RESEARCH OPPORTUNITIES IN SUPPLY CHAIN RESILIENCE

by

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ABSTRACT

Supply chains are an integral part of our everyday lives, and their importance has only increased as they expand globally. Global disruptions from the COVID-19 pandemic brought the importance of supply management to the front and center of the world's attention. Recent research has focused on the concept of supply chain resiliency as an important factor in preventing and minimizing the impact of supply chain disruptions. However, scholars and practitioners alike have yet to agree on a common definition or implementation strategy for supply chain resiliency. This thesis explores the state of the literature regarding supply chain resiliency to arrive at a comprehensive definition of supply chain resilience, explain its importance in managing supply chain risks, describe the pillars of supply chain resilience, and the implications of implementing resilience for large firms and small to medium enterprises alike. Finally, I will discuss solutions for implementing supply chain resilience in a global economy.

Chapter 1

INTRODUCTION

The onset of the COVID-19 pandemic in 2020 sparked many issues across the world. Supply chains in all industries suffered due to the shutdown of factories worldwide, trade reductions, and shipping issues causing mass shortages and supply chain issues, also known as disruptions. Since World War II, 2020 was the first time that output volumes and trade reduced significantly. Industrial production and trade were also similar to the levels during the global economic crisis of 2007 (Arriola & von Tongeren 2021).

The horrors of the COVID-19 pandemic brought global attention to many aspects of life often taken for granted. One of the biggest challenges brought to bear was the breakdown of global supply chains resulting in widespread product shortages. Supply chains in all industries suffered due to border closures, factory shutdowns, changing consumer behavior, and loss of human life. Any event like this that causes a supply chain to not function as intended is called a disruption, and can lead to numerous adverse consequences like product shortages, excess inventory, price inflation, trade reductions, and shipping delays.

When supply chains function properly, most consumers don't think about -- or perhaps even know of -- their existence. Business professionals and policymakers are often the only ones aware of the intricacies and challenges that keep consumer products moving. However, the widespread product shortages and unprecedented wait times resulting from COVID-19 disruptions brought the fragility of global supply chains to the front pages around the world.

While COVID-19 caused these extreme and visible supply chain issues, supply chain disruptions are more frequent and widespread than many consumers realize. Any event that prevents supply chains from operating the way they are intended to ultimately results in delays and increased costs. Disruptions might be small and quickly resolved like a winter storm, all the way up to something extensive and devastating like the Russia-Ukraine War.

In this thesis, we will first explore the types and causes of supply chain disruptions. Then, we will address how to mitigate the impacts of disruptions by building supply chain resilience. Supply chain resilience, or the ability to recover from or minimize the effect of supply chain disruptions, is a recent focus for both researchers and managers. Research into supply chain resilience is still in the early stages, with no clear consensus on best practices or implementation. Therefore, the contribution of this thesis is a broad review of the current state of research into and practice of supply chain resilience. We present different definitions and characterizations of resilience, how it varies across industries, and suggestions for building more resilient supply chains. We also discuss a particularly under-researched area: supply chain resilience for small and medium-sized enterprises (SMEs).

The rest of this paper is organized as follows: In Section 2, we establish the research context and review relevant background literature. In Section 3, we discuss the current state of supply chain resilience. In Section 4, we propose future research avenues and conclude.

Chapter 2

Background & Literature Review

This thesis draws from and contributes to the literature on supply chain resiliency, specifically its role in SMEs. In this section, we first establish the history and importance of supply chain management. Then we discuss the risks and disruptions inherent in supply chains. Finally, we detail the more recent focus on building resilient supply chains.

Supply Chain Management

A supply chain is the entire network of people, organizations, processes, and locations that play a role in transforming inputs into final products – usually consumer goods. Each entity that provides a good or service that goes into the final product is a link, and when they all come together, it becomes a chain. For example, the supply chain for an automobile would include all raw materials, like metal, rubber, and petroleum; parts and component suppliers, like those that make engines, tires, and semiconductors; all manufacturing stages; and support processes, like software and financial services.

Supply chains have existed as long as humans have been producing and trading goods, however, supply chains as we know them now are a fairly new concept. Before the Industrial Revolution, most products were made by one person from start to finish. For example, a blacksmith would source their own metal and complete every step in the process to make a final consumer product, like a plow or a knife. It was very easy to trace product origins because so few entities were involved in production.

