either to achieve resiliency.

11 Conclusions

This thesis was motivated by the continued increases in trade volumes, lengthening of supply chains, and increased focus on disruptions and resiliency within the supply chain community. As enterprises attempt to improve transportation resiliency, it is important to understand their perception of the concept and the means by which they attempt to achieve resiliency. Through interviews it appears that while resiliency was in the field of vision of interviewees, the concept was not a supply chain priority. While resiliency, specifically related to transportation, can impact supply chain costs and efficiency, and enterprises often cited costs and efficiency as supply chain priorities, there appeared to be a disconnect between the impacts of resiliency and enterprise priorities. Resiliency, while acknowledged, was not part of most enterprises' daily language, or discussed using other terms such as reliability and consistency.

Despite this, evidence of transportation resiliency within enterprise supply chains was encountered. Through the eleven enterprise interviews, fifteen resiliency strategies were identified.

Four are categorized as enabler strategies:

- Relationships
- Use of Information and Technology
- Communication
- Flexible Culture.

Enabler strategies are identified as strategies used to increase the effectiveness of other resiliency efforts and are often an integral part of supply chain operations prior to concerns about resiliency.

Eleven strategies are categorized as strategic resiliency strategies and include:

- Flexible transportation
- C-TPAT Certification
- Distribution Center Structure/Size of Network
- Resilient Nature of Suppliers
- Expedited Freight
- Use of Multiple Ports/Carriers
- Employees Overseas
- Extra Capacity at Distribution Centers
- Off-Peak Deliveries
- Domestic Sourcing of Components
- Premium Transportation

These strategies are typically part of a long term plan of action, but are often implemented on a day to day or as needed basis. Both enabler and resiliency strategies result in the reduction of exposure to supply chain disruptions and/or the mitigation of disruption impacts.

Defining types of strategies, such as enabler and resiliency, provides consistency within a vague concept. While enablers are seemingly nebulous concepts which this research was attempting to avoid, their value is exemplified by the extensive relationships between enablers and strategic resiliency strategies and an understanding of their importance in promoting the success of strategic resiliency strategies. Additionally, upon deeper examination of implementation of resiliency into enterprise supply chains, it became clear that the vague discussion regarding resiliency is necessary due to the multitude of scenarios regarding both disruptions and strategies.

Identifying commonly used strategies can assist those who manage transportation systems in understanding how enterprises continue to operation in the face of disruptions. This understanding allows these managers to implement transportation system resiliency measures which compliment those strategies employed by the enterprises who use the system.

Both a qualitative assessment of strategies and a ranking of enterprises were attempted to give a value to resiliency efforts. The amount of information required, which is often difficult to gather, to assess the value of resiliency strategies within a supply chain makes this type of assessment both time consuming and costly. A ranking of enterprises is most useful when comparing enterprises in similar industries and with similar supply chains. The most accurate way to rank enterprises in order of the overall resiliency would use an outside source to evaluate the efforts within the enterprise to achieve resiliency.

The list of identified strategies within this research is not all-inclusive. The strategies evaluated were drawn for the interviews conducted and it is acknowledged that additional strategies may be used by both these and other enterprises not interviewed. As strategies identified within the interviews, it can be assumed that these strategies are commonly utilized among supply chains in various industries such as the ones considered here.

The selection of resiliency strategies by an enterprise gives insight into their resiliency experience, which is often driven by the operating climate of the industry in which the enterprise does business. Enterprises in which disruptions are common and the continued flow of goods is crucial to operations, such as JIT manufacturers or food providers, are more likely to have a more developed resiliency portfolio, although this is often not the result of more developed enterprise-wide thinking concerning transportation resiliency, but response to common occurrences or events within the supply chain. Enterprises which have less experience with disruptions or disruption impacts, whether due to lack of competition, less volatile supply chains, or

good fortune, are more likely to have less developed resiliency portfolios, with more focus on enabling strategies than strategic resiliency strategies.

Overall, enterprises can benefit from the implementation of enabling and strategic resiliency strategies. Incorporating the strategies which are best individually suited for a given supply chain can improve resiliency and improve productivity and efficiency, reducing costs and increasing sales.

11.1 Recommended Areas for Future Study

While understanding of the enterprise role in creating a resilient supply chain is critical, a better understanding of the agencies (i.e. DOT, port authority, railroad, highway patrol, local governments) role in improving resiliency is also required. As stated earlier, the enterprise view of transportation resiliency cannot be isolated from the resiliency of the transportation system which includes infrastructure and government policy and regulations. Enterprises depend on agencies to provide and manage the transportation system, and decisions which either party makes regarding resiliency affects the other.

Agencies have only just begun to focus efforts onto resiliency of the transportation system. Currently agencies serve as communicators of transportation system status and advocates for investment to improve resiliency. Frameworks or models can be developed to assist these agencies in incorporating resiliency into planning and operations. Further research into the interaction between agencies and enterprises can help determine the best methods to improve overall freight system resiliency. Additionally, chains of command and assignment of responsibility should be formalized for cases of disruption, and plans for disruption response and recovery should be developed and evaluated.

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Appendix A: Interview Questions

First Round Interview Questions:

(Note: Not all questions were asked of all interviewees.)

CURRENT PRIORITIES

- What are your company's transportation priorities?
- How do these priorities align with your company's missions and goals?
- Have these changed in the last year or few years?
- What is your company doing to try and meet these priorities?
- What metrics does your company use to manage its supply chain or transportation?
- How do these metrics impact the choice to use or where to locate distribution centers?
- Have you been involved in developing a new distribution center, or relocating a distribution center? Please describe.
- Once a region is identified as home for a new distribution center, what are your priorities for selecting a location?
- Have you seen these priorities change over time?

THE ROLE OF RESILIENCY/RELIABILITY

- Has your handling strategy been based in the past on delivering your product for the cheapest cost?
- Define resiliency and reliability.
- Have reliability or resiliency become more important qualities in your company's transportation or supply chain management? Over what period? Over the last year?
- What have been the other changes in priority?
- What makes your transportation unreliable?
- How does your company manage travel time variability?
- What is your company trying to do to reduce variability in travel times?
- What is efficient transportation?
- Do you consider reliability as a key component of efficiency?

FUTURE RELIABILITY

- What are changes to your company's transportation or supply chain management?
- Is your priority reducing cost? Improving reliability? Reducing loss?
- What will be your transportation challenges in the next year?

Second Round Interview Questions:

(Note: Not all questions were asked of all interviewees.)

- What are your company's transportation priorities?
- Have these changed in the last year?
- What is your company doing to try and meet these priorities?
- Define resiliency and reliability.
- What makes your transportation unreliable or vulnerable?
- Are you taking any specific actions to reduce these vulnerabilities? Why or why not? Do you want to do more to reduce vulnerabilities?
- Are there redundancies or resiliencies built into your supply chain?
- Is there anything about your company (profile, structure, culture) that you feel leads to a natural redundancy or resiliency in your transportation network?
- How are disruptions to your supply chain currently handled?
- Do you have a plan to address high impact, low probability disruptions? What is it? How specific is it?
- Do you think the current state of our transportation infrastructure impacts the resiliency or reliability of your company (the amount of roads, quality of roads, potential for failure)?
- Do you think that improvements to the resiliency of the transportation infrastructure network would improve the resiliency of your supply chain?
- What will be your transportation challenges in the next year?

Email - Final Question Regarding Supply Chain Resiliency for UW Research:

Good Afternoon,

Within the past year, I conducted an interview with you as research for my thesis involving resiliency within the supply chain. I am only a few weeks away from finishing and was hoping you could take a minute or two to respond to this email and help with my final conclusions.

As one of the final steps in my research I'd like to identify which strategies you use to improve resiliency in your supply chain, as opposed to just the ones which came up in our conversation. Below is a list of 15 "resiliency strategies" which I discerned from the various interviews I conducted. Would you be able to take a minute to indicate which your company utilizes as a means of minimizing

exposure to or mitigating impacts of disruptions (you can just delete the strategies which you DO NOT use in the reply email). If you are interested in how I define these strategies, I've attached another document with this information, but you can also just take the strategies at face-value based on their names.

Development and use of Relationships

Use of Information and Technology

Use of Communication

Flexible (corporate) Culture

Flexible Transportation

C-TPAT Certification

Distribution Center Structure – Size of Network

Resilient Nature of Suppliers

Expedited Freight

Use of Multiple Ports/Carriers

Employees Overseas

Extra Capacity at Distribution Centers

Off-Peak Deliveries

Domestic Sourcing of Components

Premium Transportation

I sincerely appreciate the time you have taken to help with my research! I wanted to remind you again that all replies are anonymous. If you are interested in reading my final report, let me know and I can send you a copy once I have finished.

