In Pursuit of Supply Chain Resilience: Three Essays Providing Guidance for Firms to Thrive in Uncertain Times

Dissertation

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Abstract

Supply chains have grown increasingly global and interconnected over the past decades. Technological advancements have enabled organizations to pursue improved performance while simultaneously reducing costs; all in pursuit of increased profits. However, this same supply chain globalization has amplified companies' risk exposures. These risks lead to increased supply chain disruptions- interruptions in the flow of materials and products between entities in supply chains. At the same time, high-impact disasters- from various causes- are increasing in frequency. For example, evidence from the COVID-19 pandemic has revealed how discrete events cause ripples felt across industries and geographies. Therefore, it is essential to improve our understanding of resilience- an organization's ability to withstand, recover and grow from disruption- not only to further scientific knowledge, but also to provide actionable guidance to our practitioner community.

This dissertation examines how organizations respond to disruptions and communicate those disruptions- to partner organizations and public stakeholders. In Chapter 2, we utilize semi-structured interviews to explore how an organization's capabilities of agility, adaptability, and alignment (AAA capabilities) connect to and enable its resilience. We find empirical evidence suggesting that alignment between and within organizations drives the ability to respond to short-term disruptions (agility) and

make long-term adjustments (adaptability). In Chapter 3, we utilize an online scenario-based experiment to assess whether the timing and accuracy of shared disruption-related information influence the relationship between a buyer and supplier. Much of the literature on information sharing during supply chain disruptions assumes that the information transmitted is accurate, an assumption unlikely to be true given the uncertainty surrounding supply chain disruptions. We show that when a supplier shares information quickly, regardless of that information's accuracy, the buyer has greater trust and willingness to continue the relationship with the supplier. In chapter 4, we collect a unique dataset of qualitative documents to investigate how organizations communicate a sustained component shortage. We find that organizations utilize a broad playbook of communication strategies to broadcast the shortage and their organizations' response to that shortage to public stakeholders. Finally, in Chapter 5, we provide conclusions. Each chapter of this dissertation expands the theoretical understanding of how organizations can better respond to disruptions and pursue resilience. Additionally, each chapter offers practical applications for organizations experiencing disruptions.

Dedication

This dissertation is dedicated to my wife, Megan. She is my partner, best friend, and biggest cheerleader. Without her constant support, I could never have started, much less finished, this journey.

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Chapter 1. Introduction

In recent years, significant disruptive events have become increasingly common. A global pandemic, an international conflict, multiple natural disasters, and economic uncertainty are a few different events facing organizations just during the writing of this dissertation. A few factors have driven this increase in global supply chain disruptions- interruptions in product flow between supply chain partners (Craighead et al., 2007). First, technological advances have enabled firms to better operate and manage global supply chains. These technological advances have allowed firms to increase outsourcing, utilize a more dispersed supply base, and serve a more extensive customer base while achieving greater supply chain performance. However, this increase in the scope and complexity of supply chains has effectively provided a more prominent "target" for disruptions (Chopra & Sodhi, 2014; Craighead et al., 2007).

Secondly, global competition has driven a relentless pursuit of efficiency and a never-ending quest for cost reductions. These factors have driven companies to reduce inventories and remove many buffers (e.g., safety stock, excess capacity) that have insulated them from the impact of disruptive events. Advances that allow organizations to operate global supply chains with fewer resources- human, capital, and inventory- accelerate these reductions in buffers (Knemeyer et al., 2009). A relentless focus on the bottom line is practical when conditions are as expected. However, there has been an

increase in the occurrence of significant disruptive events- natural disasters, mismatches of supply and demand, and human-caused incidents in recent years (ASCM, 2021). These factors combine to increase the importance of an organization's ability to survive, adapt, and grow in the face of unexpected events (Fiksel, 2006), an ability called resilience.

The ability to thrive in uncertainty is no longer a luxury for firms. Chaos in global markets seems to be the new normal; organizations must ensure that their supply chains can operate regardless of the events occurring in the external environment. The uncertainty that has plagued the past few years shows no sign of abating. We do acknowledge that this dissertation is not the first to examine resilience. However, resilience is a topic that continues (and deserves to) receive significant scholarly and managerial interest. Multiple scholars have advocated for increased examinations of how organizations can better respond to the constantly changing environmental conditions (Richey et al., 2022; Richey & Davis-Sramek, 2022). A recent Gartner survey found that 87% of all supply chain managers are looking to invest in resilience within the next year (Hippold, 2021). The Global Supply Chain Pressure Index (GSCPI), a measure that gauges the influence of supply constraints on the global economy, has exceeded all previous records[1] for the last 12 months (Federal Reserve Bank of New York, 2022). Wall Street has even embraced the importance of supply chain resilience, with most earnings calls mentioning supply chain (78%) and logistics (61%) in Q4 of 2021 (Oak, 2022). Responding to and recovering from disruptions has become one of the pressing

[1] The index starts in 1997; before 1997 some of the data needed to calculate are unavailable.

issues today for supply chain managers and is absolutely essential to ensuring that supply chains operate effectively.

Based on this need and the growing importance of supply chain resilience, we seek to uncover insights that can 1) offer advice to managers operating global supply chains and 2) add to the already rich scholarly work focused on supply chain resilience. This dissertation provides a multi-level and multi-method investigation into resilience. In Chapter 2, we focus on an individual organization, finding capabilities that aid organizations' pursuit of resilience. Next, we focus on the relationship between a buyer and supplier, exploring the effects of shared disruption-related information in Chapter 3. Subsequently, Chapter 4 explores how firms communicate a sustained disruption to their public stakeholders. Throughout all three essays, we underscore the importance of connections between entities- whether differing functions in an organization (Chapter 2), a buyer and supplier (Chapter 3,) or an organization and its public stakeholders (Chapter 4). In global supply chains, organizations cannot act as if they operate in a vacuum but must acknowledge the critical roles of others and examine the consequences, intentional and unintentional, of their actions.

In Chapter 2, we conduct semi-structured interviews to help uncover organizations' strategies to pursue supply chain resilience. We connect an organization's Agility, Adaptability, and Alignment (AAA capabilities) (Lee, 2004) to its pursuit of supply chain resilience. Previous scholars have examined the role of agility- an organization's ability to adjust to short-term imbalances in demand and supply- and adaptability- the ability to adjust to long-term shifts in market conditions (Gligor et al.,

2019; Patrucco & Kähkönen, 2021). However, the role of alignment- ensuring incentives are aligned to drive optimal behavior for all parties- has been largely unexamined. We not only explore the vital role of alignment within and between organizations in helping organizations pursue resilience, but we also find the importance of the combination of AAA capabilities on an organization's resilience.

In Chapter 3, we conduct an online scenario-based experiment to investigate the communication of supply chain disruption information. The focus is on how the message about a disruption is communicated to a supply chain partner. We manipulate two variables related to the sharing of disruption-related information- the timing of the shared information, either before or after a disruption's consequences are experienced, and the accuracy of the shared information, either accurate or inaccurate predictions relating to the expected duration of a disruption. Situations related to a supply chain disruption bring great uncertainty, and accurate information is difficult, expensive, and time-consuming to find (Sheffi & Rice, 2005). The overwhelming sentiment of supply chain disruption literature suggests that information sharing in response to a disruption is beneficial (Bode et al., 2011; Scholten & Schilder, 2015). However, factors related to the quality of the information shared are largely underexplored. Our study helps assess organizations' realistic tradeoffs when sharing disruption-related information. We find that sharing disruption-related information earlier rather than later is beneficial and that sharing inaccurate disruption-related information is, while not preferred, not penalized.

In Chapter 4, we turn our attention from how disruptions are communicated with supply chain partners to how they are communicated to public stakeholders. To do so, we

research the semiconductor shortage that plagued the automotive industry from 2020-2022. We collect a secondary dataset of publicly available documents from 15 global automotive companies. From this dataset, we determine a "playbook" of strategies organizations can utilize to communicate a sustained supply disruption to public stakeholders. Supply chain disruption literature has frequently utilized press releases and earnings announcements to identify disruptions (Hendricks & Singhal, 2005b; Liu et al., 2020; Ni et al., 2014). However, the content of these press releases identifying the disruptions is largely ignored. Additionally, much of the supply chain disruption literature focuses on firm-specific events (for example, Filbeck et al., 2016; Hendricks & Singhal, 2005b). The literature investigating a specific incident usually examines performance outcomes (for example, Jacobs & Singhal, 2017; Wiedmer et al., 2021). We utilize the semiconductor shortage of 2020 (and beyond) as an example to examine how firms communicate a sustained supply disruption.

Finally, Chapter 5 summarizes the findings and conclusions from the three essays that make up this dissertation. We reemphasize the importance of this research to academic and practitioner communities and propose further avenues for research related to the questions investigated in this dissertation.

Chapter 2: Is Your Supply Chain Breaking Down? Call AAA

1. Introduction

Supply chain disruptions can negatively affect an organization and its supply chain partners (Hendricks & Singhal, 2003). These supply chain disruptions (hereafter: disruptions) can come from various sources (internal and external to an organization) and causes (human and naturally caused) and impact the supply chain to varying degrees. As globalization has enabled supply chains to extend beyond national and continental borders, disruptions have grown increasingly frequent; at the same time, these disruptions have grown more consequential (GEP, 2021). For some organizations, disruptions can have significant negative consequences, but other organizations display resilience, the ability to survive, adapt and grow in the face of turbulent change (Fiksel, 2003).

In 2004, Lee introduced the notion of Triple-A (AAA)- agile, adaptable, and aligned- supply chains, identifying firms with successful long-term performance and proposing that these AAA capabilities led to their performance (Lee 2004). But, it made us wonder, is there a connection between these concepts? Do AAA capabilities enable an organization's resilience? Organizations with AAA capabilities can respond to unexpected market changes, adjust their supply chains to changing environments, and align the interests of all entities within their supply chain with their own (Lee, 2004). While these general capabilities are known to be effective enablers of long-term success, SCM scholars have yet to provide a link between AAA and resilience or to uncover the

mechanisms that enable organizations to build these AAA capabilities. Therefore, we seek to examine the following research questions:

> RQ1: How do AAA capabilities support an organization's pursuit of supply chain resilience?
>
> RQ2: How do AAA capabilities manifest in the processes, behaviors, and structures that make up organizations?

To investigate the above research questions, we utilized semi-structured interviews. We interviewed 35 key informants from 25 organizations across various industries, supply chain positions, and sizes. In this research, we seek to connect the AAA capabilities that drive success during "blue sky" times to the capabilities that can drive supply chain resilience. Additionally, we provide prescriptive measures for managers as to *how* to build these AAA capabilities.

The remainder of this manuscript is as follows. First, we detail the relevant literature connecting supply chain resilience and AAA capabilities. Next, we detail the qualitative methods used to conduct the research. We then detail the findings from the interviews to answer the research questions. Finally, we provide specific recommendations for managers and the theoretical implications.

2. Literature Review

We discuss literature relating to resilience- both in SCM and other disciplines and AAA capabilities.

2.1 What is Resilience?

The term resilience is used across many fields, including ecology (Holling, 1973), engineering (Bhamra et al., 2011), individual psychology (Smith et al., 2008), neurobiology (Karatsoreos & McEwen, 2013), physiology (Nindl et al., 2018), sports

(Martin-Krumm et al., 2003), and supply chain management (Sheffi, 2008). Within SCM literature, there are two common perspectives of resilience: the engineering view and the socio-ecological view (Wieland & Durach, 2021). The *engineering* perspective views resilience as the ability of a system or entity to "bounce back" to its original state, while the *socio-ecological* views that resilience also includes the ability to adapt, transform, and develop new capabilities (Wieland & Durach, 2021). Much of the literature on SCM resilience takes the engineering view; however, the engineering view discounts that organizations can adapt to new environments and change. Likewise, supply chains- and the organizations that comprise them- are complex systems that should constantly adjust and evolve (Wieland & Durach, 2021).

In the ecological view of resilience, organizations and systems do not have a "normal state" to return to but can adjust (Holling, 1973). For example, after a forest fire, new species emerge and flourish. We view resilience as "the capacity for an enterprise to survive, adapt, and grow in the face of turbulent change" (Fiksel, 2006). In some instances, survival entails returning to the original state without developing new abilities; in other instances, survival entails developing new capabilities. We utilize this definition as it incorporates both the ecological and engineering conceptualizations of resilience.

Supply Chain Resilience (hereafter: referred to as resilience) significantly overlaps with Supply Chain Risk Management (SCRM). However, resilience extends beyond the study of SCRM. SCRM focuses on risk identification, assessment, and mitigation (Manuj & Mentzer, 2008). Resilience includes both the proactive ability of resistance and the reactive ability of recovery (Melnyk et al., 2014; Wiedmer et al., 2021). While SCRM focuses on an organization's ability to prepare for and respond to

predictable and quantifiable events, resilience prepares organizations to be "ready for anything" and respond to unexpected events (ASCM, 2021).

2.2 Factors Influencing Supply Chain Resilience

Various factors increase an organization's susceptibility to disruption (Pettit et al., 2010). First, globalized supply chains have increased the "length" of supply chains- effectively exposing supply chains to not just local but global disruptions. This length includes the physical distance between supply chain partners and the number of entities in a supply chain (Serdarasan, 2013). As a result, disruptions occurring worldwide will likely affect an organization's supply chain. Advances in technology have had competing effects on resilience. On the one hand, increasing connectivity and visibility to impending disruptions allows organizations to respond quickly to or prevent disruptions from occurring. On the other hand, technological advances and a relentless push for efficiency have enabled organizations to operate increasingly complex supply chains with fewer human and capital resources, especially inventory (Knemeyer et al., 2009). As a result, disruptions that affect these supply chains have greater consequences due to the lack of "slack" or capacity to absorb fluctuations (Hendricks et al., 2009; Knemeyer et al., 2009). In addition, external pressures can affect industries, regions, countries, or the entire globe nations- for example, inflation and social change. Resource limits can constrain organizations- limiting production or sales; in recent years, toilet paper, semiconductors, and lumber are all product categories that have faced limited production in some ways. Table 1 details the vulnerabilities making firms more susceptible to disruptions.

In addition to disruptions that directly affect a company's output, a firm's risk of disruption is also impacted by the resilience of its supply chain members. For example, a

fire in an extended tier supplier can disrupt a downstream firm. However, according to a recent Deloitte survey, only 15% of organizations track risks beyond their tier 1 suppliers (Deloitte, 2021), suggesting that disruptions beyond an organization's tier 1 suppliers may be surprising and poorly handled.

In addition to factors that make firms more susceptible to disruptions, organizations can exhibit several enablers that improve their resilience (Hohenstein et al., 2015). However, resilience literature remains inconsistent in the terminologies used. Some authors use elements (Christopher & Peck, 2004; Peck, 2005), capabilities (Jüttner & Maklan, 2011; Pettit et al., 2010; Pettit et al., 2013), antecedents (Ponomarov & Holcomb, 2009), enhancers (Blackhurst et al., 2011), and competencies (Wieland & Marcus Wallenburg, 2013). These terms are used broadly; some elements that build supply chain resilience include behaviors (e.g., information sharing), firm capabilities (e.g., agility), or processes (e.g., risk monitoring). We use the term capabilities.

Table 1 Vulnerabilities Increasing Organizations' Susceptibility to Disruptions

Vulnerability	**Definition**	**Examples**
Connectivity	Dependence and reliance on outside entities	The extent of outsourcing, reliance on singular sources
Deliberate Threats	Intentional attacks to cause harm (human or financial)	Theft, terrorism/vandalism, labor disputes
External Pressures	Influences that create business constraints or barriers but are not targeted to the organization specifically	Competitor innovation, social change, regulatory change, price pressures
Globalized supply chains	Interaction between people, companies, and governments across the globe	Supply base from differing regions
Resource Limits	Constraints on output due to availability of production requirements	Capacity (e.g., supplier, production, transit), Labor
Supply Chain Partner Disruptions	Susceptibility of suppliers and customers to external forces or disruptions	Supplier reliability, customer disruptions
Turbulence	An environment characterized by frequent changes to external factors beyond the organization's control	Natural disasters, geopolitical disruptions, pandemics

Much research has detailed the specific capabilities that improve resilience (see for reviews: Bhamra et al., 2011; Hohenstein et al., 2015). These capabilities include the abilities to "sense," "anticipate," and avoid *potential* disruption, as well as the abilities to recover from disruptions that inevitably do occur (Wiedmer et al., 2021). Flexibility describes the ability of an organization's or its supply chain's willingness and ability to make short-term adjustments due to the external environment (Richey et al., 2022). Flexibility inherently includes capabilities internal to an organization- siloed (i.e., production schedule changes) and cross-functional (i.e., redesigning a product)- and capabilities in collaboration with supply chain partners (Zsidisin & Wagner, 2010). Table 2 identifies many capabilities that enable firms to develop supply chain resilience.

Table 2. Capabilities Influencing Resilience

Capability	**Definition**	**Examples**
Adaptability	Ability to adjust the supply chain's design to meet structural shifts in markets and modify the supply chain to strategies, products, and technologies	Seizing advantage from disruptions, alternative technology development, learning from experience, strategic gaming and simulation, environmental sustainability
Anticipation	Ability to discern potential future events or situations	Demand forecasting methods, risk identification and prioritization, monitoring/communicating deviations and "near misses," recognition of early warning signals, business continuity planning, emergency preparedness, recognition of opportunities, business intelligence gathering, government lobbying, awareness of global change
Capacity	Availability of assets to enable sustained production/demand levels	Backup utilities, raw materials, reserve capacity, labor capacity, ecological capacity
Collaboration	Ability to work effectively with other entities for mutual benefit	Sharing forecasts or resources, risk-sharing
Dispersion	Broad distribution or decentralization of assets	Distributed suppliers/production/distribution, distributed decision making, location-specific empowerment, dispersion of markets
Efficiency	Capability to produce outputs with minimum resource requirements	Labor productivity, asset utilization, quality management, preventive maintenance, process standardization, resource productivity
Flexibility in Manufacturing	Ability to quickly and efficiently change the quantity and type of outputs	Product/service modularity, multiple pathways, and skills, manufacturing postponement, changeover speed, batch size, manufacturing expediting, reconfigurability, scalability, rerouting of requirements
Flexibility in Sourcing	Ability to quickly change inputs or the mode of receiving inputs	Common product platforms, supply contract flexibility, supplier capacity, supplier expediting, alternate suppliers
Flexibility in Order Fulfillment	Ability to quickly change the method of delivering outputs	Multi-sourcing, demand pooling, inventory management, alternate distribution modes, transportation capacity, transportation expediting, customer price contracts
Recovery	Ability to return to normal operational state rapidly	Equipment repairability, resource mobilization, communications strategy, crisis management, consequence mitigation
Visibility	Knowledge of the status of operating assets and the environment	Information technology, status of inventory/equipment/personnel, information exchange with supplies/customers/carriers, market visibility, external monitoring

Adapted from Pettit et al. (2013)

2.3 AAA Capabilities

AAA capabilities have been proposed to enable organizations' long-term success (Lee, 2004). However, to succeed in the long term, organizations must not only find ways to thrive in "blue sky" or uninterrupted times but also during and after disruptions.

The term agility originated in manufacturing and quickly expanded to SCM; while many different definitions of agility exist, there is some agreement on what it includes (Gligor & Holcomb, 2012). Agility describes the ability to quickly respond to short-term changes in supply and demand (Lee, 2004). In response to disruptions, agility is an essential trait that helps firms respond to changing conditions. Agility is a strategic ability of an organization that enables change internally and with key partners in response to change and uncertainties (Fayezi et al., 2017). Cohen and Kouvelis (2021) match agility with robustness, extending the concept to include all abilities to respond in the short term, including security, buffer stocks, and capacity.

Adaptability describes how organizations adjust their supply chains in the long term to meet shifts in market conditions (Lee, 2004). Agility focuses on short-term reactions and changes, while adaptability deals with long-term shifts. Both agility and adaptability require that organizations enact flexibility, with the duration of changes implemented being different. Many different terms describe how organizations change their supply chains over time; adaptability describes how an organization can make small or large changes gradually or immediately in response to any changes.

Finally, alignment describes that incentives are calibrated to drive optimal behavior for all parties involved (Lee, 2004). In addition, alignment ensures that metrics

drive appropriate behavior cross-functionally within organizations and for the different entities interacting (Melnyk et al., 2020). According to Wong et al. (2012), the six constructs that enable supply chain alignment include: 1) organizational structure, 2) internal relational behavior, 3) customer relational behavior (but notably, supplier relational behavior is not mentioned), 4) top management team (TMT) Support, 5) information sharing, and 6) performance measurement systems.

These AAA capabilities are mentioned- sometimes in different terms- in studies examining ecological resilience. According to Fiksel (2003), resilient systems display characteristics that include adaptability- the flexibility to change in response to new pressures and cohesion- the existence of unifying relationships and linkages within the system and its elements. Fiksel (2003) advocates for creating a distinctive culture and developing strong partnerships to develop alignment (he uses the term cohesion) in enterprise systems. Within SCM research, there are connections between agility and resilience (Azevedo et al., 2016; Gligor et al., 2019) and adaptability and resilience (Patrucco & Kähkönen, 2021; Richey et al., 2022). However, we are unaware of any empirical work examining the influence of alignment and resilience or the combination of all three AAA capabilities and resilience.

We have conducted a review of literature related to organizational resilience, the capabilities that influence an organization's resilience, and AAA capabilities. While much research is related to all three topics, our study aims to help academics and managers synthesize the overwhelming literature and identify prescriptions to implement these capabilities. First, we address *how* AAA capabilities influence an organization's

response to disruptions. This gap represents a yet undiscovered area for scholars. Additionally, we provide prescriptive advice for how managers can implement processes that *build and develop* the AAA capabilities to improve an organization's response to disruptions.

3. Method

To investigate our research questions, we utilized multiple sources of qualitative data; multiple sources of data can better answer a research question (Sanders & Wagner, 2011). Our methods included in-depth semi-structured interviews, analysis of publicly available documents (including corporate websites, news articles, and press releases), and artifacts shared by our interview subjects. These artifacts included corporate presentations, training and development plans, scorecards, and business continuity plans, among other documents.

3.1 Interviews

Our primary data source included in-depth, semi-structured with 35 key informants from 25 different organizations. Qualitative research methods, including interviews, are an appropriate research methodology to build in supply chain and logistics research (Ellram, 1996). Participating firms were selected from a purposive sample of large organizations across various industries and sectors. Rather than focus our findings on one industry, we allowed our study to encompass multiple industries, sectors, and roles within the supply chain- ensuring that our findings were generalizable. Interview subjects were senior leaders-including vice presidents, directors, and senior managers- all

having at least 15 years of experience in supply chain and related roles (e.g., procurement, category management, transportation).

Our interviews were guided by an interview protocol we developed before beginning the interviews (Voss et al., 2002; Yin, 2009). Our team developed our protocol- which included multiple experts within the field of supply chain resilience- and reviewed by multiple outside parties. The interview protocol was refined iteratively, as we made slight changes during the interview process. While most questions on the protocol stayed consistent, we changed the order in which questions were asked and altered questions to generate better responses. As our interview discussion was "free-flowing," we often would change the order of the questions we asked to flow with the conversation. Our interview protocol included a specific opening of the interview. The protocol included a request to record, the research scope, an introduction to the research team members, and a closing. Before conducting interviews, we detailed which of our research team would ask specific, probing, and follow-up questions to ensure minimal interruption of the interview subjects. Before conducting the interview, we emailed each participant a one-page summary of the research overview and a guide to the interview (Voss et al., 2002; Yin, 2009). If we did not finish the interview protocol within the pre-arranged time, we asked the subjects to respond to the remaining questions over email. Email interview responses can be an effective interview technique for qualitative research (Burns 2010). We found that email responses from our subjects were direct, detailed, and concise responses to our remaining interview questions.

Interviews ranged from 60-90 minutes and were conducted by teleconference (we utilized Zoom and Microsoft Teams). We recorded all interviews with participant permission. We transcribed the interview within 24 hours (Eisenhardt, 1989). We analyzed the data as we collected it (Eisenhardt, 1989) to identify repeated themes, revisions to our interview protocol, and issues that our participants identified. We began the analyses by creating a written transcript from each interview. Next, we read the transcripts multiple times and created summary reports for each interview. When asked, we shared these summaries with our subjects, who indicated that the conversation had helped provide an opportunity to reflect upon their internal processes. We utilized the software package MAXQDA to create a database of our interview transcripts (*MAXQDA* (version 2020)). We stopped collecting additional data (adding more interviews) when interviews no longer provided additional insights to our study (Eisenhardt, 1989)

While our main data source was our interviews, we utilized multiple additional data sources to help supplement our data and triangulate our findings (Jick, 1979). These additional sources included archival documents and publicly available documents.

3.2 Archival Documents

During the interviews, executives often referenced documents related to their organization's pursuit of resilience. We asked to receive copies of these confidential documents from our interview subjects. Primary documents are considered a valid data source for qualitative research, specifically in the context of supply chain resilience (Zsidisin et al., 2000). We received scorecards, business continuity plans, and training and development plans, among others.

3.3 Public Information

Before conducting the interviews, we gathered data from corporate websites, press releases, and news stories to gather a holistic picture of each organization. This background information allowed us to familiarize the research team with each organization and to ask specific, targeted questions about the organization and recent events. We also found multiple useful documents on some corporate websites. These included documents related to resilience, supplier ethics, supplier quality expectations, and conflict mineral policies. We distinguish these documents from the archival documents as this set of documents is freely available and not confidential. We infer that these documents were designed to be shared with interested supply chain partners and public stakeholders; therefore, these documents would highlight practices important to the organization. The intention to publicly share these documents may have influenced the design and language used within these documents.

4. Data Analysis

We began analyzing the data as it was collected (Eisenhardt, 1989) and utilized the software MAXQDA 2020 to build a database of our qualitative findings. To begin the coding process, we started the first-order analysis (i.e., open coding) using descriptive coding (Saldaña, 2013). For nearly all qualitative research, descriptive coding is a recommended starting point (Saldaña, 2013). Descriptive codes "are identifications of the topic, not abbreviations of the content" (Tesch, 1990). To do this, we assigned each line of the interview transcripts to a code (e.g., process, behavior, supply chain structure, measurement). Then, we utilized sub-coding to further break down the data into smaller

chunks- paragraphs, sentences, or phrases - that helped answer our questions (Scholten & Schilder, 2015). For example, after coding a section of the transcript as "behavior," we then further separated the data into sub-sections like "behaviors-individual" and "behaviors-firm." Our interview protocol had multiple distinct sections, and our conversations followed a similar outline. Using descriptive coding as a first step helped focus the analysis of the data. Once we finished coding the transcripts using descriptive coding, we then utilized initial coding within each of the sub-sections (Charmaz, 2006). Within, each of the sub-sections, we created a large list of unique descriptors. This resulted in a large subset of codes which we were able to collapse into second-order codes (axial coding) after multiple interviews had been conducted and analyzed. Rather than start with a list of predetermined codes, we allowed second-order themes to arise from the data, using words and phrases used by our interview subjects (Saldaña, 2013). When possible, we utilized codes and concepts from previously published resilience studies to ground our coding in the literature (Eisenhardt, 1989). We then grouped the second-order findings into aggregate dimensions to develop theory. Grouping the second-order findings into aggregate dimensions was an iterative and repetitive process. We slowly found underlying themes that emerged from the data.

After identifying themes from the underlying data, we generate a set of research propositions. Propositions are novel statements specifying relationships between concepts; exploratory empirical research can be utilized to derive propositions (Ulaga et al., 2021). Following their recommendations, we have derived four propositions connecting AAA capabilities to an organization's resilience. Well-developed propositions

should follow an iterative cycle of grounding propositions theoretically, crafting proper arguments, connecting constructs based on evidence, and simplifying the arguments (Ulaga et al., 2021). This process helped derive clear, consistent, concise propositions contributing to a theoretical gap in the SCM literature.

5. Findings

While our interview guide did not specifically focus on AAA capabilities and their relation to resilience, AAA capabilities consistently emerged as a theme from the data. Table 3 summarizes the findings from the study and shows how organizations use processes, foster behaviors, and design their organizational structures to develop AAA capabilities. Agility emerged through processes that enabled quick and effective responses to supply chain disruptions. Adaptability emerged through formal processes to institutionalize change. Finally, alignment emerged through internal and external alignment findings, TMT support, designing effective structures, and effective measurement systems, among other factors.

> *P1: Organizations that display AAA capabilities (agility, adaptability, and alignment) are more resilient to disruptions that organizations without these capabilities.*

Table 3. Processes, Behaviors, and Structures Enabling AAA Capabilities

	Agility	**Adaptability**	**Alignment**
Processes	• Planned responses to disruptions • Multi-sourcing • Supplier segmentation by risk profile	• After-action reviews	• Resilience (multi-sourcing) integrated early in the sourcing process • Aligned metrics • Risk partnerships
Behaviors	• Employee training focused on a cross-functional perspective • Technology to simplify decision making	• Embrace Change • Supplier/customer requirements limit flexibility (negative)	• Top management support • Providing resources for resilience • Focus on a few metrics
Structure	• Quick response teams • Decentralized decision making	• Decentralized decision making	• Centralized outward-facing functions (i.e., customer service, category management) • Strong internal cross-functional relationships

5.1. Agility

Executives interviewed discussed how their organizations attempted to increase the speed with which they reacted to disruptions or displayed agility (Lee, 2004). These included planned responses, building flexibility into the supply chain, and effective employee training. We discuss several processes, behaviors, and structural qualities that helped enable the above and enable agility.

5.1.1 Planned Responses

Executives discussed the differing ways that planned responses allowed individual employees, departments, and entire organizations to respond more effectively,

quickly, and appropriately in response to unexpected disruption. Speed of response is related to the effectiveness of the response, with faster responses being more effective in general (Bode and Macdonald 2017). These planned responses included quick response teams, BCPs, and disruption playbooks.

Quick response teams are an organizing structure that facilitates disruption response. These teams are described as a group of employees automatically responsible for leading the disruption response- regardless of the type of disruption. In determining the makeup of these groups, it is essential to have cross-functional involvement in determining how the disruption will affect various parts of the organization. Executive 34 detailed, *"it all depends on the disruption, but usually, we will get a small group of people together, and we will look at different plans we may already have in place. Hopefully, we have at least thought about the problem before, and in some cases, we have built-in redundancies that we can just start executing on."* Executive 9 added that "*We have a response team that is responsible, and they typically start the communication as soon as we get wind of any type of potential disruption."* Executive 12 elaborated, describing the importance of frequent, regular internal and external meetings, "*when the [Texas Freeze of 2021] happened we went to an everyday meeting internally, and there was an everyday meeting externally."* Incorporating a variety of functional areas and seniorities within these response teams helps to ensure that strategic and operational perspectives are included for various functional areas within the organization. For example, having only senior leaders on These teams can help determine the unexpected effects of new developments and help determine the appropriate reactions. As Executive

30 detailed, *"[we have standing meetings when a crisis happens]; we had an 11:30 standing meeting where all the business units would come together-including operations, sales, procurement, and logistics. It is quick, you are not going to sit there and resolve the problem, but you are going to understand what the issues are and then determine with whom to work offline."* This consistent group of employees from various functions helps ensure that responses incorporate all necessary perspectives and align responses.