As larger manufacturing practices were introduced during the Industrial Revolution, producers often specialized in one area of work and began to outsource aspects of their products. For example, a clothing manufacturer would purchase fabric from another company specializing in fabric production instead of weaving its own material. In time, the emergence of trains, high-speed ships, and eventually airplanes and the internet led to supply chains expanding. We are now in an era where global supply chains are the norm, with the materials and services that go into finished goods originating from all parts of the world. Because of the complexity of modern production, supply chains are really more of a network than a linear "chain" (Peck 2004).

While supply chains have been around for much of human history, the idea of "managing" the chain was not introduced until 1982 (Oliver & Weber 1982). Around this time, managers began to realize that the inputs sourced and the transportation methods used could have an effect on their organizational performance. For example, organizations realized that reliable delivery and major cost savings could be achieved through well-planned transportation routes. Moreover, since all "links" in a supply chain need to work together to be efficient, any problems in one link cascade through the whole supply chain. For example, if a company purchases materials from a supplier that cannot deliver on time, this causes a domino effect that delays its own production and leads to unhappy customers. Today, supply chain management is considered a broad field, encompassing all the plans and decisions associated with procuring, transforming, and transporting goods and services from the raw components to the final consumer product (IBM 2019).

Supply Chain Disruptions

Managing supply chains has been shown to improve organizational performance (S. Brambrick et al. 2023, Li et al. 2016). But, importantly, there is extensive evidence that the *lack* of supply chain management can cause major problems. This stems from the idea of supply chain risks, which are the potential disruptions, threats, or vulnerabilities that can impact the normal performance of a supply chain network. This is because of the global nature of supply chains, where the potential of a “risky” event entering the supply chain is so much greater. When an adverse event affects some link in the supply chain, the repercussions of this extend to and affect the operations of the rest of the supply chain. This was most evident during the COVID-19 pandemic, where disruption stemmed from closed borders, limited production, stay-at-home orders, transportation stoppages, and widespread loss of life. For example, factory closures around the world led to limited production which led to global shortages.

While COVID-19 may be the most visible example of the cascading effects of supply chain disruptions, pandemics – which historically occur every few decades – are far from the only event to cause supply chain disruptions. In fact, supply chain disruptions lasting at least one month happen every 3.7 years (Howells & Burnham n.d.). The Business Continuity Institute also found that in the past twelve months, 85% of businesses experienced at least one supply chain disruption (A. Marley et al. 2014).

Supply chain disruptions stem from several potential sources. One example is natural disasters, where extreme weather can disrupt numerous links in a supply chain, slowing or even stopping the delivery of goods. After the Great East Japan Earthquake

(GEJE) and tsunami, Japan's GDP growth declined by 0.47%, and firms with supply chain links in Japan experienced disruptions and lost an average of 5.21% of their shareholder values over a one-month period (Carvalho et al. 2020). Hurricane Katrina resulted in the shutdown of the Port of New Orleans, one of the United States's largest commercial shipping ports. Approximately 37% of Dow Chemical Co.'s North American production capacity was affected by the Katrina shutdowns (Katz 2005). In more recent years, the Texas Freeze (2021) shut down chemical plants all over Texas, leading to shortages in many raw materials, mainly plastic. Companies such as Honda Motor Co. (automobiles), PPG Industries (paint manufacturing), and the Container Store Group (storage and shelving) consequently faced shortages that influenced profit margins. Amid the housing shortage, home-building companies such as David Weekley Homes faced major shortages that caused delays for home starts, further increasing housing costs (Matthews et al. 2021). Many companies did not realize how much of their supplies came from the affected Gulf Coast area until the disruption happened. Moreover, as climate change continues to accelerate, more shutdowns due to extreme weather disruptions can be expected.

Human-centered events are also drivers of supply chain disruptions. For example, the 1911 Triangle Shirtwaist Factory fire in New York City could reasonably have been prevented by basic safety measures. In 2013, the Rana Plaza textile factory in Bangladesh collapsed due to structural issues, killing more than a thousand workers. The garment industry is the largest contributor to Bangladesh's GDP, accounting for approximately 80% of exports and millions of jobs (Ayres 2014). Rana Plaza produced clothing for many major global companies, such as Zara, Primark, and Walmart. These companies not only lost Rana Plaza as a supplier (and thus, any orders currently in process), but the unsafe working conditions exposed by the building collapse resulted in boycotts by consumers around the world. The 2015 China Port Explosion in Tianjin caused an estimated $9 billion in damages, one of the costliest disasters in terms of money (Wang 2016). Even though it was only the third most damaging disaster in 2015, it was the largest non-natural disaster that year. Tianjin, a major port city an hour away from Beijing, is home to over three hundred Fortune 500 companies and factories, many of which produce parts for electronics, cars, and other machinery exported around the world. Overall, these supply chain disruptions were reasonably preventable by practicing more ethical management, like by creating safer working conditions and providing more transparent sourcing.