Thank you.

Email - Attachment:

RELATIONSHIPS

Developing and maintaining relationships with suppliers, carriers, and customers, with the belief that strong relationships will result in increased assistance and flexibility during disruptions.

USE OF INFORMATION AND TECHNOLOGY

Using information, generally gathered through increased technology, to manage disruptions. Tools such as Transportation Management Systems (or similar enterprise information software) and procurement agents can help track goods and detect potential or actual disruptions.

COMMUNICATION

Relaying information about disruptions, potential or actual, to those who have the authority to take action to prevent or mitigate the disruption.

FLEXIBLE CULTURE

Having a flexible culture as resiliency strategy means working within a business environment that promotes supply chain security and resiliency practices. The culture of a company can simply be stated as “the way we do things around here” (Sheffi, 2005).

FLEXIBLE TRANSPORTATION

Having the ability to make last-minute changes to your transportation providers or routes in case of disruption. It may include:

- (1) Importer subcontracts transportation: Flexible contracts/agreements with transportation providers or making use of backup carriers.
- (2) Importer provides own transportation: Making use of trucking in teams, or detours. This may also include having drivers that are trained for multiple tasks and equipment that is standardized, making it easy to substitute drivers.

C-TPAT CERTIFICATION

Being Customs-Trade Partnership Against Terrorism (C-TPAT) certified. C-TPAT is a voluntary government-business initiative that aims to improve U.S. border security. In order to be certified an importer must meet criteria that falls under the categories of: business partner requirements, container security, container inspection, physical access controls, personnel security, and procedure security.

DC STRUCTURE, SIZE OF NETWORK

Having the ability to serve, on short notice, a destination/store from a different distribution center than typically served to handle product shortages due to transportation (or other) disruptions.

RESILIENT NATURE OF SUPPLIERS

Development of resiliency within a supply chain due to the natural resiliency of the supplier component of the supply chain.

EXPEDITED FREIGHT

Upon identifying a disruption, deciding to use accelerated freight transportation to move additional freight or to speed up delivery of existing shipment.

USE OF MULTIPLE PORTS/CARRIERS

Importing goods through more than one port or using multiple carriers (marine, truck, rail), as part of a regular supply chain structure in order to avoid having a disruption affect the entire supply chain.

EMPLOYEES OVERSEAS

Locating company employees located overseas, in countries which are part of the supply chain, to oversee and manage operations.

EXTRA CAPACITY AT DISTRIBUTION CENTERS

Scaling distribution centers to have a capacity much larger than required for current volumes of goods moving through the distribution center.

OFF-PEAK DELIVERIES

Delivering goods during off-peak hours to distribution centers or stores to avoid congestion which may cause delays.

SOURCING OF COMPONENTS DOMESTICALLY

Acquiring components/goods from domestic suppliers instead of from suppliers overseas, where they may be cheaper, because of perceived reduction in disruption potential.

PREMIUM TRANSPORTATION

Using more expensive modes of transportation (air or z-trains), assuming they offer better service, which is more reliable or can move goods in a quicker fashion.

Appendix B: Interview Notes

Enterprise: Enterprise A

Date: 11/29/2007

- **What are you company's transportation priorities?**

International Ocean, International Air, Domestic Trucking

Goods are imported into one of three de-consolidators at Portland, New Jersey or Chicago (international air). Enterprise A has 6 domestic DCs: Oregon, Northern California, Southern California, Iowa (handles catalog and website sales), Maryland and Florida. These DCs service regions.

A priority is on-time delivery, Enterprise A considers their merchandise perishable so they need to get it there when it is wanted by consumers or they will have to discount it.

Some goods they bring in directly, but others they buy from other US companies. They take control of this merchandise after it arrives in the US – this is a bit riskier than the stuff they bring in directly because they have less control (example – Enterprise A does not bring goods in through LA/LB, but they buy from [manufacturer] who does. If something happens at LA/LB, they are affected).

- **Define resiliency and reliability.**

Resiliency: how long it takes to be back to normal; to be able to respond most efficiently to unforeseen issues.

Reliability – inherent to “normal” (see above)

- **What makes you transportation unreliable or vulnerable?**

(These could be at any point in the supply chain)

Labor – longshoreman strike

Weather

Human error

Terrorist event

Production delays

Systems issue (theirs or service)

I asked about congestions and they said that consistent congestion is a problem. Now it takes 3 hours to drive from Tacoma to Portland. If it becomes 8 (or some given number) they might consider using the Port of Portland instead. They work to develop relationships that can influence things like loading priorities.

- **Are you taking any specific actions to reduce these vulnerabilities? Why or why not? Do you want to do more to reduce vulnerabilities?**

Enterprise A has contingency place for most vulnerabilities. Some work well and others don't. For example: if ports are shut down on the West Coast, there isn't much that Enterprise A can do. But if a specific port is shut down, they can re-route to another.

Enterprise A has thought of a lot on the operations side - if something happens and people can't get to work, corporate employees can work from home. There are ways to make a sale without electricity to run the cash register...

A lot is dependence on others, like governmental contingency plans. Enterprise A thinks there is more that the government can do (interviewees seemed to be rather informed on this topic).

Enterprise A is taking a rather active role in trying to plan for disruptions (more than their peers), but know they still have gaps.

I asked about Security Measures at the Ports: Enterprise A is very involved with CTPAT and other such certifications. They are highest C-TPAT tier. Enterprise A was asked to participate so they did join because of resiliency, but also as part of a corporate citizenship duty and to minimize daily affects of new security procedures. Their status helps security of their goods too.

- **Are there redundancies or resiliencies built into your supply chain?**

There are some in some systems – they have primary consolidators and backups, primary carriers and backups.

They are not solid if an entire region or country was affected.

They have tried to identify high vulnerabilities in specific regions and focus work/effort there.

- **Is there anything about your company (profile, structure, culture) that you feel leads to a natural redundancy or resiliency in your transportation network?**

If anything, the fact that Enterprise A is very decentralized. All the knowledge is spread out amongst people; lots of eyes on what is going on.

Enterprise A leadership supports these kinds of initiatives (like CTPAT, the CEO was onboard with that from the very beginning).

Enterprise A is a relationship company. They have good relationships with other members of the supply chain. They are on the ground, traveling a lot. Their service providers feel like they are part of the family. They have very long relationships with them.

- **How are disruptions to your supply chain currently handled?**

The international logistics department communicates problems to the affected parties. Enterprise A does not have people overseas. They have agents (who are very exclusive to Enterprise A) there and consolidators who can act on their behalf.

Almost all disruptions are reported to someone at corporate – anything that there is a chance might miss an expected date.

It is mostly just notification that something is late, but they sometimes will switch from water to air. I asked what kind of merchandise would justify this switch: advertised merchandise, merchandise for the anniversary sale, hot items (don't know ahead of time that it will be hot), higher-end designer goods, small shipments that are actually cheaper by air.

- **Do you think the current state of our transportation infrastructure impacts the resiliency or reliability of your company (the amount of roads, quality of roads, the potential for failure)?**

There is a definite direct impact, but it is out of their control. Specifically, congestion between Portland and Seattle and getting out of ports are issues for Enterprise A.

- **Do you think that improvements to the resiliency of the transportation infrastructure network would improve the resiliency of your supply chain?**

Yes, a definite impact.

- **What will be your transportation challenges in the next year?**

Fuel costs

Congestion

Environmental regulations (fees, changes, rules, CO2 emissions)

Labor (longshoreman regulations – keeping a close eye on it)

Getting others on board with security measures (there are not ships with solely Enterprise A or C-TPAT goods on it, this could cause hang-ups for Enterprise A).

Domestic trucking – capacity (it just means prices will go up)

Continuing to maintain a balance between trade and security

Things like 10+2 and TWIC cards are good ideas, but hard to implement, especially in the current environment. There are a lot of regulations that are difficult to comply with. Even if Enterprise A is in the position to comply, their partners might not be.

Political changes make changes to the field of logistics.

- **Other:**

With regards to inventory policy, Enterprise A is “pretty lean,” but not extremely. They turn faster than many retailers, but nothing like a JIT system.

With regards to IT, Enterprise A has medium level systems which meet their needs. They have EDI and event and milestone tracking. They have come a long way in the last 4 or 5 years. They said that it isn't all that essential to know exactly where “that blue sweater” is.

Enterprise: Enterprise B

Date: 10/3/2007

- **What are you company's transportation priorities?**

From a systems standpoint, a consolidated system (one computer system) for domestic transportation management is a priority. They want a lasting system that can adapt as things change.