In addition to identifying response teams, organizations that create specific plans reap more targeted benefits before disruptions occur. These response plans allow the organization to act upon predetermined plans, rather than scramble to identify decision-makers, determine appropriate responses, and then, finally, execute the response. Business continuity plans (BCPs) seek to eliminate or reduce the impacts of a disruptive event- before or after that event occurs (Cerullo & Cerullo, 2004). Executive 32 detailed how his organization handled "predictable" disruptions*, "most of our supply chain interruptions that we see are almost predictable; [Our most common issues are] hurricanes as most of our customers sit on the Gulf of Mexico. It is not if, but when somebody is going to get whacked by a hurricane, [we have a plan to execute]."* These general plans are set before an event affects an organization. Creating plans before disruptions occur removes the added stressors of disruption and can be more thorough than those plans created during uncertainty.

BCPs are general response plans for any event, while playbooks are created for a distinct type of event (Preen, 2021). Both documents provide value, but BCPs can be described as generic, while playbooks are specific (Preen, 2021). For example,

organizations may implement different playbooks for supplier bankruptcies, hurricanes, and, in recent years, pandemics. Executive 14 detailed how her organization utilized playbooks for specific events, including M&A activities, supplier quality issues, or natural disasters. While BCPs may include overarching strategies specifying who to involve and what general actions to take, disruption playbooks are tailored to a specific type of event, location, region, or business unit. For example, while a factory in Florida would not need a blizzard playbook, that same factory would benefit from a playbook specific to hurricanes. Likewise, in a particular disruption, like a cyber-attack, a generic BCP would provide less benefit than a cyber-attack playbook.

5.1.2 Building Flexibility

Supply chains do not just become flexible but are made that way through conscious decisions and actions. One of the most common ways organizations build flexibility into their organization is to utilize multiple suppliers. Ideally, multiple suppliers can produce the same product, allowing purchasing organizations to switch between their direct suppliers easily. This flexibility provides purchasing organizations security if a disruption occurs to a specific supplier. Supplier B can be utilized if an event happens to supplier A. Executive 18 described how his organization effectively used multiple sources of supply, *"we may single source certain plants to get consistent product coming in from a consistent vendor but then have a different facility somewhere else in the world using a different supplier."* Multi-sourcing can take various forms; organizations can split their purchasing volume between multiple suppliers or have backup suppliers "pre-qualified" and ready to be activated should the need arise.

While multi-sourcing is generally accepted as a more risk-averse strategy, there are philosophical and practical reasons that organizations may elect to use single sources of supply. Executive 11 described both sides of the debate, *"theoretically, in supply chain, you never put all your eggs in one basket. However, the other side is that if you can build a better relationship with your vendors, you are going to get better, preferential treatment."* Using fewer suppliers not only limits the directions that require the attention of individual employees and the organization as a whole but also directs a higher proportion of an organization's spend toward each supplier (Habermann et al., 2015). Organizations face the competing interests of building deep relationships and diversifying their supplier base.

Additionally, practical reasons can impede an organization from developing this ability to switch between suppliers. For instance, product characteristics can hinder such flexibility. Executive 24 described that *"the critical elements of our supply chain come from really complicated, high-end technology suppliers. While there is a desire to dual source, a lot of our technologies just do not allow for that."* Furthermore, not all single sources of supply are due to necessity. As Executive 1 discussed, *"[some products] are single-sourced because they have to be, there is one and only one manufacturer of that product; [some are] single-sourced because of economic reasons."* It is impossible for suppliers that own the intellectual property to multi-source away from their product. Executive 7 described, *"If you only have a single source who owns the intellectual property on the part when you have a problem or a disruption in the supply chain, [recovery is more difficult]."* Executive 11 discussed a philosophical reason against

multi-sourcing, saying that the payoff for some commodity products is not worth the added complexity. *"We are not going to go [through efforts to source commodity products from multiple sources] when we can get them all from our key distributor."* Most organizations would *theoretically* prefer to use multi-sourced suppliers; however, practical factors hinder this.

5.1.3. Employee-Focused Actions

Within a supply chain, individual employees exhibit many behaviors that drive performance (Adobor, 2019). For example, information sharing and collaboration are widely viewed as capabilities that increase resilience, but it is individual employees that communicate and interact with their supply chain partners. Organizations can facilitate and encourage these employee-driven behaviors. Organizations help their employees drive agility by simplifying decisions, using technology, and designing effective training programs. Our section on internal alignment discusses an additional strategy- fostering internal relationships.

Simplifying Decisions

Organizations that simplified the decision-making process for their employees made operating their global supply chain a significantly less complex undertaking. Some organizations we interviewed reported using over 10,000 direct suppliers. Theoretically, organizations should monitor and help improve the operations of all their suppliers. However, this is not practical. The practice of segmentation- identifying a subset of suppliers to focus on- is quite helpful (Dyer et al., 1998; Lambert & Schwieterman, 2012). Traditionally, supplier segmentation categorizes suppliers by cost. However, many other criteria should inform segmentation. Executives described the criteria they use to

segment their supply base. Executive 22 described the problem perfectly *"spend is an important factor, but the main trigger is what is the impact if this supplier were to disappear. We look at it from a business impact standpoint. At any given point in time, if the maker of this screw that we spend, say $500 a year on ceases to exist, then we might be in big trouble if [that product is hard to replicate]."* Executive 21 detailed a different philosophy, describing that her organization *"targets small businesses, ones that are [geographically exposed] could be even more vulnerable. We usually find that many small businesses [lack business continuity plans] or have a weak plan."*

Once the subset of suppliers is identified, the next step is prioritizing the potentially most impactful suppliers for an organization's operations. As Executive 3 described, *"we then categorize every supplier as high, medium, or low risk [independent of their spend]. Then for the high-risk suppliers, we develop an action plan to mitigate those risks."* The vast number of suppliers that organizations have can hinder employees from acting. Identifying a smaller subset of those suppliers can make the process more efficient and effective, helping employees focus on the most potentially impactful problems. The next step is to mitigate the identified risks.

Technology Systems

Technology systems can provide great assistance to individual employees. Many of our executives lamented the difficulties of managing their supply base using technology not designed for that purpose, specifically Microsoft Excel. Executive 4 said, "*We have tried to [manage our supply base] manually using Microsoft Excel and some people. But then COVID came, and boy did that get exposed. We could not process*

information fast enough, and there were too many limitations." Executives touted the increased visibility that technology platforms can provide. These technology platforms would alert *potential* areas of disruption, whether natural disasters (i.e., weather monitoring), supplier bankruptcy (financial tracking), ethics-related monitoring, and geopolitical tensions. These technology systems allowed individual employees to determine areas of potential disruption within the supply chain, whether this would be a late-arriving shipment or a political protest outside a supplier facility. Executive 33 detailed his organization's technological system that helped focus employee attention on potential problem areas. *"That is where our predictive tool helps. So when the Ever Given turned sideways, within hours, we could give a detailed report of all cargo on every ship and suggest specific shipments that may need to be replaced by air freight. They may not like the answers we are laying out, but it gives the ability to act proactively."* Technology systems can also allow organizations to connect better with supply chain partners and avoid manual communications. Executive 34 described, *"[Our system] connects us to our suppliers globally, so rather than using emails and spreadsheets, a supplier in China is [using the system], confirming orders and production. Then the ocean shipping teams are [using the system to provide updates,] and it's all in a connected piece of software that we can all see. Before we put that in, a lot of [communication] was done over emails and phone calls, and [we missed a lot of communication]."* Technology systems do the job of synthesizing a great deal of information and helping employees focus on areas of need, significantly reducing decision-making complexity and enabling individual employees to act quickly in the face of potential or actual disruptions.

Training Programs

Decision-making complexity refers to the difficulty of decisions made by an individual (Manuj & Sahin, 2011). Reducing a situation's decision-making complexity can help employees make quicker decisions better suited to the problem. Effective training programs reduce decision-making complexity and help employees make better decisions about the specific issue (Manuj & Sahin, 2011). Executives interviewed focused on ensuring employees understand how different parts of the business operate. As Executive 19 described, *"...you need to have people that are cross-trained, you need to have people to know how to do their jobs, and understand how their jobs influence others in the organization."* To ensure employees understand the intricacies of other functions, Executive 24 described how his organization *"focuses on rotating people and moving people [between roles and business units], we try to make conscious decisions about when that's appropriate."* Employees that understand multiple roles can help avoid behaviors that negatively affect different parts of the organization. It is essential that employees that understand the "big picture," as well as the intricate details of their own roles. As Executive 12 described, *"[a lot of early career employees] don't understand the bigger picture, so we try to give them the tools to grow*." He described how ensuring that individual employees understand key financial indicators, like EBIT and EBITDA help to drive better performance and responses. Executive 33 described the importance of embracing training throughout the entire organization, *"training programs can be very powerful if company leadership embraces them and it is not something that just HR is doing."* Embracing these training programs as part of an organization's culture can help

ensure employees understand the implications of any actions they take, for their role and business function, as well as their cross functional and supply chain partners.

General training does provide significant benefits. However, training specific to disruption preparation provides improved responses. Executive 24 described, "*we do tabletop exercises a few times a year… with the idea that if an event happens, [we have not a general plan] to say a general disaster has happened. Therefore, these are the steps you follow, but actually a very specific plan to say we identified that this might happen, we planned what we would do in that circumstance there, and we're now going to execute that plan."* These simulations provide more detailed preparation than any playbook or response plan could. Executive 20 described how his organization used tabletop simulations to work with suppliers on disruption preparation. These simulations better prepare suppliers for specific events. Executive 20 explained, *"we have done tabletop exercises [with suppliers], we have a training we go through, and we have gotten excellent feedback from those suppliers who embrace it."* These drills and simulations allow employees to experience a version of disruption to prepare for a real scenario.

Therefore, we generate our first research proposition:

P1: Organizations that develop agility can respond better to unexpected events and improve their resilience.

5.2 Adaptability

Executives also mentioned several enablers of Adaptability within their organizations. We note that this is where we found the least discussion in our interviews. It seems managers are so focused on the day-to-day operations that they might not take a

strategic, long-term view. They may be so hyper-focused on putting out the day-to-day "fires" that arise that they do not think about structural and strategic changes that might need to be made to the supply chain or their business model.

Familiar to many of these instances of Adaptability was a discrete event that drove lasting change. Not surprisingly, for many of these organizations, that specific event was the COVID-19 pandemic. Executive 7 described how after his organization acquired a rival company, they realized they now had more supplier relationships than they could ever manage. Even this extensive supply base was not immune to disruption. He discussed a disruption in his organization's extended supply chain, *"there was an IC resistor that's 49 cents that we can't get that goes to our tier 2 supplier that goes to our tier 1 that goes to [our organization, and this was a significant problem]."* This organization then redesigned its final product to be able to accommodate this IC resistor from multiple suppliers. Other executives discussed the more specific learnings directly from the COVID-19 pandemic. Executive 3 described, *"There was a key learning [from COVID] that we do not have visibility beyond tier 1. One key aspect that we are working on now is to gain visibility to that supply base."* His organization has since addressed visibility to understand and react more quickly to disruptions outside their immediate suppliers.

We highlight a few examples of Adaptability, some from our executives interviewed from sources outside our sample. Multiple executives in our sample described how their organizations changed their reporting structures and responsibilities to better adapt to their new environments. Executive 35, VP of an apparel retailer,

detailed how his organization had to adjust its returns process at the onset of the COVID-19 pandemic. Out of necessity, their fulfillment centers developed a new returns process during the peak of COVID-19 lockdowns. In the early days of the pandemic, physical retail stores were closed, so all returns were sent directly to fulfillment centers already handling a significant influx of outbound online orders. Executive 35 described how his organization streamlined its returns handling and refund process to keep customers satisfied- a process they still use today. Executive 34 explained how his organization- a 4PL- centralized customer service to improve the experience for their customers. Previously, customers would need to connect with customer service members from various regions and business units. In the wake of an interruption to their customer's service, keeping one consistent contact for a customer improved their experience and ensured all organizational responses were aligned.

We highlight a few more examples of adaptability that exemplify how organizations can change in response to a disruption. For example, before the semiconductor shortage of 2021, automobile companies dealt only with their immediate Tier 1 suppliers. However, this left their smaller OEM suppliers working with the semiconductor manufacturers directly (whom the OEMs purchased from) and competing with other, much larger organizations from different industries for the precious semiconductor chips. In response to the semiconductor shortage, many automotive companies, including Toyota, BMW, and Mercedes Benz Group, have partnered directly with semiconductor manufacturers on behalf of their Tier 1 suppliers. In addition, responding to changes from the COVID-19 pandemic, many large retailers (including

Nordstrom, PVH, and Gap) have now enacted strategies to purchase and hold excess inventory rather than trying to operate with the minimum (Sultan, 2022). While holding extra inventory may not be economically optimal in theory, carrying "extra" inventory has allowed these retail organizations to remain in operation through the frequent disruptions of the past few years.

5.2.1 After Action Reviews

After a significant disruption, evaluating the organization's performance is critical. This critical evaluation can help identify the deficiencies and strengths relative to the disruption. An After Action Review (AAR) is a formal process that organizations can utilize to help improve (Darling et al., 2005). Conducting an effective AAR is more than a meeting after an event concludes; it is a continual process to help organizations synthesize information and adjust plans, tactics, and strategies. Effective after-action reviews help codify effective procedures into an organization's strategy. Organizations must utilize AARs after must be conducted regardless of performance. As Executive 34 described, *"…because the result was good does not necessarily mean what you did was good. You could have just been lucky*." Successful after-action reviews require timely, cross-functional, and critical feedback. In an AAR, one does not provide general feedback to the entire organization, but explicit, pointed suggestions that are often only useful for the specific department that deals with the exact issue.

Therefore, we generate the following research proposition:

P2: Organizations can adapt to long-term shifts in the market. Organizations that improve their ability to adapt are better equipped to handle short-term disruptions.

5.3 Alignment

Alignment in supply chains emerged in internal (cross-functional) and external (with supply chain partners).

5.3.1 Internal Alignment

Instead of thinking about the big picture- how the entire organization can best operate- it is typical for individual employees, regions, and business units to focus on their own success. Executive 9 described, "*we do not have an 'S&OP' in the traditional sense. We have an S, and we have an OP but not together."* This lack of alignment led to various preventable issues in normal and disrupted times, with sales managers making commitments other departments could not keep. Executive 1 also described his organization's disjointed view of its supply chain, *"[our organization] tends to think of [resilience] in two separate pieces 1) getting product into our distribution centers and 2) managing outbound product from our distribution center…we do not think on a holistic basis."*

One of the most critical drivers of internal alignment and effective response to disruption is Top Management Team (TMT) support (Sawyerr & Harrison, 2020). TMT support allows leadership to allocate human, technology, and capital resources to ensure solutions to problems are aligned (Sawyerr & Harrison, 2020; Wong et al., 2012). Executives in our sample described how senior leaders and the executive board developed a newfound focus on supply chain resilience in response to the COVID-19 pandemic. As Executive 5 described, *"[Our CEO] has provided us the resources, both human and capital, to make the investments we need [for resilience]… we have the*

highest level of support from the organization to get this done." Internal organizational leadership and external stakeholders (i.e., board of directors) must support resilience initiatives. Executive 21 described, *"[resilience] is more of a procurement initiative with our board's backing, so everyone knows about it, and we involve other functions as needed."* Support from the board of directors is necessary as investments in resilience can be expensive, and the value of these investments is often unquantifiable before disruptions occur. Resilience investments can include short-term (e.g., additional safety stock) and long-term (e.g., upgrading technology systems); long-term investments can be harder to quantify. Executive 6 lamented that leaders in his organization did not grasp the significance and importance of resilience, "*some leaders view [resilience] kind of as a checkmark exercise as opposed to a pillar of strategic sourcing*." When the importance of resilience is not understood, it is more challenging to ensure buy-in from all departments.

Integrating and overlapping with other functions is necessary to successfully implement resilience within an organization. Executive 21 referred to this as a "left shift"- integrating procurement's (her function) involvement earlier into process timelines, especially in the new product development (NPD) process. In a well-designed NPD process, organizations bring innovative ideas for products or services to the market in collaboration with internal partners, suppliers, and customers (Rogers et al. 2004). Executive 6 described, "*the best time to dual source or technically consider dual sourcing, is that new product introduction phase when there is already overlap and any necessary plans can be altered."* Validating multiple sources of supply early in new product development ensures that- should any unexpected disruption happen to a source

of supply- there is already an existing, additional source of supply that prevents complete stoppage in production. Without backup suppliers, production must halt until a new source is validated, often a slow process requiring redesign (involving other functions) should there not be a supplier who can provide an exact replication.

The appropriate alignment of incentives is a significant factor in ensuring that internal departments work together. Aligning incentives within a single organization can ensure different departments, business units, and individuals act in ways that benefit the company as an entity. Executive 14 described how her organization switched from incentives based on regional performance to incentives based upon the organization's performance as a whole, clarifying that *"this encourages business units and functions to make sacrifices that help out the organization as a whole."* Before this change in incentive structure, some leaders were unwilling to bear additional costs that helped a different region at the expense of their own incentives. The newly aligned incentive structure helped her organization maximize receipt of product on allocation, a significant obstacle due to repercussions from the COVID-19 pandemic. Executive 13 described his organization's (a food distributor) process to align incentives between inbound and outbound functions. "*We have a constrained item process that [aligns our internal departments] when we have a long term out of stock item we [allocate them based on historic demand] and [we prevent product promotions] with the concept being that if we cannot procure it, we do not want to increase demand for any reason."* Before implementing this aligned process, promotions designed to increase sales would exacerbate product shortages.

Formal incentives drive behavior, but organizations must also consider "informal incentives." Executive 29 detailed how their manual, time-intensive process potentially discouraged and deterred employees from calling out *potentially "*risky" suppliers, *"…when a buyer begins to formally raise that risk to [ensure suppliers] are compliant with our process, [that buyer creates] a lot of work for themselves in terms of documentation and paperwork involved. We need a better system."* While no "formal" incentive discouraged employees from identifying these at-risk suppliers, the presence of these informal disincentives may influence behavior. These informal incentives can significantly alter perceptions within an organization. Executive 2 described, *"[cross functional partners] become frustrated that our sourcing department 'wastes' time looking for backup suppliers that we may never use."* Colleagues outside of purchasing departments would express frustration with how the purchasing department employees devote time. These colleagues would prefer purchasing department employees spend time negotiating better prices with suppliers they are guaranteed to use instead of finding backup suppliers with only a slight chance of being utilized. These implicit and informal incentives can deter individuals from executing tasks that can be of the most significant value to their organization.

Internal Relationships

Relational capital is a crucial driver of resilience in response to supply chain disruptions- especially for small and medium enterprises (SMEs) (Polyviou et al., 2019)- and can lead to improved operational performance (Whipple et al., 2015). Smaller firms hold higher value on relational capital than larger firms (Welbourne & Pardo-del-Val,

2009). Relational capital develops through employee interactions (Polyviou et al., 2019). Developing relational capital in large organizations with more employees and fewer overlapping interactions may be more challenging. However, organizations can influence how relationships form through their organizational structure or a "seating chart." Executive 13 described how his organization assigned tasks that ensured significant overlap between individual employees. By ensuring that employees always worked with the same regional distribution centers, the relationships between purchasing and the distribution centers could be developed over time. Executive 13 described, *"at the end of the day, the people that are successful in our supply chain role are going to be people that have those relationships and can get the proper sense of urgency with a phone call versus the people who do not take the time to build out those partnerships."* Executive 2 described how her organization's small size helped to foster these relationships "*because we are so small, we can all get together [on the phone] every single day and sites can talk about their issues [and help solve them]."* While organizations cannot develop relational capital for employees, they can design their structure to ensure consistent interactions between employees. Executive 10 detailed how his organization used rotational programs- moving individuals between functions (i.e., procurement, logistics, operations) and business units- to ensure that employees developed relationships with more individuals within their organization. Executive 12 illustrated how his organization's training and development program moved individuals between inbound (i.e., purchasing) and outbound (i.e., mostly sales) roles to ensure that employees would 1) gather deeper knowledge about complementary aspects of the business and 2) develop

relationships with individuals from the other departments. When a disruption inevitably occurred, an employee would not only understand the potential consequences for multiple parts of the business but could lean on their relationships to mitigate the consequences.

Metrics

If alignment requires metrics that drive desired behavior, the logical follow-up question is, “what metrics should be used to drive resilience?” SCM relies heavily on a broad array of metrics to measure performance; these metrics are key to building a strategic supply chain (Melnyk et al., 2020). These metrics provide a critical link between the strategy of resilience, tactical execution of that strategy, and value creation within supply chain partners (Melnyk et al., 2004). Resilience is a key area of supply chain management that lacks consistent metrics (Han et al., 2020). Without metrics to track resilience, organizations struggle to quantify resilience improvements, and leaders cannot justify the ROI of resilience initiatives (Khan & Perez, 2018)

Traditionally, cost savings are one of the most critical measures for supply chain managers, but this narrow mindset is limiting (Ellram & Tate, 2021). Executive 24 bemoaned his organization's myopic focus on cost-saving, "*in procurement, we are obsessed with the dollar sign, savings, and cash. We are almost self-defeating regarding supply chain resilience; we struggle to make a difficult decision when it will cost us more money but is worth doing.*" While we do not want to discount the importance of financial metrics, resilience sometimes requires a commitment that veers from pure cost minimization. Without a commitment to resilience, organizations may struggle to tolerate additional costs- especially for investments that are hopefully not utilized.

"What gets measured gets managed," as Peter Drucker famously opined. However, resilience is a difficult concept to measure. None of the executives interviewed could provide metrics that accurately assess their organization's resilience. Traditional metrics assess supply chain performance during "normal time."

An organization can measure performance before, during, and after a disruption. However, how can one measure the significance of an event before it happens or the impact if a disastrous event is avoided? If an event's significance cannot be quantified, an organization's response to that event can also not be quantified. Traditional KPIs fail to measure firm resilience adequately; scholars and practitioners have turned to alternate metrics. In a systematic literature review of metrics related to resilience, Behzadi et al. (2020) categorized all resilience metrics into three broad categories: time to recover (TTR), recovery level (RL), and loss of performance while recovering (LPR). The benefit of these metrics is that they can be based on metrics the organization tracks in normal and disrupted times.

The balanced scorecard is a popular tool to measure an organization's performance (Kaplan & Norton, 1992). One of the factors increasing the balanced scorecard's popularity is that managers already have to keep track of a seemingly overwhelming list of metrics (Kaplan & Norton, 1992). Creating metrics specific to measuring resilience would only exacerbate the issue. In addition, adding new metrics increases the decision-making complexity individuals must manage. Enacting a new set of metrics in response to a supply chain disruption requires that individual employees

understand how to drive performance using both “normal metrics” and a new set of “disruption metrics.”

Instead of specific metrics focused solely on resilience, our executives described that their organization relied on the same metrics that assess performance in “blue sky” times as evidence of their resilience. Maintaining high performance despite changing environmental circumstances is one way to measure resilience (Han et al., 2020). Executive 14 described this by saying, *“We do not use different metrics in disrupted times; we measure how much our metrics change."* This same philosophy applies to how organizations should measure their resilience- assessing metrics from various perspectives and watching how the metrics change. Executive 34 described how his organization utilized multiple metrics to create a more balanced view. *"We use two principle metrics [in all times]. One measurement being OTIF- on time in full on the delivery- and the other is what we call COLT- customer order lead time. We have standards to what those need to be. In a disruption, we will see them get worse, but the question is how quickly, can I get those back to the company standard, and that will tell you how long that disruption took."* It is important to measure both financial and performance metrics. Executive 13 described, *“While we want to provide great service to our customers, our customers don't pay higher prices for the products that we worked our butt off and spent more hours and more dollars to get in. [We try to be] resilient enough to serve our customers, while still being intelligent enough to not blow the bank account.”*

Organizational Structure

Organizational structure is one of the key drivers of supply chain alignment and must align with an organization's strategy and external environment (Wong et al., 2012). However, the relationship between organizational structure and resilience is multifaceted and unclear. For example, in High-Reliability Organizations (HROs), where any mistake can have a disastrously negative consequence (i.e., nuclear power plants and aircraft carriers), decentralized decision-making is often cited as preventing disasters (Roberts et al., 1994; Sawyerr & Harrison, 2020). Yet, centralization can improve an organization's resilience capabilities, including centralized knowledge management and the ability to leverage resources.

Executives in our sample described how the centralization of specific functions improved their ability to respond to unexpected disruptions. Multiple executives described how dispersed technology systems hindered their organization's ability to communicate effectively. Multiple executives touted the benefits of centralizing outward-facing functions to streamline communication during a disruption. As Executive 34 described the change his organization is undergoing, *"…today we run customer service in each division, but some large customers touch all divisions. So we have this disjointed customer-facing group; it is not disjointed in each division, but when you start to cross [divisions], responses across regions and units are not perfectly aligned. We are moving toward creating one centralized customer service unit."* Executive 3 described how his organization recently undertook a similar change, this time for roles that supplier facing roles. As he described, *"we may have had three [category managers] managing the same*

relationship with the same supplier, and they were not aligned. While one division was reducing business with one supplier because of risk or performance, the other could be doing the opposite. Now we have stronger, consolidated relationships." Outward-facing functions- both to customers and suppliers- can gain significant benefit from centralization.

On the other hand, decentralization allows separate parts of the organization to respond more quickly, with plans specific to their situation rather than general plans. As Executive 23 detailed, *"[Decentralized units] have a better understanding of their supply base and how issues are potentially going to affect the product, but being decentralized doing these huge risk projects can be a lot harder."* Executive 18 described the philosophy of his global organization succinctly, *"Think global, but act local."* While global philosophies can and should guide strategy, the actual tactical execution should be done at the region or unit level.

Many of our executives described how their organizations utilized hybrid or center-led structures to utilize the best of both organization structures. A hybrid structure divides tasks between the head and local offices. The head (centralized) office takes responsibility for some tasks (e.g., negotiating longer-term contracts), and local offices have responsibility for other tasks (e.g., execution of purchase orders) (Trautmann et al., 2009). Exactly how tasks are divided within an organization may vary, some organizations are divided geographically, others by business unit or product, and others may use both. For example, executive 21 described, *"we are a hybrid structure. We have central offices, but the actual tactical buyers fall through regional sectors."* Executive 4

described, *"we have progressively [decentralized as we have added businesses], and I do not think we are ever going to be centralized because we have too many disparate businesses."*

5.3.4 External Alignment

In an aligned supply chain, incentives drive behavior that helps all participating organizations. However, when incentives are misaligned, organizations compete at each other's expense. Executive 9 summarized the quandary perfectly, describing how their suppliers sometimes behave, *"Our suppliers are getting more efficient at our expense. They will dictate [terms, locations, and quantities]… that is being a distributor middleman, we are handcuffed to being supply chain resilient or being supply chain, efficient."* Executive 12 described the importance of having consistent supplier relationships and not switching between suppliers for cost savings; *"...having a trusted supply base that through thick and thin we are both in it for the long haul… I see many people get into trouble playing the market- looking for those opportunities to either push somebody really, really hard or to kind of jump around to make that quick [switch between suppliers]."*

While driving internal alignment can be difficult, aligning with one's supply chain partners may be even more challenging. Executives in our sample detailed specific examples of how alignment with partners improved resilience- or a lack of alignment deterred resilience- within their supply chains. Multiple organizations in our sample described how their organization entered partnerships that helped support suppliers. For instance, executive 24 described how his organization realized that a product line with more than $100M in revenue depended on a single machine at a tier 3 supplier. Their

organization then arranged and assisted their tier 3 supplier with qualifying a second machine to ensure supply continuity. In addition, individuals D and E (from organization 4) detailed how their organization offered capital loans to their suppliers- who then utilized the loans to improve their own and, by extension, company 4's resilience. Executive 12 also detailed how his organization avoided focusing solely on cost initiatives with suppliers. By focusing only on cost, his organization would incentivize suppliers to cut out redundancies, find cheaper materials, and risk decreasing production quality. While driving down costs are (generally) beneficial, its unintended consequences can be intensely negative.

Hoarding behavior, as seen quite often by individuals and organizations during the COVID-19 pandemic, is an example of misaligned incentives. Executive 17, a packaging distributor, detailed his frustrations with customer hoarding behavior. His organization was responsible for holding and storing empty plastic bottles of soap (bulky, inexpensive products) that customers had requested but not purchased yet. "*We end up with a warehouse full of product, and customers say that they aren't able to sell as many…now we're stuck with mountains of [product].*" Instead of having a system where inventory is distributed optimally, incentives can drive uneven allocations.

Executive 10 described how his organization's drive to lower inventory costs negatively impacts their supplier partners, *"We try to operate with minimal inventory, which means our suppliers need to cover the risks with their inventory."* The supply chain is not optimized when individual organizations make decisions solely for their benefit.

These decisions may not be just "not in the best interests" of their partners but may harm partner organizations.

During a supply disruption, communication between partners is essential. However, executive 13, a distributor, described how his organization unintentionally incentivized suppliers to misrepresent disruption information. He described, *"…suppliers are most certainly incentivized to [imply they will return to normal sooner] because if [we think] a supplier is out of something for [a long time], we absolutely will [explore alternatives]… as a distributor that is the last thing we want because we have shared those expectations with our retail partners."* Only through trust and building relationships with suppliers could they expect suppliers to communicate with them honestly.

Another example of inter-organizational alignment specific to supply chain disruptions is validating supplier BCPs. Organizations do not exist in vacuums but in networks with their suppliers and customers. We discussed utilizing BCPs in the Agility section, but organizations must ensure that critical suppliers also have effective BCPs. Validating BCPS for thousands of suppliers can be a monumental task. Executive 6 detailed how his organization simplified the magnitude of the task*, "We did not ask for the full BCPs, but we could see enough from the table of contents. When they said their Vice President of sales was in charge of their internal BCP, we knew it was more BS than BCP. If we looked at the agenda items and they had only three or four things, you knew [it was not thorough]. Then that is when we gave them remedial training."* Realizing that

each organization does not exist in isolation but in interaction with their suppliers is essential for organizations to best plan for the unexpected.