Economic and political issues have especially begun to affect supply chains worldwide due to globalization. In the past forty years, global value chains have become more popular, meaning supply chains have transcended borders. Global supply chains are beneficial from a business perspective because they increase efficiency and reduce costs, however, they are more vulnerable to disruptions than domestic supply chains. In July 2018, trade tensions began between the United States and China, which led to a significant decrease in American companies using China-based manufacturers, and instead looking to Vietnam and Mexico for alternatives (Alfaro & Chor 2023). This trade war affects not only the US and China but also many other countries, specifically in Europe and resource-rich countries. China quickly invested in the Democratic

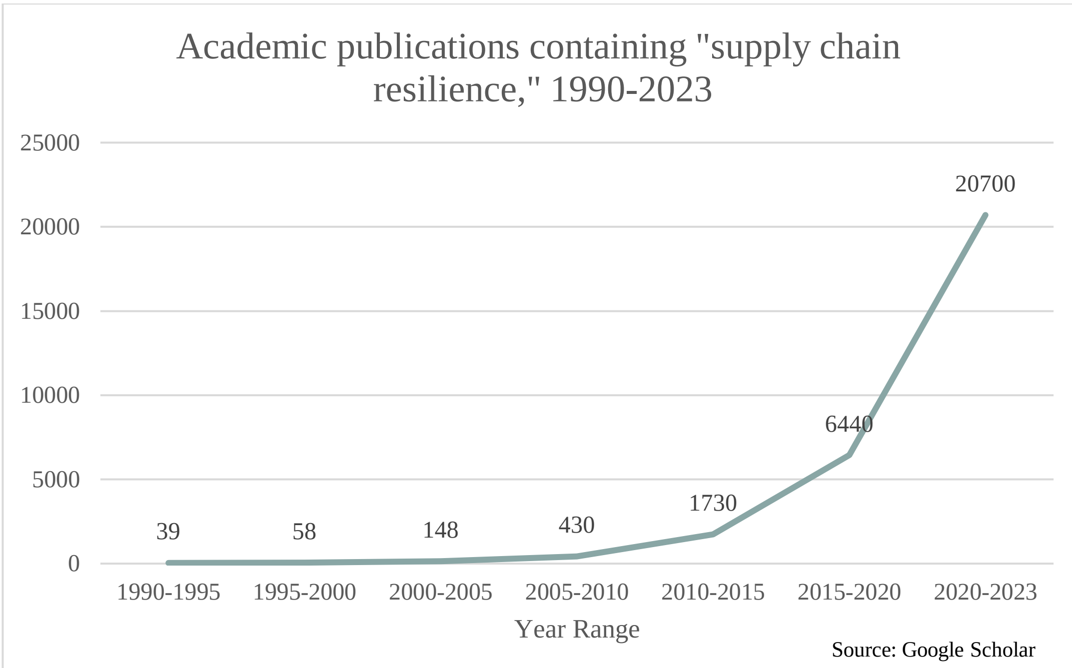
Republic of Congo, which has about 60% of the world's cobalt supply, an important material used in lithium-ion batteries. This created trouble for American companies since China holds large investments in Africa (Wolf & Kalish 2021). Brexit has caused major disruptions in trade between the EU and the UK, leading to longer lead times, inventory buildups, and ultimately higher consumer prices (Alicke & Strigel 2020). Brexit ranked higher than COVID-19, Russia's war with Ukraine, and rising energy costs for disruptions in UK businesses, with an average loss of 18% in revenue (Tetley 2022). The UK exports approximately half of its goods to the EU, making it the UK's largest market. Due to the still ongoing uncertainty of Brexit, companies need to be proactive in reviewing their supply chains (Tetley 2022). Political instability with Russia's attacks on Ukraine has led major companies to stop production in sites located in Crimea and Ukraine, leading to delays and rerouted resources (Kettering University 2018). Global political and economic instability have forced companies to reevaluate supply chains and move operations.

Interestingly, disruptions are not always triggered by supply issues. Rapid changes in consumer behavior can cause disruption. For example, demand for items like masks and hand sanitizer reached unforeseen levels during the early COVID era (Rose 2020a, 2020b). Traditional manufacturers, such as 3M, were unprepared to fulfill such unprecedented orders for masks and had to rework their operations to keep up with demand. Clorox more than doubled its capacity during the pandemic to keep up with soaring for disinfectants and other cleaning products. Other companies pivoted their operations to produce in-demand items outside their traditional market. For example, Honeywell began manufacturing N95 masks and Anheuser-Busch started making hand sanitizer. Another example is the widespread COVID-era toilet paper stockouts. This was partially because consumers rapidly changed their purchasing behavior, “hoarding” because of the uncertainty of future supply. But it was also because most public spaces, which use a different type of toilet paper, were closed. Consumer goods companies also had to pivot to cut the supply of industrial toilet paper and increase production of consumer-grade toilet paper. For example, P&G limited their shipments to retailers, while companies such as Charmin (toilet paper) and Bounty (paper towels) increased their production to twenty-four hours, seven days a week (Kang & Terlep 2021).