Enterprise B is growing rapidly and wants to continue to grow. They are planning to build more stores and more DCs – expanding into Alaska and Hawaii.

Efficiency in backhaul: swing into vendors after making delivery at store to bring back goods to DC.

Guest focused supply chain: JIT from DCs to stores. Aimed at minimizing store inventory, minimizing backroom labor (it takes labor to handle things several times).

To avoid having stores rent off-site storage (during holidays) – instead react to demands better.

Trailer tracking –. Enterprise B uses their own trailers from DCs to store, these trucks are tracked. Helps cut down on stolen goods.

Pallets – travel between DCs and stores. Rarely get shipped back to DCs. They have \$175 million worth of pallets in the system. Currently 20% get “lost.”

Food distribution – perishable goods. They have been having vendors distribute perishable goods, but they are looking into having Enterprise B take over that. It is very different than retail though – have to consider temperatures and shelf life. Enterprise B is working on developing processes and systems.

“Best Practices” – Enterprise B is working to standardize how logistics (processes and systems) are done – although there will always be slight regional differences.

- **Have these changed in the last year/few years?**

Yes, because of growth.

- **What metrics does your company use to manage its supply chain or transportation?**

Level of service: time measure; within hours now, working on tightening time frame. Now, inbound at DC to time processed is 48 hours.

Automated system to track time between points: all captured by reporting system which is very detailed.

Carriers: transit time target

- **How do these impact the choice to use or where to locate distribution centers?**

Rail accessibility, balance between freight costs and real estate costs.

DCs strategically located to reach stores. IWs (Import Warehouses) distribute to all DCs (not a hub and spoke system). How can you line up with carriers? Example: there DC in Colorado, but there is not a lot of business around there so it is hard to match up lanes for carriers.

- **Define resiliency and reliability.**

Reliability: Does a shopper find what they want, when they want it, in good condition? Sales, customer faith, satisfaction (guest experience)

Resiliency: being as seamless as possible – finding away around problems.

- **What are your current plans for improving your company's transportation or supply chain management?**

(Not just within Enterprise B) With the number of imports increasing, there is a need to diversify. They are working to help invest money into critical infrastructure. (Toll roads, HOT lanes, railroad improvements). It is a group effort of retailers and industry to inform government agencies.

Environmental standards – going green. Everyone is working toward the same end. Enterprise B worked with the state of California and the cities of LA/LB to introduce a fleet of green trucks. They want to show the politicians that if you tell us what you want to achieve, we (and the suppliers) will react and work towards that without regulations.

- **Other:**

Enterprise B Supply Chain: 4 Import Warehouses (IW) – goods come in from overseas; 26 regional DCs (RDC). Supply product to stores – 40% domestic suppliers, 60% import warehouse.

Logistically speaking, they are successful. The less hands touch the goods, cheaper freight costs, better control. From the Ports of Seattle/Tacoma they have a 3PL to breakdown containers for RDCs and IWs. Some full containers are taken directly to RDCs or IWs (this is what they strive for – less hands).

“Supply Chain Crisis Management” specifically addresses issues like terrorist activities, supply chain disruption. There is a team at HQ that deals with those issues. There is a hotline to call if you have a problem.

Enterprise B imports from 55 countries, and they have Enterprise B people on the ground in each of those countries, don't put all their eggs in one basket – don't just have 1 vendor, 1 steamship line, 1 trucking line.

With vendors – look at socio-political climate, willingness to accept American commerce.

Domestic concerns: labor – ILWU lockout: it took months to get back on track. Need to look at what other ports are available

Enterprise: Enterprise C

Date: 9/26/2007

- **What are you company's transportation priorities?**

"Everything"

Inbound freight consolidation, especially now with opening of 2nd DC in Pennsylvania – now ½ shipments to each DC.

- **How do these priorities align with your company's mission and goals?**

8 strategic priorities, one of which is supply chain.

A sub-area under supply chain is inbound freight, where REI is focusing on:

Predictability – understanding purchase order creation

Velocity – cross-docking aspect, direct to consumer and retail

Reliability – good data inside the system (like lead time, O/D)

Visibility – tools to see movement from origin to DC

- **Have these changed in the last year/few years?**

Director of Global Supply Chain is a new position created in the last year.

Enterprise C's supply chain just grew as the company grew. Once Enterprise C grew to the \$1 billion mark, it was decided that they needed to reevaluate their supply chain strategy. That is what they are doing now.

- **What is your company doing to try and meet these priorities?**

There is a "Process Improvement" team that does opportunity exploration, looking at ways to better the supply chain.

Working to increase cycle time to stores and to improve lead time.

Completing a cross-docking application.

Develop an international visibility tool.

Currently working on domestic visibility tool.

- **What metrics does your company use to manage its supply chain or transportation?**

Financial cost metrics - labor/facilities as a cost of goods

Moving to throughput/vendor "completes" metrics

Enterprise C is working on improving the metrics. What matters: perfect line on-time complete, throughput timing through supply chain, accuracy to customer or to store (perfect order concept).

- **How do these impact the choice to use or where to locate distribution centers?**

Focused on lead time/fulfillment time.

Blending of need to have DCs and environmental concerns.

Using all water routes to Washington and Pennsylvania DCs.

All water route to Pennsylvania means 6 extra days of lead time, but it was chosen because water mode has less CO2 emissions than rail.

In the next 3 to 4 years, they will build a new DC in either the south or central US. Want to locate it where they can decrease air freight. Major goal is to reduce air freight in entire supply chain.

- **Once a region is identified as home for a new distribution center, what are your priorities for selecting a location?**

Cultural fit to Enterprise C: loyal workforce that is passionate about the mission of Enterprise C; most likely a "rural" setting. Remember that Enterprise C is a CO-OP.

Reasons for selection of Pennsylvania DC: they specifically wanted the warehouse in the region, community is engaged in environmental issues, lots of community involvement (for example: did trail work before DC opened).

Do also look at freight movement, lead time, government regulations...

- **Define resiliency and reliability.**

Reliability: visibility, the ability to predict a failed outcome.

If you know there is a problem, it can/will be fixed in time.

Resiliency: Enterprise C does not have much resiliency in the supply chain. 75% of products are vendor purchased so Enterprise C could get it from vendors here in US instead of vendor suppliers in Asia. Pennsylvania DC is scaled to the same size as Washington DC, so lots of extra capacity in both DCs.

You can't plan for a dynamic event like a strike, terrorist attack or government action – you just have to work around it. Everyone will have to do that. They are looking proactively at the possibility of a 10-day longshoremen strike in June/July (2008) to work out a plan.

- **What makes your transportation unreliable?**

Inability to track supply, to call out suppliers if they aren't meeting targets

Unpredicted port/terminal spikes or congestions

Government Regulations/Rules – new China taxation: everyone rushed to get stuff out of Shanghai; changes to tariffs/quotas that are not publicized in advance.

I asked specifically about congestion and unreliability: you can plan for congestion. You know there is 2 days of congestion at Tacoma, and one day of congestion + one day travel at Portland – you crunch the numbers and then deal with the fact that it is 2 days. You just model in the congestion. With low cost goods, this is acceptable.

- **How are disruptions to your supply chain currently handled?**

Currently disruptions are mitigated with the level of inventory and risk associated to the product classification. As disruptions unfold, review of inventory position and duration of impact are assessed to determine if any interaction is necessary.

- **Do you think the current state of our transportation infrastructure (the amount of roads, quality of roads, potential for failure in network) impacts the resiliency or reliability of your company? How?**

In most cases the answer is the current network does not impact resiliency or reliability, only mitigation and potential cost overruns. This is to say that most network failures have a secondary, third or even 4th option that can be used with small impacts to delivery timing and cost. We are not as just in time as perhaps someone in the auto industry. However, there are some infrastructure issues that can affect our company such as port closures for labor or security reasons.

- **Do you think that improvements to the resiliency of the transportation infrastructure network would improve the resiliency of your supply chain? How?**

Focus on inbound port security and electronic track, trace, and customs clearance will do far more for the resiliency of our system than new roads. This should be a homeland security issue and resiliency issue and not a labor negotiation.

- **Other:**

Industry (but not necessarily Enterprise C) target is to have control of the inventory without actually holding the inventory (just-in-time concept). Right now Enterprise C is working to build DCs that can get the products through faster and then they will start talking about inventory reduction.

Consumers want next day/expedited delivery, but if you use air freight actual cost goes up, as well as environmental cost.

To get reliable service you need many DCs. Before 2nd DC there was a lead-time of 13/14 days to get to the east coast (without air).