In a previous section, we discussed switching between suppliers as an enabler of flexibility. Unfortunately, our executives detailed instances where customers preferred or even dictated specific suppliers, preventing this flexibility. Executive 26 said, *"sometimes our clients tell us that we have to buy from a specific source, especially software."* Executive 14 detailed the requirements her organization, a food service distributor, faced from their customers, *"there are some [brand requirements], especially with [restaurant chains]. They have standard manuals [across the globe] for how to use their equipment. If we started using different brands and equipment, their existing manuals would not work."* The executives also detailed how their organization directed their tier 1 suppliers to use specific tier 2 suppliers. As Executive 7 detailed, *"There are certain suppliers that we direct our suppliers to use for basic raw materials [due to the strict requirements of our business]."* While there were reasons to constrain the flexibility of supply chain partners, we must recognize that these reasons hinder the ability to pursue resilience.

Therefore, we generate our final research proposition:

> *P3: Alignment, both internal and external, improves an organization's resilience.*

6. Limitations and Future Research

Like all research, our study involves some limitations. We have conducted 35 interviews with senior supply chain executives representing 25 organizations of various sizes, industries, and supply chain positions. So, while a diverse set of sources, they

cannot represent all viewpoints or experiences. Our study included only qualitative methods. We did not quantitatively measure the performance of any organizations in this research. Future research can assess how the different capabilities identified in this research influence resilience performance, with actual measurements assessing resilience. Additionally, we have not segmented the organizations involved in the research into distinct categories based on their resilience. Future research can investigate how organizations with differing *levels* of resilience (i.e., high vs. low) employ these AAA capabilities. We have also proposed three distinct propositions based on our qualitative research; future scholars can and should quantitatively assess these propositions.

7. Conclusions

Supply chain disruptions seem to have grown in frequency and significance. Resilience, the ability to survive, recover, and grow during turbulent change (Pettit et al., 2010), is no longer a luxury but a necessity for organizations to develop and implement. Organizations of all sizes, industries, and supply chain positions are interested in how to avoid and respond to disruptions.

7.1. Research Contributions

Our research is the first to connect AAA abilities (agility, adaptability, and alignment) to an organization's resilience to disruptions. AAA capabilities have been proposed to help drive long-term success for organizations in response to changing market conditions (Lee, 2004). We extend these findings and show that the proposed capabilities drive effective responses to short- and long-term disruptions. We find empirical evidence that shows these proposed capabilities improve responses to

disruptions. Additionally, we are the first study to highlight the importance of alignment in driving effective responses to disruptions. While agility and adaptability have previously been examined in connecting to an organization's resilience, the role of alignment has yet to be examined. We show that alignment, both internal (within an organization) and external (between organizations), helps drive effective response to supply chain disruptions. This research responds to calls seeking to extend strategies and tactics for resilience beyond common supply chain strategies (Scholten et al., 2019).

7.2 Managerial Contributions

Our research has implications for SCM managers. We provide specific benefits as to *how* managers can help develop effective responses to disruptions in their supply chains. Disruptions have become the "new normal;" organizations must develop effective strategies to either minimize their effects or avoid disruptions completely. We not only show that agility, adaptability, and alignment can help an organization respond to disruptions, but we show how organizations can build and develop those capabilities.

We have identified specific processes, behaviors, and structures that help improve an organization's resilience. However, disruptions are inevitable, especially for organizations that utilize global supply chains. Therefore, we suggest strategies organizations can use to develop agility, adaptability, and alignment to respond to disruptions effectively.

We encourage organizations to develop their agility by developing planned responses, building flexibility into their operations, and focusing on their employees. Planned responses like BCPs, assigned disruption task forces, and disruption-specific

playbooks can help drive quick and effective responses to disruption. In addition, flexible responses, using multiple suppliers, transportation modes, or carriers, can be activated in response to a disruption. Finally, employees carry out the activities necessary to respond to disruptions. Simplifying employee decisions, using technology that helps focus attention, and using effective training programs can ensure effective responses to disruption.

Managers interviewed for this research focused on their organization's day-to-day ability to respond to disruptions. As a result, prescriptions for improving adaptability are fewer than in other sections. However, one specific practice that any organization can implement is the use of After Action Reviews, processes that help to identify and implement new solutions into an organization's operations (Darling et al., 2005)

Finally, we show the importance of alignment between and within organizations to ensure effective responses to disruptions. Organizations can help foster alignment within their organization by ensuring regular interactions between cross-functional employees and developing relational capital. A focus on a few simple metrics rather than increasingly complex specific metrics can ensure the alignment of responses. A hybrid organizational structure that maximizes efficiency and allows flexible response can facilitate these practices. Finally, external alignment, working with, rather than against, supply chain partners, can drive effective response.

Chapter 3: The Fast and (Not so?) Furious: Sharing Disruption Related Information Between Supply Chain Partners

1. Introduction

Supply chain disruptions (hereafter: 'disruptions') are often triggered by an unexpected event (Craighead et al., 2007). They can occur anywhere within a company's supply chain (Kim et al., 2015). Disruptions are a pressing concern to supply chain (SCM) managers. Recent surveys by the Business Continuity Institute and Deloitte have demonstrated the increasing attention SCM managers are providing to disruptions within their organization's control (Caldwell, 2021; Elliott & Lea, 2021; Riglietti & Aguada, 2018). At the same time, disruptions that affect a company's supply chain partners- customers or suppliers- can have significant negative effects on an organization (Hendricks & Singhal, 2003; Hendricks & Singhal, 2005b).

SCM scholars have exhibited significant interest in disruptions (Blackhurst et al., 2005). Evidence from scholarly research (Bode & Macdonald, 2017) and actual events (Sheffi, 2007) has shown that quickly processing and reacting to information improves response to a disruption. Additionally, there is evidence that information sharing between supply chain partners during disruptions provides benefits (Sarkar & Kumar, 2015) and communicating information to stakeholders during a crisis can help organizations manage

reputational damage (Coombs, 2007). The common advice given to organizations is to "tell the whole truth and tell it fast" (Coombs, 2007). However, in reality, information is unclear during and after supply chain disruptions, predictions are inaccurate, and the environment is constantly changing (Sheffi, 2007). At the same time, legal, practical, and strategic reasons may prevent companies from sharing information immediately with their supply chain partners (Patel & Reinsch, 2003). Lastly, companies may not want to alarm their partners unnecessarily, especially if such a disruption might be avoided (Bolton & Katok, 2018). Nevertheless, no study has examined the consequences of silence (not sharing information), the speed at which information is shared, or the accuracy of that shared information in the context of supply chain disruptions.

Communication between supply chain partners can benefit all parties (Diaz, 2000). Timely sharing of information from a supplier can allow an organization to make necessary changes to ensure continuity of supply; however, appropriate actions are not guaranteed to follow from that shared information. For example, Ericsson's failure to act decisively in response to communication of a fire at their supplier's (Philips) facility in spring 2000 led to long-term consequences for Ericsson (Latour, 2001). Additionally, the supply chain disruption literature generally assumes that information shared between supply chain partners is accurate. Disruptions increase uncertainty for all parties involved (Cantor et al., 2014). Finding accurate information during a disruption can be difficult, time-consuming, and expensive (Sheffi, 2007). Sharing accurate and timely information in response to disruption is challenging- if not impossible. As a result, organizations face a dilemma. The sooner they share information with a supply chain partner, the more time

that partner has to act. However, the longer an organization waits to collect information, the more likely that information is to be accurate and more valuable to supply chain partners. A recent interview with a supply chain vice president described the balancing act regarding communicating disruption-related information to supply chain partners.

> *"…you always try to insulate your customers from [negative events] in the supply chain. A couple of times, when we did run into supply disruptions, one of the key learnings was to, as early as possible, make the customers aware of what the situations were and what we were doing to deal with the situation. That way, [the customer] has much better insight into what response measures they can take to minimize the impact on their business… We used to wait for the 'haze' to clear so that we could provide both [to customers and suppliers a message saying] on this date, everything is [back to normal. The problem is] you would be so far down the path that the "haze" never cleared well enough for you to establish [those specific dates]. So even though it may be a situation where the dates we provided yesterday are different than what we are providing today, [being more transparent] regarding the information flow has greatly benefited our partners."*

Alternatively, another vice president from a different organization shared a different perspective.

> "*We will typically not share information with our customers [unless we are certain the situation is] dire and there is a very low likelihood of success… We do not want our suppliers coming to us with uncertainty because if every supplier told us they might have an issue, we would be freaking out all the time."*

Information sharing from a supplier to a buyer sends a powerful signal that the relationship is valued and provides a reason for the buyer to trust the supplier *(Ma et al., 2021)*. Information sharing in the presence of disruptions can help a buyer begin to take the appropriate actions to mitigate disruptions; however, false alarms decrease a buyer's trust in the supplier and likelihood to heed future alarms- known as the "cry wolf" effect *(Bolton & Katok, 2018)*. Therefore, it is unclear whether sharing information about

impending supply disruptions always benefits suppliers. At the same time, given the uncertainty surrounding disruptions, it is unclear whether the accuracy and timing of the information provided influence a buyer's future relationship with the supplier. Therefore, we investigate the following research questions about information sharing during a supply chain disruption.

> RQ1: How does a supplier's silence regarding a disruption influence a buyer's trust in that supplier and the buyer's likelihood to continue working with that supplier in the future?
>
> RQ2: How does the speed at which a supplier shares information regarding a disruption influence a buyer's trust in that supplier and the buyer's likelihood to continue working with that supplier in the future?
>
> RQ3: How does the accuracy of the information a supplier shares with a buyer regarding a disruption influence a buyer's trust in that supplier and the likelihood the buyer will continue working with that supplier in the future?

To answer these research questions, we have conducted a scenario-based role-playing experiment with 208 supply chain managers. The main effects of the analysis show that the more quickly a supplier shares information with their buyer, the more likely the buyer is to trust and continue working with that supplier in the future. This main effect holds regardless of the accuracy of information shared by a supplier. Suppliers are not "punished" for sharing inaccurate information. However, results from mediation analysis using PROCESS for SPSSS reveal that characteristics relating to the information shared (the presence, accuracy, and timing of information) from a supplier directly impact the buyer's trust in that supplier and the buyer's subsequent intentions toward that supplier. The buyer's trust in the supplier directly reduces the buyer's willingness to

replace that supplier and increases the buyer's intention to collaborate in the future with that supplier. When using PROCESS, no direct effects on a buyer's desire to continue working with the supplier are observed.

Our research makes several contributions to the academic literature on disruptions. We are the first (to our knowledge) to empirically examine factors relating to the information a supplier shares with a buyer during a disruption. We connect this information to the buyer's intention to 1) end the relationship completely or 2) grow the relationship in the future. This research is the first (again, to our knowledge) delineating the attributes of presence, timing, and accuracy of information sharing during a disruption. Finally, we offer prescriptive advice to managers facing disruptions about whether, when, and how to share information regarding disruptions to their buyers.

2. Literature Review

Our research involves the intersection of multiple research streams. Here we review the literature on supply chain disruptions, the benefits of information sharing in the presence of supply chain disruptions, and individual reactions in the presence of disruptions. Then we review literature related to our dependent variables of interest-supplier switching and collaborative intentions between a buyer and supplier.

2.1 Supply Chain Disruptions

Regardless of the source or cause of the disruption, disruptions have both financial (Hendricks & Singhal, 2003) and operational (Hendricks & Singhal, 2005b) consequences for both the organization experiencing the disruption (Hendricks & Singhal, 2008) and their supply chain partners (Ivanov et al., 2014). These effects can

occur in the short (Hendricks & Singhal, 2005b) and long term (Hendricks & Singhal, 2005a). To mitigate the consequences of disruptions, organizations can develop resilience, the ability to survive, recover, and grow in response to turbulent change- or supply disruptions (Pettit et al., 2010).

Many capabilities can help organizations become resilient to disruptions (Pettit et al., 2010). However, some of these capabilities are competing philosophies. On the one hand, flexibility- the ability to switch between suppliers- improves resilience by allowing companies to continue operations if a supplier experiences disruption (Pettit et al., 2010). However, collaboration and partnerships between buyers and suppliers also improve resilience. Collaboration and partnership initiatives increase the mutual dependence between buyers and suppliers (Scholten & Schilder, 2015). This increased dependence reduces the likelihood of switching suppliers, limiting an organization's flexibility. Additionally, some characteristics have competing effects on resilience. For example, Wiedmer et al. (2021) find that different aspects of supply chain complexity increase the likelihood of experiencing a disruption and a supply chain's ability to recover from disruption.

2.2 Information Sharing in the Presence of Disruptions

Information sharing between supply chain partners can also enable an organization's resilience (Azadegan et al., 2019; Hohenstein et al., 2015). Information sharing describes the degree to which firms share relevant, accurate, complete, and confidential information with their supply chain partners (Cao & Zhang, 2011). Information sharing between supply chain partners has various benefits (Colicchia et al.,

2019), including a reduction of the "bullwhip effect" (Wu & Katok, 2006) and stability in inventory levels (Cannella et al., 2011) and better demand planning (Shi & Shen, 2013). In addition, most studies addressing information sharing during supply chain disruptions assume that information shared is relevant, accurate, and complete. Therefore, increased information-sharing between supply chain partners is essential to visibility and collaboration, two capabilities enabling resilience (Brandon-Jones et al., 2015; Scholten & Schilder, 2015).

Most studies have focused on sharing information downstream- from a supplier to a buyer (Colicchia et al., 2019); however, sharing information with upstream partners (from customer to supplier) has shown greater improvement in response to disruptions (Sarkar & Kumar, 2015). Information sharing is a tool that supports decision-making during disruption responses (Sarkar & Kumar, 2015). While studies consistently show that information sharing provides many benefits, most research focuses on accurate and timely information (Li et al., 2017). In general, the accuracy and completeness of information affect the quality of decisions made regarding that information (Zhou & Benton, 2007).

Yoon et al. (2020) examine information sharing in a multi-tier supply chain under the presence of disruption, showing that the effects of information sharing are contingent upon the reliability of multiple supplier tiers; in their research, information sharing drives manufacturers to make more conservative (less than optimal) decisions. Much of the literature examining information sharing assumes that the information shared is accurate. In a quantitative analysis, Li et al. (2017) examine information accuracy and find that

lower information bias and information variance positively correlate to the value of the shared information. Mehrotra and Schmidt (2021) show that increasing investment (time and resources) in collecting more data can provide operational benefits; even though it may take longer to collect accurate information, the benefits outweigh the increased costs. The studies noted above assess the quantitative benefits of sharing inaccurate information sharing in the presence of disruptions yet do not account for individual reactions to disruption that may not be perfectly rational.

2.3 Individual Reactions in the Presence of Disruption

Another pertinent stream of literature involves individual responses in the face of disruption. In response to disruptions, organizations can develop policies, procedures, and strategies to help mitigate the consequences of these events (Craighead et al., 2007). Many of these policies and procedures that enable supply chain resilience are executed by individual employees (Adobor, 2019). For example, collaboration and information sharing are often cited as characteristics and practices that enable resilience for organizations (Hohenstein et al., 2015); these activities are carried out by individual employees (Scholten & Schilder, 2015).

Many recent studies have utilized experimental methodologies to examine individual behavioral responses to disruptions; Table 4 details much of that research. In response to a demand shock, individuals tend to "over-order" (Tokar et al., 2014). Sarkar and Kumar (2015) examined information sharing in a multi-stage "beer game" in the presence of disruption and found that sharing information about an upstream disruption (information flows downstream to a customer) has greater benefit than sharing

information about a downstream disruption (information flows upstream to a supplier). DuHadway et al. (2018) show how individuals make riskier decisions after their employer communicates improvements related to internal risk programs. Perception of resilience and an individual's exposure to resilience influence decision-making in the aftermath of disruptions (Mena et al., 2020). Mir et al. (2017) examine how disruption-related factors- including attribution and severity- influence an individual's post-disruption relational intentions. Blessley et al. (2018) examine how the attribution of a psychological contract breach leads to decreased fairness perceptions, an effect mediated by an individual's emotional responses. An individual's emotional responses mediate the effects of disruption on supplier switching intentions and the selection of riskier suppliers (Polyviou et al., 2018; Polyviou et al., 2021). Finally, Wiedmer et al. (2020) show that supply uncertainty decreases collaboration with supply chain partners.

We have not found any studies that consider whether individuals may react irrationally to the presence of information. While SCM literature does consider *intentionally* inaccurate information- mainly in negotiation-based studies (Kaufmann et al., 2018), we have not been able to find any studies regarding unintentionally inaccurate information sharing and the effects on individual responses.

Table 4. Behavioral Experiments on Supply Chain Disruptions

Author/Year	Independent Variables	Summary
Tokar et al. (2014)	Timing and uncertainty of demand shock	Individuals exhibit a bias toward over-ordering in response to a demand shock
Mir et al. (2017)	Attribution of disruption, severity, and timing	Attribution and severity of a disruption (but not the timing of the disruption) influence supplier relationship after breach & supplier switching behavior
Blessley et al. (2018)	Attribution of a breach (relational reneging, transactional reneging, or combined reneging)	Breach of a contract has a direct effect on fairness perceptions but has an indirect effect mediated by an emotional response.
DuHadway et al. (2018)	Communicated risk and historical risk related to the organization	Individuals make riskier decisions when their organization communicates improvements in risk levels.
Polyviou et al. (2018)	Controllability & Responsibility	Nature (vs. human) caused disruptions are more likely to lead to supplier non-retention; the effect is partially explained by individual anger.
Mena et al. (2020)	Communicated resilience & personal resilience exposure	Perception of resilience & personal exposure to supply chain resilience influence decision making
Wiedmer et al. (2020)	Expected resource scarcity, scarcity uncertainty	Resource scarcity decreases collaboration with supply chain partners.
Polyviou et al. (2021)	Responsibility for supplier selection & controllability of disruption	Responsibility for supplier selection and controllability of disruption influence future supplier selections

2.4 Supplier Switching

Buyer-supplier relationships are important for the long-term success of an organization; these relationships can benefit both parties when carried out appropriately (Lambert & Schwieterman, 2012). However, when executed ineffectively, these relationships may only benefit one party and may be detrimental to one of the parties. In addition, it is beneficial for buyers to keep the same suppliers, as replacing a supplier- especially for a critical component- can be a significant investment of resources, human

capital, and opportunity cost (Carr & Pearson, 1999). Therefore, choosing to end a buyer-supplier relationship represents significant consequences for both parties involved.

Chen et al. (2019) discuss three factors that lead to relationship dissolution: entity-centric factors, relationship-centric factors, and environment-centric factors. Entity-centric factors signal one entity's ability and willingness to develop and sustain a strategic relationship with the other entity; relationship-centric factors describe the characteristics of the relationship- for example, the duration (in time) of the relationship or size (amount spent) between companies (Chen et al., 2019). Finally, environment-centric factors describe factors outside each entity's control- for example, geopolitical tensions between countries (i.e., tariffs placed on products from a supplier's country of origin) could strain the buyer-supplier relationship (Chen et al., 2019). Our study examines the sharing of information- a signal of a supplier's willingness to develop a strategic relationship, an entity-centric factor. We ask participants for their recommendations on the likelihood of switching suppliers, a realistic scenario given that purchasing managers play a significant role in supplier selection (Kaufmann et al., 2012). The risk of ending a relationship increases as trust decreases between buyer and supplier (Anderson & Weitz, 1992). Individual decisions on supplier relationship dissolution may not always align with purely rational behavior (Chen et al., 2019; Polyviou et al., 2018; Polyviou et al., 2021).

2.5 Collaborative Initiatives Between a Buyer and Supplier

Suppliers are important sources of innovation for organizations (Mackelprang et al., 2018). However, resources are limited for all organizations- including buyers and

suppliers; buyers must weigh the cost and benefits of collaborative initiatives with each supplier relationship (Pulles et al., 2019). Trust is essential to collaborative innovation with suppliers (Fawcett et al., 2012). These initiatives likely bear financial and opportunity costs and, hopefully, net a positive return. Organizations are understandably deliberate and intentional when determining which suppliers with whom to innovate (Krolikowski & Yuan, 2017). Organizations choose to innovate with suppliers they trust, are committed to, and can provide the needed capabilities. Strategic supplier relationships are developed intentionally and unintentionally through interactions between a supplier and buyer (Liker & Choi, 2004). If an organization lacks confidence, trust, or commitment to its supplier, it will be less likely to innovate with that supplier. We propose that a supplier's sharing of disruption-related information signals trustworthiness to the buyer. This signal of trustworthiness directly influences the buyer's likelihood to continue and grow the relationship with the buyer.

3. Theory and Hypotheses Development

Using situational crisis communication theory and expectation-disconfirmation theory, we develop hypotheses about the effects of two attributes (timing and accuracy) of disruption information sharing between a buyer and supplier.

3.1 Situational Crisis Communication Theory

Situational Crisis Communication Theory (SCCT) offers a framework for how managers should communicate in crises (Coombs, 2007). According to SCCT, managers should tailor their response strategies to the crisis. A crisis is a major event with potentially negative outcomes that affect an organization (Coombs, 2007). The roots of

SCCT lie within attribution theory- humans are rational processors of information looking for causal explanations to phenomena (Weiner, 1985). Research in SCM (Hartmann & Moeller, 2014) and crisis communication (Coombs & Holladay, 1996) has consistently shown that communication can influence an organization's reputation.

Suppliers have two choices on when to disclose information to their buyers: 1) "stealing thunder" - proactively disclosing information before the buyer finds out from another source and 2) "thunder" – not proactively disclosing that information and letting the buyer find out from another source (Arpan & Roskos-Ewoldsen, 2005). Recent research suggests that the benefits of stealing thunder far outweigh the negative consequences (Lee, 2020). Organizations that "steal thunder" (i.e., self-disclose information) are perceived as more credible, trustworthy, and honest (Arpan & Roskos-Ewoldsen, 2005); therefore, buyers would be more likely to continue the relationship and collaborate with suppliers that "steal thunder." For organizations that "steal thunder," providing objective information is the only strategy necessary; for those that do not, additional crisis response strategies to restore organizational reputation are often required in addition to communicating objective facts about the disruption (Claeys & Cauberghe, 2012; Claeys & Cauberghe, 2014). These strategies include apologies, financial remunerations, or highlighting past good works from their relationship. Early information sharing from the supplier *can* provide opportunities for the buyer to take immediate action, and the speed of response is positively related to the effectiveness of a response (Bode & Macdonald, 2017). Buyers that receive information earlier are better able to respond appropriately because of that information. Buyers that do not receive this

information could effectively "punish" these suppliers by ending the relationship or declining to collaborate on future initiatives.

Academics consistently advocate against the use of silence- a lack of communication or a failure to provide clear responses to concerns (Le et al., 2019; Woon & Pang, 2017). However, legal implications, uncertainty, and insufficient information to make accurate predictions may encourage organizations to utilize silence (Le et al., 2019). Also, individuals and organizations tend to dislike sharing bad news, especially when that news may elicit negative reactions from partners (Dibble et al., 2015; Dibble & Levine, 2010). Despite the scientific and practical evidence against silence, organizations and individuals still utilize silence as a communication tactic (Claeys & Opgenhaffen, 2016). In a recent interview conducted in part of this dissertation, a CEO of a 4PL described *"people don't like delivering bad news, they think bad news gets better with age, and it typically does not… because the customers in general, do not like to be surprised, they do not like bad news, but people hate surprises worse. Our customers' biggest complaint is hearing bad news from [a source other than us]."* Therefore, based on SCCT and our anecdotal evidence, we propose that sharing disruption-related information early (vs. late) will generate less extreme negative results than staying silent in the face of disruptions. Additionally, we propose that sharing any information, regardless of the timing of that communication, is preferred over silence. Therefore,

> H1a: When buyers receive disruption-related information early (vs. late), they will be less likely to switch suppliers.

H1b: When buyers receive disruption-related information early (vs. late), they will be more likely to collaborate with that supplier.

H2a: When buyers receive disruption-related information late (vs. none at all), they will be less likely to switch suppliers.

H2b: When buyers receive disruption-related information late (vs. none at all), they will be less likely to collaborate with that supplier.

3.2 Expectation Disconfirmation Theory

Expectation Disconfirmation Theory (EDT) states that satisfaction results from comparing expectations and outcomes (Oliver, 1981). When performance exceeds expectations, a positive disparity results in positive outcomes (i.e., satisfaction). Conversely, when performance falls short of expectations, a negative gap results in dissatisfaction (Oliver, 1981). In addition to this theoretical motivation, there are practical reasons why inaccurate predictions would negatively affect a buyer and scenarios where suppliers would be incentivized to share inaccurate predictions.

As a vice president of a food distributor described:

> *"….You have a supplier that is incentivized to be aggressive with [predicting a return from disruption]. As a distributor, that is the last thing we want. We want a realistic timeline, and if you [are back in stock] two weeks earlier, that is great. The worst thing is that you tell us [you will be back in stock] on June 1. Then it is not until July 15 because now we have created that expectation with our retail partners that we will be back on June 1… [However, the longer that a supplier tells us they will be out of stock] the more likely we are to have conversations with our retailers about alternatives." (VP, Food Distributor)*

Therefore, we propose our next hypotheses:

H3a: When buyers receive accurate disruption-related information (vs. inaccurate), they will be less likely to switch suppliers.

H3b: When buyers receive accurate disruption-related information (vs. inaccurate), they will be more likely to collaborate with that supplier.

3.3 Trust

Organizations that disclose information early (as opposed to late) are viewed as more trustworthy (Arpan & Roskos-Ewoldsen, 2005). Trust between a buyer and supplier leads to greater levels of commitment between the pair (Morgan & Hunt, 1994). If partners trust each other, they are more likely to collaborate to solve difficult problems and find solutions (Walter, 2003). Therefore, we propose our next hypotheses:

H4a: When buyers receive disruption-related information early (vs. late), they will have more trust in their supplier. They will then be less likely to switch suppliers. Therefore, trust mediates the relationship between information timing and the likelihood of switching suppliers.

H4b: When buyers receive disruption-related information early (vs. late), they will have more trust in their supplier. They will then be more likely to collaborate with that supplier. Therefore, trust mediates the relationship between information timing and collaboration.

H4c: When buyers receive disruption-related information late (vs. none), they will have more trust in their supplier. They will then be less likely to switch suppliers. Therefore, trust mediates the relationship between information timing and the likelihood of switching suppliers.

H4d: When buyers receive disruption-related information late (vs. none), they will have more trust in their supplier. They will then be more likely to collaborate with that supplier. Therefore, trust mediates the relationship between information timing and collaboration

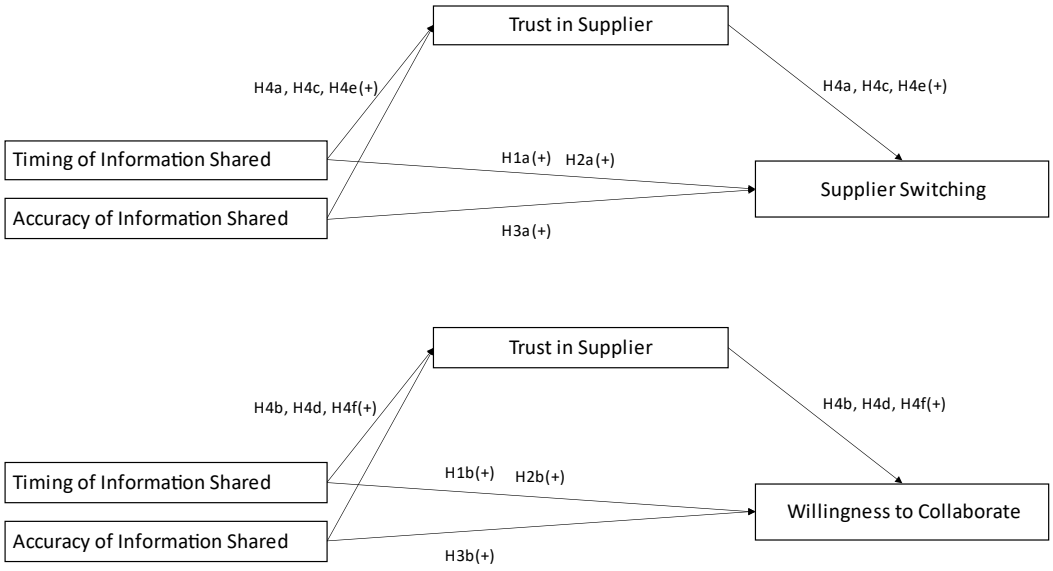
H4e: When buyers receive accurate disruption-related (vs. inaccurate), they will have more trust in their supplier. They will then be less likely to switch suppliers. Therefore,

trust mediates the relationship between information accuracy and the likelihood of switching suppliers.

H4f: When buyers receive accurate disruption-related (vs. inaccurate), they will have more trust in their supplier. They will then be more likely to collaborate with that supplier. Therefore, trust mediates the relationship between information accuracy and collaboration.

Figure 1 presents the conceptual model that we experimentally assess in the study. This model relates our two dependent variables of interest (Timing and Accuracy of Information Shared) to our outcome variables (intent to switch suppliers and collaborate in the future). Trust mediates the relationship.

Figure 1 Conceptual Model



4. Method: Scenario-Based Role-Playing Experiment

To test our hypotheses, we collected data using a scenario-based role-playing experiment (Rungtusanatham et al., 2011). In a scenario-based role-playing experiment, respondents adopt an assigned role and are presented with different versions of a

descriptive vignette that reflect different treatment conditions. Each treatment condition includes specific changes designed to influence levels of the factors of interest. Factors not of interest are "controlled" or held constant across these conditions (Rungtusanatham et al., 2011). After reading the vignette, respondents respond to questions assessing their comprehension of the scenarios, the dependent variables of interest, and demographic questions.

4.1 Vignette Design

In developing the vignette, we gathered information from practitioner-focused articles that described the semiconductor shortage of 2021. The first draft of the vignette was circulated among a group of four supply chain professors in US academic institutions with expertise in supply chain resilience. Additionally, the draft was circulated to four senior leaders of an industry association focusing on supply management strategy. Their feedback was incorporated into the final version of the vignette- helping ensure the realism of the vignette

4.2 Baseline Context and Controls

The descriptive vignette in our study asked respondents to take on the role of Purchasing Director in a fictitious automotive manufacturer (Fast Auto). The scenario described that Fast Auto suddenly began experiencing incomplete deliveries from one of its critical suppliers (Safe Technologies). Safe Technologies provides a critical product (ASICs) for the assembly of Fast Auto's automobiles. Without the ASICs, Fast Auto cannot produce its automobiles and, as a result, will lose sales. Participants were also

informed that their metrics and, as a result, their compensation would be impacted. Appendix B presents the complete scenario.