Supply Chain Resilience

Supply chain disruptions on any scale will always exist, which is why approaches to minimize disruptions and their impacts have become a critical topic for both researchers and managers. The realization that supply chain disruptions can be mitigated through proper planning and management has introduced the importance of building a supply chain that can be “resilient” to disruptions. Research in supply chain resilience has increased in the last decade and has grown especially rapidly in the wake of COVID-19 disruptions (see Figure 1). Given this recency, research is still quite fragmented and scholars have yet to agree upon a standard definition.

Figure 1: Number of research papers discussing supply chain resilience published from 1990-2023



Numerous papers have proposed potential definitions. For example, Ponomarov and Halcomb (2009) define resilience as the capacity to adjust and maintain desirable functions under challenging conditions and bounce back from hardships. Wildavsky (2017) defines resilience as learning from error and how to bounce back in better shape. Even though this definition acknowledges the importance of improving to get to a better spot than before, it takes a reactive stance by waiting for errors to arise, instead of being proactive in protecting the supply chain. Researchers such as Fiksel (2006) have similar definitions of resilience as the ability to recover from or adjust to adversity. Mallak (1998) also offers a similar definition but includes the design and implementation aspects of the immediate situation while enduring minimal stress. Table 1 summarizes more relevant academic definitions of supply chain resilience.

In addition to academic research, companies have also proposed several definitions of supply chain resilience. For example, GEP Inc. describes supply chain resilience as the ability of supply chains to withstand disruptions while minimizing the effects on revenues, costs, and customers (GEP n.d.). Gartner defines resilience as the ability to sense and respond to disruptions in demand or supply quickly and reliably, without compromising cost or quality (Hippold 2021). Boston Consulting Group also identifies six important aspects of supply chain resilience: (1) decreasing global reliance by increasing redundancy, (2) developing a diversified inventory strategy, (3) maintaining suppliers, (4) gaining end-to-end transparency of their supply chains, (5) monitoring risks, and (6) proactively planning to address weak points (Schuster et al. 2021). Table 2 summarizes more relevant managerial definitions of supply chain resilience.

Table 1: Academic Publications on Supply Chain Resilience

Author/Publication	Definition
Ponomarov & Halcomb (2009)	The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function.
Wildavsky (1988)	Resilience is the dynamic capacity of organizational adaptability that grows and develops over time.
Mallak (1998)	The ability of an individual or organization to expeditiously design and implement positive adaptive behaviors matched to the immediate situation, while enduring minimal stress'.
Fiksel (2006)	The capacity of an enterprise to survive, adapt, and grow in the face of turbulent change.
Carvalho et al. (2012)	Resilience is the supply chain's ability to cope with unexpected disturbances.
Ponis & Koronis (2012)	Supply chain resilience encompasses the ability to anticipate disruptions, adaptively respond to unexpected events, maintain control over supply chain structure and function, and achieve robustness post-event.
Hamsel & Valikangas (2003)	Resilience implies a certain level of flexibility and the ability to adapt to environmental differences, so resilience is a prerequisite for sustainable economic development.

Table 2: Business Research on Supply Chain Resilience

Firm/Author	Definition
Gartner, Hippold (2021)	The ability to adapt to structural changes by modifying supply chain strategies, products, and technologies, and agility is the ability to sense and respond to unanticipated changes in demand or supply quickly and reliably, without sacrificing cost or quality.
GEP Inc. (n.d.)	The ability of supply chains to withstand disruptions while minimizing the effects on revenues, costs, and customers.
Boston Consulting Group, Schuster et al. (2021)	Six important aspects of supply chain resilience 1. Decreasing global reliance by increasing redundancy 1. Developing a diversified inventory strategy 2. Managing suppliers 3. Gaining end-to-end transparency of their supply chains 4. Monitoring risks 5. Proactively planning to address weak points

While both researchers and managers have different ways to define supply chain resilience, for the remainder of this thesis, we will consider supply chain resilience as the ability to recover from or minimize the effect of supply chain disruptions.