Cross docking is currently the goal for Enterprise C's retail segment. Currently they use pick and pack for mail-order segment of business. Everything is in inventory.

Want to increase pick cycle and decrease lead time.

*Enterprise C's products – private label: they control bringing the stuff in
direct buys: all over the place, working to have Enterprise C control it*

*Slow development – working on on-time delivery rate (for private label)
– hiring people to help manage supply chain*

Enterprise: Enterprise D

Date: 10/4/2007

- **What are you company's transportation priorities?**

Low cost

On time service

Maximize use of space – "maximizing cube," use 53' trailers, 45' ocean containers, more product per load, less overall loads.

- **How do these priorities align with your company's mission and goals?**

Mission Statement:

"Obey the law" – signed agreements with carriers that they will do this too.

"Respect our vendors" – want vendors to profit as well, be/have good partners, both respect commitments

"Take care of employees" – treat them well

"Reward shareholders" – make a profit

"Take care of members"

- **What metrics does your company use to manage its supply chain or transportation?**

- Monitor on-time deliveries

- Quarterly reviews with providers (look at what causes delay)

- Visibility tool for the supply chain (improving it – not hiring more people instead just have to work smarter)

- Timeliness of response to concerns

- Equipment availability, space availability

- **How do these impact the choice to use or where to locate distribution centers?**

Look at DOT requirements for trucks on roads

Industrial area (air pollution, noise)

Cost of property

Narrow is down to several properties then look at costs, network of transportation (Utah DC is across from railhead).

- **Define resiliency and reliability.**

Reliability: providing right equipment at right time, consistency, on time delivery

Resiliency: adaptable to changes, flexible

All water to DCs – don't care about how long it takes and long as that travel time is consistent. Use rail instead of road because it is cheaper.

- **What are your current plans for improving your company's transportation or supply chain management?**

Improve visibility

Using technology better – bid optimization tools

Transportation system visibility

- **How are disruptions to your supply chain currently handled?**

Enterprise D has people around the country to track day to day activity and report to HQ. People in the field identify problems. Quick notification of a problem. Notification to buyers – let them decide if they should airfreight

Problems are handled on an “exception” basis: example – labor disruption at LA railhead – corporate does in and prioritizes shipments and gets more drivers, looks at alternate routes and moves along alternate routes. If there is a problem, look at why it happened and see if you can mitigate for it.

Keep abreast of weather, make predictions if changes need to be made.

Everyone wants their stuff on Monday (based on weekend sales) so there is a lot of congestion in DCs/stores

Carrier makes appointment so it is their responsibility to get there on time

Lots of communication (especially between traffic group and DC) helps prioritize things. Corporate oversees everything, but need people regionally to handle things on a daily basis.

On big delays (which typically occur in the ocean leg), try to “hotleg” it to a destination. Typically Enterprise D will order 300 containers of 1 item, so if some are delayed, they can move around the others to minimize problems.

- **What will be your transportation challenges in the next year?**

Feels the transportation market is now soft – there is a shortage of truckers, current ILWU negotiations. Drayage – underpaid/overworked truckers, green trucks, join union?, TWIC

Beijing Olympics – potential for factories closing during event

Railroad in Canada – Canadian port structure, congestion, Vancouver weather, big delays in Vancouver.

Increased security costs.

Capacity – truck capacity: less drivers, average age of drivers is increasing; intermodal capacity: stresses on the rail system

Low cost versus level of service

Expansion – servicing rural area (finding companies to service those areas - nothing coming back from there so have to pay a premium)

- **Other:**

15 DCs

Inbound freight – 100,000 loads per year, outbound – 300,000 loads per year

#1 purpose of using DCs is to lower net landed cost (the total expense of receiving goods at place of retail sale, including retail purchase price, transportation costs, duties, value added taxes, excise tax and other taxes)

Enterprise D builds new DCs because of freight costs –look at freight rates, future growth of Enterprise D stores, cost to build

Good relationships with providers, give them lots of business. Use 1 steamship line.

Enterprise D is a true cross-dock facility. At the end of the day, nothing is left in the DC.

At the Southern California DC – 400 trucks a day

Trucks from DCs to warehouses – all have appointments.

There is a restriction on using forklifts out on the floor during business hours so it is important that trucks arrive when they are supposed to.

If the truck is late, the dry goods can just be stored in receiving areas. Refrigerated stuff – the truck has to sit and wait.

Enterprise D uses own fleet of trucks as well as other carriers.

Typically trucks get to warehouses (stores) between 4am and 9 am and a bit in the evening. They try not to run too much overnight because of the impact on employee quality of life. Sometimes trailers are just dropped off and opened later.

Transportation priorities: pricing (freight cost is part of net landed cost), capacity – JIT, inbound to DCs, outbound to stores

Industry issues – price of diesel fuel, new engine emissions standards

Enterprise: Enterprise E

Date: 9/27/2007

- **What are your company's transportation priorities?**

Retail: inventory availability (esp. seasonal merchandise which has a shorter shelf life), operate in a higher margin

Beverages: low cost, predictability

- **How do these priorities align with your company's mission and goals?**

One of Enterprise E's guiding principles: to "develop enthusiastically satisfied customers all of the time." Enterprise E wants to serve the customer. There are lots of promotional products, which require a predictable supply chain.

Another of the guiding principals is to recognize that profitability is essential.

- **Have these changed in the last year/few years?**

They are focusing on flexibility and scalability. The company is growing so quickly that they have to change how they do business.

Building flexible infrastructure into the company.

Pushing transportation into regional offices, where there is local knowledge.

Outside partners need to be flexible as well.

Much more outsourcing – data entry, booking; this allows the people at Enterprise E to focus on strategic decisions.

- **What metrics does your company use to manage its supply chain or transportation?**

Room for growth

On-time pickup and delivery (well tracked)

Financial performance metrics in North America, gaps in international metrics

Would like: supplier ready data; demand patterns

How do these impact the choice to use or where to locate distribution centers?

"Network Optimization" group does a lot of good modeling. They have good outbound data with store locations and demand patterns.

For stores, you want to minimize variability – they have tight windows of when they can accept goods (can't bring in products when there is a line out the door for coffee).

In Seattle and other congested areas, they use overnight delivery (drivers bring the stuff in during the middle of the night, have a key to the store)

- **Define resiliency and reliability.**

Reliability: delivering during time windows; into DCs – 15 minute windows (very high standard), into stores – 2 to 4 hour time window, not bringing it in during peak times

- **How does your company manage travel time variability?**

Inbound – contracts with ocean carriers

Domestic Outbound – outsourced – Enterprise E says “I don’t care how, but you need to have 98% on-time delivery” and another company manages all the carriers to make it happen.

If a company is not making it, they are switched out.

- **What are your current plans for improving your company’s transportation or supply chain management?**

Inbound – improving metrics, data integrity, supplier scorecards, investments in technology

Outbound – developing optimal distribution model, bringing in partners to manage the details

- **What will be your transportation challenges in the next year?**

Capacity – there are not enough drivers, need to move their product

10+2 (new customs requirement, extra information required) – Enterprise E understands the purpose but it is hard to comply with.

New markets – especially in places that are infrastructurally challenged (Russia, Egypt, Brazil)

Understand the inevitably something “bad” will happen. It is impossible to prevent but they need to work to minimize the effects.

- **Do you think the current state of our transportation infrastructure (the amount of roads, quality of roads, potential for failure in network) impacts the resiliency or reliability of your company? How?**

Locally in Seattle there are many pinch points. Looking at store level deliveries, there is a tight time window in which deliveries can be made without impacting store operations (to customers and Enterprise E partners/employees. There are usually no loading docks to temporarily store things, or provide places to park for an extended period.

They are impacted by things like SR 99 having to close for various inspections. They were impacted in Minnesota by the 35W bridge collapse.

The current infrastructure leads to unpredictability and reductions in velocity.

- **Do you think that improvements to the resiliency of the transportation infrastructure network would improve the resiliency of your supply chain? How?**

Absolutely. We don’t know to what degree it affects things like where to open a new store, but it does affect how you service it.

- **Other:**

There is a natural redundancy and an ability to flex in Enterprise E's supply chain.

5 main DCs (dealing with merchandise in stores and stuff in the back)

Washington (Port: Seattle/Tacoma)

Nevada (Port: LB/Oak) – good from the government side – lower taxes, but not transportation

Pennsylvania (Port: Baltimore)

Texas (Port: Houston, Norfolk, LA)

Tennessee (Port: Houston, Norfolk, LA)

Try to do all water routes, don't want to deal with land transportation. Also having relationships with several ports gives you more flexibility if something goes wrong at another port. Example: if there is a problem at Norfolk, you can just ship more through Baltimore.