4.2 Independent Variables

After reading the baseline scenario, respondents were provided information from their supplier regarding the incomplete deliveries. Information provided to the respondents described why the incomplete deliveries were happening (a fire at one of Safe Auto's suppliers' facilities) and the expected duration of the decreased production. The information provided to respondents varied on two factors: timing (respondents read that the information was either relayed before or after the incomplete deliveries occurred) and the accuracy of the information. In the accurate condition, respondents read that the disruption would last four weeks; in the inaccurate condition, the respondents read that the disruption would last two weeks. For all conditions, the disruption lasted four weeks.

Additionally, we included a condition where respondents were provided no information from their supplier, effectively a control group. Control groups can help determine if the information provided (the independent variables) drove behavior rather than an extraneous variable (Dean et al., 2017). In our case, the control group helped determine if any communication was better than silence. Adding the control group provided five conditions for an effective 2x2 +1 design. Table 5 describes all the different conditions utilized.

Table 5. Summary of Experimental Conditions

	Condition	Description
Accuracy of disruption information	Accurate Information	Predicted disruption duration: 4 weeks Actual disruption duration: 4 weeks
	Inaccurate Information	Predicted disruption duration: 2 weeks Actual disruption duration: 4 weeks
Timing of disruption information	Early Timing	Information shared before incomplete deliveries started to occur
	Late Timing	Information shared after incomplete deliveries started to occur
Control Group	No Info	You have not received any information from your contact at Safe Technologies regarding the incomplete deliveries.

4.3 Dependent Variables

We assessed the dependent variables (DVs): the respondents' likelihood to 1) replace the supplier and 2) invest in innovation with the supplier, using Likert scales anchored from 1 ("Extremely Unlikely) to 7 ("Extremely Likely). Table 6 provides the actual questions utilized.

Table 6. Specific Dependent Measures Used

Measure Assessed	How likely are you to…	Adopted From
1. Supplier switching	…recommend that FAST Auto replace Safe Technologies with another supplier?	(Chen et al., 2019)
2. Innovation investment	…invest in innovation with this supplier?	(Ma et al., 2021)

4.4 Trust- the Mediating Variable

Trust, the mediator in our study, was measured using a single-item measure, assessed on a 1-5 scale. Single-item measures can be utilized to measure common constructs (Bergkvist & Rossiter, 2007); Wanous et al. (1997) show that single-item are

reliable (when compared to multi-item scales). Trust specifically has been measured utilizing a single-item scale in the discipline of psychology (Ferrin et al., 2006), as well as business- outside SCM- (Searle et al., 2011) and SCM (Eckerd et al., 2016). Capturing globally assessed attitudinal variables through single-item measures is supported by precedence in the literature (Eckerd et al., 2016). Therefore, we assessed this question by asking, "how much do you trust [your supplier] after this incident?"

4.5 Respondents

We recruited experimental respondents from two groups of supply chain professionals. The first group included 142 supply chain executives from 52 different organizations that are members of CAPS Research, a research center focusing on procurement and supply management. The second set included 80 respondents with individual memberships in the Council of Supply Chain Management Professionals (CSCMP), a professional organization for individuals in supply chain and related industries. Combining the two respondent pools provided 222 respondents.

We targeted experienced supply chain professionals for our study, as our scenario was specific to the context of a supply chain disruption. Table 7 summarizes the professional characteristics of our sample. Not only did our sample find the scenarios realistic (see Section: Realism Checks), but respondents came from specific functions in their organizations that would deal with a disruption like this. Our sample also included senior professionals with decision-making authority to champion an effective response in their organizations.

Table 7. Respondent Demographics

Business Function	CAPS	CSCMP	Total
Sourcing/Procurement/Supply Management	133	14	147
Logistics	1	19	20
Operations or Manufacturing	4	17	21
Information Technology	3	3	6
Other	0	14	14
Professional Experience with Supply Disruptions			
No professional experience	0	2	2
Relatively low experience	13	11	24
Moderate professional experience	67	20	101
Extensive professional experience	61	34	81
Blank			
Professional Experience			
Less than 1 year	0	3	3
Between 1 and 5 years	7	13	20
Between 5 and 10 years	18	23	28
More than 10 years	116	28	157
Blank			
Employment Level			
Analyst or no direct reports	34	19	53
Manager/Sr. Manager	69	20	89
Director	22	8	30
Vice President	5	7	12
C-Level	5	10	15
Other	6	3	9
Total Respondents	141	67	208

4.6 Experimental procedure

The 208 respondents were randomly assigned to one of five versions of the vignette. First, participants were instructed to assume the role of Director of Purchasing and were provided a brief description of their organization (Fast Auto) and their supplier (Safe Technologies). Next, respondents were provided the scenario that their supplier (Safe Technologies) had recently been delivering lower quantities than Fast Auto had

ordered. Respondents were then presented with one of the five experimental conditions regarding information about the disruption. Finally, after reading the information provided, respondents were asked to answer questions regarding their future intentions toward the supplier (the DVs), the mediator variable (trust), manipulation checks, and individual demographics.

4.7 Experimental Checks

We utilized a variety of experimental checks, including a factual manipulation check, realism checks, and manipulation checks.

Factual Manipulation Check

We incorporated a factual manipulation check (FMC) designed to assess whether or not respondents were paying attention (Kane & Barabas, 2019). We utilized the factual manipulation check "what type of product does Safe Technologies supply to FAST Auto?" The FMC was provided immediately after the background vignette and before the specific information conditions were supplied to the respondents. Before data analysis, we removed one respondent from the CAPS sample and 13 respondents from the CSCMP sample that failed the FMC. Removing subjects that answer an FMC incorrectly improves data validity (Kane & Barabas, 2019).

Realism Checks

We assessed the perceived realism of the vignette using a four-question scale adopted from Pilling et al. (1994). The questions asked participants to indicate on a scale from 1 ("Disagree very strongly") to 7 ("Agree very strongly") the following statements: 1) the scenarios of this study are realistic (mean = 5.68, std. dev =1.20), 2) I am familiar with the issues described in the scenarios of this study (mean = 5.72, std. dev =1.08), 3)

In my real work experience, I have encountered similar issues as the ones described in the scenarios of this study (mean =5.59, std. dev = 1.32), and 4) I took my assigned role as Purchasing Director at FAST Auto seriously as I was responding to the questions (mean =6.04, std. dev =1.04). In addition to the realism scale, multiple respondents indicated either in email responses or in a free response question at the end that the survey was realistic and that they had dealt with similar scenarios not just in their career but recently. Therefore, we conclude that this experiment depicted a very realistic scenario.

Manipulation Checks

Manipulation checks show whether the manipulated factors (the dependent variables) have been perceived as intended (Hauser et al., 2018). For example, the manipulation check for Information Timing asked, "Which statement describes the information that Safe Technologies provided about the disruption duration?" Respondents were provided three multiple-choice options: 1) Safe Technologies contacted me before the incomplete deliveries arrived at FAST Auto's facility, 2) Safe Technologies contacted me after the incomplete deliveries arrived at FAST Auto's facility, and 3) Safe Technologies did not contact me at all regarding the incomplete deliveries. For the timing of information, X^2 (4, 208)= 212.3 p<.001). The manipulation check for Information Accuracy asked, "Which statement describes the information that Safe Technologies provided about the disruption duration?" Again, respondents were provided three multiple-choice options: 1) Safe Technologies accurately predicted the length of the disruption, 2) Safe Technologies did not accurately predict the length of the disruption, and 3) No information was provided about the disruption duration. For the

Information Accuracy manipulation, X^2 (4, 208) = 164.25, p<.001. Given these results, we conclude that manipulations were interpreted by the respondents as intended.

5. Data Analysis

To test our proposed hypotheses, we conducted rigorous and appropriate statistical tests.

5.1 Control Variables

We tested the effects of various individual differences (e.g., years of experience, experience with supply disruptions, role) on the responses. Of these variables, we found that the sample used (i.e., CAPS/CSCMP) and years' work experience were significant predictors of Trust. Members of CAPS (vs. CSCMP) reported lower Trust (b= -0.442, p= .002), meaning that for two individual subjects with the same demographics and experimental condition but from different samples (CAPS vs. CSCMP), the subject from CAPS would be expected to report lower values for Trust (see Table 10.) We applied a multi-categorical numbering system to the response question for years of experience (0=less than 1-year professional experience, 1=between 1 and 5 years, 2=between 5 and 10 years, and 3=more than 10 years). The effect of years of experience was a significant and positive predictor of Trust, with more experienced respondents reporting higher levels of Trust.

We also applied a multi-categorical numbering system to the variable for an individual's role. We used the following system: 0) other, 1) analyst/no direct reports, 2) manager or senior manager, 3) director, 4) Vice President, and 5) C-level. An individual's role significantly impacted both dependent variables of interest (switching intentions and

desire to innovate with the supplier). An individual's role significantly and negatively influenced the Intention to Switch and Willingness to Innovate (See Table 9); "higher" roles report a lower likelihood to switch and less willingness to innovate.

We included covariates for the sample, years of work experience, and individual role in all analyses. Participants with more professional experience reported higher Trust in the fictitious supplier. Individuals with greater professional experience are likely to have witnessed more disruptions throughout their careers and understand the negative consequences cannot be avoided.

5.2 Dunnett Method

Table 8 shows the results of the Dunnett Method utilizing the "No Information" condition as the control. The Dunnett Method provides a set of confidence intervals for preplanned treatment vs. control contrasts. The test provides smaller confidence intervals than other comparison tests; however, the Dunnett Method should only be utilized to measure treatment vs. control conditions (Dean et al., 2017). Therefore, it is an appropriate test to utilize in our context. We utilize this test to determine if there are significant differences in the dependent variables of interest compared to the control condition. Of note from this table, regardless of the accuracy of information shared, sharing information before the consequences of disruption are felt provides significantly improved outcomes- lower intentions to switch suppliers and a higher likelihood to innovate with the supplier. Therefore, H3a is partially supported.

In some- not all- cases, any information is preferred to silence. Early information sharing leads to a lower likelihood of switching suppliers and a higher reported Trust in

the supplier, while late information sharing has no significant differences. Accurate information leads to greater willingness to innovate and higher reported Trust in the supplier. Reporting inaccurate information has no statistically significant differences based on the Dunnett Method.

Table 8. Dunnett Method of Treatment vs. Control

Comparison: No Information…	Switch	p	Innovate	p	Trust	p
…and No Information	4.36	--	4.07		2.36	
…and Early Information	3.59	.035**	4.90	.107	3.20	<.001***
…and Late Information	4.00	.419	4.29	.664	2.55	.388
…and Accurate Information	3.74	.109	4.76	.043*	3.06	<.001***
…and Inaccurate Information	3.85	.197	4.43	.363	2.68	.107

****p ≤ 0.01, **p ≤0 .05, *p ≤ 0.10*

5.3 Direct Effects of Independent Variables

Table 9 presents the direct effects of information accuracy and timing on the desire to switch suppliers and innovate with the supplier. We utilized multiple linear regression to determine the direct effect of the variables of interest. In addition, we utilized previously identified covariates (years' experience, membership in CAPS/CSCMP, and an individual role.)

The effect of Early Information was significant at the p<.05 level for both intent to switch suppliers (less likely to switch) and innovate (more likely to innovate). This finding suggests that a supplier that communicates disruption-related information early is less likely to experience negative consequences from their buyer. Conversely, late information had no significant direct effects. This suggests that a supplier that communicates information after the consequences have been felt by their customer

provides no benefits relative to providing no information. Thus, H1a and H1b are both supported; however, H2a and H2b are not.

Table 9. Direct Effects of Timing and Accuracy of Information on Outcome Variables

	Switching			Innovate		
	b	S.E.	P	b	S.E	p
Main Effects: Timing (0: No Information)						
1) Late Information	-0.384	0.326	.236	0.205	0.294	.487
2) Early Information	-0.838**	0.326	.011	0.787***	0.297	.009
Main Effects: Accuracy (0: No Information)						
1) Inaccurate Information	-.0552*	0.325	.090	0.333	0.297	.264
2) Accurate Information	-0.659**	0.328	.046	0.651**	0.300	.031
Controls						
CAPS Membership	-0.758***	0.258	.004	-0.730***	0.256	.005
Role	-0.041	0.092	.657	-0.033	0.092	.715
Years' Experience	0.100	0.131	.447	0.095	0.130	.460

$***p \leq .01$, $**p \leq .05$, $*p \leq .10$

The effect of inaccurate information was significant at the p<.1 level for intent to switch suppliers (less likely to switch than the "No Information" condition). However, the effect of accurate information was significant at the p<.05 level for both intentions to switch suppliers (less likely to switch) and innovate with the supplier (more likely to innovate). This finding suggests that customers prefer accurate information. Thus, H3a and H3b are both supported.

5.4 Indirect Effects of Information Timing via Trust

To test the indirect effects of Timing and Accuracy on supplier switching and willingness to innovate via Trust, we utilized PROCESS for SPSS (Hayes, 2013). PROCESS macros are based on OLS regression and have been used in previous LSCM research (Cantor & Jin, 2019; Peinkofer et al., 2016). PROCESS macros can estimate various statistical models, from simple to complex. There are several standard models to

utilize; other models can be customized. PROCESS uses bootstrap confidence intervals to determine the significance of the indirect effects. We utilized PROCESS model 4 in our study.

Table 10. Direct Effect of Information Timing on Trust

	b	S.E	p	LLCI	ULCI
Intercept	2.137	0.267	<.001	1.610	2.664
1. Late Information	0.168	0.163	.305	-0.154	0.489
2. Early Information	0.775***	0.165	.000	0.451	1.099
CAPS	-0.442***	0.142	.002	-0.722	-0.163
Role	-0.089*	0.051	.080	-0.189	0.011
Years' Experience	0.206***	0.072	.005	0.064	0.348

****p ≤.01, **p ≤.05, *p ≤.10*

In our study, the Timing and Accuracy of information shared were the manipulated conditions that directly affected Trust and Relational Intentions (supplier switching and desire to innovate) toward the supplier. To analyze the data, we utilized PROCESS Model 4. The "No Information" was coded as 0, Late Information was coded as 1, and Early Information was coded as 2. The PROCESS for SPSS feature that allows for multi-categorical variables was utilized.

Table 10 shows the direct effects of Information Timing on Trust, the mediator variable in our study. The intercept in this instance is the value of Trust when the indicator code is 0; in our study, this is the "No Information" condition. As the Trust variable was assessed on a 1-5 scale, Trust for the No Information condition is below the average of the scale. Furthermore, the Late Information condition coefficient was positive but not significant. On the other hand, the coefficient for Early Information was positive and significant at p<.001. Therefore, we can conclude that providing information before

the negative consequences of disruption are experienced is positively related to a buyer's Trust.

Table 11. Bootstrapped Results for Regression Model- Information Timing

	Switching				Innovate			
	b	S.E	LLCI	ULCI	b	S.E	LLCI	ULCI
Intercept	6.58	0.48	5.61	7.48	2.88	0.53	1.81	3.90
Late Information	-0.29	0.33	-0.92	0.35	0.09	0.29	-0.48	0.66
Early Information	-0.41	0.34	-1.08	0.23	0.26	0.31	-0.35	0.87
Trust	-0.55	0.14	-0.80	-0.26	0.67	0.12	0.44	0.91
CAPS	-0.68	0.28	-1.25	-0.15	-0.43	0.24	-0.89	0.05
Role	-0.30	0.11	-0.52	-0.10	0.03	0.08	-0.14	0.18
Years' Experience	0.05	0.12	-0.19	0.28	-0.04	0.11	-0.26	0.17

$***p \leq .01$, $**p \leq .05$, $*p \leq .10$

Table 11 shows the bootstrapped results of the regression model for the direct effects on the outcome variables. The 95% confidence intervals were created through 5,000 bootstrapped samples. As "No Information" was the condition coded 0 in this analysis, the intercept describes the condition where no information is provided. Both information conditions negatively affected supplier switching, suggesting that any information provided by the supplier would lead to a lower likelihood of switching suppliers. However, 0 is captured in the Confidence Interval for both information conditions suggesting that these effects were not statistically significant. The effects of both (late/early information) conditions on Innovation were positive (more likely to innovate); however, zero was again captured in the confidence interval, suggesting that these effects were not significant.

Table 12. Relative Indirect Effects of Information Accuracy and Timing Via Trust

	Switching				Innovate			
	b	S.E.	LLCI	ULCI	b	S.E.	LLCI	ULCI
Late Information	-0.09	0.09	-0.29	0.08	0.11	0.11	-0.09	0.33
Early Information	-0.42	0.13	-0.71	-0.18	0.52	0.14	0.28	0.81
Inaccurate Information	-0.17	0.10	-0.39	0.00	0.21	0.12	-0.01	0.46
Accurate Information	-0.37	0.13	-0.65	-0.15	0.44	0.13	0.20	0.73
Inaccurate Information*	-0.17	0.10	-0.35	-0.02	0.21	0.12	0.02	0.41
Accurate Information*	-0.37	0.13	-0.60	-0.17	0.44	0.13	0.24	0.68

**Confidence interval relaxed from 95% to 90%*

Table 12 shows the relative indirect effects of Information Accuracy and Timing on both outcome variables, supplier switching and desire to innovate with the supplier, and the upper and lower bounds of 5,000 samples of a bootstrapped confidence interval. This table captures the effect of information timing on the outcome variables through the mediator variable of Trust. If zero is captured in the confidence interval bounds, then the effect is not statistically different than zero. The effect of Late Information has zero within the bounds of the confidence interval for both the intent to Switch Suppliers and the Willingness to Innovate with the supplier, suggesting that the effect is not significant statistically. Early Information has a negative coefficient on the intent to switch suppliers (those whose suppliers share information early are less likely to switch suppliers); zero is not within the confidence interval supporting the statistical significance. Conversely, early information positively affects Willingness to Innovate (those whose suppliers share information early reported higher Willingness to Innovate); again, zero is not within the bounds of the confidence interval, supporting its statistical significance. Therefore, H4a and H4b; however, H4c and H4d are not supported.

5.5 Indirect Effects of Information Accuracy via Trust

In our study, the Timing and Accuracy of information shared were the manipulated conditions that directly affected Trust and the relational intentions toward the supplier. The "No Information" was coded as 0 for both conditions. Again, we utilized the PROCESS Macro feature that allows for multi-categorical variables with "No Information" coded as 0, "Inaccurate Information" coded as 1, and "Accurate Information" coded as 2. In line with our theorization, we utilized PROCESS model 4 for Study 1, with Trust as the mediator between the information supplied and the intentions toward the supplier. We assessed two models, Model 1 measures the likelihood of switching suppliers, and Model 2 measures the likelihood of innovating with the supplier.

Table 13 shows the direct effects of Information Accuracy on the mediator variable of Trust. The effect of inaccurate information was positive (0.295) and significant at the $p<.1$ level. On the other hand, accurate information was positive (0.639) and significant ($p<.001$). This finding suggests that sharing information, regardless of accuracy, improves a buyer's Trust in its supplier. Therefore, H4e and H4f are supported.

Table 13. Direct Effects of Information Accuracy on Trust

	b	S.E.	p	LLCI	ULCI
Intercept	2.159	0.277	<0.001	1.613	2.705
1. Inaccurate Information	0.295	0.168	0.081	-0.037	0.627
2. Accurate Information	0.639	0.170	<0.001	0.304	0.975
CAPS	-0.472	0.146	0.002	-0.761	-0.183
Role	-0.097	0.052	0.066	-0.200	0.007
Years of Experience	0.210	0.075	0.005	0.063	0.357

$***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.10$

Table 14 displays the relative direct effects of Information Accuracy on the outcome variables. The table also includes the lower and upper bounds of 5,000 samples

of a bootstrapped confidence interval. In all instances, 0 is within the 95% bootstrapped confidence interval; this suggests that the relative direct effect is not different than zero.

Table 12 displays the relative indirect effects of Information Accuracy on the dependent variables (intent to switch and willingness to innovate). In essence, this table shows the effect of the dependent variables on the independent variables through the mediator variable of Trust. Table 12 also included the upper and lower bounds of a 95% bootstrapped confidence interval. Where the confidence interval does NOT include zero, the conditional effect is statistically different than zero. The effect of Accurate Information on the dependent variables- both supplier switching and willingness to invest in innovation, does not include 0. Therefore, we infer that there is a relationship different from zero. Concerning inaccurate information, both bootstrapped confidence intervals include 0. If the Confidence Interval is relaxed from 95% to 90%, zero is no longer captured within the confidence interval for inaccurate information. Thus, H4e and H4f are partially supported.

Table 14.Bootstrapped Results for Regression Model- Information Accuracy

	Supplier Switching				Innovation			
	b	S.E	LLCI	ULCI	b	S.E	LLCI	ULCI
Intercept	6.65	0.47	5.73	7.54	2.84	0.51	1.84	3.85
Inaccurate Info	-0.38	0.33	-1.01	0.28	0.13	0.29	-0.44	0.72
Accurate Info	-0.29	0.33	-0.92	0.38	0.21	0.29	-0.38	0.77
Trust	-0.57	0.13	-0.83	-0.30	0.69	0.11	0.48	0.91
CAPS	-0.68	0.28	-1.24	-0.12	-0.43	0.24	-0.89	0.04
Role	-0.30	0.11	-0.52	-0.09	0.03	0.08	-0.14	0.18
Years' Experience	0.05	0.12	-0.20	0.28	-0.05	0.11	-0.27	0.18

$***p \leq 0.01$, $**p \leq 0.05$, $*p \leq 0.10$

Table 15 shows all hypotheses tested and whether our statistical analysis supports the respective hypotheses.

Table 15. Summary of Hypotheses Tested

	Summary	Supported?
H1a	When buyers receive disruption-related information early (vs. late), they will be less likely to switch suppliers.	Supported
H1b	When buyers receive disruption-related information early (vs. late), they will be more likely to collaborate with that supplier.	Supported
H2a	When buyers receive disruption-related information late (vs. none at all), they will be less likely to switch suppliers.	Not Supported
H2b	When buyers receive disruption-related information late (vs. none at all), they will be less likely to collaborate with that supplier.	Not Supported
H3a	When buyers receive accurate disruption-related information (vs. inaccurate), they will be less likely to switch suppliers.	Supported
H3b	When buyers receive accurate disruption-related information (vs. inaccurate), they will be more likely to collaborate with that supplier	Supported
H4a	When buyers receive disruption-related information early (vs. late), they will have more trust in their supplier. They will then be less likely to switch suppliers. Therefore, trust mediates the relationship between information timing and the likelihood of switching suppliers.	Supported
H4b	When buyers receive disruption-related information early (vs. late), they will have more trust in their supplier. They will then be more likely to collaborate with that supplier. Therefore, trust mediates the relationship between information timing and collaboration.	Supported
H4c	When buyers receive disruption-related information late (vs. none), they will have more trust in their supplier. They will then be less likely to switch suppliers. Therefore, trust mediates the relationship between information timing and the likelihood of switching suppliers.	Not Supported
H4d	When buyers receive disruption-related information late (vs. none), they will have more trust in their supplier. They will then be more likely to collaborate with that supplier. Therefore, trust mediates the relationship between information timing and collaboration	Not Supported
H4e	When buyers receive accurate disruption-related (vs. inaccurate), they will have more trust in their supplier. They will then be less likely to switch suppliers. Therefore, trust mediates the relationship between information accuracy and the likelihood of switching suppliers.	Supported
H4f	When buyers receive accurate disruption-related (vs. inaccurate), they will have more trust in their supplier. They will then be more likely to collaborate with that supplier. Therefore, trust mediates the relationship between information accuracy and collaboration.	Supported

6. Analysis and Conclusions

Our study offers theoretical contributions as well as implications for SCM managers. We also discuss our work's limitations and future research recommendations based on our study.

6.1 Information Timing and Supplier Relational Intentions

Consistent with SCCT, our findings show that the earlier a supplier informs its customer of a disruption, the less negative the consequences are on their relationship. SCM literature has not yet examined how suppliers communicate disruption-related information to their partners. Ours is the first study (to our knowledge) that manipulates the timing of information shared between supply chain partners, but not the consequences of the disruption. In other studies and the real world, early communication of information from a supplier allows the focal organization to make necessary adjustments. The earlier an organization can react, the better and more effective the response can be (Bode & Macdonald, 2017). We manipulate only the timing of the communication, not the consequences of acting upon that information, to disentangle the effects of early communication and the consequences of disruption. Not only does early sharing of disruption-related information from a supplier allow a buyer to act quickly, but that act of communicating disruption-related information helps develop a buyer’s trust. This trust leads to a lower likelihood of switching suppliers (not severing the relationship) and a greater likelihood of innovating with the supplier (strengthening that relationship).

6.2 Information Accuracy and Supplier Relational Intentions

Our findings reveal that the accuracy of disruption-related information shared from a supplier to a buyer directly influences the buyer's trust in that supplier. Information accuracy positively relates to a buyer's trust in its supplier; this trust directly influences a buyer's likelihood to keep that supplier (not switch to a new supplier) and collaborate with that supplier. While accurate information is preferred, we also note that even providing inaccurate information is preferred over "silence." Inaccurate information leads to higher levels of trust between the buyer and supplier. However, the effect is not as strong as when accurate information is shared but is statistically significant($p<.1$). Our findings suggest that suppliers should communicate disruption-related information, even if that information is later proved inaccurate. Even though the information is proved to be incorrect, the act of communicating develops trust. This trust helps lead to a decrease in the likelihood of a buyer replacing that supplier.

6.3 Managerial Implications

Our study has implications for suppliers. Organizations can reduce internally caused disruptions; however, no single organization can attempt to control their entire supply chain and external environment. Natural disasters are occurring more frequently (Smith, 2020), increasing the likelihood that a major disaster will impact an organization's supply chain. Organizations must craft and implement detailed Business Continuity Plans and specific playbooks to respond to disruptions. In addition to these action plans, communications plans and philosophies detailing how to share information

with their supply chain partners are of great value. We advise managers to communicate these disruptions with their supply chain partners quickly.

The adage “tell it all, and tell it fast” provides advice for organizations experiencing a crisis. Our study shows that customers react less negatively to supply disruptions that are communicated quickly. Early communication of disruptions can allow customers to respond quickly, making necessary changes. In a famous example, competitors Nokia and Ericsson utilized the same critical component supplier. When that supplier experienced a damaging fire, Nokia took quick actions and adjusted its supply chain, purchasing, and production processes; Ericsson adopted a “wait and see” approach. As a result, Nokia’s short and long-term performance improved while Ericsson struggled. Our study examines the perceptive effects of information sharing while keeping the consequences of the events constant. We find that buyers prefer suppliers that share information early, even if that information sharing does not allow a supply chain partner to reduce the consequences of the disruption. This effect holds even if the information provided is found to be inaccurate.

Disruptions are sources of great uncertainty; finding accurate information can be difficult, time-consuming, and expensive. Our results show that, in general, customers prefer accurate information over inaccurate information. However, this effect is negated if a supplier quickly shares information with their buyer.

7. Conclusions.

We detail the limitations of our study, provide a few examples that can build on our research, and offer conclusions.

7.1 Limitations

In our scenario-based role-playing experiment, we examine the presence, accuracy, and timing of shared disruption-related information from a supplier to a buyer. Scenario-based role-playing experiments present subjects with scenarios that mimic realistic situations and provide the manipulation of the factors of interest (independent variables) while controlling for all other relevant factors (Rungtusanatham et al., 2011). Scenario-based role-playing experiments are designed to find causal relationships between a set of predetermined variables; however, the method is ideal for investigating a relatively small number of experimental factors. As the number of experimental factors increases, so does the number of scenarios, necessary subjects, the complexity of the design, and administration costs (Polyviou et al., 2021). Disruptions can come from various sources; we have simplified the disruption scenario to ensure our study's feasibility. We have only assessed one type of product in one type of supply disruption and have only manipulated a small number of factors.

7.2 Future Research

Future research can build off our study to address related questions contributing to this landscape. First, we have examined one type of product, an extraordinarily complex, technical, and critical product in production. Future research should examine different types of products to determine if buyer responses are different. Additionally, future research can examine the role of critical vs. commodity products and if these product types have differing effects.

Our study examined one example of disruption- a fire that occurred to a tier 2 supplier (a supplier of an immediate supplier). A disruption at a tier 2 supplier represents an example of an uncontrollable disruption for the supplier. Controllability deals with how an organization can influence its surroundings and has been utilized as a factor in previous studies on supplier disruptions (Polyviou et al., 2018; Polyviou et al., 2021). Future research could examine how controllability, either through the cause (i.e., natural vs. supplier caused) or the location (internal or external), influences the consequences of different communications.

We examine one instance of inaccurate information, where a supplier provides an underestimation of a disruption's expected duration to a buyer. Future research can continue investigating inaccurate information, assessing different degrees and directions of shared "wrong" information. For example, future research can compare overestimating and underestimating a disruption's expected duration. Additionally, future research can examine if the magnitude of a prediction's inaccuracy influences future relational intentions toward the supplier.

Finally, as we have stated, disruptions bring great uncertainty for organizations and their supply chain partners. Future research can examine whether communicating uncertainty from a supplier to a buyer influences any of the previously mentioned factors. Communicating uncertainty may lead buyers to provide grace and understanding for suppliers' inaccurate predictions. On the other hand, uncertainty may also lead to buyers believing their supplier lacks control of the situation. Uncertainty can be communicated

in various forms (Rydmark et al., 2020) and may provide many opportunities to examine the communication of disruption-related information.

7.3 Conclusions

In a scenario-based role-playing experiment, we manipulated several characteristics of the disruption-related information that a supplier communicated to a buyer. Our study found that communicating information can influence how a buyer perceives their supplier, even when the consequences of that disruption remain constant. All else equal, providing any information is preferred over staying silent. The speed at which a supplier provides information to their buyer can lead to better outcomes, with faster communication leading to better results. Finally, all else equal, accurate information is preferred to inaccurate information. Communicating disruption-related information is an important strategy for organizations experiencing disruption; our study adds to the academic literature.

Chapter 4: Unprecedented Times: An In-Depth Analysis of Firms' Communication During the Semiconductor Shortage

1. Introduction

In recent decades, supply chains have grown increasingly complex- increasing the physical distance that products and raw materials travel, the number of parties involved, and interdependencies between entities (Serdarasan, 2013). At the same time, the number of significant disruptions has increased in frequency (Smith, 2020). Driven by a relentless pursuit of efficiency, organizations have removed "slack" from their global supply chains, increasing the consequences of each discrete event (Hendricks et al., 2009). Organizations can endeavor to mitigate and prevent disruptions within the scope of their operations (Marley et al., 2014). However, an organization's influence on its external partners is limited, and its influence on the external environment is even less- if existent. These combined factors have amplified the likelihood of large-scale global disruptions from "rare" to "inevitable." Even if an organization can avoid consequential internal disruptions, partner firms' disruptions have significant consequences for focal organizations, as do complex global disruptions (Hendricks & Singhal, 2005b).