Chapter 3

Supply Chain in Practice

Given the recency of supply chain resilience research, there is little consensus about best practices and implementation. Therefore, the contribution of this thesis is synthesizing types and examples of supply chain resilience in practice. In this section, we first survey the academic and managerial literature for the benefits of supply chain resilience. Then, we illustrate different approaches to resilience across industries. Next, we summarize how firms can build supply chain resilience. Finally, we examine the state of supply chain resilience for a particularly vulnerable subset of firms: small and medium-sized enterprises.

Benefits of Supply Chain Resilience

On a basic level, building supply chain resilience can help reduce and overcome vulnerability to risks (Scholten et al. 2014). Research shows that by investing in supply chain resilience, the impacts of disruptions can be managed. Although building resilience is expensive, the benefits can outweigh the costs. Usually, supply chain resilience is more focused on reactivity - ensuring that the supply chain quickly recovers after a disruption, however, firms should be focusing more on attempting to prevent the effects of the disruptions instead of waiting for them to happen. There are strategic, financial, operational, and market advantages to this proactive approach to building resilient supply chains.

Companies that do not have resilience built into their strategy take longer to recover from disruptions, face increasing costs, and lose potential profits. By proactively planning and designing a supply chain network, a company can quickly revert to its full operational capacity after a disruption. Therefore, having resilience as a supply chain strategy can be important both for short-term survival and long-term competitiveness (Tukamuhabwa et al. 2015). A firm's competitive position and its supply chain's responsiveness are crucial in determining its resilience. A firm’s supply chain must be able to respond quickly to the disruption or they will risk loss of market share. Companies that can quickly react are well-positioned to gain market share from competitors that are not resilient and/or flexible (Sheffi & Rice 2005).

Supply chain resilience significantly impacts a firm’s financial performance, specifically its preparedness, which is why a proactive approach to supply chain planning is important (Li et al. 2017). Therefore, one of the most important benefits of building resilience is financial protection. Currently, most companies are designed for cost-efficiency rather than resiliency, which is only beneficial in the absence of any disruption (Hippold 2021). Firms affected by disruptions during COVID-19 experienced a significant decline in shareholder value in two weeks and a subsequent decrease in operating performance in one year (Wang et al. 2023). A supply chain can also face risks from the demand side. For example, during the global economic crisis of 2007, there was a sudden fall in demand for finished goods. This spread back through supply chains, and affected suppliers throughout the world (Mefford 2009). Events like this can cause financing issues, logistical problems, and cost effects, but these risks can be mitigated by building supply chain resilience.

Supply chain resilience is also vital for maintaining operational continuity when disruptions arise (Zhu & Wu 2022). Supply chain resilience supports the idea of supply chain sustainability, which emphasizes the importance of long-term viability and responsible practices, both of which have implications for positive supply chain performance.

A resilient supply chain is also crucial for keeping customers happy and retaining market share. In an empirical investigation conducted by Alfarsi, Lemke, and Yang (2019) which conducted seventeen in-depth interviews in the UK manufacturing sector, it was revealed that having resilient supply chains helps a firm sustain and maintain a good reputation. Firm reputation is important since it can affect profitability, word-of-mouth marketing, customer trust, entry barriers for competitors, and the ability to influence industry prices. A negative reputation can be harmful for the company, and could even push them out of the industry. Especially in industries with a lot of competition, staying ahead or on schedule is vital. Depending on how long it takes for a company to recover after a disruption, customers may be inclined to go to other companies for substitutions.

Resilience Across Industries

Resilient supply chains are also difficult to characterize because they often differ across industries. Supply chain disruptions can and do affect all industries, but disproportionately affect manufacturing. Manufacturing suffers the most from supply chain disruptions, because of the focus on physical goods. This was especially apparent during the height of COVID-19. Lockdown policies disrupted the supply of raw materials and the demand for finished goods, leaving firms struggling to reconfigure their internal and external supply chain networks. Supply chain resilience can help protect manufacturing firms by ensuring timely product delivery and reliable sales volumes (Tarigan et al. 2021).

For example, the tech and electronics industries face a lot of pressure because of the importance of these goods to functioning modern society. At the beginning of 2021, the semiconductor industry faced shortages due to a short disruption in Taiwan that lasted ten days. Semiconductor chips are an essential component of electronic devices such as computers, smartphones, routers, and even automobiles. This disruption caused a ripple effect through the entire supply chain that lasted over one year. Nearly all semiconductor chips are produced in Taiwan, China, and South Korea, then they are shipped globally to finish assembling the final product. The concentration of this production in one area of the world poses numerous supply chain risks. Geographically, should any natural event happen in this area to preclude production or distribution, global supply chains will be in trouble. The political and economic concentration of just these few countries poses similar threats. To combat this risk, the United States Congress passed the CHIPS and Science Act in 2022 to decrease reliance on foreign production and establish domestic production in order to increase and secure supplies of semiconductors (Simchi-Levi et al. 2022).