Critical components are sourced domestically for many reasons (food you want sourced here), but a big part is because of the risk associated with not having them available.

A C-TPAT member – if things shut down at the ports, C-TPAT companies will get priority when things get moving again.

Experimenting with container security, tamper locks.

Deliveries: fresh food (overnight)

paper products (daily)

beverage/ merchandise (daily)

Overnight delivery: in congested areas, deliveries of critical things that come in at night. Delivery person has key and can unload goods.

Things they are thinking about is that all these goods could come into a cross-dock and then all be delivered overnight. Right now in some locations merchandise/paper/beverage is stored at fresh food distributors and delivered when needed (b/c fresh food is coming everyday anyway). This means less inventory at stores and b/c fresh food is local, stores can get stuff faster.

I asked about a previously mentioned comment that there is a natural redundancy or resiliency in Enterprise E's transportation network/supply chain: Multiple (5) distribution centers carry all of the SKUs and then consolidated DCs (35 to 50 of them) carry limited SKUs and the perishable items. These are at a very local basis. Because of the number of consolidated DCs, they can move stuff around if something (transportation or otherwise) breaks down the supply chain.

This is done partly for resiliency, but mostly because of the scale of the company. There is a limit to the size of a single DC. They have millions of SF and DC space and for various reasons you don't want a single DC of that size.

Enterprise: Enterprise F

Date: 12/19/2007

- **What are you company's transportation priorities?**

In general:

- *Getting it in one piece at one time*
- *Feeding manufacturing centers*

Commodity market

Major manufacturer \$2 billion per year

- **Have these changed in the last year?**

Yes – last December's windstorm. They had a total meltdown. They were without power for one week, and had no products, and not enough trucks. They have since developed an Emergency Operations Team to handle disruptions.

The flow of products is generally consistent. There is no extra capacity in the transportation system.

- **What is your company doing to try and meet these priorities?**

There are different levels of crisis's (color coded like TSA levels).

Get all parties involved – including 3PL people and outside labor

- *discuss changing conditions (field men can tell you which farms you can get to, haulers tell you what roads can useable)*
- *strict agenda, discuss what is real/not real*

Example – I-5 closure in Chehalis: triggered early morning phone conversation, declared "emergency"

- **Define resiliency and reliability.**

Resiliency: to Enterprise F – they know they are going to have issues so they want to act quickly to work the problems.

Aim to not get overwhelmed by emotions. Understand what info is accurate and what is not. Plan for the worst at the beginning.

Getting back to normalcy.

- **What makes you transportation unreliable or vulnerable?**

Capacity: they are dependent on roads and infrastructure (specifically N/S routes)

I asked about congestion:

- *it impacts inbound because product is moved 24/7 (receiving bays are the constraint, have to be used continuously)*
- *outbound starts in the city early (2am) and moves outwards so not affected.*

- **Are you taking any specific actions to reduce these vulnerabilities? Why or why not? Do you want to do more to reduce vulnerabilities?**

Work closely with states of WA, OR, and ID.

Want people at state level to be familiar with Enterprise F so they aren't just one of many calling when there is a problem.

Road limitations/weight limits: negotiate weight limits (in Idaho you can apply for higher weight limits)

Take part in a lot of general committees

New president of Enterprise F in 2001 – new push for reliability

(Do you want to do more to reduce vulnerabilities?) – The problem is money. There is a tradeoff. They could run parallel (power) lines if you were willing to spend the money, but that still doesn't help all situations.

- **Are there redundancies or resiliencies built into your supply chain?**

Multiple plants can do the same things.

"Balancing" plant that does surplus on the weekend.

Drivers that can be mobile. Haulers use the exact same equipment so drivers can be interchanged (certifications – to drive the tanker, handler test... specialized truckers)

- **Is there anything about your company (profile, structure, culture) that you feel leads to a natural redundancy or resiliency in your transportation network?**

Suppliers are resilient by nature.

State and customers like product – there is a warm spot for the product.

- **How are disruptions to your supply chain currently handled?**

Enterprise F has a command center. Each person has their duties.

One thing they have learned – if there is no power, can't charge cell phones.

Have computer networks and printers backed up. Info is backed up but need to work on communications (last year, a lot of people on vacation at time of disruption)

I asked about their IT systems – fairly modern enterprise system. They have recently beefed up IT staff. They are further along than most other dairies, but still low-medium in the whole scope of things.

- **Do you have a plan to address high impact, low probability disruptions? What is it? How specific is it?**

Power is the biggest deal to them. If the roads go down, they can route around it.

- **Do you think the current state of our transportation infrastructure impacts the resiliency or reliability of your company (the amount of roads, quality of roads, the potential for failure)?**

Yes.

- **Do you think that improvements to the resiliency of the transportation infrastructure network would improve the resiliency of your supply chain?**

Found WSDOT emails (particularly with I-5 closure) a good way to get accurate communication, but they would like them to be more frequent and regularly scheduled.

- **What will be your transportation challenges in the next year?**

Fuel prices

Don't see a driver shortage as a problem currently

Infrastructures in WA (viaduct)

Environmental issues (trucks, discharges – butter fat)

Cost of supply chain is skyrocketing. Everyone wants to cut costs. Now trying to minimize the increasing costs.

Healthcare costs/teamsters pensions

A lot of people in the 50 to 60 year old range – starting to retire.

- **Other:**

In a bad situation, food is comforting. It can act as a civil disobedience buffer. Food gets to go (move) first because it calms people.

Enterprise F benefits from that. They are part of a huge industry in Washington that has political backing.

I-5 closure in Chehalis: traffic thinned out 6-8 hours after reopening. Had teams running around detour, relays meeting in Yakima.

Inventory: varies

Moving products – both rail and truck, dependant on product

Feels there is a rail monopoly, which is a big problem. There is increased pricing – now 95% of truck costs (not considering travel time).

Enterprise: Enterprise G

Date: 12/19/2007

- **What are your company's transportation priorities?**

Not price (they do look for value of course)

Look for vendors who are:

- *Reliable*

- *Process-Orientated: have processes in place that meet Enterprise G's standards, and have their own resiliencies*

- *Culturally Aligned: similar culture to Enterprise G, focused on technology*

I asked how Enterprise G ranked with others in their field in terms of technology use and he said that they are cutting edge, but he sees the industry is changing and catching up. One example of their cutting edge work is that instead of going to each carrier's site to get rate quotes, they can input the amount and distance into their computer and the best rate will be pulled up.

- **Define resiliency and reliability.**

Resiliency – having the ability to have a constant service, back-ups

Reliability – Important to their company. They sell to a lot of manufacturing companies who are JIT., and their products are expensive.

- **What makes your transportation unreliable or vulnerable?**

Weather

Driver shortages (on long-haul) – note: I had mentioned this earlier. Changing DOT regulations (indirectly)

Requirements for specialized trucking (temperatures, hazardous materials)

I asked about changing in regulations since 9/11 – he said not really too much change, just more visibility.

- **Are you taking any specific actions to reduce these vulnerabilities? Why or why not? Do you want to do more to reduce vulnerabilities?**

Despite fully outsourcing their transportation, they do stay in close contact with their vendors to understand what is going on.

Example: they have a key product line in Ohio. Last year there were lots of weather problems and they looked at the possibility of relocating the logistics provider.

- **Are there redundancies or resiliencies built into your supply chain?**

Things like communications to warehouses. (from Enterprise G's side – doesn't take into account their transportation vendors)

- **Is there anything about your company (profile, structure, culture) that you feel leads to a natural redundancy or resiliency in your transportation network?**

They use technology as much as they can to create a natural resiliency (natural for a dot com).

There is lots of communication with their partners so they know when things get shipped/arrive and for invoicing.

I asked about the time frame from order to delivery and it is about 2 days. Occasionally there is more lead time. Their product does have a shelf life though, they consider it perishable.

- **How are disruptions to your supply chain currently handled?**

Because transportation is outsourced, they work with vendors to be proactive.

Example – the Teamsters talks in the spring – with LTL they have plans in place for non-union drivers if needed.

They don't put all their eggs in one basket.

Quarterly reviews look at "can do" metrics (objective) – service metrics like late shipments and fill rates, and also "will do" metrics (subjective) like fit, philosophy and then ability to move nimbly.

Transportation is a commodity to them so if their vendors don't perform, then they can replace them.

I asked what happens if a disruption does occur: with something like a weather delay, they rely on technology. There are auto alerts of delays and they proactively alert customers of problems. Not too much else they can do at that point.