When disruptions of any size occur, organizations must address their consequences operationally- internally and in collaboration with outside partners (Sheffi, 2007). Communicating disruption-related information can reduce the information

asymmetry between the organization, its supply chain partners (suppliers, customers, and intermediaries), and outside stakeholders (Benton et al., 2022). Supply chain scholars have paid much attention to the tactics and strategies that can prevent disruptions (Marley et al., 2014) or the ways to improve response to disruptions that have occurred (Pettit et al., 2010). Additionally, scholars have focused on how communication and collaboration between supply chain partners can facilitate recovery from disruptions (Sheffi, 2015a). Yet, little academic attention has been placed on how organizations have communicated supply chain disruptions to public stakeholders. Although, public announcements of supply disruptions are often utilized in studying the effects of disruptions (For example, Filbeck et al., 2005; Hendricks & Singhal, 2003; Hendricks & Singhal, 2005b; Jacobs & Singhal, 2017). However, these announcements are primarily used as an acknowledgment that a significant disruption has occurred. Rarely do SCM scholars investigate *how* an organization communicates the actual implications a disruption has on its stakeholders. Additionally, most of these disruptions examine discrete, firm-specific events instead of events that extend across multiple firms in an industry for an extended period. Therefore, we seek to answer the following research questions:

RQ1: What strategies are used to communicate information to public stakeholders during a sustained supply chain disruption?

RQ2: Do organizations change communication strategies to public stakeholders as the severity of a sustained disruption changes over time?

To address these research questions, we examine how companies communicate an industry-wide shortage of a critical component (automotive semiconductors) by examining a series of publicly available- mostly qualitative, but some quantitative-

documents from 2020 through the beginning of 2022. Through content analysis, we examine 15 distinct cases (each case representing a particular automotive company). We assess the varied methods utilized by these organizations and offer recommendations for ways organizations can enhance their communication efforts to public stakeholders regarding a sustained supply chain disruption.

2. Description of the Semiconductor Shortage

Starting in late 2020 and extending through 2022, automotive supply chains have been experiencing a significant shortage of semiconductors that has sent ripple effects across the global economy. As of Q1 2022, experts estimate that the semiconductor crisis has cost the automotive industry over $200 billion in lost revenue (Wayland, 2021). A perfect storm of unfortunate events has amplified the crisis, including geopolitical tensions, natural disasters, economic conditions, errant strategic decisions, and a global pandemic.

2.1 Automotive Supply Chains

Automotive supply chains are increasingly global; events that occur in one area of the world have global consequences (Chopra & Sodhi, 2004). Automobiles are increasingly complicated to manufacture and require thousands of components from large numbers of global suppliers. Additionally, automotive supply chains operate using Just in Time (JIT) principles- a system designed to maximize efficiency and minimize *Muda*- the Japanese term for waste (Monden, 2012). These JIT principles can drive incredible cost savings and efficiencies when there are no interruptions but can amplify the consequences of disruptions when they occur (Hendricks et al., 2009).

Semiconductor suppliers are generally Tier 2 (or beyond) suppliers to an automaker. Automakers buy products that require semiconductor chips; for example, automakers would purchase seats directly from a seat manufacturer and the seat manufacturer would purchase semiconductors directly from the semiconductor manufacturer (powered seats require semiconductors to operate). This seat example is just one of many examples of how semiconductors are ingrained in automobile production. As vehicles have become more complex and integrated, nearly everything- touch screens, backup sensors, and anti-lock brake systems- can require a semiconductor; modern vehicles can utilize thousands of semiconductors (Ewing & Boudette, 2021). As BMW described in a press release, semiconductors *"serve various functions by performing arithmetic and control tasks in computers, storing data or even handling multiple tasks at the same time. The share of electronic components in vehicles is likely to increase further in the future."* However, the auto industry only purchases about 3 percent of the total semiconductor volume, dwarfed by smartphone and computer makers (Ewing & Boudette, 2021). These purchases of semiconductors come from hundreds of OEMs that are contracting directly with the semiconductor manufacturer; the individual volume of most OEMs is insignificant to the semiconductor manufacturers.

Semiconductor production facilities (knowns as fabs or foundries) are capital intensive, requiring more than $1B to complete (Yonhap, 2021). Moreover, semiconductor fabs often operate continuously, leaving little slack capacity to absorb fluctuations in demand to maximize return on the high initial investment cost. Moreover, even before the COVID-19 pandemic, geopolitical tensions in recent years have strained

the semiconductor industry- with the US-China Trade war and tensions between Japan and Korea further restricting an industry with already limited excess capacity.

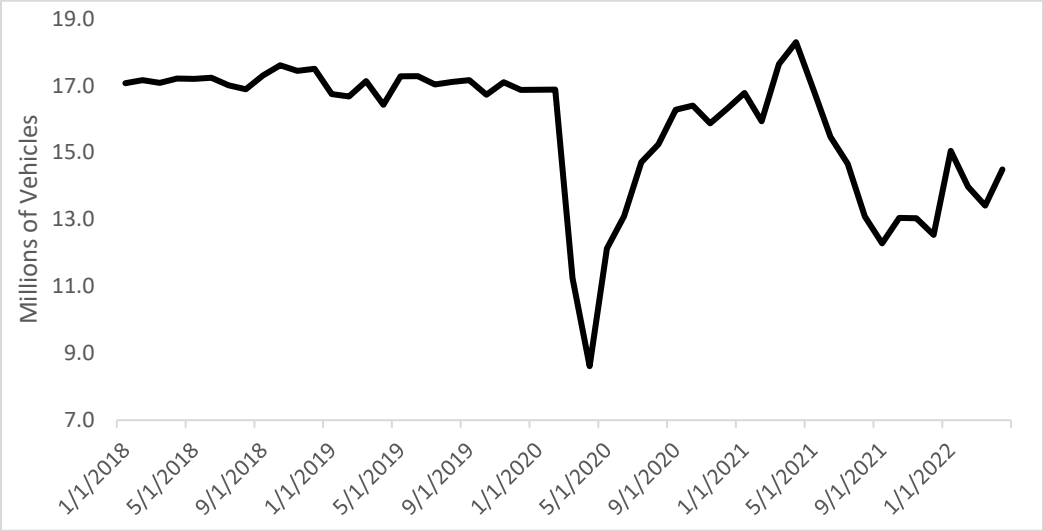
2.2 COVID-19 Challenges

At the onset of the COVID-19 pandemic, global lockdowns limited manufacturing capacity across various industries. Across the globe, many factories (including those that produced automobiles and semiconductors) shut down completely, eliminated shifts, or decreased production after implementing social distancing measures. Driven by the combination of local guidelines, fear of spreading COVID-19, decreased supply of critical components, and demand for their final products, many factories temporarily shut down and furloughed some or all of their employee base. While factories were temporarily closing, demand patterns were also shifting. At the onset of the COVID-19 pandemic, automobile sales plummeted, with sales figures decreasing in Europe, China, and the United States by 80, 71, and 47 percent, respectively (Hensley et al., 2021). This dramatic decrease in sales led many automotive companies to cancel standing orders to their suppliers and their suppliers to cancel many orders from their respective suppliers (tier 2 suppliers from an automaker's perspective)- including semiconductor suppliers (Aboagye et al., 2022). While automobile sales were plummeting, demand for semiconductors increased from other sources. As people stayed home for work, school, and entertainment, PC, tablet, and video game sales spiked. These increases more than made up for the decreases in demand from the automotive sector.

However, this dramatic drop in automotive sales was temporary; sales quickly rebounded and even surpassed their "pre-COVID" numbers. As individuals avoided public transportation and moved away from urban population centers, demand for

automobiles skyrocketed in the 2nd half of 2020 and beyond. Figure 2 depicts the monthly sales of vehicles in the United States from 2018 through 2021Q1. Figure 2 shows that pre-COVID monthly sales barely fluctuated, with a steep drop in sales in 2020Q2, followed by a rapid increase even surpassing pre-COVID levels, and then a sharp decrease due to semiconductor constraints. By the time the automotive industry recovered, semiconductor facilities had already shifted their production to meet the demands of other industries (Aboagye et al., 2022). As automakers tried to increase their production, semiconductor suppliers could not meet the additional demands from their customers. As a result, semiconductor makers prioritized their larger customers, which were not typically the automotive OEMs necessary for automotive production. For the automobile companies, production rapidly decreased; sales outpaced manufacturing and quickly depleted the inventory on auto dealer lots.

Figure 2. Vehicles Sold per Month in the United States[2]



[2] Source: https://fred.stlouisfed.org/

2.3 Force Majeure Events

Multiple disasters aggravated the already precarious situation for the entire industry. The increased demand for semiconductors led to a shortage of ABF substrate, a critical raw material in semiconductor production (Fusion Worldwide, 2021). Two separate fires at Japanese manufacturers, one at Nittobo in July 2020 and the second at the Asahi Kasei Microdevices (AKM) plant in Miyazaki, Japan, in October 2020, further constrained the industry (Fusion Worldwide, 2021). Sensing the industry's fragility, customers began to panic and hoard products to buffer against further supply disruptions (Fusion Worldwide, 2021). In the short term, this bullwhip effect only increased the price of semiconductors. The pandemic, raw material shortages, and increased demand strained supply chains; resilience became more critical to alleviate the shortages and resolve interruptions (Fusion Worldwide, 2021). Early in 2021, an earthquake caused a blackout, temporarily suspending production at a Renesas facility in Naka, Japan; this same facility experienced a fire shortly after the earthquake- further limiting production and constraining the supply of wafers (Kim, 2021). At the same time, a “once in a century” winter storm ravaged the southern part of the United States, leaving many parts of Texas with freezing temperatures and without power, including multiple semiconductor plants. Additionally, repeated lockdowns designed to slow the spread of COVID-19 in countries like Malaysia and seasonal flooding hampered semiconductor supply (Fusion Worldwide, 2021). While the industry could have “weathered” each discrete event, the totality of these events sent the industry, along with the shifting landscape of demand, amplified the impacts of the events on automotive semiconductor availability.

In addition to discrete events, seasonal patterns and long-term trends influenced semiconductor production. For example, in addition to COVID-19, ASEAN (Southeast

Asian) countries navigated typhoon season, major flooding, and multiple port closures (Fusion Worldwide, 2021). In addition, a years-long drought in Taiwan reduced the output of semiconductor factories in the nation due to semiconductor production requiring significant water; companies located in Taiwan produce over 50% of global semiconductors (Fusion Worldwide, 2021).

2.4 A Move Toward The Future

Industry and governments have taken steps to help resolve this shortage and prevent future crises. However, geographic dispersion of semiconductor manufacturing could have limited many but not all consequences of the shortage. Estimates suggest that semiconductor manufacturing facilities take at least two years and as much as $10B to complete; even immediate plans to build new semiconductor fabs will require years before production can start (Schoolov, 2021). Governments across the globe have led investments to bring semiconductor manufacturing facilities within their borders. In the United States, the CHIPS act proposes $50B to promote the research, development, and production of semiconductors within the United States (Arcuri, 2022). The EU has proposed the European Chips Act, which designates €30 billion in public investments, and India will provide up to 50% of the cost for two semiconductor production facilities (Agarwal, 2021).

These events combined in a truly "perfect storm" to bring automotive supply chains to a screeching halt. The shortage limited companies in a variety of industries across the globe (Aboagye et al., 2022). To our knowledge, none of the automotive companies have emerged unscathed from the crisis. Some companies (like Tesla) have experienced much less severe consequences than others. Companies have taken a variety

of tactics to mitigate the negative effects of the shortage, including building "nearly complete" vehicles that lack a few necessary components, forging partnerships directly with the semiconductor makers, and increasing prices- to the dismay of consumers. Additionally, as we examine in our paper, organizations have utilized various strategies to communicate the shortage to public stakeholders.

3. Literature Review

Our study integrates three separate literature streams. First, we discuss supply chain disruptions and their negative effects. Then, we synthesize literature analyzing earnings transcripts and how firms communicate with public stakeholders. Finally, we discuss literature related to automotive manufacturing.

3.1 Supply Chain Disruptions

Supply chain disruptions are known to have negative effects- both operational and financial (Hendricks & Singhal, 2003; Hendricks & Singhal, 2005b). These negative effects can persist long after a disruption occurs (Hendricks & Singhal, 2005a). In SCM, a notable amount of research has investigated the consequences of announcements and press releases surrounding supply chain disruptions (For example, see Chávez & Lorenzo, 2006; Hendricks & Singhal, 2005a; Ni et al., 2014). These studies have primarily been designed as event studies that focused on myriad factors- for example, demand-supply mismatches (Hendricks et al., 2009), announcements of supply chain partnerships (Filbeck et al., 2005), macroeconomic environmental effects on disruption (Filbeck et al., 2016), and the causes of supply chain disruptions (Zsidisin et al., 2016). Much research investigating disruptions and their effects has focused on firm-specific disruptions. For example, a disruption at a specific location of one firm, like the May

2021 fire at a Renesas factory in Naka, Japan. Additionally, much of the research studies disruptions that face multiple industries, but only a few studies have focused on the negative consequences in a specific industry- like the automobile industry (Filbeck et al., 2016). A few scholars have investigated the effects of one discrete event, the 2011 Japanese Earthquake and Tsunami (JET), and its short and long-term (negative) effects on stock prices (Hendricks et al., 2020) and operational performance (Wiedmer et al., 2021). Yet, in all this research, firm announcements are treated uniformly; *how* a firm communicates these disruptions is not considered.

3.2 Earnings Calls

One important way organizations communicate to public stakeholders is through earnings calls. An earnings call is a voluntary teleconference in which leaders of an organization- generally high-level executives like the CEO, CFO, or COO- discuss past operational and financial results and provide an outlook regarding the organization's future performance (Benton et al., 2022). These earnings calls are an opportunity to examine firms' voluntary disclosures of risk; financial markets react to these disclosures beyond what is mandated by a firm's financial statements. Earnings calls are usually available to the public, but those in attendance typically include major investors and analysts that follow the organization (Benton et al., 2022). Analysis of earnings call transcripts is a well-established research method and has been used to study a variety of topics, including optimism about future performance (Davis et al., 2015), various kinds of risks (e.g., Hassan et al., 2020), behavioral differences based on gender (Francis et al., 2020), and sentiment and uncertainty (Loughran & Mcdonald, 2016).

During an earnings call, the executives may discuss issues specific to the firm, the industry, or the general environment (i.e., economic conditions) that may influence the organization's current and future performance (Benton et al., 2022). Earnings calls lead to more timely incorporation of information into stock prices (Kimbrough, 2005) and impact investor trading (e.g., Matsumoto et al., 2011). Managers care greatly about crafting their language about risk and other threatening topics, as these communications can trigger significant reactions from investors (Benton et al., 2022). When unexpected events occur, like supply chain disruptions, the information provided by organizations helps shape how stakeholders determine if and how an event will impact that organization. Information regarding risk serves two primary roles: 1) increasing the supply of information known by the public by revealing known and unknown risks and 2) influencing how stakeholders perceive the possible performance outcomes by the organization (Bao & Datta, 2014).

Earnings calls have two critical portions: 1) presentation and 2) discussion (Matsumoto et al., 2011). The calls start with the presentation that follows a structure dictated by the organization; this presentation is usually vetted by multiple leaders across different functional areas in an organization- including accounting, finance, supply chain, and legal (Matsumoto et al., 2011). In the presentation, executives, usually the CEO but sometimes other leaders, follow a script. Executives are tasked with being the stewards of their organizations; objectively assessing the risks faced by their organizations is critical for the success of both the organization and the individual's longevity in their role (Davis et al., 1997; Donaldson & Davis, 1991). Executives are expected to communicate those risks to important stakeholders of the firm (Fjeld et al., 2007). The discussion session can

be more “free-flowing” as analysts can ask questions- either expected or unexpected by the leaders. The executive leading the conference call serves as a “Master of Ceremonies;” they can field questions directly or defer to a specific subject matter expert. For instance, a question about a specific supply chain topic could be fielded by the CEO but would likely be better answered by a supply chain executive (Goldman & Zhang, 2022). Because of its conversational nature, the Q&A portion can provide new information beyond that contained in the earnings press release (Chen et al., 2018). Studies have shown that the Q&A portion is the most economically significant section of the earnings call (Matsumoto et al., 2011).

3.3 Literature on Automotive Supply Chains

Automotive supply chains have received much interest from scholars and practitioners. By some estimates, the global automotive industry is more than $2.7T in size and employs as many as 9 million people globally (OICA, 2022). The automobile industry is considered an indicator of a country’s economic performance; in the United States, automakers are some of the largest manufacturing employers. The global automotive industry is a heavily concentrated industry, with the top 5 largest automakers accounting for more than 50% of the global market share (OICA, 2022)- making it a suitable industry to study competition (Filbeck et al., 2016). Automotive supply chains are often described as essential for national security (Helper & Soltas, 2021).

According to Operations Management literature, many current practices of efficient supply chain management have been established by Japanese Automakers- including Total Quality Management, Kaizen, six-sigma, JIT (Just in Time Manufacturing), and lean (Filbeck et al., 2016). These practices are credited with

improved operational performance across supply chains (Ruiz-Benítez et al., 2018). In addition, some lean principles have been shown to reduce the occurrence of disruptions (Marley et al., 2014) but have also driven an increase in the consequences of disruptions that inevitably occur (Hendricks et al., 2009). Automotive supply chains have always been complex, requiring a large number of individual parts sourced from a large number of global suppliers. However, in recent years, these complexities have grown as the technologies and capabilities of automobiles have improved. This increase in the number of components has required an increase in complexity of the supply chain, requiring more global suppliers; complexity can lead to increased prevalence of disruption and greater recovery from disruption (Wiedmer et al., 2021). As developed by Toyota, Lean Management Systems strive to reduce complexity systematically and are utilized by many automakers (Monden, 2012).

Traditionally, Japanese automakers operate differently than their global peers. Japanese automakers have pioneered the *keiretsu* structure, an interconnected structure of business relationships, enabling automakers to be lean and flexible while still enjoying some control over supply (Ahmadjian & Lincoln, 2001). These close relationships between the automakers and their suppliers influence how the automakers manage disruptions, like a global semiconductor shortage (Kumar et al., 2015). Relationship factors, including history, can influence an organization's reaction to an unintended disruption (Chen et al., 2019). Japanese automakers focus more on trust-based relationships and seek to avoid breaking that trust than their global counterparts (Dyer et al., 1998); this focus on trust-based relationships with suppliers may influence how disruptions are communicated to public stakeholders.

Organizations generally experience negative financial returns after experiencing a disruption; automakers are no exception. However, the economic conditions (bear vs. bull markets) do not influence the negative consequences experienced by Japanese automakers as they do for US-based automakers (Filbeck et al., 2016); this is an incredibly pertinent finding given the rapidly changing economic conditions throughout the semiconductor shortage.

4. Theoretical Basis

Situational Crisis Communication Theory (SCCT) offers a framework for organizations to communicate crisis-related information to their stakeholders (Coombs, 2007). Although there are various definitions of the term crisis, a crisis in the supply chain occurs when one or more members' activities are interrupted, which results in a major disruption in the usual flow of goods and services (Natarajarathinam et al., 2009). Crises are generally unexpected, disruptive, and obvious; they are also sources of uncertainty, harmful to multiple stakeholders, and involve interactions of individuals, organizations, and the environment (Bundy et al., 2017). Crises can fall into three different categories. First, immediate crises arrive with little to no warning; these include natural disasters. Emerging crises are slow in arriving, but their consequences are unpredictable (global warming would be considered an emerging crisis). Finally, sustained crises can last for an extended period- weeks, months, or years (Parsons, 1996). The semiconductor shortage has caused significant interruption for a large number of firms, was unpredictable, and has caused significant financial harm to automobile producers and purchasers, we describe the semiconductor shortage as a sustained crisis.

Organizations can execute a variety of strategies in response to a disruption. These include operational tactics designed to mitigate the consequences and

communicate the disruption's effects. While we do not negate the importance of tactics to reduce the occurrence and significance of crises, SCCT focuses on how to communicate a crisis to stakeholders- public stakeholders, stockholders, financial institutions, or trading partners. SCCT is rooted in attribution theory- the theory that individuals make judgments about causes of events based on the event's locus of control, stability, and controllability (Coombs, 1995). Individuals attribute more responsibility for negative events occurring within an organization's locus of control, are more stable, and are more controllable (Weiner, 1985). Higher attributions of responsibility for a negative event generally lead to more negative perceptions from an individual (Coombs & Holladay, 2001).

Accordingly, there are different types of crises based on attributions of responsibility for the crisis; these different clusters have varying degrees of reputational threats to the organization (Coombs, 2007). These clusters are victim, accidental, and preventable. In victim crises, the organization is a victim alongside its public stakeholders; victim crises arise from uncontrollable events like natural disasters and sabotage (Coombs & Holladay, 2002). Accidental crises are driven by unintentional actions of the organization and can include some recalls and technical breakdowns (Coombs & Holladay, 2002). Finally, preventable crises are described because they involve organizations that purposefully place stakeholders at risk or intentionally take inappropriate actions (Coombs & Holladay, 2002). Preventable crises drive the greatest reputational threat to an organization; victim crises drive the least. Crisis response strategies have been studied extensively across a variety of disciplines. One perfect strategy does not exist to respond to all crises, but strategies depend on the type of crisis

at hand. SCCT provides the link between crises and crisis response strategies. Different groups of strategies based upon building perceptions of accepting crisis responsibility; these strategies are 1) denial, 2) diminish, and 3) rebuild (Coombs, 2006). Denial strategies include asserting that the crisis does not exist, blaming another entity for responsibility, or denying an organization's intent to harm during the crisis (Coombs, 2007). Diminishing strategies focus on arguing how a crisis is not as bad as people may think or that the organization has no control over the crisis (Coombs, 2007). Rebuilding strategies attempt to improve the organization's reputation, usually offering aid to victims- symbolic (i.e., apologies) or material aid (Coombs, 2007). A secondary strategy- to be used in conjunction with any of the primary strategies- is bolstering- where organizations attempt to fortify positive perceptions of their organization by praising stakeholders (like employees) and reminding stakeholders of past good works done by the organization (Claeys & Coombs, 2020).

The most common advice for organizations in a crisis is to "tell it all and tell it fast" (Dilenschneider & Hyde, 1985). In fact, "stealing thunder" is a strategy of disclosing potentially negative information about oneself before others can disclose it (Arpan & Roskos-Ewoldsen, 2005); this strategy is advocated across various disciplines. However, the legal and regulatory strategy may supersede ideal crisis communication in theory and inform *how* an organization communicates the effects of corporate crises (Fitzpatrick & Rubin, 1995). There can be significant negative consequences for firms disclosing negative information (Hendricks & Singhal, 2003). The SEC requires publicly traded companies to disclose significant risks to their investors and are legally prohibited from making untrue or misleading statements (Hayes, 2021). Firms may disclose the bare

minimum information necessary to meet requirements to keep in line with SEC guidelines. But this inevitably leads to a "slippery slope," with firms disclosing only the bare minimum information and stakeholders demanding more answers. However, textual risk disclosures have differing effects on investor perceptions of risk (Bao & Datta, 2014).

5. Description of Data Sources

We have built a diverse secondary data set from publicly available data to answer our research questions. We have utilized both quantitative and qualitative data sources- as multiple data sources and data analysis methods can better answer a research question (Jick, 1979). Our qualitative data sources include earnings call transcripts, press releases, annual reports, and SEC disclosure forms. Our quantitative data sources include a proprietary data set that estimates the impact of the semiconductor shortage and Compustat data to gather firm-level financial information.

Table 16 shows all of the companies included in our dataset. The dataset includes 15 of the largest automotive companies in the world. First, we included companies in the top 10 in global production of light vehicles (BMW, Ford, GM, Honda, Mercedes, Stellantis, Toyota, VW).[3] Second, we also included members of the Renault-Nissan-Mitsubishi Alliance (collectively, they would be the 3rd largest producer of light vehicles). Third, we added the remaining automakers with the top 10 sales in the United States (Mazda, Subaru, Volvo). Finally, we added Tesla; Tesla has a market capitalization of more than three times its largest competitor (Toyota) despite producing

[3] Hyundai Kia and SAIC round out the top 10, no earnings transcripts were available for either company so they were excluded from the data

about 10% as many vehicles as Toyota. These 15 unique cases provide a diverse sample that allows a thorough investigation of our focal research questions.

Table 16. Companies in Sample

Company	HQ	Rev.[4] (Rank)	Production	MktCap (Rank).[5]
Bayerische Motoren Werke (BMW)	Germany	112.8 (7)	2,461,269	$53.02 (6)
Ford Motor Company.[6] (Ford)	USA	136.3 (4)	3,942,000	$48.2 (8)
General Motors Company (GM)	USA	122.5 (5)	6,291,000	$48.4 (7)
Honda Motor Company (Honda)	Japan	121.8 (6)	4,136,018	$42.6 (10)
Mazda Motor Corp (Mazda)	Japan	15.8 (18)	1,074,987	$5.3 (36)
Mercedes-Benz Group AG (Mercedes)	Germany	175.9 (3)	1,943,930	$69.4 (5)
Mitsubishi Motor Corp (Mitsubishi)	Japan	9.6 (>25)	1,049,174	$5.2 (37)
Nissan Motor Co. Ltd (Nissan)	Japan	62. 0 (11)	3,585,153	$15.6 (27)
Groupe Renault (Renault)	France	54.7 (14)	2,825,414	$7.3 (33)
Stellantis N.V.[6] (Stellantis)	France	98.8 (9)	6,049,000	$40.6 (11)
Subaru	Japan	25.1 (19)	914,729	$14 (29)
Toyota Motor Corp (Toyota)	Japan	249.4 (2)	8,583,985	$216.6 (2)
Tesla, Inc (Tesla)	USA	18.8 (12)	930,422	$686.5 (1)
Volvo Car (Volvo)	Sweden	38.3 (17)	699,000	$21.7 (22)
Volkswagen Group (VW)	Germany	254.1 (1)	8,300,000	$103.6 (4)

(Source: OICA.net)

5.1. Qualitative Sources

To assess the strategies of automotive companies to communicate sustained disruptions, we have gathered the following types of documents: earnings transcripts, press releases, and SEC Filings. Table 17 summarizes the qualitative documents collected from the various sources for this research.

[4] Revenue and market cap are shown in billion USD,
[5] Market Capitalization is calculated as Total Shares* Current Share Price calculated on June 14, 2022
[6] Production data in unavailable for these companies, sales data was used in place

Table 17 Summary of Qualitative Sources

Company	Earnings Transcripts	Press Releases*	SEC Filings
BMW Group	8	13	0
Ford	9	7	4
General Motors	9	25	6
Honda	9	13	0
Mazda	9	15	0
Mercedes Benz Group	10	19	0
Renault-Nissan-Mitsubishi Alliance	21	18	0
Stellantis	14	9	2
Subaru	10	33	0
Toyota	9	1	0
Tesla	9	9	9
Volvo Car	9	6	0
Volkswagen AG	9	17	0

**We have collected all press releases from each firm since Jan 1, 2020, including press releases for various unrelated topics to our research question. For example, many automotive companies regularly publish press releases about their sponsored racing teams; these are irrelevant to our study. Therefore, we have only included the press releases that mention or address the semiconductor shortage in the total.*

Earnings Call Transcripts

We have collected transcripts of quarterly and year-end earnings calls from the period starting Jan 1, 2020, through April 1, 2022. These quarterly earnings transcripts are- for the most part- publicly available and can be downloaded directly from a company's IR (investor relations) page on their corporate website. We downloaded each of the documents from corporate investor relations web pages. None of the companies in our data set addressed the semiconductor shortage before December 2020. Including the entire year of 2020 allows us to ensure that we have collected every earnings call that mentions the semiconductor shortage.

SEC Forms

The Securities and Exchange Commission (SEC) requires public companies in the United States to file regular financial statements and disclosures. These statements are relied upon by financial professionals, investors, and potential investors to make

informed decisions about investing in specific companies. SEC filings can be accessed via EDGAR, the commission's free, public online database (www.sec.gov/edgar). The SEC requires these forms to promote and ensure transparency to investors. The SEC requires a variety of forms to be filed regularly. Depending on the form, these are required annually or quarterly. While each SEC form serves an intended purpose, we utilize three of the forms as data sources for our research. These forms are Form 10-K, Form 10-Q, and Form 8-K.

SEC form 10-K is a detailed document that must be provided annually- within 60 to 90 days of a company's fiscal year ending (*SEC.Gov | How to Read a 10-K/10-Q*, 2021). This document thoroughly communicates the company's financial situation, including information that overlaps with- and extends beyond- the annual report. The 10-K has sections that include: a business summary, management discussion and analysis, financial statements, and additional sections. Form 10-K requires that companies compile comprehensive financial information in various complex tables. Within the 10-K, item 1A is called "business risks" and requires that companies disclose the most significant risks to their operations or securities (*SEC.Gov | How to Read a 10-K/10-Q*, 2021). These are generally listed in order of increasing significance and can describe risks pertaining to the company, industry, region, or the world- in the case of the COVID-19 pandemic (*SEC.Gov | How to Read a 10-K/10-Q*, 2021). SEC Form 10-Q is an abbreviated version of form 10-K, filed quarterly for the first three quarters of a company's fiscal year (Form 10-K is filed after the 4th quarter and, therefore, the end of the fiscal year). The form must be filed within 40 days from the end of the quarter. Form 10-Q is less detailed than Form 10-K, and its statements are unaudited. However, Form

10-Q is filed three times as often after a company's first three quarters, and Form 10-K is filed after Q4.

SEC Form 8-K is what a company uses to disclose any major developments that occur between filings of 10-K/10-Q. These developments can include events like bankruptcies, natural disasters, or executive departures. Legally, companies must file these promptly (within four business days of the triggering event) and cannot wait until their next quarterly call. The information must be accurate, or companies face stiff penalties from the SEC. A variety of events can trigger an 8-K, including (but not limited to): entry/termination of a material agreement, material impairments, fair regulation disclosure (companies cannot disclose information to private investors without sharing that same information with the public), and other events important for public knowledge (Hayes, 2021). Therefore, these statements are valid to analyze and utilize for research purposes. While SCM researchers have not frequently utilized these forms, authors in other fields have utilized these data sources (For example, see Bryant-Kutcher et al., 2013; Kim et al., 2019; You & Zhang, 2009). These documents represent SCM scholars' potentially rich data source (Mir et al., 2018). We have collected these forms directly from the SEC EDGAR database.