The textile and apparel industries face their own sets of challenges. One of the main reasons is that textile companies are often concentrated in unstable emerging economies that sit in regions with many natural disasters, making them more vulnerable to disruptions. For example, the Sri Lankan apparel industry has vulnerabilities that can be affected by disruptions. Sri Lanka, a tropical island in the Indian Ocean, specifically faces many natural disasters such as droughts, cyclones, and floods due to climate change. These disasters will continue and will get worse as climate change intensifies. In the Vietnamese textile industry, inbound logistics and reengineering have become more important to construct a more resilient supply chain. Improving inbound logistics can encourage firms to be more proactive in handling disruptions. Reengineering is the ability to modify supply chain strategies and processes. Reengineering can reduce uncertainty and enhance competitiveness, which is why it positively affects supply chain resilience (Bình Nguyễn Thị et al. 2023).

Supply chain resilience is especially hard to implement in the apparel industry because of rapidly changing demand and turnover. Apparel firms tend to use a just-in-time supply chain to increase efficiency and decrease waste and costs of unused or outdated products. The success of just-in-time relies on having a steady supply chain without disruptions, however, this is becoming increasingly impossible. Firms need to find a balance between just-in-time and planning for the uncertainty disruptions can bring (Abeysekara et al. 2019).

Because of the risk of a disruption causing shortages, many manufacturers think that resilience is just having a larger inventory. The reality is much more complex.

Having excessive inventory could actually increase the likelihood of downstream disruptions, so some researchers believe the lean management approach of having lower inventory levels and eliminating complexity is a better practice (Marley et al. 2014). By eliminating complexities and increasing visibility in the supply chain, problems can be easily identified, and smaller investments of time and money are needed.

The practice of redundancy, keeping some resources to be used in case of a disruption, is another popular solution to increasing supply chain resilience in manufacturing. This could either be through creating a safety stock or diversifying suppliers. Safety stocks introduce the concept of just-in-case supply chains, but these can cause issues similar to just-in-time supply chains (Sheffi & Rice 2005). Finding a balance between efficiency and redundancy is hard, but in terms of resiliency, having a surplus inventory provides more flexibility. A better way to control a supply chain is through informed estimates of safety stocks given the market conditions and coming up with a reasonable estimate of stock.

Harnessing data and analytics is another way of building supply chain resilience. Using data in business decisions is not a new concept, but its use in creating more resilient supply chains is a more recent application. One study found that institutional experience with navigating supply chain disruptions harmed firms' ability to build resilience, but developing their big data capabilities and analytics allows them to effectively utilize firm knowledge and develop supply chain risk resiliency (Singh & Singh 2019). Big data analytics within an organization include collecting, mining, analyzing, and visualizing data effectively, enabling decision-makers to develop solutions for decision-making. Having digital systems in place to analyze big data can improve supply chain resiliency. Artificial intelligence is also a powerful tool that can aggregate data from news, politics and public policy, sales reports, competitor activity, and customer feedback to determine market trends and give firms real-time insights to prepare for and respond to disruptions (SAP).

Supply Chain Pillars

With the knowledge that resilience is crucial in supply chains, but that specific needs vary across industries, it becomes difficult to prescribe solutions for firms to build resilience. Instead, researchers have identified four "pillars" that comprise a resilient supply chain to direct firms on which areas they should focus (Razak et al. 2021). These pillars are summarized in Table 3. A firm may be proficient in one or two of the pillars, but it must continuously work on all aspects of resilience to prevent detrimental consequences from disruptions.

Flexibility is a reaction to environmental uncertainty and the organization's general ability to effectively adapt or respond to change (Vickery et al. 1999). Some examples of flexibility can include creating contracts that allow for modifications in delivery schedules to decrease downtimes or adapting volume changes to meet demand needs (Scholten & Schilder 2015). A flexible approach to managing the supply chain can enable making small adjustments to decrease costs and minimize risks building up.

Velocity is the ability to complete an activity as quickly as possible (Carvalho et al. 2012). Especially in a time of "fast and free" shipping, velocity is incredibly important to stay relevant. One link in the supply chain having delays could cause major issues downstream. High velocity can shorten lead times and cycle times, which means the product will get to the end user faster. One example of a company that has created an incredibly efficient supply chain through velocity is Amazon.