In the future they are looking to track with RFID tags – this will help Enterprise G because right now they don't have any real knowledge of their inventory and where it is.

- **Do you have a plan to address high impact, low probability disruptions? What is it? How specific is it?**

Just starting it, not very robust.

Have a second server that could be up and running in a day or two.

Expect vendors to have alternate communications and transportation to have backup fleets. Enterprise G is depending on them to perform.

- **Do you think the current state of our transportation infrastructure impacts the resiliency or reliability of your company (the amount of roads, quality of roads, the potential for failure)?**

Indirectly, aware of roads problems and support vendors lobbying for improvements. Port policies do affect their imports, being held longer in the port. Changing DEA regulations with regards to transportation.

- **What will be your transportation challenges in the next year?**

Consistent, reliable service.

Improving communications, using IT capabilities

- **Other:**

They provide web enabled distribution.

They buy chemicals from companies, then market and sell the chemicals. Have no physical warehouses or transportation services.

Outsource to 3PLs and common carriers – form a partnership.

Have 17 DCs that are public warehousing.

Most of imports come from inside the US. Increasing import operations though. They have operations in Europe, but product is sourced and sold in Europe.

DOTs requirements – shipper has to know what is in it, its classification, first responder codes of how to handle it.

Drivers need to be certified (I mentioned and he agreed that with driver shortages, this make it a more severe problem)

They form solid relationships with a chosen few vendors – they might miss out on some cost savings, but feel this is worth the dependability they get.

Send stuff either LTL, parcel packages, or truck load. Parcel stuff is the really critical, smaller shipments where reliability is key. Also the handling is important – don't want damaged goods.

Reverse logistics is important too – returns and damaged/destroyed products.

Enterprise: Enterprise H

Date: 5/24/2007

- **What are your company's transportation priorities?**

Service is Enterprise H's highest priority, in production. After market, inbound it is price and outbound it is service. Inbound and for warehouses is not as critical as the outbound. Outbound to dealers: DCs are strategically located so they are within one overnight service by ground to all of dealers.

- **What metrics does your company use to manage its supply chain or transportation?**

The biggest metric is cost per truck. The second is premium freight. The metrics are really cost driven. Typically the premium freight is a gauge of how the network is performing. There are reason codes in there, so is it ordering issues, is it transportation issues that are driving the premium freight, premium transportation. They are going towards, as they get the supplier compliance up in the system, a score care with on-time shipment. Before they were measuring is the product here when we need it? But you can go through a whole bunch of stuff and spend a whole bunch of money and still have the product here when we need it. So they are looking at is it leaving the supplier when they expected it to leave.

- **Have you been involved in developing a new distribution center, or relocating a distribution center? Please describe.**

They actually just built a new distribution center in Oklahoma. That whole locating process was driven by the fact that Enterprise H had kind of a hole in the middle of the US in their network. And it was driven more by how they could improve that coverage to the dealer based on next day shipment from a DC. Other concerns are supply chain disruptions like if they are building a component in Mexico and can't get it across the border then they can't build product. And there are also the cost tradeoffs, and the transportation. When they located the plant they looked at what is the optimal location and they looked at all the other factors that go into it – hurricanes, weather-disruptions, and all those other disruptions, and tried to locate it in an area that is most conducive to all those needs.

- **Once a region is identified as home for a new distribution center, what are your priorities for selecting a location?**

Ease of getting to and from the highway, and number of truck trips.

Working with that community to make sure you locate the plant somewhere where you are not going to become a nuisance to the city.

Easy-on/easy-off.

With the warehouses, located with other distribution centers, because carriers are already serving that area and it just flows with it.

- **Have you seen these priorities change over time?**

Originally some of the distribution centers relocations and locations were more labor related. The idea was to relocate DCs to places that were more labor friendly and had more labor. More recently the focus has been on service (to the dealer).

We moved from California to Nevada because Nevada is just a more favorable place to do business, and now they have the new distribution network down there now. There are just 100s of DCs that service California out in Nevada so the whole transportation system down there has changed to ship all the stuff over the mountains every night because everyone has moved their DCs to Nevada because it is a lower cost location to do business than California.

- **Define resiliency and reliability.**

Resiliency: availabilities to react if things aren't going right. Whether it is rail lines that are down or suppliers that have fires and get shut down. Redundancies, what s the ability to back up and cover those things?

Reliability is the ability is to deliver... for all of their stuff it is typical to establish a schedule where they have an expectation. If they ship on Tuesday it arrives Friday. If they ship Wednesday, it arrives Sunday. They set those up, and reliability is our ability to consistently meet that

Resiliency is when they can't do that, how do they recover without excessive cost.

They've had two major fires at suppliers in the last 2 years, and they've been able to keep building trucks through that, either by rescheduling trucks or getting other suppliers online to cover the parts until the original supplier can get back up.

They tend to try to be very proactive if they think there is going to be a problem. They will react and ship extra stuff ahead because if they wait and find out on Friday night at 10 that they really aren't going to get the rails open, then it is too late. So they are very decisive to take action very early. And they think that is how they stay resilient.

- **What makes your transportation unreliable?**

Carriers that can't perform.

People at the consolidations – if they have turnovers and people who aren't knowledgeable that created reliability issues because they start not sorting freight correctly and to the right docks. Everything is sorted to a bunch of levels to support off-sites and to support the plants.

There are issues where 3 days a week in November and December there is going to be a pass closed. You work around it and put people on teams and spend the extra money to move it the other way to try and overcome the unreliability.

- **What is efficient transportation?**

When they can route our stuff normally and not need to pay extra. When everything goes as planned it is much more efficient. If they didn't have to pay an extra 5 cents a mile to run teams in the winter so they know they can get product through. If they didn't have to pay an extra \$500 containers because if they know if they have my container on a regular rail and the transit is six days it is going to really be six days. The other efficiency effort is making sure the trucks are full. They save money by putting stuff on trucks. It might be fixing packaging, packaged product, how they handle returnables going back, making sure they don't have dead air space in their shipments.

- **What are changes to your company's transportation or supply chain management?**

Working with the system and the suppliers to where they have that metric on their scorecard of on-time shipment. And what that really relates to a bigger metric where if their scorecard isn't good enough they can't do business with Enterprise H anymore. Suppliers have a big impact on reliability, so getting that metric in place, having them get the stuff when they are supposed to so they don't have to make up for it in the transportation network is critical.

The other thing they are doing is looking at overseas shipments. Instead of buying all that part from third parties as landed costs to third parties, they are starting to take over that chain themselves so they have control of it from cradle to grave, and they have control of the costs.

- **What will be your transportation challenges in the next year?**

The biggest challenge is the integration of new facilities – the migration of the supply base. The supply base is migrating to Asia, Eastern Europe and Mexico. That lengthens the supply chain, and it is that much more risk and work that they need to do to make sure they have reliable supply. The borders are always a concern. The northern border is pretty good. The southern border, still with the whole mess of changing trucks – one carrier turning over to another carrier, turning over to another carrier. It always creates issues. It has really been a problem as more supplier move to Mexico. It really introduces risk just because of the hands that are involved in every transaction. And to some extent the same issue with Asia. As they lengthen that chain it just adds more risk to the equation. And people don't realize that ships break down, and have fog, and containers fall off ships. There is a lot of different issues that could happen. They are going to put it on the ship and it is a 13 day transit, which is accurate 90% of the time. The other 10%, it can be a big issue. The other issue in North American is just capacity. The US went from a very tight truck load market to a very loose truck load market. There have a lot of people getting out of the business again. As the economy picks up just having the capacity available to move what needs to be moved is going to be tight. Right now you can find a truck anywhere you want one in two minutes, but is going to be like and probably worse than it was a few years ago. People are pushed out of the business and there is not as much elasticity in the network to cope with it. And the rail doesn't have any more capacity, so they are putting just about as many containers through the rail network as they can without some major expenditures.

- **Other:**

Spend more money to reduce variability. With the rail they spend about \$500 extra a container to move the containers on the BNSF Z trains which are given priority. Say there is a derailment in Montana and all the trains get stacked up. The Z trains get passed to the head of the line so when the rails reopen, those trains are all in first. It is like an insurance policy.

With trucks they are using teams and things to work around any issues so that they can drive around issues. Sometimes it doesn't work and it ends up with the teams trapped somewhere. But they are willing to spend that extra money to try and keep that variability at a minimum.

They have 7 DCs in North America. They cover about 95% of the dealerships with next day ground from one of those DCs. 80% of the dealers have next day ground from 2 DCs because they end up overlapping as one day service ranges have gone up. And that is just because their parts are big and you don't want to air express them.