Press Releases

Press releases are written documents for the media that announce newsworthy events for public knowledge. Press releases are tools that organizations use to communicate directly in attempts to influence the narrative (Lewis et al., 2008) and are voluntary disclosures intended to keep stakeholders informed of newsworthy items (Healy & Palepu, 2001). Press releases have been utilized in previous SCM research and are viewed as a way to garner inferences about the firm's perspectives (Karanja & Rosso,

2017). Press releases differ from earnings call transcripts as they are much less formal, have no usual frequency, and can be written about various topics. Press releases have been identified as an opportunity to examine transparency in supply chain (Sodhi & Tang, 2019).

Annual Reports

A company's annual report is a formal public document detailing performance, strategic plans, and corporate sentiment. Annual reports developed in response to mandatory reporting elements of Western countries but have evolved to portray management's picture of the organization to its public stakeholders (Stanton & Stanton, 2002). Annual reports include quantitative financial and qualitative information detailing the organization's past performance and plans for the future. Annual reports are a common, established source for content analysis (Stahl et al., 2021).

5.2 Quantitative Sources

Proprietary Semiconductor Shortage Estimates

The data set we utilize comes from a company that provides forecasts to the automotive industry. The data set provides forecasts for every light passenger vehicle worldwide- across six continents and 60 countries. Light passenger vehicles in the US include motor vehicles with "at least four wheels, used for transport of passengers, and comprising no more than eight seats in addition to the driver's seat" (OICA, 2022). The data set includes 1579 rows, where each row is a unique combination of Brand Owner (i.e., Subaru), plant location (i.e., Lafayette, IN), and vehicle (i.e., Ascent). Some automobile plants produce only one type of vehicle (the Ford plant in Dearborn produces only F-Series trucks); others produce multiple vehicles (the Subaru plant in Indiana produces multiple vehicles).

The data is collected from announced shutdowns at each plant across the globe. The data starts with a monthly forecast for every light vehicle worldwide. Then, the company tracks news mentions of every announced automotive plant shutdown across the globe. Using daily production rate calculations multiplied by the shutdown length, we can quantify the expected production losses at a vehicle/plant/month level. It is important to note that our data only includes plant shutdowns due to the semiconductor shortage, not other factors. In addition, we account for factories that have attempted to recoup some losses by adding extra shifts and production to their normal volumes. The data spans from January 2021 through April 1, 2022; there are 23,640 plant-vehicle-month observations. This dataset includes all global automotive companies; however, we only examine the communication for a subset of global automotive companies (see Table 16 for a complete list).

Table 18 Description of Data Sources

Data Source	Purpose
1. Investor Relations Pages of Automaker websites (e.g., www.ir.tesla.com)	Collect earning transcripts, press releases, and annual reports for qualitative analysis
2. Semiconductor Analysis Report (Proprietary from company that provides forecasts to Auto Industry)	Determine the operational significance of semiconductor shortage on a sample of firms
3. SEC EDGAR database	Collect SEC documents (10-K, 10-Q, 8-K, etc.)
4. Compustat	Operational and financial information reported by auto companies
5. International organization of mote vehicle manufacturers (www.OICA.net)	Annual production and delivery quantities for auto companies

Compustat

We have utilized Compustat to collect firm-level financial information. This information includes inventory and revenue.

Table 19 Manufacturer Performance Due to Shortage

Company	Units Lost	Production/yr.[7]	Pct Lost	HQ	Cluster
Tesla	15,376	930,422	1.65%	USA	1. Top
BMW Group	188,266	2,461,269	7.65%	EU	1. Top
Mazda Motor	104,251	1,074,987	9.70%	Japan	1. Top
Volvo Car	85,085	699,000	12.17%	EU	1. Top
Renault-Nissan-Mitsubishi	949,126	7,459,751	12.72%	Japan/EU	1. Top
Subaru	145,177	914,729	15.87%	Japan	2. Mid
Mercedes Benz Group	310,409	1,943,930	15.97%	EU	2. Mid
Toyota Motor	1,396,848	8,583,985	16.27%	Japan	2. Mid
Volkswagen	1,467,716	8,300,000	17.68%	EU	2. Mid
General Motors	1,326,424	6,291,000	21.08%	USA	3. Poor
Honda Motor	912,294	4,136,018	22.06%	Japan	3. Poor
Stellantis*	1,361,087	6,049,000	22.50%	EU	3. Poor
Ford Motor*	1,038,444	3,942,000	26.34%	USA	3. Poor
*Annual production numbers were not available; annual deliveries were used					

Table 19 shows the manufacturing performance in the face of the semiconductor shortage. We have separated the major automakers into three categories based on performance relative to the semiconductor shortage; no global companies have emerged unscathed from the crisis. However, some companies have fared better than others. To determine performance, we have utilized our proprietary dataset to determine the percentages of units lost over the calendar year 2021 due to the semiconductor shortage. To determine the baseline performance, we collect annual production data from the recent annual reports collected in our dataset. Some companies report production numbers (e.g., Tesla), while others report only deliveries. We utilize production numbers

[7] Source: OICA.net

when available and deliveries in all other instances.[8] Table 19 categorizes the automotive companies based on the lost production due to the semiconductor crisis.

6.1 Initial Analysis

After quantifying the significance of the shortage for the automakers, we compare the differences in *how* these organizations communicate this sustained disruption to their stakeholders. To analyze the qualitative content in our sample, we first imported all the documents into a database in MAXQDA 2007. Our data analysis included within-case and cross-case analyses (Eisenhardt, 1989).

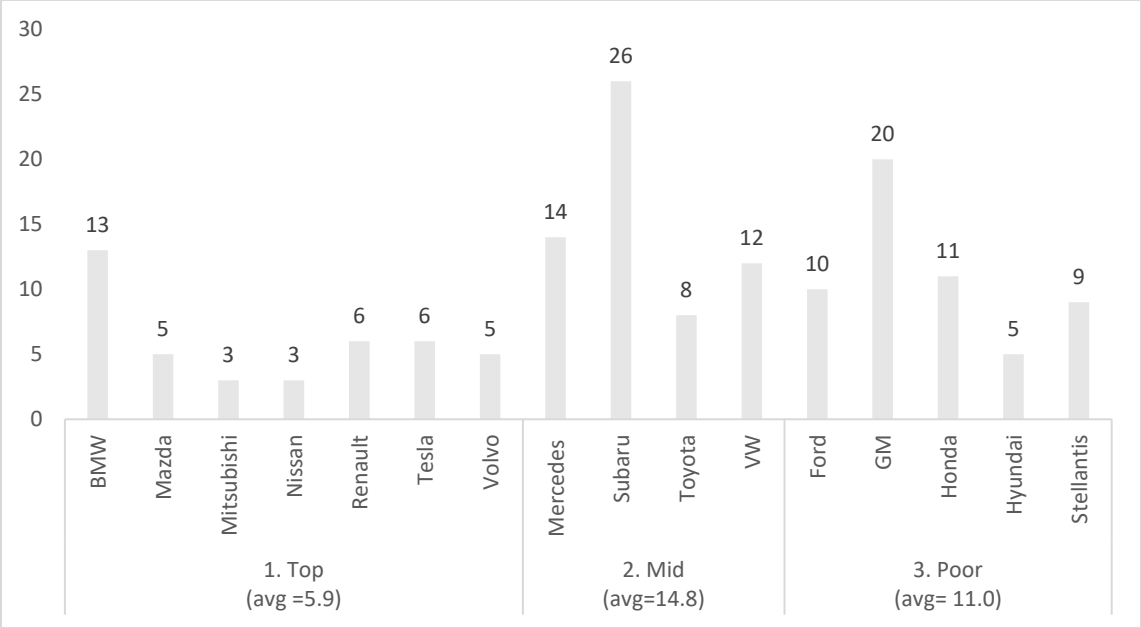
Frequency of Announcements

Table 3 displays the frequency of voluntary disclosures (including press releases, annual reports, sustainability reports, etc.) from each company that includes any mention of the semiconductor shortage. We count press releases as these are entirely voluntary disclosures of information. Whereas earnings presentations and SEC forms *require* information disclosures, press releases are entirely voluntary. We discover an inverted U-shaped relationship between frequency of disclosure and performance. First, we note that the Top Performers publish press releases about the semiconductor shortage with the lowest frequency, letting their performance do the "talking." This strategy of not calling unnecessary attention to a negative event can be classified as "silence" (Le et al., 2019). Next, the middle and poor-performing groups address the shortage with the greatest frequency. This elevated frequency explains their lack of success and touts how their

[8] Finding automobile production units is a difficult task. OICA used to produce annual statistics. However, since 2017 they have stopped producing this number. Many global automotive companies do not produce this

employees and organization are combating the situation. Finally, the worst performing group publishes press releases with frequency in between the other two groups, needing to explain away any negative results without drawing unnecessary attention to those negative results.

Figure 3: Frequency of Press Releases Mentioning Semiconductor Shortage



6.2 Addressing or Ignoring The Semiconductor Shortage in Quarterly Earnings

Within earnings calls, there are generally two main sections 1) Presentation and 2) Discussion. In the presentation, corporate representatives (usually the CEO or other high-level leaders) start the call and deliver remarks prepared in advance with input from corporate communications experts and the corporate council; typically, this is read from a script (Kimbrough, 2005).” Once this section ends, the team opens up for questions from the general public and the analysts attending the earnings call- the discussion section.

According to researchers, the discussion portion is the most economically important part of the conference call (Matsumoto et al., 2011).

Our next analysis simply addresses whether companies address the semiconductor shortage in their earnings calls. We also have distinguished companies that address the shortage in the "presentation" section and the subsequent "discussion" section of their earnings calls. Addressing the shortage during the presentation would suggest that the organization understands that the semiconductor shortage is a serious threat. During their earnings calls, nearly every company addressed the shortage in their presentation, with one exception. During earning calls in Q1 and Q2 of 2021 (Q3 and Q4 of Toyota's fiscal year), Toyota elected not to address the shortage in its presentation. This omission of the semiconductor shortage is consistent with the theory that Japanese culture is more accepting of silence as a communication tactic (Fujio, 2004). In early 2021, Toyota felt minimal consequences early in the semiconductor crisis due to changes in their procurement strategy in the wake of the 2011 Tsunamis. In the aftermath of the Tsunami, Toyota operates with a stockpile of semiconductors to ensure continuity of supply. This strategy worked for the automaker to ensure production until the stockpile was depleted (Barrett, 2021). Most automotive manufacturers utilized the presentation to discuss the impact of the semiconductor shortage during every call, utilizing that time as an opportunity to "steal thunder" and control the narrative of the shortage. However, Toyota behaved as the only outlier that did not use this strategy. During both earnings calls that Toyota elected NOT to speak on the semiconductor shortage, analysts did in fact ask questions regarding the shortage.

Perhaps not surprisingly, given the economic significance of the semiconductor shortage, the semiconductor shortage was one of the most common topics analysts addressed during the period. Analysts asked questions specifically about the shortage during every call in the period, with one exception. During three of Tesla's earnings calls, analysts did not mention the shortage. Tesla was the automotive company least affected by the semiconductor shortage (See Table 20), and the issue was addressed during the planned remarks section in each of these calls. Omitting a topic can signal that analysts were confident with Tesla's current situation and did not feel the need to discuss the shortage further.

Table 20. Earnings Calls Omitting the Semiconductor Shortage

Company	**Quarterly Call**
Tesla	2021Q1- Not Addressed in Discussion 2021Q2- Not Addressed in Discussion 2021Q4- Not Addressed in Discussion
Toyota	2021Q1- Not Addressed in Presentation 2021Q2-- Not Addressed in Presentation

6.3 Content Analysis

The findings based on documents analyzed from the 15 automotive companies are summarized in this section. All companies included in the sample were affected by the semiconductor shortage and communicated information related to the shortage to their stakeholders. Yet, each company utilized different strategies, tactics, and media to communicate this information to their stakeholders. Some companies were quite reserved and guarded in their communications, while others were much more transparent. Some companies provided specific information about partnerships, suppliers, and plans; others provided generic and vague descriptions of similar initiatives. Some companies regularly and voluntarily published announcements regarding production shutdowns; others

published the bare minimum required by the SEC. Several strategies utilized fell into the larger image restoration strategies of diminishing responsibility, corrective actions to reduce the consequences, and bolstering strategies to improve organizational reparation (Benoit, 1997). The primary strategies are detailed in the remainder of this section.

To analyze the data, we utilized qualitative coding. We utilized MAXQDA to identify the relevant portions of our data. Large portions of our data sources were unrelated to our research question and did not need to be analyzed. For example, in these earnings calls, there were many discussions about new model introductions, warranty expenses, new executive hires, and other unrelated topics to our research questions. We do not dismiss the importance of these topics, but they are unrelated to our research question. In annual reports and SEC documents, large sections are devoted to financial tables; again, these are important but irrelevant to our research question.

To find the relevant sections, we searched through all documents looking for any mention of "semiconductor," "chip," "shortage," "component," "supply," "situation.," and "crisis." Different speakers- analysts or executives, leaders from different companies, and occasionally employees of the same company- would use different terminologies to describe the ongoing shortage. We iteratively followed this process, first searching for "semiconductor" and "chip," then slowly adding more keywords to the search as we better understood how companies and analysts were discussing the semiconductor shortage.

We first utilized descriptive coding to qualitatively code the relevant parts of our sample (Saldaña, 2013). Descriptive codes are "identification of the topis, not abbreviations of the content" and provide a good starting point for nearly all types of

qualitative research (Saldaña, 2013). To do this, we assigned each relevant section a code (e.g., financial guidance due to semiconductor constraints, supplier relationships, production strategies). Once we used descriptive coding, we utilized initial coding on the aforementioned codes (Charmaz, 2006). These initial codes resulted in a large list of unique descriptors that we then collapsed into second-order themes. We allowed these themes to arise from the data rather than start with a pre-identified list. When possible, we utilized codes and concepts from resilience or crisis communication literature (Eisenhardt, 1989). We then grouped the second-order themes into aggregate dimensions as we developed theory. Moving from second-order themes into aggregate dimensions that emerged from the data was a slow, repetitive, and iterative process.

Diminishing Responsibility for the Semiconductor Shortage

The first strategy we discuss is the communication of factors that lead to the shortage or, effectively, "how did we get here?" Many different companies made explanations as to the causes of the semiconductor shortage. While their explanations differed in terms of phrasing, details, and specificity, each of these different explanations diminished each company's responsibility for *causing* the semiconductor shortage. For example, an executive from Nissan described, "*Why [did the shortage] happen? I would say there are two categories. The first category is the production losses during the COVID lockdown, and the second is the capacity constraints due to the sudden increase in demand, not only by automotive but also by the non-automotive [sectors].”* As an executive from Honda described, *“[Our supplier] told us that -- well, because of COVID-19, demand would come down… Therefore, they reduced the production of semiconductors at that time. And then, in fact, people played games or used computers more because of COVID-19. Therefore, there was increasing demand for*

semiconductors, not for [automotive] but for other [industries]. And then, at the moment, we are asking them to produce more, and suppliers are also planning to increase their production volume." Executives utilized these descriptions to emphasize their organization's limited role in causing the shortage. The emphasis on many of these statements was to drive responsibility for the current situation beyond the organization's locus of responsibility. Factors left unsaid were their organization's roles in reducing demand or actions their organizations failed to take to prevent the situation. In immediate response to COVID-19, most automotive companies expected a decrease in aggregate demand- as did most experts. As a result, the decision to decrease the standing orders to their suppliers alleviated capacity for the semiconductor manufacturers.

Automotive companies also attempted to diminish responsibility for the shortage by emphasizing the uncertainty of the situation. Every organization in the sample somehow emphasized the uncertainty due entirely to the semiconductor situation. This uncertainty inhibited their ability to manage the changing landscape or make accurate predictions. An executive from Mercedes concisely described the role of supply chain in the global landscape, *"I guess managing uncertainty is part of our job."* Many companies embraced semiconductor-related uncertainty and attempted to carry on with normal business; others leaned on the uncertainty as a convenient excuse. As an executive from Ford detailed, "*the global semiconductor shortage is creating uncertainty across multiple industries and will influence our operating results this year. The situation is changing constantly, so it's premature to size what the shortage will mean for our full-year results."* Individuals are biased against uncertainty; expressions of uncertainty in earnings class can negatively affect the reporting organization (Hassan et al., 2020).

Utilizing the uncertain situation to withhold a prediction of results is effectively an admission that the organization cannot even quantify, much less control, its surrounding environment.

Managing a supply chain is an increasingly global endeavor, ensuring that products, information, and money flow properly between entities across national and cultural boundaries (Christopher et al., 2011; Lambert et al., 1998). The automotive industry is no exception. Production relies on a carefully executed supply of products to arrive in the right place, the right amount, the right quality, and at the right time. Multiple companies within our sample frequently emphasized the global nature of their supply chain and their dependence on suppliers. Emphasizing the global nature of their supply chains underscores the massive scope and difficulty of the efforts to coordinate a variety of processes necessary to ensure global production. In a 10-K filed for Fiscal Year 2020, Tesla described the potential risk events inherent in their global supply chain, *"Our products contain thousands of parts that we purchase globally from hundreds of mostly single-source direct suppliers, generally without long-term supply agreements. This exposes us to multiple potential sources of component shortages."* Interestingly, this 10-K was filed in early 2021 before many consequences of the semiconductor shortage had even appeared. Emphasizing the global nature of the supply chain and the dependence and reliance on outside entities diminishes the organization's role in causing the shortage. As a Tesla executive shared, *"The chip supply is fundamentally the governing factor on our output. It is difficult for us to see how long this will last because we don't have -- this is out of our control essentially."* An organization's admission to a lack of control over the issue distanced themselves from responsibility for the shortage. In both SCM

disruption and SCCT research, individuals are more likely to blame an organization and have future intentions toward organizations responsible for a negative event (Coombs & Holladay, 2002; Hartmann & Moeller, 2014).

The shortage, already detrimental to automotive companies, was aggravated in early 2021 by multiple unrelated events. In February 2021, Winter Storm Uri ravaged Texas and much of the Gulf Coast region, shutting down multiple semiconductor factories (BBC News, 2021). In addition, on March 19, 2021, a fire significantly damaged a Renesas Electronics Corporation Facility that provided semiconductors to a significant portion of the automotive industry (Kim, 2021). Many companies mention these events as further escalating the semiconductor shorter. Most do not hesitate to name Renesas as the key supplier that greatly affected their supply chain. As Ford described in its 10-Q for the period ending September 30, 2021, *"the industry faced another setback on March 19, 2021, when Renesas Electronics Corporation, a key supplier of semiconductors for the automotive industry and for us in particular, experienced a significant fire at its Naka Factory."*

Interestingly, some companies cite these specific events but elect not to name the afflicted supplier. For example, on May 5, 2021, Stellantis described the incidents as *"…in Texas, in particular, and in Japan due to a fire in one of the key suppliers."* Most analysts attending automotive earnings calls follow the entire industry and would already know of the incident at Renesas. However, Stellantis' executives continually elected not to identify the supplier (Renesas) by name. Specifically, blaming external factors can lead to negative abnormal returns and a reduced likelihood of executive turnover (Noh & Zhou, 2022). Stellantis' executives choosing not to cite the specific supplier signals that

the organization does not want to blame another for an unfortunate situation. To our knowledge, there is no research examining the effects of a company specifically naming or keeping vague an affected supplier in their communications.

Strategies to Suggest the Shortage is Not as Bad as it Appears

In addition to distancing themselves from responsibility for the situation, automotive companies in our sample used a variety of strategies intended to reduce the offensiveness, or the significance, of the semiconductor shortage. Downplaying the consequences of an event is a common strategy used to restore organizational image in the wake of a crisis (Benoit, 1997; Coombs, 2007). These strategies included ways the organizations show the semiconductor shortage's impact to be less significant than stakeholders expected. For example, strategies included companies using increased prices and cost reduction measures to buoy financial performance, comparisons to (usually worse-performing peers), and attributing previously learned lessons to minimize the consequence of the shortage.

Despite severely restricted production, many automotive manufacturers experienced high- in some cases record-breaking- profits in the wake of the semiconductor shortage; the lowered supply and high demand allowed companies to charge high prices for new and used cars (Greimel, 2022). Every automaker communicated their ability to generate higher margins and profits on the vehicles they produced. These higher profits were driven by a few factors: 1) higher prices on the vehicles produced, 2) producing higher-margin vehicles within regions, and 3) allocating production to higher-margin regions. A consistent theme across nearly all automakers was the ability to increase prices. These increases driven by high demand, not increased

costs, flowed directly to bottom lines. An executive from Mercedes described, *"[price increases are happening] across the market. It is not something unique to us. We see it among several players and in the market… there is demand going into passenger cars, in particular, at the higher end, in the premium and the luxury space."* Not only did companies focus on higher prices of the vehicles they produced, but they focused their actual production on higher-margin vehicles. This "value over volume" strategy, as Renault phrased, helped to minimize negative financial consequences. As a Stellantis executive described, *"In this context, we focused on margin maximization….[we] also focused production through the year on higher-margin vehicles- in particular, Ram."* Again, this strategy was not unique to one company; broadcasting their ability to handle fluctuations in semiconductor supply is intended to relieve external stakeholders' worries. Closely related to simply allocating semiconductors toward more favorable vehicles, companies also prioritized regions of the world better able to withstand these price increases. As a Nissan executive described, *"We mitigated the semiconductor supply shortage impact by selling from our existing inventory and by strategically allocating semiconductors to the profitable regions and models."* Optimizing inventory around the global network These strategies of minimizing the consequences placate stakeholder worries. Table 21 displays representative quotes from various automotive companies referring to pricing strategies.

Table 21. Representative Quotes Exemplifying Pricing Strategies

Company	Date	Representative Quote
BMW	3/17/2022	"Despite the volatility in the last weeks, we have seen strong pricing… So that's a positive element."
Ford	10/27/2021	"Across our Automotive business, our playbook remained consistent as we optimize production for customer orders, new launches, and our most profitable vehicles."
GM	5/5/2021	"So, for example, things like the used car vehicle prices that GM Financial is clearly benefiting from -- that's likely to stay in place as long as new car inventories remain low. So that's an example of, I would say, a variable that's sort of hedged directly against the challenges of the semiconductor."
Mercedes	4/23/2021	"That's definitely our intention [to remain price disciplined], but I think it would not be appropriate to say more on this call."
Stellantis	5/5/2021	"On pricing, I think if we look over the last few years on ex PSA or ex FCA, we've seen margins improving steadily through the period. And a large part of that has been an improvement in average transaction prices and price positions. And so we are seeing a benign pricing environment."
Subaru	11/5/2021	"In the automotive industry, incentives have gone down as inventory levels have decreased substantially. We feel that there have been some significant benefits of low inventory levels, such as increased efficiency of business operations among retailers in terms of financing and used car prices stabilizing at higher levels, which has led to higher profitability, so we in the industry do not think that the high inventory levels of the past will return."
Volvo	2/11/2022	"I can start with the truck pricing. Of course, we are increasing prices to mitigate the cost, but also to try to improve our margins. But if you take a look some years back in time, we have been used to 1%, maybe 2%."
VW	5/6/2021	"In terms of margin guidance, as I said before, we have really a strong product momentum. We see a strong mix, pricing discipline."

Finally, organizations communicated how lessons learned from previous disasters directly improved their organization's performance during the semiconductor shortage. In 2011, an earthquake off the coast of Japan caused tsunamis that ravaged much of Japan and wreaked havoc on global supply chains- especially those of Japanese automotive companies (Sheffi, 2015b). In response to the 2011 events, Toyota and Honda made massive investments to improve their supply chains. Toyota emphasized the importance of its system, RESCUE, in reducing the consequences of the current shortage. Because of

this system, Toyota regularly communicated with suppliers beyond their Tier 1 and shared detailed, long-term production plans deep into their supply chain. Sharing these plans helped to absorb the immediate consequences of the semiconductor shortage. Toyota emphasized how the earthquake and Tsunami (JET), which caused significant financial and operational difficulties for their organization, actually improved their response to the semiconductor shortage. As an executive from Toyota described, "*After the global financial crisis, we had a reflection on seeing a [disruption] in our supply chain. So we have looked into the multiple tiers of our suppliers and created a system that we call RESCUE to find out where we need to rescue after seeing challenges… we can say we are providing a rather sure production volume plan [for several months to our suppliers]… with our business continuity plan. But for each of the [component], we have secured 4 to 6 months of stocks, as necessary."* The increased safety stock on critical components was intended to insulate the company from disruptions. However, the duration of the semiconductor shortage has overwhelmed Toyota's efforts, causing significant consequences to the organization.

Strategies to Bolster Perceptions of the Organization

In addition to the strategies designed to minimize the consequences of the shortage, organizations utilized other strategies designed to improve stakeholders' perceptions of the organization and its employees. We first discuss two largely symbolic strategies of praising employees and apologizing to customers. We describe these as symbolic as both strategies require minimal cost and have no specific, tangible benefits.

An extremely basic strategy, one of the most commonly utilized by the organizations in our sample, is to praise the efforts of team members. This strategy serves

to elevate the opinion of employees in the eyes of stakeholders and assure that the company is safe. These statements of praise included internal employees, focusing on SCM functions but extending to cross-functional employees, the dealer network, and supplier relationships.

Another strategy utilized was to offer an apology. A BMW executive described, *" I can't judge what others are doing, but what I can tell you is that our team is really working, and I'm not exaggerating, day and night with our suppliers around the world to optimize and to find a solution even for difficult situations…not only the procurement department, but also our production colleagues"* These offerings of praise often did not include tangible, or measurable benefits, but simply praising employees serves to bolster the opinions of public stakeholders. This strategy is commonly used in crisis communication (Coombs & Holladay, 2002)

While almost entirely symbolic, multiple organizations examined did offer apologies to their customers. We describe these as symbolic as organizations did not extend any tangible benefit with these apologies. Apologies can come with a tangible reward strategy called redress (Arendt et al., 2017), but no organizations utilized this strategy. Compensation is a strategy best utilized when the focal organization has high responsibility for the crisis (Coombs, 2015). For example, an executive from Nissan led their quarterly call by saying, *"Let me first start by apologizing to our customers for the inconvenience caused by delayed deliveries due to the impact of the semiconductor shortage and the pandemic."* Nissan offered no admission of guilt or responsibility, simply acknowledging the plight of their customers. The effectiveness of apologies is debated in crisis communication literature; apology effectiveness is related to crisis

responsibility. Apologies when the organization is not at fault or a lack of apology when the organization is at fault can lead to a decrease in shareholder wealth (Racine et al., 2020).

Interestingly, Nissan, Mazda, Toyota, and Honda-all Japanese companies- were the only companies to apologize to their customers for any negative consequences felt-like increased wait times to receive or the complete lack of ability to purchase their cars. This apology is consistent with the premise that the Japanese culture is more likely to apologize than Western cultures (Haruta & Hallahan, 2003; Lee et al., 2012). According to experts, a good apology: acknowledges wrongdoing, accepts responsibility, expresses regret, provides assurances that the act will not be repeated, and is well-timed (Kellerman, 2006). Interestingly, the apologies offered by this subset of automakers do not meet all the criteria for successful apologies. The only criteria met is these apologies are timely.

Strategies to Communicate Benefits Arising from the Semiconductor Shortage

"When life gives you lemons, make lemonade." Many companies in our sample attempted to spin semiconductor shortage- a giant strain on their supply chains- into a positive. Some companies were more direct than others. For example, Subaru credited reduced production from the semiconductor shortage with a reduction in carbon emissions, *"energy consumption decreased by 1,174 [Terra joules] due to a decrease in production, and emissions decreased 58 thousand tons due to the use of renewable energy and the temporary suspension of factory operations due to COVID-19 and the semiconductor shortage."* While these benefits were abnormal, releasing this information to public stakeholders signals a benefit from the semiconductor shortage's mostly negative environment.

Another strategy the organizations utilized to communicate the shortage focused on corrective actions- communicating their strategies, plans, and tactics to reduce the consequences of the shortage (Coombs & Holladay, 2002). A common strategy that organizations utilized was to emphasize relationships with suppliers. Not only did organizations emphasize the works of their own team, but they emphasized the acts of collaboration with their suppliers. Collaboration with partners is a frequently cited enabler of resilience (Scholten & Schilder, 2015). As an executive from Ford described, *"..our team is working with our suppliers around the clock to optimize the constrained supply, minimize the profit impact while prioritizing customer orders, new vehicle launches."* Some organizations kept the collaborations with suppliers vague, but others identified specific suppliers with whom they worked. For example, in a press release, BMW announced an *"agreement with high-tech microchip developer INOVA Semiconductors and GlobalFoundries, a manufacturer of feature-rich semiconductors."* BMW noted these partnerships to ensure their supply of semiconductors for the near future.

These newfound partnerships represent a sharp departure from the status quo for automotive companies. Semiconductor suppliers are not direct suppliers to the automotive companies but tier 2 or beyond. Many automotive companies announced partnerships with these extended tier suppliers, a departure from their "normal" business. As a Ford Executive described, *"How different it is? It's different. We need different talent at the company. We need physical inspection of the actual producers. We need direct contracts with them. We need to design the SoC ourselves… In some cases, we need to direct them to use supplier XYZ… And this takes talent. It takes a different*

approach. It takes more resources." These new partnerships represent a new capability, developed by necessity that will improve the organization's capability eventually. These exemplify the concept of plasticity, "rapidly making major changes to a supply chain to accommodate significant shifts in the business environment" (Zinn & Goldsby, 2019).

In addition to changing procurement strategies, companies communicated changes related to their overall business. Executives communicated that these lessons learned from the strained environment of the semiconductor shortage have driven a reduction in inventories, which could negatively influence the business's ability to operate. However, multiple companies spun this news as a positive, suggesting that the conditions caused by the semiconductor shortage have led to an ability to operate more effectively, learning how to operate with lower inventory stocks and directing customers to a different purchasing channel. As a Ford executive succinctly described, *"Navigating these chip constraints has led us to make important permanent changes in our business model at Ford. We are modernizing our go-to-market strategy. What does that mean? We're placing a greater emphasis on build-to-order sales bank, not just low stocks. We have learned that, yes, operating with fewer vehicles on lots is not only possible, but it's better for customers, dealers, and Ford."* Many of the companies in our sample communicated that these trying times would lead directly to an improved company.