Supply chain visibility is the extent to which actors within the supply chain have access to the timely and accurate information that they consider to be key or useful to their operations (Somapa et al. 2018). Visibility is beneficial to supply chains because it enables players in the supply chain to achieve a higher level of market responsiveness and mitigate the risk of disruptions to the flow of materials and products. Exchanging information upstream and downstream is vital to understanding customer needs and quickly reacting to disruptions. Visibility can aid in traceability, so if an issue arises, it can easily be identified from the start.

Collaboration is the capability of two or more autonomous firms to work effectively together, planning and executing supply chain operations toward common goals (Cao et al. 2009) (Soosay & Hyland 2015). This could mean communicating the needs and demands of your firm across the entire supply chain. This can lead to more competitive advantages and higher profits than can be achieved by firms acting alone (Simatupang & Sridharan 2002).

Overall, these four pillars work together to not only dampen the effects of disruption, but they can also help address supply chain inefficiencies. A classic example of what happens when supply chains lack these pillars is the bullwhip effect. In the bullwhip effect, a small change in consumer demand causes retailers, manufacturers, and suppliers to increase their production in order to meet the new demand (Lee et al. 2004). This continues upstream and is exacerbated with each unit until the first link in the chain increases production significantly more than the original demand. This will result in excess inventory and increased costs. Visibility and collaboration in the supply chain can decrease this issue. Retailers can determine the cause of the small changes in demand and will inform the wholesaler and so on until the beginning of the supply chain. Sharing accurate information will allow each unit in the chain to determine the correct production amount, avoiding the issues of excess inventory and costs. The degree of flexibility, velocity, visibility, and collaboration integrated into the supply chain supports a quick response to disruptions and recovery, which will influence the supply chain's performance and competitiveness (Carvalho et al. 2012).

Table 3: Four Pillars of Supply Chain Resilience

Pillar	Definition
Flexibility	A reaction to environmental uncertainty and the organization's general ability to effectively adapt or respond to change
Velocity	The ability to complete an activity as quickly as possible
Visibility	The extent to which actors within the supply chain have access to the timely and accurate information that they consider to be key or useful to their operations
Collaboration	The capability of two or more autonomous firms to work effectively together, planning and executing supply chain operations toward common goals

Small to Medium Enterprises

While research on supply chain resilience has become more common in recent years, nearly all of this research has focused on large multinational corporations. Small and medium-sized enterprises (SMEs) have often been excluded from supply chain research in general, but it is a stark oversight when these organizations are so vulnerable to the risks of disruptions. An SME is an independent organization with under 250 employees - most of which have under 10 employees.

SMEs were disproportionally affected by COVID-19 as 34% of small businesses closed in the four months at the beginning of the pandemic (Ghosh 2021). SMEs are especially vulnerable to disruptions due to their niche product offerings, fewer financial and technological resources to aid in recovery, and a smaller workforce. They are also at a disadvantage because they often cannot invest in new technologies (Acemoglu et al. 2022).

The small amount of research addressing SMEs defines resilience as a combination of adaptability, responsiveness, sustainability, and competitiveness, and it is usually incorporated into short-term operations planning (Bak et al. 2020). Two pillars of resilience in particular can support small to medium enterprises during these difficult times. Flexibility has a positive impact on their sales and marketing performance, and it enables management to prepare for any disruptions (Alshahrani & Salam 2022). Collaboration, specifically businesses combining existing resources to solve problems and maximize business opportunities, is also important for small to medium enterprises. Collaboration enables small to medium enterprises to share resources to overcome resource constraints, which is important in times when resources are scarce or there are rapid changes in consumption patterns (Ramanathan et al. 2021).

It is just as important for small to medium enterprises as it is for global corporations to develop supply chain resilience to survive. This is not only because there are currently over 33 million small businesses in the US, making up 99.9% of all American businesses and almost half of its workforce (Main 2022), but also because larger corporations rely on them to survive as well. As sustainable supply chain practices become more widespread, large firms often depend on SMEs when reshoring their production (Lerberg Jorgensen & Steen Knudsen 2006).

The explosion of globalization, or “hyperglobalization,” beginning in the late 20th century was beneficial for expanding markets, reducing costs, and increasing efficiency (Gong et al. 2022). Hyperglobalization was mainly due to technological advances, including the rise of the internet, beneficial trade agreements, such as the formation of the North American Free Trade Area (NAFTA) and ASEAN free trade agreement in Asia, and the spread of capitalism in areas such as China, India, and Eastern Europe (Antràs 2020). But this reckless expansion in pursuit of cheaper labor has also contributed to the breakdown of supply chains. This became truly a matter of life or death when import-reliant countries were left vulnerable during the early stages of the COVID-19 pandemic. Essential medical product production is heavily concentrated in a small number of countries, leaving most other countries to rely on importing them, causing devastating shortages (Leibovici & Santacreu 2020).