Last year they spent about \$11 million in air freight just to get stuff into the plant when they had suppliers that were later shipping or weather issues or whatever generated the problem. They flew about \$11 million in freight but there was a lot more value in parts. When you start going cross-country, the only recovery is typically air.

They used to have warehouse and some buffer at the plants, but they've pulled all that buffer out. Essentially all the material they have "in storage" is really, moving inventory. It is a moving Because of this on-time performance is becoming more important because the plant has no buffer if something goes wrong. The only buffer is our transportation buffer.

Active role at looking at what suppliers are doing: if you don't have the parts, you don't have control. The brokers aren't Enterprise H's, the carriers aren't Enterprise H's, but they are stuck with the flow. They can call the supplier all they want, but they don't have control over the chain.

They have a lot of suppliers on the west coast and plants on the west coast, so transiting the Rockies. They are watching the weather and will pull freight up as needed. If they see there is going to be a big storm affecting the passes in California, and they will try to work with the suppliers and pull freight and try to ship a day early if at all possible. They also use a lot of teams in the winter, so they can divert - run from Washington down to California and across to get back out to Ohio and such. Also will work with suppliers like in the Carolinas so if a bad storm is coming they can try and pull shipments up a day to get the stuff out of there ahead of the storm to avoid disruptions the day of the storm.

Enterprise H moves products out of Europe right now and they ship four days a week on four different lines, because they don't want to put a week's worth of product on one ship and have a causality and have to turn around or divert. They want to spread that risk. And then also that minimizes what they have to carry as buffer here (with overseas stuff, you are forced to carry some buffer but they want to minimize that buffer). The same thing out of Asia, should they bring it in just through LA or should they bring it in through two ports with two different ocean liners?

Enterprise: Enterprise I

Date: 5/16/2007

- **What are your company's transportation priorities?**

It is imperative not to delay delivery of product.

Also want to use schedule transportation efficiently to minimize expediting.

They are always going to have to expedite because suppliers are always going to fall behind on their parts – that is more the issue. There are also raw materials issues, they can't get the raw materials to make the parts or their plant went down, some machine went down so the parts are going to be 2 or 3 days late... Delays in transportation are often because the supplier was delayed to begin with

- **Have these changed in the last year or few years?**

There have been slow, yet consistent changes. Big company, lots of history.

- **What metrics does your company use to manage its supply chain or transportation?**

Premium freight transactions – how much air freight are you using instead of cheap modes?

How many on-time deliveries?

How many times an LTL carrier rejects a load? If they have a contract with a carrier, what good is a contract if they can never haul any of the loads?

- **What makes your transportation unreliable?**

If drivers don't make it...

- quality of drivers, getting updates on say a 5 day journey.

- want to schedule labor (high priced) but don't know exactly when the part is getting there.

- **How does your company manage travel time variability?**

Monitor the transit times, don't take their expected delivery time as good.

- **What is your company trying to do to reduce variability in travel times?**

Paying more for better service.

Product damage – an issue but liability rule make it not worth it to claim.

- **Do you consider reliability as a key component of efficiency?**

Looking for low cost service, but won't do business with substandard companies.

Looking to save money if you can, but Enterprise I will spend money if needed,

- **What are changes to your company's transportation or supply chain management?**

Procuring an on demand transportation management system

Keep those people in touch and allow them to do their job

There is a lot of opportunity there to reduce cost but there is also opportunity to get the visibility of how big our transportation network is for what we are doing

- **Other:**

Idea is for the parts to come in right to the assembly line and be given to the mechanic out there. No inventory – lean enterprise.

Procurement agents (30,000 of them) deal with parts that are late. All they are doing company wide is expediting parts when it doesn't arrive, solving problems.

You delay the delivery date and it is millions of dollars in penalties, not the extra thousand you spent to get the part in. So that is what they are there for, to make sure that line goes and we don't miss delivery dates. And that is why they have all these people out there because it is a big issue.

Sometimes it is a lot better to pay more for transportation than it is to hold that inventory, especially if your parts are really expensive.

Tradeoff for inventory savings versus hiring some more people to then manage this system is less balanced than other categories of goods.

Implementing this Transportation Management System for the visibility aspect. Right now in the enterprise, the only visibility they have is freight payment data.

Enterprise: Enterprise J

Date: 10/9/2007

- **What metrics does your company use to manage its supply chain or transportation?**

Time and money:

-transit time

-cost

-"failures"

Enterprise J always had domestic contracts with customers. Wanted to reduce the number of freight forwarders used (have reduced from 70+ to only 10 now). Allows you to leverage buying power, and overall just having to manage less freight forwarders is better/easier.

Now Enterprise J does not make a lot of the parts, just puts them together. They depend on suppliers to ramp up. They will pay for premium transportation if they need it now.

- **Have you been involved in developing a new distribution center, or relocating a distribution center? Please describe.**

A DC in Belgium burnt down. Enterprise J did a study to determine if they needed another DC in Europe (already one in London). At this time the Netherlands was being very proactive about getting business into the country and was offering lots of incentives. Enterprise J decided they did need another DC and Amsterdam was chosen because of the business climate in the country.

- **Once a region is identified as home for a new distribution center, what are your priorities for selecting a location?**

All DCs are at/near airports. Here in Seattle, the DC used to be in Auburn. 13 years ago it was moved to Sea-Tac in order to be closer to the airport. Traffic was increasing and in this industry, time is money. The faster the parts can get to the airport (to be shipped), the better.

Now with increased security, proximity to the airport is even more important. There are a limited number of flights headed for certain regions each day. You want to get things to your customer as soon as possible and increased security means that things at the airport take longer.

- **Have you seen supply chain/transportation priorities change over time?**

They used to get orders for 20 bolts, now it is just for 2 bolts. Just-in-time manufacturing is changing things.

- **What are changes to your company's transportation or supply chain management?**

Less ocean freight (things take 14 days on the ocean from Asia) because of new air freighters. They were expensive to build but they must save in inventory. Logistics costs go up, but business costs (like inventory) go down.

JIT – leading to parts shortages. Have yet to reach the balance needed to make it work.

It is hard to predict which customers will have which demands (lots of things are unexpected). Enterprise J works with customers to forecast expected demands like maintenance.

- **What will be your transportation challenges in the next year?**

- Security
- Export Compliance – composite materials have military uses and now are being introduced to commercial world. Going to have to get government approval to sell to certain people.
- Little improvements to the supply chain: costs, maximizations
- Every place in the world is a potential customer.
- Logistics challenge: embargoes countries, like Cuba have to get approval from US government to send part to Canada to send to Cuba.

- **Other:**

Enterprise J services an industry. Seattle feeds the “sister” stores in: Beijing, Singapore, London, Amsterdam, Dubai, Atlanta and LA. The intention is to get a part to a customer in 24 hours.

The reason the DCs are located where they are political and a marketing tool. Example: London is a huge market, Asia buys products from US to keep the trade balance – DCs there. .

Quality control is done here in Seattle. Things need to pass through Enterprise J's hands to be inspected. Long run – it is probably cheaper to have Enterprise J people in manufacturing centers who are able to certify parts (instead of shipping from Asia to US and back to Asia...)

Most of the product is moved by air. Never by rail, very occasionally by truck. Within the US – still a lot by air but some is by truck. It depends on the size of part and the time frame.

Dealing with disruptions to the transportation system:

jump right in, unique solutions to unique products/problems, same parts move from same O/Ds, problems occur from late in production, port strikes..., plans in place for what ifs

Out of Seattle, shipping lanes change daily (based on who needs what, when).

Reliable sources have been built over time, lots of trust involved.

Security: since 9-11, Homeland security/TSA have been making commerce harder. Before you didn't have to think about security much/at all.

C-TPAP – visible supply chain, advanced documentation, packing things differently. Are these security measures making the supply chain more effective? Slowly, maybe over time.

In industry, minutes mean 1000s of dollars.

Use people like FedEx and DHL because you know you'll have a reliable supply chain.

Enterprise: Enterprise K

Date: 10/1/2007

- **What are you company's transportation priorities?**

#1 priority: cost. This is why they are opening new manufacturing facilities overseas.

Also safety (getting in and out of the facility, safety while transporting), and reliability (on-time deliveries) are important.

- **How do these priorities align with your company's mission and goals?**

Mission (parent company) – "improve the lives of people around the world"

Enterprise K: fundamental concern is for the customer. Want to have product when and where the customer wants it.