Another set of strategies communicated focused on the production of semiconductors. The ability to substitute similar components in manufacturing greatly increases the flexibility of manufacturing. However, switching semiconductors between vehicle platforms is not a simple task. An executive from Volkswagen described, *"It is not so easy to switch semiconductors between car lines and platforms. It's mostly really*

specific." An executive from Stellantis described the importance of embracing flexibility in their production, saying, "*because of this semiconductor issue [it has become necessary] to move towards more standardized parts, more interchangeability, between vehicle lines on the same platform and between different platforms."* Tesla is one company that exemplified flexibility. Probably not coincidentally, Tesla has experienced the least significant losses due to semiconductor constraints (See Table 16). However, automobiles are not simple products, and semiconductors are an extraordinarily complex part of automobile production. A Tesla executive described the process of utilizing substitute products in manufacturing *"We were able to substitute alternative chips and then write the firmware in a matter of weeks. It's not just a matter of swapping out a chip. You also have to rewrite the software. So it was an incredibly intense effort of finding new chips, writing new firmware, integrating with the vehicle, and testing in order to maintain production."* Communicating these strategies to increase flexibility can ensure that stakeholders have an accurate perception

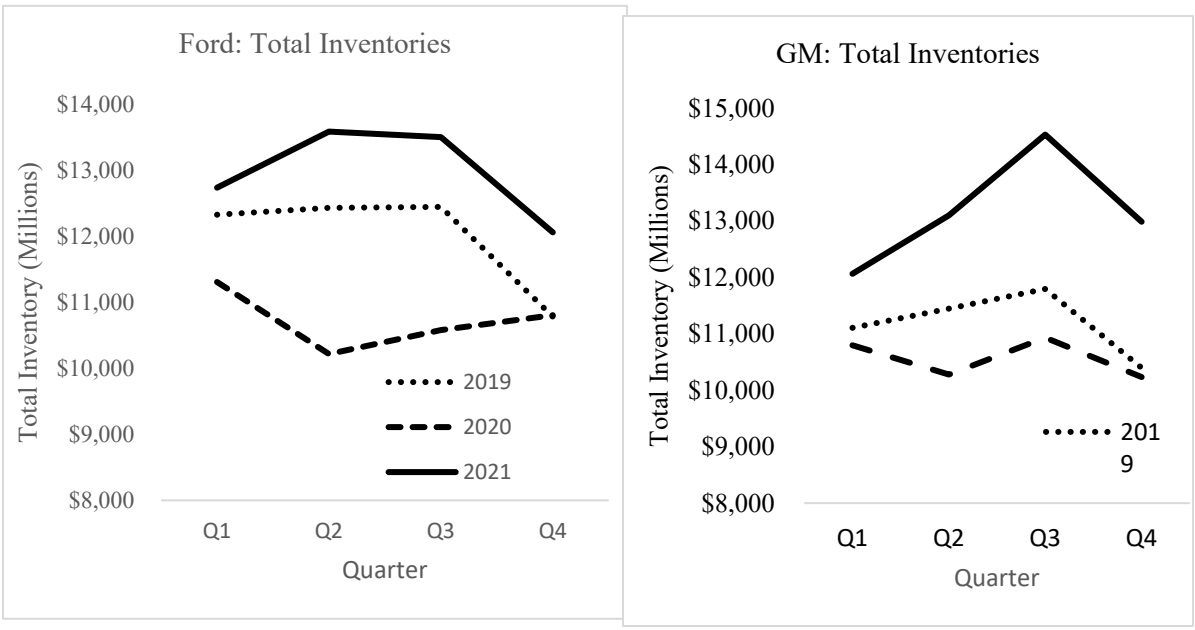
A final set of strategies utilized revolved around communicating optimized production. Shutdowns or reductions in production lower the possible production output. However, how transparent and public companies were about this process differed across our sample. Most companies in our sample reduced their production due to the shortage. In an extreme example of transparency, Subaru published press releases to the public every time production was affected, announcing shutdowns due to semiconductor constraints. Tesla is one company that publishes monthly production statistics but does not publish press releases with the transparency of Subaru. Other companies have announced ways to compensate for the lost production, including operating through the

traditional summer shutdown. As an executive from GM described, *"We plan on operating through the traditional U.S. summer shutdown in early Q3 at select facilities."*

Finally, some companies have built vehicles lacking the necessary semiconductors. Customers cannot purchase these vehicles that lack necessary components; these vehicles sit unfinished on dealer lots. Ford and GM utilized this strategy which directly increased their inventory.[9] An executive from Ford described, *"we grew inventory by $2.2 billion. Now this includes parts for vehicles we could not build due to the lack of chips, but it also included approximately 22,000 vehicles, and those are primarily in North America, that are awaiting installation of chip-related components."* Ford utilized a strategy that could have long-term benefits. Once the final semiconductors are acquired, these massive backlogs of unfinished automobiles could be immediately acquired, boosting revenues. However, the longer these vehicles sit incomplete, the closer they are to becoming obsolete as new model years arrive (See Figure 4).

[9] These vehicles built without the final semiconductors were counted in Finished Goods inventory, despite being not technically complete

Figure 4. Graph of Ford and GM Inventory 2019-2021



Highlighting this strategy and its effects on increasing inventory is unusual in our sample. Most companies reported inventories decreasing- many reported this decrease to be of noteworthy magnitude- due to unavailable components. Table 23 summarizes all the strategies used by companies in our sample. Some strategies (for example: highlighting uncertainty) have been utilized by a large portion of our sample. However, other strategies (for example: emphasizing how lessons learned from previous disasters have improved this response) are only utilized by a small portion of our sample. Table 22 details various quotes demonstrating how most companies experienced a decrease in their inventories and a few quotes describing companies that experienced an increase in their inventories. Inventory was such a heavily discussed topic that we included one representative quote from every company in our sample.

Table 22. Representative Quotes Describing Inventory Changes

Company	Quote	Source
BMW	Good working capital management related to lower inventories due to the semi-conductor situation…	Earnings call FY 2020 (March 17, 2021)
Ford*	Our inventory includes vehicles completed but awaiting installation of components affected by the semiconductor supply shortage. As a result of the shortage, our inventory in 2021 was higher than in prior years.	10-K for FY ending (December 31, 2021)
GM*	Inventories at June 30, 2021, increased primarily due to certain vehicles being manufactured without final components as a result of the global semiconductor supply shortage.	10-Q (filed June 30, 2021)
Honda	... about the inventory situation. Well, the industry on the whole, the inventory level is quite low… the industry average is 25 days. Honda is currently 23 days compared to the normal situation; there is a very low level of inventory.	Earnings call (August 4, 2021)
Mazda	We worked on maximizing sales and profit through lean inventory management	FY March 2022 Q1 Financial Results
Mercedes*	The semiconductor shortages caused a temporary extraordinary increase of unfinished goods, translating into a more than EUR 900 million negative impact	Earnings call (October 29, 2021)
Mitsubishi	As a result by March 2021, our total inventory has been reduced to an appropriate level of 310,000 units. Currently, inventory levels are declining further through production adjustment due to a shortage of semiconductors and growth in retail sales.	Earnings call (July 7, 2021)
Nissan	...Q2 is where we will be hit the largest. Needless to say, our inventories have decreased largely, so we need to manage smartly.	Earnings call (July 28, 2021)
Renault	But you've seen that we reduced drastically our inventory in and out of the company versus last year;	Earnings Call (April 28, 2021)
Stellantis	We see our inventory status. Inventory levels remain healthy overall, with significant reductions in both group and dealer inventories over the last 12 months, due to the impacts of COVID and the semiconductors, combined with positive commercial performance.	Earnings call (May 5, 2021)
Subaru	Our normal dealer inventory levels are around 45 days' supply... The most recent levels have been very low at around a six- or seven-day supply, and this has led to dealers actively selling pipeline inventory even more than before.	Financial results (August 3, 2021)
Tesla	…we do have an increase in inventory of vehicles that we were unable to deliver at the end of Q1.	Earnings Call (April 29, 2020)
Toyota	In the U.S, vehicle inventory has remained quite low since the middle of 2020 due to rapid recovery in demand and it has further declined in201 due toa shortage of semiconductors, severe cold weather and other multiple factors.	Slide deck accompanying Financial Results (August 4, 2021)
Volvo	Let me put it this way the current level of dealer inventory is low, very low. I will not give a more precise number than that.	Earnings call (July 23, 2021)
VW	We are well below ideal stock. ...currently due to the semiconductor topic, we are understocked.	Earnings call (May 6, 2021)
*Companies reported higher inventory due to building incomplete vehicles		

Table 23 summarizes all the strategies used by companies in our sample. Some strategies (for example: highlighting uncertainty) have been utilized by a large portion of our sample. However, other strategies (for example: emphasizing how lessons learned from previous disasters have improved this response) are only utilized by a small portion of our sample.

Table 23. Strategies Employed in Communicating Semiconductor Shortage

		BMW	Ford	GM	Honda	Mazda	Mercedes	Mitsubishi	Nissan	Renault	Stellantis	Subaru	Tesla	Toyota	Volvo	VW
Strategies to Diminish Responsibility	Highlighting uncertainty of situation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Declining to offer predictions		x								x				x	
	Emphasizing global nature of the shortage	x	x	x	x		x	x	x	x	x	x	x	x	x	x
	Comparing to peers as a reference	x			x						x			x		x
	Dependent on suppliers		x			x					x	x	x			x
	Citing specific events increasing shortage		x	x	x		x	x	x					x	x	x
	Not naming specific suppliers				x		x	x						x	x	
Strategies to Minimize Consequences	Increased pricing	x	x	x	x		x	x	x	x	x		x			x
	Prioritizing higher-margin vehicles		x	x	x		x	x			x					x
	Allocating chips globally where needed			x	x	x										x
	Finding substitute chips				x								x	x		x
	Build incomplete vehicles		x	x			x									
	Adjusting production (Shifts, closures, etc.)	x	x	x	x	x	x				x	x			x	
	Specific strategies to make up production		x	x	x		x		x	x		x				
Bolstering own Perception	Emphasizing supplier relationships	x	x													
	Lessons from previous disasters				x	x								x		
	Apology to customers				x	x			x					x		
	Praising employees	x	x	x	x		x		x	x	x	x	x		x	x
	Praising suppliers		x	x						x			x			
Benefits Gained	Partnership with chip suppliers	x	x	x			x		x	x	x			x	x	x
	Learning to operate with lower inventory		x		x	x	x	x			x	x			x	x
	Emphasize online purchasing channel		x	x					x							

6.4 Analysis of Communication Over the Duration of the Crisis

To answer our second research question- how organizations have communicated the semiconductor shortage over its duration, we have quantitatively analyzed the transcripts of earnings calls. First, we have quantified the portion of each earnings transcript devoted to discussing the semiconductor shortage. Addressing a topic during any portion of the conference call would suggest the reporting organization believes it to be a significant issue (Hassan et al., 2020). Moreover, the larger the portion of an earnings call devoted to a topic, the more significant the organization believes the topic to be (Benton et al., 2022). Quantifying the proportion of earnings transcripts devoted to a specific topic has been utilized to assess many different risks, including political risk in general (Hassan et al., 2019), Brexit (Hassan et al., 2020), and the COVID-19 pandemic (Benton et al., 2022; Hassan et al., 2020).

Other authors have utilized text-mining algorithms to quantify the proportions of earnings calls devoted to specific topics. We have utilized a manual process for multiple reasons: 1) our dataset is manageable to do manually, 2) we are already conducting qualitative analysis of the documents, and finally, 3) automotive companies use a variety of different terms, phrases, and descriptions to describe the semiconductor shortage (i.e., both chip and semiconductor are used almost interchangeably; shortage, situation, crisis, are all words used often, occasionally companies describe a component shortage). For example, in response to a multi-part question, an executive from VW responded, *"...so we lost 100,000 cars so far, and the disturbance in Q2 might be even higher slightly."* This answer was in response to a question about semiconductors but included none of the

keywords that would be identified utilizing a pure text mining approach. Additionally, questions asked by analysts have multiple parts, and not all parts address the semiconductor shortage; answers from executives address the issue without using any specific term. To ensure we capture all the relevant portions of documents addressing the semiconductor shortage- and no unnecessary parts- we utilized manual coding.

We analyze all earnings calls from our sample that mention the semiconductor shortage. In this analysis, we only include calls that have a published transcript. Some companies (i.e., Mazda, Subaru, Nissan)[10] produce only summaries in English. We examine full-length transcripts. Table 24 shows the summary statistics describing the length of the earnings calls. We divide our sample into three groups based on nationality: 1) EU, 2) Japan, and 3) the USA. The EU group includes BMW, Mercedes, Renault, VW, and Volvo; the Japanese group includes Honda, Nissan, and Toyota

Regardless of company nationality, the discussion section is longer than the presentation section, consistent with others' findings (For example, Matsumoto et al., 2011). To create Table 24, we have utilized MAXQDA to code sections of earnings calls. We have categorized call sections as "Presentation" or "Discussion" and totaled the word count in each section, respectively. Most earnings calls clearly delineate between the presentation and the discussion section, either marked clearly with "Questions and

[10] Mazda, Nissan, and Subaru produce abbreviated versions of earnings calls in English. While these summaries are useful for extracting themes and were utilized in the previous section, to examine quantitatively we need to have entire transcripts that follow a uniform structure. Therefore they are excluded from this portion of analysis.

Answers" written in the transcript or indicated when the executive leading the call (or the operator) indicates it is time for questions.

Earnings calls allow executives to interact with investors and public stakeholders. The discussion session is more informative for stakeholders than the presentation section (Matsumoto et al., 2011), as an earnings release can augment the presentation. Much advice generally suggests keeping the presentation sections shorter and allowing more time for the discussion (Corner et al., 2019; Cossette, 2009). Based on Table 24, transcripts of EU-based companies were generally the longest (in totality), with earnings calls for Japanese companies the shortest. Additionally, EU-based companies also had the highest portion of their call in the presentation (43%), with Japanese and American companies devoting a lower portion (33%) of their calls to the presentation.

Table 24. Average Word Count of Transcripts

	Presentation	Discussion	Total
EU	31,299 (42.3%)	42,613 (57.6%)	73,912
Japan	13,336 (33.4%)	26,537 (66.6%)	39,873
USA	17,949 (33.2%)	36,158 (66.8%)	54,107
Total	23,115 (38.6%)	36,843 (61.4%)	59,958

To create Table 25 we have included the total word count of all sentences addressing the semiconductor shortage in earnings transcripts. We found all instances discussing the semiconductor shortage through a text mining approach augmented by manual search. Sentences were identified using the "lexical search" function in MAXQDA, with the search terms "semiconductor," "chip," "shortage," and "component" as search terms. All instances identified were manually examined to determine if the

words, phrases, or sentences related to the shortage. When appropriate, we included the preceding or following sentences that discuss the semiconductor shortage but do not include any of our search terms. Often, these sentences were directly applicable, but because they did not contain any search terms, they would have been "missed" using a pure text mining algorithm. For example, an executive from Ford described, *"it is very important to highlight that even though our volume has decreased, we have worked to contain EBIT."* Our analysis ensured this phrase would be included. We then sum all words in the sentences discussing the shortage and sum all words in each section of the earnings call.

We separate the portions discussing semiconductors based on the section of the earnings call- either presentation or discussion. In addition to the total portion devoted to semiconductors, we differentiate based on the presentation and the discussion as these sections reflect different perspectives. The presentation section represents exactly what the organization wants to discuss in a carefully planned and articulated manner. The discussion section includes issues that analysts in attendance ask. These are topics that analysts and audience members designate as needing further elaboration- based on a combination of the presentation, previous information about the organization, or external environmental conditions- for example, COVID-19, inflation, and Russia's invasion of Ukraine were often addressed (Kimbrough, 2005).

Table 25 displays P_{PRES} and P_{QA}- the portions of the Presentation and Discussion as a function of the total call length.

That is:

$P_{PRES} = \sum(Words\ on\ semiconductor\ shortage\ in\ Presentation) / \sum(Words\ in\ call)$

$P_{QA} = \sum(Words\ on\ semiconductor\ shortage\ in\ Discussion) / \sum(Words\ in\ call)$

$P_{TOTAL} = P_{PRES} + P_{QA}$

We note a few takeaways from Table 25. First, the total words devoted to semiconductors peaked between 2021Q2 and 2021Q3, evidenced in P_{PRES} and P_{QA} and, therefore, P_{TOTAL}.

The discussion section is generally a larger portion of the earnings transcript (See Table 24), so the fact that P_{QA} is often larger than P_{PRES} is not surprising. Therefore, we further analyze the word count devoted to the semiconductor shortage by comparing it to the total word count in each section. We divide the total words devoted to the semiconductor shortage in a specific section (S_{PRES} and S_{QA}) by the total words of that section.

That is:

$S_{PRES} = \sum(Words\ on\ semiconductor\ shortage\ in\ Presentation) / \sum(Words\ in\ Presentation)$

$S_{QA} = \sum(Words\ on\ semiconductor\ shortage\ in\ Discussion) / \sum(Words\ in\ Discussion)$

Table 25. Portion of Earnings Transcripts Devoted to Semiconductor Shortage

	Portion of Total Call			Portion of Each Section	
Calendar	P_{PRES}	P_{QA}	P_{TOTAL}	S_{PRES}	S_{QA}
2021Q1	2.7%	7.3%	9.2%	8.6%	11.5%
2021Q2	5.6%	11.4%	15.6%	14.1%	19.1%
2021Q3	8.0%	10.3%	17.3%	16.5%	19.2%
2021Q4	7.6%	7.9%	14.2%	20.1%	10.9%
2022Q1	6.5%	8.2%	13.4%	11.5%	13.1%

We note that the S_{PRES} rapidly increased from early in the semiconductor shortage to later quarters. S_{PRES} peaked in 2021Q4; in calls during that quarter, S_{QA} actually decreased from the previous period. When organizations devote larger portions of the discussion section of their earnings calls (that is, increase S_{PRES}) to the semiconductor shortage, a seemingly lower portion of the resulting discussion session focused on semiconductors follows (i.e., S_{QA} is lower).

Table 26 compares the portion of each section of earnings calls devoted to the semiconductors shortage separated by the Japanese, European, and American companies. Again, we note some themes across our sample. First, we examine the portions P_{PRES} and P_{QA} (Section I) for each nationality. Then we further examine the portion of S_{PRES} and S_{QA} for each nationality (Section II).

We discuss P_{PRES}, P_{QA}, and P_{TOTAL} based on company headquarters. P_{TOTAL} peaked in 2021Q2 for American and European carmakers, but for the Japanese automakers, P_{TOTAL} peaked the following quarter (2021Q3) and continued to stay high in the next two quarters. The relatively low S_{PRES} for Japanese automakers indicate a stark difference between national cultures. This lack of content on the semiconductor shortage

in the presentation section did not mean these earnings calls ignored the semiconductor shortage. On the contrary, the shortage was consistently (and heavily) examined during the subsequent discussion sections; that is, S_{QA} was relatively high. The fact that Japanese companies did not specifically and proactively address the negative consequences of the semiconductor shortage as much as their peers is consistent with the theory that silence is more accepted in Japanese cultures (Fujio, 2004). Effectively, Japanese automakers have elected not to proactively address the semiconductor shortage, allowing analyst questions to control the narrative.

Table 26. Portion of Earnings Calls Devoted to Semiconductors by Region

		I. Portion of Entire Call			II. Portion of Each Section	
HQ	Calendar Quarter	P_{PRES}	P_{QA}	P_{TOTAL}	S_{PRES}	S_{QA}
EU	2021Q1	0.9%	3.3%	4.2%	11.0%	5.1%
	2021Q2	3.8%	11.1%	14.9%	12.1%	18.3%
	2021Q3	6.6%	7.0%	13.5%	12.8%	17.1%
	2021Q4	7.9%	4.2%	12.1%	24.0%	7.1%
	2022Q1	2.9%	4.3%	6.6%	5.3%	7.9%
Japan	2021Q1	3.5%	17.8%	20.1%	6.4%	27.9%
	2021Q2	3.5%	11.5%	13.9%	6.3%	19.2%
	2021Q3	4.9%	20.3%	25.1%	14.6%	33.3%
	2021Q4	4.8%	15.1%	19.9%	16.5%	21.8%
	2022Q1	6.4%	15.2%	21.5%	19.7%	22.6%
USA	2021Q1	2.5%	3.6%	6.1%	6.7%	5.8%
	2021Q2	9.4%	11.8%	21.2%	25.3%	20.4%
	2021Q3	7.0%	9.1%	16.1%	23.7%	13.3%
	2021Q4	3.8%	6.6%	8.2%	17.1%	6.2%
	2022Q1	4.6%	10.2%	14.8%	16.3%	15.6%

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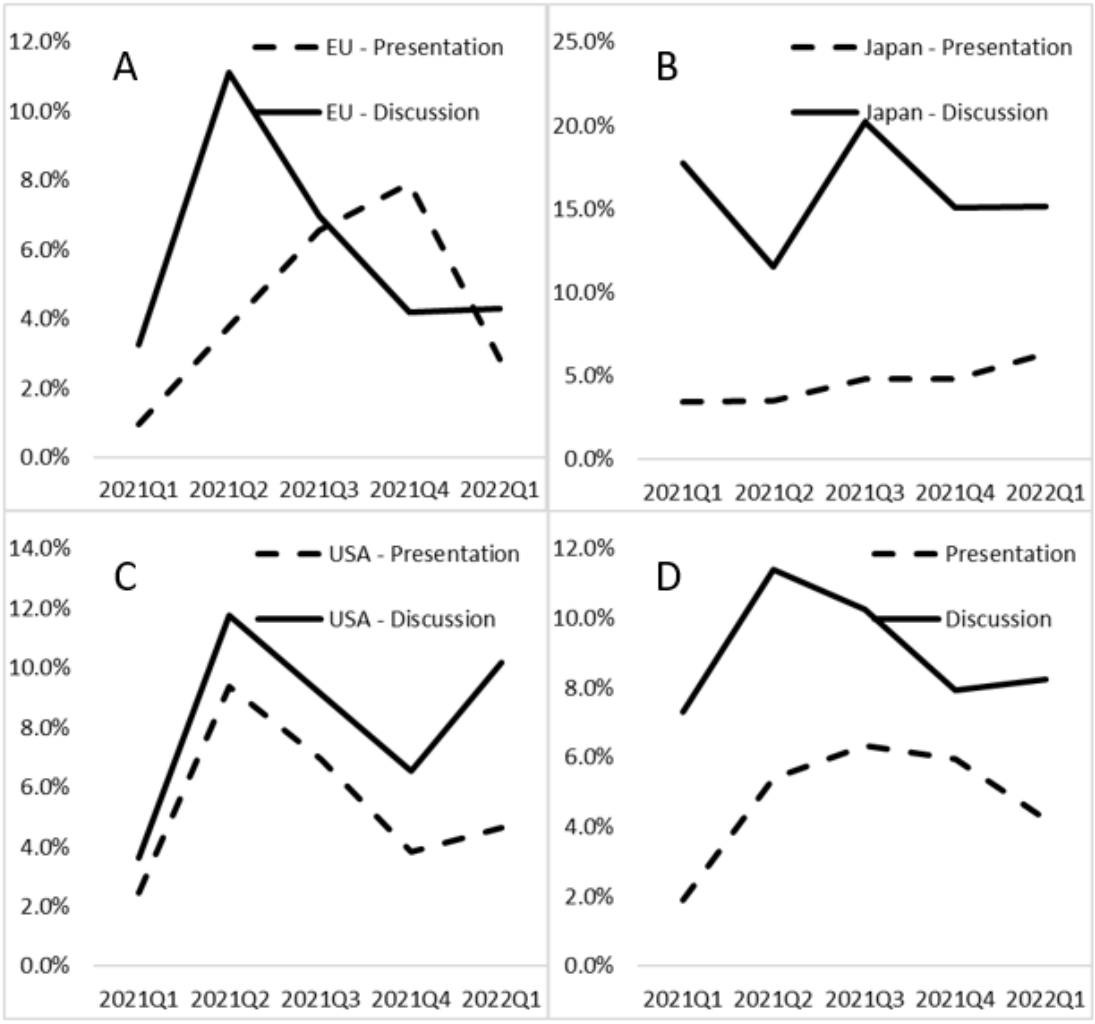
Figure 5 Portion of Total Earnings Devoted to Semiconductor Shortage



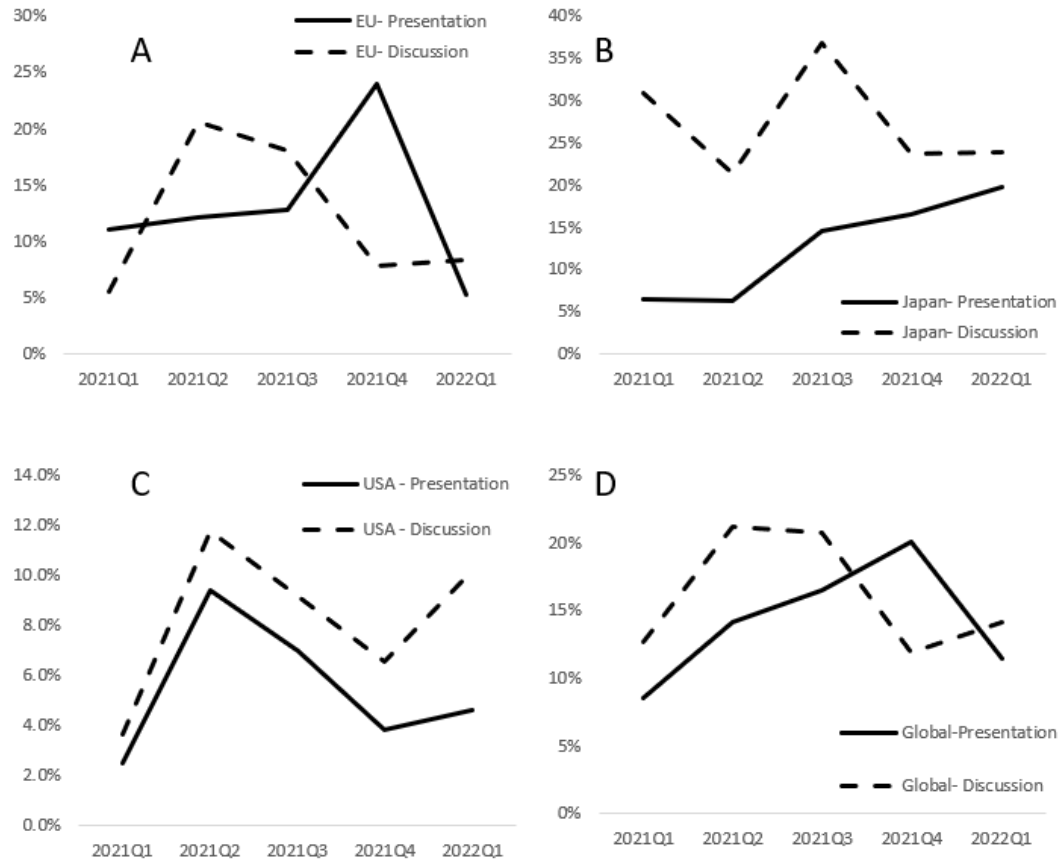
A)European Automakers only, B) Japanese Automakers only, C) American Automakers only, and D) Global Automakers

Additionally, we address how the portions of the total calls change over time. Figure 5 shows how the portion of earnings calls related to the semiconductor shortage changed over time. In Figure 5, Charts A-C show the total portion of the calls discussing the semiconductor shortage. For Japanese companies (Chart B), the portion devoted to semiconductors in the discussion is consistently notable lower than that of the discussion section, suggesting that executives are not answering analyst questions thoroughly. For

European companies (Chart A), as the portion from the presentation increases, the portion from the discussion decreases. For American companies, the portion from the discussion section is consistently higher than the presentation; however, these volumes increase and decrease almost in synchronization.

Next, we discuss S_{PRES} and S_{QA} (the portions of each section devoted to semiconductors as a proportion of the section, not the entire earnings transcript). As the presentation section is significantly smaller than the discussion section, this measure should better reflect the composition of the presentation and discussion sections, respectively. In Figure 6, Charts A-C represent an individual region (European, Japan, and USA, respectively), and Chart D represents the global industry. It is notable how SPRES is consistently lower for Japanese companies than SQA; a smaller portion of their presentation sections focuses on the semiconductor shortage than the relative portion of subsequent discussion sections. For American companies, the opposite holds; SQA is consistently higher than SPRES. Finally, for European companies, as SPRES increases, SQA decreases, suggesting that organizations that devote time during the presentation section of the call experience fewer semiconductor shortage-related questions from the audience

Figure 6. Portion of Relevant Sections of Earnings Calls Discussing Shortage



A)European Automakers only, B) Japanese Automakers only, C) American Automakers only, and D) Global Automakers

For Japanese companies, P_{PRES} is consistently lower than P_{QA}; for Japanese companies, S_{PRES} is consistently lower than S_{QA}. For Japanese companies, P_{PRES} and S_{PRES} are also consistently lower than P_{PRES} and S_{PRES}, respectively, for European or American companies.

Table 27. Frequency of Voluntary Disclosures of Semiconductor-Related Documents

	Company	2021Q1	2021Q2	2021Q3	2021Q4	2022Q1	Total
EU	BMW	1	3	5	4	0	13
	Mercedes	3	1	2	4	4	14
	Renault	1	1	2	1	1	6
	Stellantis	0	2	1	1	3	9
	Volvo	0	0	4	0	1	5
	VW	2	1	3	4	2	12
	Avg_{EU}	1.2	1.3	2.8	2.3	1.8	9.8
Japan	Honda	1	0	3	3	4	11
	Hyundai	1	1	1	1	1	5
	Mazda	1	1	2	1	0	5
	Mitsubishi	1	0	1	1	0	3
	Nissan	0	0	1	1	1	3
	Subaru	1	4	5	7	8	26
	Toyota	0	0	1	0	7	8
	Avg_{Japan}	0.7	0.9	2.0	2.0	3.0	8.7
USA	Ford	1	0	3	2	1	10
	GM	1	4	3	2	3	20
	Tesla	0	0	1	0	0	6
	Avg_{USA}	0.6	1.5	2.5	2.2	3.7	13.1
	Total	17	22	40	34	37	150

Table 27 displays the frequency of quarterly press releases for each company in our sample. This table includes all voluntary disclosures of the semiconductor shortage. We differentiate these voluntary disclosures from earnings transcripts as it is customary, and sometimes required, to release earnings publicly. Press releases are different. No laws compel companies to disclose information via press releases. Public companies in the United States must disclose 8-Ks, should any major event occur that shareholders must know. These events are usually more economically significant than adjusting

production. Sharing potentially negative information with public stakeholders signals transparency to public stakeholders.