The more recent trend of reshoring, or moving production back domestically, can help increase supply chain visibility and cut down on transportation costs. It has also been found that by reshoring to the U.S., material and labor costs go down while quality and energy efficiency increase. This is because companies initially offshored in pursuit of low labor wages, but this is not true anymore (Kandil et al. 2020). Domestically produced products are also more appealing to many consumers (Donahue 2021). Some reshoring is not voluntary, as policies like the CHIPS Act resulting from the semiconductor crisis in 2021 have required mandatory levels of domestic production.

While reshoring can be helpful, it alone does not create resilience for either large corporations or SMEs (Donahue 2021). As demonstrated by the 2020 meat shortage, since the industry is completely domestic and has been greatly consolidated, shutting down just one plant can lead to detrimental shortages (Simchi-Levi et al. 2022).

Supply chains certainly will remain global, but the pursuit of resilience is causing managers and policymakers to find a balance between international and domestic operations. Instead of pure globalization or domestic production, the practice of "slowbalization," or slowing down the pace of global integration, could be a better solution. First introduced after the global economic crisis in 2007, slowbalization became a product of the COVID-19 pandemic as borders closed, the movement of goods and services slowed down, and global value chains collapsed (Kononenko et al. 2020). Moving forward, firms need to be intentional when deciding where to locate their activities and who completes them. As large multinational corporations begin to more strategically reshore their operations, developing a force of resilient SMEs will be critical to rebuilding supply chains that are stable and sustainable.

Chapter 4

Conclusion

Supply chains are extremely complex and fragile structures that transform raw materials into final consumer products. Supply chains are essential to our livelihood, but there are many threats that could stop them from working properly. As much as firms try to avoid these threats – or disruptions – they cannot always be avoided. Therefore, firms should instead focus on mitigating their impacts by making their supply chains more resilient.

Resilient supply chains may not be the lowest cost option when structuring a supply chain, but they help to manage unexpected issues in the business environment (Carvalho et al. 2012). Creating a resilient supply chain has financial, operational, strategic, and market advantages, in addition to keeping a firm safe from threats.

To achieve resilience, companies must find a balance between a just-in-time supply chain that values lean practices but leaves them vulnerable to disruptions and a just-in-case strategy that protects the supply chain from disruptions but creates inefficiencies. The proper balance can be found by building resilience in the supply chain and focusing on the four pillars (flexibility, visibility, velocity, and collaboration) for guidance.

Critically, nearly all research on supply chain resilience has examined large multinational corporations. Therefore, what we know about building supply chain resilience is limited to companies with power and resources. For example, collecting, analyzing, and interpreting large amounts of data is critical for building visibility. Moreover, getting access to the data of supply chain partners requires collaboration. These types of solutions are understandably out of reach for many SMEs. They may not have the resources to harness data and analytics, and likely lack the relational power to facilitate collaborative partnerships.

This is a major oversight in the understanding of supply chain resilience, as SMEs make up more than 99% of American companies (Main 2022). Not only that, but as larger companies trend toward reshoring and domestic production, SMEs will form the backbone of that movement. Overall this lack of understanding leaves both SMEs and large multinational corporations vulnerable to supply chain risk, disruption, and any ensuing issues.

The upside to this is that there is a lot of potential for research into supply chain resilience for SMEs. Since the area is not yet well understood, researching the nature, frequency, and intensity of disruptions at various SMEs will be an important first step. Researchers can use methods like case and field studies to interview and survey actual managers and employees of SMEs. As more is understood about the nature of disruptions at SMEs, more specific studies can ask questions and implement interventions to assess different tools for resilience. Another potential avenue of inquiry is investigating the collaborative relationships between SMEs and larger companies to see how resilience may flow between them in their shared supply chains. Neutral organizations that promote business interests, like the International Trade Council or chambers of commerce, might help facilitate such collaborative studies. Moreover, we can even look beyond SMEs, like not-for-profit and non-governmental organizations, to see how non-commercial organizations respond to supply chain disruptions.

Overall, supply chain resilience is an issue for all types of organizations worldwide. The global nature of today's world makes disruptions more common and sometimes more devastating. Researchers and practitioners are just beginning to understand the importance of building more resilient supply chains, and the mechanisms that enable them. There is still much work to be done as the world endeavors to rebuild more resilient supply chains in the wake of COVID-19.

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