- **Have these changed in the last year/few years?**

Increasing focus on cost – new facilities

- **What is your company doing to try and meet these priorities?**

Improving logistics

Smarter choices of suppliers, leveraging buying power

- **What metrics does your company use to manage its supply chain or transportation?**

On-time percentage. On-time windows vary by material delivered

Damaged goods (amount of). Important because they order exact number needed with no buffer.

Correct quantity. Again, they order exact numbers. Buyer monitors product and expedites it if needed, but it is supplier's "problem."

- **Define resiliency and reliability.**

Reliability: doing what you say you'll do

Reiliency: ability to respond to changes (like – we [Enterprise K] screwed up 15, can you produce 15 more, quickly, for us)

- **Have reliability or resiliency become more important qualities in your company's transportation or supply chain management? Over what period?**

Growing rapidly.

They haven't had any problems with the Port so they have never really looked at congestion/unreliability there.

No immediate resiliency in the system.

Labor and raw materials are not an issue – logistics (money and time) are.

Brittle supply chain.

- **What are your current plans for improving your company's transportation or supply chain management?**

Improving cost, viability.

Have good suppliers who are very reliable.

Just now beginning to look at risks.

- **Other:**

Originally all manufacturing was done at two sites in Washington, and product was shipped all over the world. Now Enterprise K has 50 manufacturing sites.

City where HQ is doesn't really want Enterprise K there. The plant (which was there first) is near residential areas – many complaints.

JIT company – no warehouses. Some things are delivered 4 or 5 times a day, generating a lot of truck traffic.

Beginning next year, manufacturing will be done here, in England, and in Asia – don't know how the transportation aspect will work, but it shouldn't effect what is happening here in the Puget Sound.

All components are brought into the Ports of Seattle/Tacoma. Have sole-sourced components – if something happened, manufacturing would be shut down in 30 days (30 day lead time), so they just started looking at options. Everyone was buying from their own suppliers, not leveraging volume buying power.

"Rationalizing" supply chain – matching supplier capabilities with Enterprise K's own needs to get the best deals, and the best optimization. If you reduce the number of suppliers, you reduce the number of trucks.

DC's – East Coast (1), Southern Midwest (1), England (1), China (1); no plans to add more.

- **How are disruptions to your supply chain currently handled?**

There are several kinds of disruptions Enterprise K could experience. Assuming interest is infrastructure associated disruption: most often disruptions, which are a consequence of infrastructure failures, are not visible to Enterprise K, or only as a report from logistics provider: "Your goods will be delayed because the port was blocked." Or some weather event causes the pass to close and we can't ship between 2 manufacturing centers. If the disruption continues for sufficient time that they exhaust buffer stocks of materials, they shut down the production lines.

- **Do you think the current state of our transportation infrastructure (the amount of roads, quality of roads, potential for failure in network) impacts the resiliency or reliability of your company? How?**

One major problem is a thoroughfare constructed to improve traffic flow near facility. It means they will not be able to use parking lot as a buffer for finished goods while waiting for arrival of trucks to ship our products to customers. Most shipped by highway is sent east, so any delay in getting to I-90 can be a problem. But the distances are such that truckers can generally make up any delay they encounter in the Puget Sound region.

Nothing is shipped by rail, neither incoming nor finished goods. Reliability is so poor they can't see how anyone is able to use railroads as a major logistics resource.

- **Do you think that improvements to the resiliency of the transportation infrastructure network would improve the resiliency of your supply chain? How?**

Probably, but it would be difficult to quantify.

Appendix C: Description of Strategy Relationships

Relationships and:

- **Communication** – Relationships are developed and strengthened by communication.
- **Flexible Culture** – Taking the time to develop strong relationships is encouraged by flexible culture, where the value of these relationships is deemed important.
- **Flexible Transportation** – Strong relationships with carriers increase the potential for flexibility and priority in the wake of a disruption.
- **C-TPAT Certification** – Strong relationships are essential in order to achieve C-TPAT compliance because all members of a supply chain need to be certified. An importer must have a relationship with other members of the supply chain to ensure that compliance is achieved.
- **Resilient Suppliers** – Strong relationships are required to understand resiliency of suppliers
- **Expedited Freight** – Relationships need to be in place in order to make last minute transportation decisions.
- **Multiple Ports and Carriers** – Relationships with multiple ports/carriers increase the potential for flexibility and priority in the wake of a disruption.
- **Employees Overseas** – A relationship between all parties involved allows operations to move smoothly and disruptions to be anticipated or detected.
- **Off-Peak Deliveries** – Strong relationships are required in order develop overnight delivery procedures.

Communication and:

- **Relationships** – Communication develops and strengthens relationships.
- **Information and Technology** – Communication is enhanced by technology, and relays information.
- **Flexible Culture** – Taking the time to communicate effectively is encouraged by flexible culture, where importance of communicating disruptions, and potential disruptions, is understood.
- **Flexible Transportation** – Communication is needed to articulate transportation needs and capacities.
- **C-TPAT Certification** – Communication with other members of the supply chain and with the federal government is needed to maintain C-TPAT compliance.
- **Expedited Freight** – Communication is needed to articulate transportation needs and capacities.
- **Multiple Ports and Carriers** – Communication strengthens the relationships with multiple ports/carriers.
- **Employees Overseas** – Communication, often via technology, is important to maintaining a connection to employees overseas.

Information & Technology and:

- **Communication** – Information is relayed by communication and technology enhances communication.
- **Flexible Culture** – Flexible culture often encourages the development of and financial backing required for technology infrastructure.
- **Flexible Transportation** – Implementation of flexible transportation requires information about potential or existing disruptions.
- **C-TPAT Certification** – Technology enhances the C-TPAT program and visibility in the supply chain provides information about potential or existing disruptions.
- **Distribution Center Structure** – Making use of a large distribution center structure to route around delays requires information about potential or existing disruptions.
- **Expedited Freight** – Implementation of expedited transportation requires information about potential or existing disruptions.
- **Multiple Ports and Carriers** – Making use of multiple ports/carriers to route around delays requires information about potential or existing disruptions.
- **Employees Overseas** – Technology enhances communication over long distances.
- **Premium Transportation** – Technology enhances the visibility of premium transported goods. Information about goods shipped via premium transportation is expected to be more accurate than other transportation methods.

Flexible Culture and:

- **Relationships** – The development and maintenance of strong relationships are encouraged by flexible culture.
- **Information and Technology** – The development of and financial backing required for information technology infrastructure is encouraged by flexible culture.
- **Communication** – The importance of communication is encouraged by flexible culture.
- **Flexible Transportation** – The importance of enabling flexible transportation is encouraged by flexible culture.
- **C-TPAT Certification** – Flexible culture, through the support of upper management is important to successfully reach C-TPAT compliance.
- **Expedited Freight** – Flexible culture encourages the use of expedited freight when considered necessary, despite the increased costs, in order to react to disruptions.
- **Multiple Ports and Carriers** – Flexible culture encourages the use of multiple ports/carriers, despite the increased costs, in order to be prepared to react to disruptions.

- **Extra Capacity at Distribution Centers** - Flexible culture encourages the development of extra capacity at distribution centers, despite the increased costs, in order to have the ability to hold more inventory.
- **Off-Peak Deliveries** – Flexible culture encourages the use of off-peak deliveries, despite the increased costs, in order to avoid exposure to disruptions.
- **Sourcing Domestically** – Flexible culture encourages the use of domestic sourcing, despite the increased costs, in order to avoid exposure to disruptions.
- **Premium Transportation** – Flexible culture encourages the use of premium transportation, despite the increased costs, in order to avoid exposure to disruptions.

Flexible Transportation and:

- **Expedited Freight** – A flexible transportation policy allows for the use of expedited freight when necessary.
- **Multiple Ports and Carriers** – Flexible transportation allows for last-minute changes in the movements of goods from multiple ports or with multiple carriers. Having relationships with multiple port and carriers allows for flexible transportation.
- **Off-Peak Deliveries** – Flexible transportation allows for off-peak deliveries.
- **Premium Transportation** - A flexible transportation policy allows for the use of premium transportation when appropriate.

C-TPAT Certification and:

- **Employees Overseas** – Having employees overseas may simplify the C-TPAT certification process. Reaching C-TPAT compliance may require overseas employees.

Distribution Center Structure and:

- **Multiple Ports and Carriers** – A large, wide-spread distribution center structure may make the use of multiple ports and carriers more effective and efficient.
- **Off-Peak Deliveries** – A large, wide-spread distribution center structure encourages off-peak deliveries because there are distribution centers closer to the urban stores which require off-peak deliveries.
- **Expedited Freight** – Using a distribution center structure to improve resiliency assumes expedited transportation is available to move goods to desired locations.