Table 27 summarizes themes consistent with our previous analysis. First, 2021Q3 was the quarter with the greatest number of press releases addressing the semiconductor shortage; 2021Q3 is also the quarter in which companies devoted the highest portion of earnings calls to the semiconductor shortage. The volume of press releases suggests that the semiconductor shortage peaked in 2021Q3. Also, this table shows that American companies have published the greatest number of press releases that mentioned the semiconductor shortage compared to Japanese and European automakers. This difference would be more pronounced if not for the prolific Subaru. Subaru published more press releases than any other company during the period, singlehandedly driving an increase for all Japanese automakers. American and European companies publishing more press releases indicates that these companies are more forthcoming about semiconductor shortage-related issues. Finally, our finding that American companies more readily publish information related to the semiconductor shortage is consistent with our earlier analysis that American and European companies are more likely to disclose information proactively in earnings calls than Japanese companies. Based on our analyses, Japanese companies are less likely to proactively disclose information related to a sustained crisis.

7. Conclusions

Supply chain disruptions seem to be increasing in frequency and severity for organizations of all sizes. As global economies become increasingly interconnected, disruptions have local and global consequences. It is important that organizations not

only address these disruptions operationally to reduce consequences, expedite recovery, and avoid future similar disruptions. It is also important (and in some cases legally required) to communicate the presence of these disruptions to supply chain partners, investors, and other public stakeholders. Sustained disruptions that cause a shortage of critical components are increasingly likely. To date, SCM research has yet to examine how organizations communicate these disruptions to their public stakeholders. SCM scholars have used communications of supply chain disruptions simply as an indication that an event has occurred but do not consider the methods used to communicate. That is, SCM research has largely ignored *how* sustained disruptions have been communicated.

7.1 Theoretical Contributions

To our knowledge, ours is the first study in the SCM literature that studies how multiple organizations communicate the same supply chain disruption. Prior research that investigated the response to a single discrete event has focused on company-specific events. Our research focuses on one event that influences an entire industry. We analyze how companies communicate the semiconductor shortage, identifying various strategies utilized by different automotive companies. The strategies that we find include diminishing responsibility for the situation, suggesting the shortage is not as bad as it seems, bolstering or improving perceptions of the organization, and communicating benefits arising from the situation.

We then quantitatively address how organizations have communicated the ongoing semiconductor shortage. We do this by calculating the portion of earnings calls devoted to discussing the semiconductor shortage in the respective sections of earnings

calls. Our analysis shows that Japanese companies are less likely to discuss the semiconductor shortage in the presentation section of their earnings calls. This evidence suggests that Japanese automakers are less likely to proactively communicate negative events to their public stakeholders. This finding can help academics studying supply chain disruptions examine future research questions by understanding that cultural and organizational factors can affect how an organization communicates an ongoing shortage. This finding can help scholars examine future inquiries into the communication of supply disruptions.

7.2 Managerial Contributions

Our research also provides managerial contributions. We provide a playbook of sorts for managers experiencing a sustained disruption of a critical component. We show a variety of strategies that an organization can utilize to communicate a sustained disruption to its public stakeholders. These strategies are designed to improve the perceptions of an organization in the wake of sustained supply disruptions.

7.3 Limitations and Further Research

As is true of all research, our research has limitations. We have thoroughly examined a dataset of qualitative documents to gather our insights. We did not connect any of our insights to any measurable output variables. The lack of connection to an output variable is a limitation of our dataset and an opportunity for scholars to connect strategies communicating a disruption to quantifiable output variables. A possible extension of our research would be to examine how company stock prices change in reaction to the portions of earnings calls devoted to a disruption. Our research has

focused on how automotive companies have communicated the semiconductor shortage; however, semiconductors are a pain point not just for the automotive but for various global industries. Further research could examine how organizations in different industries have communicated the semiconductor shortage. Assessing the semiconductor shortage across industries would also provide an opportunity to collect a larger dataset and quantitatively examine semiconductor shortage-related communication. Because we chose to focus on the automotive industry, we limited our focus to large organizations. Comparing the communication strategies of large organizations with SMEs could provide interesting results. Additionally, one interesting observation emerged in our study regarding whether organizations should specifically name other companies. For instance, some companies described the fire at a Renesas plant as "a fire at a supplier in Japan." Further research could continue to examine the consequences of specifying, or not specifying, a supplier in communication to public stakeholders. There are many opportunities for future research related to this study.

Chapter 5: Conclusion

The preceding three essays examined how organizations react and respond to disruptions in three different contexts. Supply chains are networks of organizations; disruptions that occur to one member of the supply chain have great effects on the organization, its direct trading partners (suppliers and customers), intermediaries, and stakeholders. Therefore, we have conducted a multi-method and multi-level investigation of resilience. In our first essay, we studied the organization level. We utilized semi-structured interviews to unearth the capabilities that help an organization react effectively to disruptions and, if necessary, adjust their organization or supply chain. In our next essay, we examine disruptions at the buyer-supplier relationship level, utilizing an online vignette-based experiment to assess how the accuracy and timing of supply chain disruption-related information influence future relationship intentions of supply chain partners. In our final essay, we examine supply chain disruptions at the industry level, investigating how organizations communicate a sustained disruption to their public stakeholders. To do this, we collect and analyze publicly available secondary data from automotive companies concerning the semiconductor shortage of recent years.

Our first essay (Chapter 2) examined the capabilities that enable an organization to respond to supply chain disruptions. We found evidence that its AAA capabilities

(agility, adaptability, and alignment) improve its resilience. Agility- the ability to react to mismatches in supply and demand- and adaptability- the adjust to long-term changes in market conditions- have been shown to influence an organization's resilience (Gligor et al., 2019; Patrucco & Kähkönen, 2021). In addition, we noted the importance of alignment- having metrics and incentivizing behaviors that benefit the entire supply chain's performance (Lee, 2004)- in pursuing resilience. This connection has not been previously made clear in SCM literature.

In addition to the previously mentioned theoretical contributions, we also provide actionable recommendations to SCM managers on processes, behaviors, and organizational structures that can be implemented to develop these three capabilities. We found through our interviews that managers are more focused on responding to short-term mismatches (agility) than long-term adjustments to the supply chain (adaptability). We recommend several processes that facilitate agility by enabling quick responses from individuals and business functions; these include having pre-determined plans, utilizing multiple sources of supply, and segmenting suppliers by risk profile. Organization can improve their adaptability by utilizing After Action Reviews (AARs), processes conducted immediately following a disruption to identify strengths and weaknesses to improve upon (Darling et al., 2005). Finally, alignment can be enabled by implementing resilience initiatives early into process timelines and keeping consistent metrics across departments. These processes can be supported by behaviors that organizations can foster. Ensuring that training includes a cross-functional perspective and the employees utilize technology to simplify decisions can improve the speed and effectiveness of

responses to disruption, enabling agility. Embracing a change mindset for the organization rather than resenting and resisting change can enable adaptability (Taylor, 2017); however, strict requirements from supply chain partners can hinder this ability. Support for resilience from the top management (TMT) and providing resources- capital, human, and financial- facilitates all these behaviors, as does the focus on a small number of metrics. Finally, utilizing the appropriate structure can enable these behaviors. While a centralized organizational structure best supports alignment, decentralization can better support agility and adaptability. Therefore, we recommend a hybrid organization structure to best support resilience. Specifically, centralizing outward-facing functions, like customer service and category management, can simplify communication for supply chain partners during disruption.

During many of the interviews conducted for Chapter 2, we discussed the topic of sharing disruption-related information between supply chain partners. While the overwhelming sentiment of supply chain disruption literature advises sharing accurate information as quickly as possible, disruptions represent scenarios rife with uncertainty. In addition, environments are constantly changing, and finding accurate information is difficult, time-consuming, and expensive (Sheffi & Rice, 2005). Our interview subjects discussed two differing philosophies regarding when and how to share disruption-related information. One philosophy suggested that it was best to share information early and often, even though that information may change. The other philosophy was only to communicate information when confident in the accuracy of that information.

We conducted an experiment to determine if either philosophy of sharing disruption-related information influenced buyer-supplier relationships. Specifically, we conducted an online scenario-based experiment to manipulate the timing and accuracy of supply chain disruption information between partners. We assessed two variables: 1) accuracy of information (either accurate or inaccurate) and 2) timing of the information shard (either before or after the buyer experienced the consequences of the disruption; we also assessed a control condition with no information). We found that sharing information (from a supplier to a buyer) is more beneficial than sharing none. Sharing information more quickly between partners resulted in the buyer having a stronger desire to continue and grow the relationship. We also found that the accuracy of the information shared has no significant impact. The buyer's trust mediated the dependent variables in our study in the supplier. Our findings show that communicating disruption-related information to a supply chain partner earlier rather than later increases the trust and likelihood of growing the relationship in the future. This effect holds regardless of the accuracy of information shared. Our recommendations to SCM managers are clear, communicate disruption-related information early and often, and do not hesitate to share information that information's accuracy is uncertain.

Continuing our examination of sharing disruption-related information, we investigate a different context. Chapter 4 examines how organizations communicate a sustained supply chain disruption to public stakeholders. To do this, we build a dataset of publicly available documents (including press releases and earnings calls) from 15 automotive companies to investigate how they communicate about the ongoing

semiconductor shortage that has impacted the auto industry and many others. We identify various strategies organizations utilize to manage the impressions of public stakeholders. These strategies include diminishing responsibility for the situation, downplaying the negative consequences, bolstering the perception of their organization, and showing benefits gained from the situation. Some strategies, like emphasizing the uncertainty of the situation, are utilized by a great majority of companies. In contrast, others, like offering apologies to affected customers, are only used by a subset of companies. Nevertheless, these strategies effectively provide a playbook, showing how organizations can successfully communicate a sustained supply chain disruption to public stakeholders. Long-term supply shortages seem to be increasing in prevalence, specifically in the auto industry, which also faces a shortage of materials critical for battery production. This research will continue to be relevant and impactful to company leaders in auto and other industries.

We also find that cultural differences influence how and when a company communicates. For example, Japanese automakers have addressed the shortage with different strategies and lower volumes than their American and European counterparts. In addition, Japanese companies were the only ones to apologize to customers regarding the ongoing shortage. Also, Japanese automakers publish fewer press releases than their counterparts; this type of document is notable for analysis as these documents are not mandated and are published voluntarily. Additionally, the opening segment of an earnings call- the presentation- usually follows a script approved by multiple leaders within the organization. In this section specifically, Japanese automakers address the

semiconductor shortage less than their American and European counterparts. In the following discussion sections (the second half of an earnings call), analysts devoted more attention to the semiconductor shortage than their European and American counterparts. These insights help improve our understanding of the factors that influence how organizations communicate supply chain disruptions.

Supply chains have long focused on cost-minimization, striving for efficiencies and improved bottom lines. Decades of technological advances, increasing globalization, and new management philosophies (JIT, Lean, etc.) have enabled this focus on efficiency and led to improved performance, reduced costs, and increased profits. This relentless focus on efficiency has motivated companies to remove "slack" from their supply chains and decreased their ability to absorb short-term fluctuations in demand and supply (Knemeyer et al., 2009). During the writing of this dissertation, the world has experienced myriad disasters with global supply chain consequences. Scientific and empirical evidence suggests that climate change will increase the frequency of these high-impact natural disasters (Van Aalst, 2006).

The COVID-19 pandemic greatly influenced the global economies in ways still unfolding, exposing the global and interconnected nature of supply chains. According to the Global Supply Chain Pressure Index, a measure that assesses the conditions facing supply chains, global supply chain pressure has, for almost 18 straight months, exceeded its pre-COVID peak (Federal Reserve Bank of New York, 2022). In addition, a confluence of unfortunate events- including natural disasters, political events, and changing demand profiles- has crippled the global semiconductor industry (Fusion

Worldwide, 2021). A recent recall and shutdown of a U.S-based baby formula production facility led to nationwide shortages, revealing how policy restrictions can inhibit an entire industry's ability to recover from disruption (Morris et al., 2022). In addition, Russia's invasion of Ukraine has caused ripple effects across the globe- including surging fuel prices, shortages of fertilizer inflating commodity prices, and a shifting of global alliances (Selyukh et al., 2022). At the time of writing this, inflation is rampant across the globe and its effects on global supply chains are yet to be fully realized.

For decades, the average consumer has underestimated the importance of supply chain. The complex networks of organizations using overlapping processes were not understood by the consumer as long as the desired products were readily available for purchase. Additionally, customers and consumers have become more demanding, expecting increasingly complex and customized products available through more channels, with reduced lead times and improved supply chain performance (fill rate, service level, on-time delivery, etc.). However, several high-profile recent disruptive events have brought supply chain, long known to be important to SCM managers and scholars, into the forefront of conversations in boardrooms, newsrooms, and dining rooms across the globe. The increased interest is a good development for those working in and studying supply chains! To be clear, we do not celebrate these disastrous events that led to this increased interest in our discipline, but we welcome the newfound interest in it. For years, supply chain managers and academics have identified a talent crisis in supply chain (Ackerman, 2016; Henderson, 2020). Recently, there has been evidence of a growth in the number of students wanting to study supply chains (Peacher, 2022). As

educators, we are hopeful that this growth in our discipline continues and that these recent graduates will spend their early careers helping us alleviate some of the issues plaguing supply chains today and hopefully avoiding similar issues throughout their careers.

In response to these high-profile disasters, the importance of resilience in supply chains has not gone unnoticed by scholars, SCM managers, Wall Street, and national governments. At the time of writing, there are four open special issues in supply chain and related journals examining how supply chains respond to changing environments. First, a recent Gartner survey showed that nearly all (87%) of SCM managers intend to increase investments in supply chain resilience (Hippold, 2021). “Supply chain” has become one of corporate earnings calls' most commonly used phrases (Oak, 2022). President Biden has even signed an executive order designed to increase the resilience of supply chains in the United States (United States Government & Executive Office of the President [Joseph Biden], 2021). The consistent underlying theme is that resilience is not a luxury for organizations that want to thrive but a necessity for organizations to survive.

Resilience to disruptions also has larger implications for society as a whole. COVID-19 has been the biggest disruption in decades and has sent shockwaves across various industries and exposed a lack of resilience. In the United States alone, a logjam at many busy ports forced companies to alter supply chain practices (Leary & Berger, 2021). Various events and trends have thrown the airline industry into disarray (Sider, n.d.). A nationwide baby formula shortage- exacerbated by restrictive policy- panicked the nation (Morris et al., 2022). Gas prices have hit record highs, driven partly by supply

constraints (Restuccia et al., 2022). In each instance, government intervention has attempted (with varying degrees of success) to alleviate supply chain problems with significant consequences for society. Natural disasters are expected to occur with increasing frequency and cannot be prevented. Unfortunately, disruptions will inevitably occur and affect cities, regions, countries, or the entire world. However, ensuring that organizations, infrastructure, and government can collaborate to ensure that society as a whole can withstand and recover quickly from these events is essential.

This dissertation contributes to the already rich literature on supply chain resilience. In our first essay, we provided empirical evidence, collected through semi-structured interviews- that AAA capabilities improve an organization's resilience. We propose that alignment specifically enables resilience. Although we add to the literature, many directions can build from our research. In times of disruption, much uncertainty exists, and environments constantly change. Individual employees are often confused and unsure how to act; there is a great need to investigate how to best prepare employees that can handle unexpected disruptions. Given the importance and frequency of disruptions, educators should begin incorporating resilience into the undergraduate and graduate curricula. Research into the best methods to teach resilience can also help organizations effectively train their employees. Trying to improve an organization's resilience can be daunting for managers; organizations with immature resilience capabilities can be overwhelmed and unsure where and how to focus efforts on improving their organization's resilience. A maturity model that provides organizations a tool to assess

their current resilience maturity and provides sequential steps toward improving that resilience would be a great tool for practitioners.

In our second essay, we examined how characteristics of shared disruption-related information between supply chain partners influence the relationships between supply chain partners. We found that sharing information earlier (rather than later) is preferred, and disruption-related information accuracy does not influence relationship intentions. Further research should expand on this inquiry and investigate other factors related to the information. We investigated how receiving information would alter a buyer's intention to work with the supplier. Further research could investigate disruption-related circumstances influencing a supplier's likelihood to share information with a buyer.

Additionally, we held constant the type of relationship between buyer and supplier; future research could explore how the strength of the relationships between buyer and supplier influences consequences related to information sharing. For example, do buyers expect more transparency from close suppliers? When these suppliers err, are buyers more forgiving of those withholding information?

Our third essay explored how firms communicate a sustained disruption to public stakeholders. Based on how differing automotive companies have communicated the semiconductor shortage, we identify multiple strategies organizations can use to communicate to public stakeholders. Future scholars can use experiments to investigate how individuals react to announcements of critical component shortages. These differences in how potential public stakeholders react to firm announcements could inform those communicating supply chain-related topics to public stakeholders.

In conducting these three studies on organizations' response to supply chain disruptions, we have expanded our academic knowledge of supply chain resilience. We have provided implications for scholars and practical recommendations for supply chain managers. We hope our research can provide practitioners with direction and inspire more research into this important topic for SCM managers. Given the increasingly connected nature of supply chains and the growing number of significant natural disasters, we expect supply chain disruptions to remain prevalent. While we are no longer in the initial stages of scholarly investigation into supply chain resilience, there continue to be valuable areas of inquiry for scholars.

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Appendix A: Complete List of Interview Subjects

Org	Exec	Title	Industry	SC Position	Revenue
A	1	Senior VP Global Sourcing	Medical Devices	Distributor	IV. $100B+
B	2	VP Business Development & Procurement	Food Distribution	Distributor	I. $10M-$1B
C	3	Director, Enterprise Supply Mgmt. Ops	Manufacturing	Manufacturer	III. $10B-100B
D	4	VP Supply Chain Mgmt., Global	Manufacturing	Manufacturer	III. $10B-100B
D	5	Global VP Materials & Logistics	Manufacturing	Manufacturer	III. $10B-100B
E	6	VP-Global Sourcing	Medical Devices	Manufacturer	II. $1B-10B
E	7	Associate Director Sourcing Compliance	Medical Devices	Manufacturer	II. $1B-10B
F	8	Director Transportation and Analytics	Transportation	Service Provider	I. $10M-$1B
G	9	Sr Director Replenishment	Food Distribution	Distributor	$10B-100B
H	10	Head of Strategic Procurement	Manufacturing	Manufacturer	II. $1B-10B
I	11	Director of Materials Mgmt.	Healthcare	Retailer	II. $1B-10B
J	12	VP Strategic Sourcing	Packaging	Manufacturer	II. $1B-10B
K	13	VP, Supply Chain Fresh	Food Distribution	Distributor	II. $1B-10B
L	14	Chief Supply Chain Officer	Food Service Equipment	Manufacturer	II. $1B-10B
M	15	VP, Director of Sales	3PL	Service Provider	I. $10M-$1B
N	16	CEO and President	Transportation	Service Provider	I. $10M-$1B
O	17	District Sales Manager	Packaging	Manufacturer	II. $1B-10B
P	18	CIO and VP Business Services	Chemical	Manufacturer	III. $10B-100B

Continued

Appendix A (Continued)

Q	19	Supply & Services Division Chief	Military	Military	N/A
R	20	Global Category Director	Aerospace & Defense	Manufacturer	III. $10B-100B
R	21	Strategic Procurement Manager	Aerospace & Defense	Manufacturer	III. $10B-100B
S	22	IT Procurement Manager	Semiconductors	Manufacturer	III. $10B-100B
S	23	Commodity Procurement Manager	Semiconductors	Manufacturer	III. $10B-100B
T	24	Head of Procurement Excellence	Aerospace & Defense	Manufacturer	II. $1B-10B
U	25	VP, Procurement	Conglomerate	Manufacturer	IV. $100B+
U	26	National Procurement Manager	Conglomerate	Manufacturer	IV. $100B+
U	27	National Procurement Head	Conglomerate	Manufacturer	IV. $100B+
U	28	Director of Procurement Operations	Conglomerate	Manufacturer	IV. $100B+
U	29	Head of procurement [Division Redacted]	Conglomerate	Manufacturer	IV. $100B+
U	30	Head of procurement [Division Redacted]	Conglomerate	Manufacturer	IV. $100B+
U	31	Director, Supply Mgmt.	Conglomerate	Manufacturer	IV. $100B+
V	32	CEO and President	Chemical Transportation	Service Provider	I. $10M-$1B
W	33	Chairman and CEO	4PL	Service Provider	I. $10M-$1B
X	34	VP Integrated Supply Chain	Textiles	Manufacturer	II. $1B-10B
Y	35	Senior VP, Distribution & Logistics	Apparel	Retailer	II. $1B-10B

Appendix B. Experimental Stimuli Used

Baseline Scenario[11]

FAST Auto is an automotive manufacturer. The automobiles that FAST Auto produces have built-in Automotive Driver Assistance Systems that help its automobiles avoid collisions and accidents. These systems require several semiconductor chips with built-in "intelligence" (ASICs).[12]

FAST Auto's primary supplier of these ASICs is Safe Technologies. Without these ASICs, FAST Auto cannot manufacture any of its vehicles. The ASICs are expensive and FAST Auto utilizes Just-in-Time (JIT) principles, striving to minimize on-hand

[11] The baseline scenario was seen by participants in all conditions

[12] Original source for image: https://www.canstockphoto.com/computer-cpu-or-central-processor-unit-49785324.html

inventory. Safe Technologies is a long-term supplier of FAST Auto and has always had stellar performance. FAST Auto's purchasing department (your department) and the account management team at Safe Technologies have frequent and consistent communication.

--------Represents Start of New Page of for Participants -------

Which of the following best describes the product that Safe Technologies supplies to FAST Auto?[13]

A. All season tires
B. Anti-lock brake systems
C. Semiconductor chips (ASICs)
D. None of these products

--------Represents Start of New Page of for Participants -------

For the past few weeks, Safe Technologies has been delivering significantly fewer ASICs than FAST Auto has ordered. Without the ASICs, FAST Auto has been forced to reduce its production output. This has dramatically reduced the sales that FAST Auto can make (lower product availability leads to lower sales), hurting the company as a whole as well as your personal performance metrics and, most likely, your bonus.

--------Represents Start of New Page of for Participants -------

Experimental Stimuli (Each participant sees only one condition)

1. Late x Accurate Information Condition

You received the below message from Taylor, your contact at Safe Technologies

Unfortunately, we have had to dramatically decrease our production of ASICs. Our primary supplier of silicon wafers, a critical component in manufacturing ASICs, experienced a fire in their main production facility. Fortunately, no people were seriously injured. However, their inventory was damaged beyond usability and their production capabilities, and therefore, our production capabilities will be very limited. We will need to find a new supplier. We have already begun the process of qualifying a new supplier and are completing this as fast as we can. **We are not certain, but we expect to return to normal production in four weeks. After four weeks, our facility will return to normal production. We apologize for the issue.**

---

[13] This question served as the Factual Manipulation Check

Safe Technologies eventually returned to normal production levels **four weeks later, exactly as Safe Technologies had predicted**.

Your contact at Safe Technologies, Taylor, reached out **after** the incomplete deliveries started to occur.

Despite the early notice, FAST Auto was unable to exercise its contingency plans. The qualified backup suppliers had no additional available capacity. Therefore, FAST Auto could not procure ASICs, and had to reduce production by 50% for multiple weeks.

This lost production led to a decrease in FAST Auto's revenue, a surge in incomplete deliveries to FAST Auto's customers, and strained relationships between FAST Auto and its customers. It also affected several performance metrics tied directly to your compensation.

2. Early x Correct Information Condition

You received the below message from Taylor, your contact at Safe Technologies.

Unfortunately, we have had to dramatically decrease our production of ASICs. Our primary supplier of silicon wafers, a critical component in manufacturing ASICs, experienced a fire in their main production facility. Fortunately, no people were seriously injured. However, their inventory was damaged beyond usability and their production capabilities, and therefore, our production capabilities will be very limited. We will need to find a new supplier. We have already begun the process of qualifying a new supplier and are completing this as fast as we can. **We are not certain, but we expect to return to normal production in four weeks. After four weeks, our facility will return to normal production. We apologize for the issue.**

Safe Technologies eventually returned to normal production levels **four weeks later, exactly as Safe Technologies had predicted**.

Your contact at Safe Technologies, Taylor, reached out **before** the incomplete deliveries started to occur.

Despite the early notice, FAST Auto was unable to exercise its contingency plans. The qualified backup suppliers had no additional available capacity. Therefore, FAST Auto could not procure ASICs, and had to reduce production by 50% for multiple weeks.

This lost production led to a decrease in FAST Auto's revenue, a surge in incomplete deliveries to FAST Auto's customers, and strained relationships between FAST Auto and

its customers. It also affected several performance metrics tied directly to your compensation.

3. Early x Correct Information Condition

You received the below message from Taylor, your contact at Safe Technologies.

Unfortunately, we have had to dramatically decrease our production of ASICs. Our primary supplier of silicon wafers, a critical component in manufacturing ASICs, experienced a fire in their main production facility. Fortunately, no people were seriously injured. However, their inventory was damaged beyond usability and their production capabilities, and therefore, our production capabilities will be very limited. We will need to find a new supplier. We have already begun the process of qualifying a new supplier and are completing this as fast as we can. **We are not certain, but we expect to return to normal production in two weeks. After two weeks, our facility will return to normal production. We apologize for the issue.**

Safe Technologies eventually returned to normal production levels **four weeks later, two weeks later than Safe Technologies had predicted**.

Your contact at Safe Technologies, Taylor, reached out **before** the incomplete deliveries started to occur.

Despite the early notice, FAST Auto was unable to exercise its contingency plans. The qualified backup suppliers had no additional available capacity. Therefore, FAST Auto could not procure ASICs, and had to reduce production by 50% for multiple weeks.

This lost production led to a decrease in FAST Auto's revenue, a surge in incomplete deliveries to FAST Auto's customers, and strained relationships between FAST Auto and its customers. It also affected several performance metrics tied directly to your compensation.

4. Late x Wrong Information Condition

You received the below message from Taylor, your contact at Safe Technologies.

Unfortunately, we have had to dramatically decrease our production of ASICs. Our primary supplier of silicon wafers, a critical component in manufacturing ASICs, experienced a fire in their main production facility. Fortunately, no people were seriously injured. However, their inventory was damaged beyond usability and their production capabilities, and therefore, our production capabilities will be very limited. We will need to find a new supplier. We have already begun the process of qualifying a new supplier and are completing this as fast as we can. **We are not certain, but we expect to return to normal production in two weeks. After two weeks, our facility will return to**

normal production. We apologize for the issue.

Safe Technologies eventually returned to normal production levels **four weeks later, two weeks later than Safe Technologies had predicted**.

Your contact at Safe Technologies, Taylor, reached out **after** the incomplete deliveries started to occur.

Due to the late notice, FAST Auto was unable to exercise its contingency plans. The qualified backup suppliers had no additional available capacity. Therefore, FAST Auto could not procure ASICs, and had to reduce production by 50% for multiple weeks.

This lost production led to a decrease in FAST Auto's revenue, a surge in incomplete deliveries to FAST Auto's customers, and strained relationships between FAST Auto and its customers. It also affected several performance metrics tied directly to your compensation.

5. No Information Condition

You have not received any information from Taylor, your contact at Safe Technologies about the incomplete deliveries.

--------Represents End of Vignette for Participants-------

Response Questions

I. How likely are you to recommend that FAST Auto Replace Safe Technologies with another primary supplier for the ASICs?

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

II. How likely are you to recommend that FAST Auto continues with Safe Technologies as the primary supply source for ASICs?

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

III. How likely are you to recommend that FAST Auto adds another primary supplier of ASICs, in addition to Safe Technologies?

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

IV. How likely are you to recommend that FAST Auto actively searches for an alternative supplier for ASICs?

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

V. How much do you trust Safe Technologies after this incident?

1. Not at all
2. Slightly
3. Moderately
4. Very
5. Extremely

-------End of Page For Participants-------

VI. You are working with a cross-functional team at FAST Auto to develop new technology for autonomous vehicles. You need to involve a primary ASIC supplier in the development of the technology. Safe Technologies, as well as other ASIC suppliers in your supply base, have the capabilities to support the development of this technology. How likely are you to work with Safe Technologies on this initiative?

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

VII. Are you willing to invest in innovation with this supplier (Safe Technologies)?

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

VIII. Thinking about the information Safe Technologies provided to you, how likely are you to believe future predictions my supplier shares with me regarding supply chain disruptions.

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

IX. In the future, I will share information with this supplier (Safe Technologies) about any potential disruptions that may affect them.

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

X. In the future, I will monitor the risk management and business continuity plans of Safe Technologies.

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

XI. In the future, I will expect price concessions from Safe Technologies.

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

XII. I have decided to forgive my supplier.

1. Extremely likely
2. Moderately unlikely
3. Slightly unlikely
4. Neither likely or unlikely
5. Slightly likely
6. Moderately likely
7. Extremely likely

-------End of Page For Participants-------

Manipulation Checks

XIII. Which statement describes the information that Safe Technologies provided about the disruption duration?

1. Safe Technologies accurately predicted the length of the disruption
2. Safe Technologies did not accurately predict the length of the disruption.
3. No information was provided about the disruption duration

XIV. Which statement describes the information that Safe Technologies provided about the disruption duration?

1. Safe Technologies contacted me before the incomplete deliveries arrived at FAST Auto's facility
2. Safe Technologies contacted me after the incomplete deliveries arrived at FAST Auto's facility
3. Safe Technologies did not contact me at all regarding the incomplete deliveries

-------End of Page For Participants-------

XV. How do you identify?

1. Male
2. Female
3. Non-binary/ third gender
4. Prefer not to say

XVI. To which business function do you belong?

1. Souring
2. Logistics
3. Operations
4. Manufacturing
5. Information Technology
6. Procurement
7. Enterprise Risk Management
8. Other

Realism Scale

Rate your level of agreement to the following statements on the following scale

1. Strongly disagree
2. Disagree
3. Somewhat disagree
4. Neither agree nor disagree
5. Somewhat agree
6. Agree
7. Strongly agree

I. The scenarios of this study are realistic.
II. I am familiar with the issues described in the scenarios of this study.
III. In my real work experience, I have encountered similar issues as the ones described in the scenarios of this study
IV. I am familiar with the issues described in the scenarios of this study

Demographic questions

I. How many years of professional experience do you have?
   1. Less than 1 year
   2. Between 1 and 5 years
   3. Between 5 and 10 years
   4. Between 10 and 20 years
   5. More than 20 years

II. What is your employment level?
   1. Analyst (no direct reports)
   2. Manager
   3. Senior Manager
   4. Director
   5. Vice President
   6. C-Level
   7. Other (free response)

III. What is your level of professional experience with supply disruptions?
   1. I have no professional experience with supply disruptions.
   2. I have relatively low professional experience with supply disruptions.
   3. I have moderate professional experience with supply disruptions.
   4. I have extensive professional experience with supply disruptions.

IV. In which industry is your organization? (Free Response)