FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

WHAT ARE THE RISK FACTORS TO SUPPLY CHAIN INTERRUPTION IN THE UNITED STATES (US) AUTOMOTIVE INDUSTRY DURING THE SEMICONDUCTOR CHIP SHORTAGE

A dissertation submitted in partial fulfillment of

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by

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To: Dean William G. Hardin
College of Business

This dissertation, written by Racquel Robinson Jones and entitled What Are the Risk Factors to Supply Chain Interruption in the United States (US) Automotive Industry during the Semiconductor Chip Shortage? having been approved in respect to style and intellectual content is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

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DEDICATION

Mission: To my heavenly angels, my grandmother, and my mother, I miss you so much, and I hope I have made you proud.

Support: To my husband, thank you for your love and support during this three-year process.

Foundation: To the women of Delta Sigma Theta Sorority, Incorporated, I am eternally grateful for the opportunity to be a Diamond Life member of the best sorority in the world. All the love, prayers, calls, text messages, emails, Facebook groups, and LinkedIn posts from sorority sisters I have known for many years to the ones I just met a few days ago display true sisterhood (priceless).
Thank you for setting the foundation for me to become Dr. Jones.

Goal**:** "Education is for improving the lives of others and for leaving your community and world better than you found it." - Marian Wright Edelman

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ABSTRACT OF THE DISSERTATION

WHAT ARE THE RISK FACTORS FOR SUPPLY CHAIN INTERRUPTION IN THE UNITED STATES (US) AUTOMOTIVE INDUSTRY DURING THE SEMICONDUCTOR CHIP SHORTAGE

by

Racquel Robinson Jones

Florida International University, 2024

Miami, Florida

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The success of the production chain and practical cooperation depends on supply chain risk management (SCRM). An efficient SCRM plan will reduce risks, assist in building a competitive position, and offer long-term advantages to businesses, resulting in stakeholder satisfaction. A SCRM system should be used to manage both ordinary and unusual risks, including natural disasters and significant accidents. It is crucial to monitor changes in the supply chain, customer needs, technology, suppliers' plans, and those of rivals to respond promptly to events. Furthermore, it is critical to proactively identify risks and implement policies to lessen or prevent their effects. The essential steps involved in risk management are risk identification, assessment, mitigation, and control. This study contributes to the literature by expanding a new model that can be utilized in multiple industries to identify supply chain risk and interruption impact. The results indicate that supply risk demand risk, supply chain risk management, and relational and contractual governance directly affect supply chain interruption. Future research is needed to explore the findings centralized in one type of automotive sector in the United States, such as new hybrid vehicles with additional risk factors added. This study highlights risk factors in the US automotive industry due to the semiconductor chip shortage.

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ABBREVIATIONS AND ACRONYMS

AVE	Average Variance Explained
CA	Cronbach Alpha
CG	Contractual Governance
CHIPS	Creating Helpful Incentives to Produce Semiconductors
DR	Demand Risk
EFA	Exploratory Factor Analysis
EU	Environmental Uncertainty
MR	Manufacturing Risk
MRP	Material Requirements Planning
MSRP	Manufacturer's Suggested Retail Price
GM	Governance Mechanism
GS	Governance Structure
NADA	National Automobile Dealers Association
RG	Relational Governance
SC	Supply Chain
SCI	Supply Chain Interruption
SCRM	Supply Chain Risk Management
SEM	Structural Equation Modeling
SIA	Semiconductor Industry Association
SME	Subject Matter Expert
SR	Supply Risk
OEM	Original Equipment Manufacturer

I: INTRODUCTION

The United States automotive industry was founded around the 1890s, although the automobile with a gas engine was developed in Germany and France in the 1860s and 1870s. The United States controlled the largest market share of the automotive industry in the first half of the 20th century (Rae et al., 2024). The decades of continuous functional and process improvement techniques at national, regional, and local department levels, including employee-wide training events, centered on total quality management (TQM), Lean Six Sigma, and SCRUM, to name a few. The just-in-time (JIT) manufacturing concept gave the playbook on how to reduce inventory costs since parts were available when needed (Financial Times, 2021). The goal was to design a successful supply chain flow via a systems approach. They examined the supply chain from a systems perspective and managed the total process flow of goods inventory from the supplier to the end customer (Mentzer et al., 2001, p. 7). The concept was easy to understand, but achieving maximum quality to scale with low cost and on-time delivery still needed to be solved. The increase in volume unmeasured at a global market level outside the chip automaker's infrastructure was a dangerous secret. Several factors required one to look at the supply chain dependencies of US automakers holistically.

The mass production of parts, now semiconductor chips, created an opportunity for non-US partners to control the supply of chips needed to produce cars. However, they only increased the demand based on the shortage of chips. The shortage created an environment in which US automakers and chip makers needed to pressure the US government to play nice with non-US businesses (non-US chip makers) by not enforcing tariffs.

Car manufacturers should have judged the recovery timeframe for COVID-19, resulting in decreased inventory. The lockdowns increased the demand for electronics for work and entertainment (Financial Times, 2021). The car manufacturers felt there would not be an increase in demand for automotive vehicles during COVID-19, while the demand market for semiconductor chips was second to last. The demand share percentage was essential to have an influence and priority within semiconductor chip production (See Figure 1).

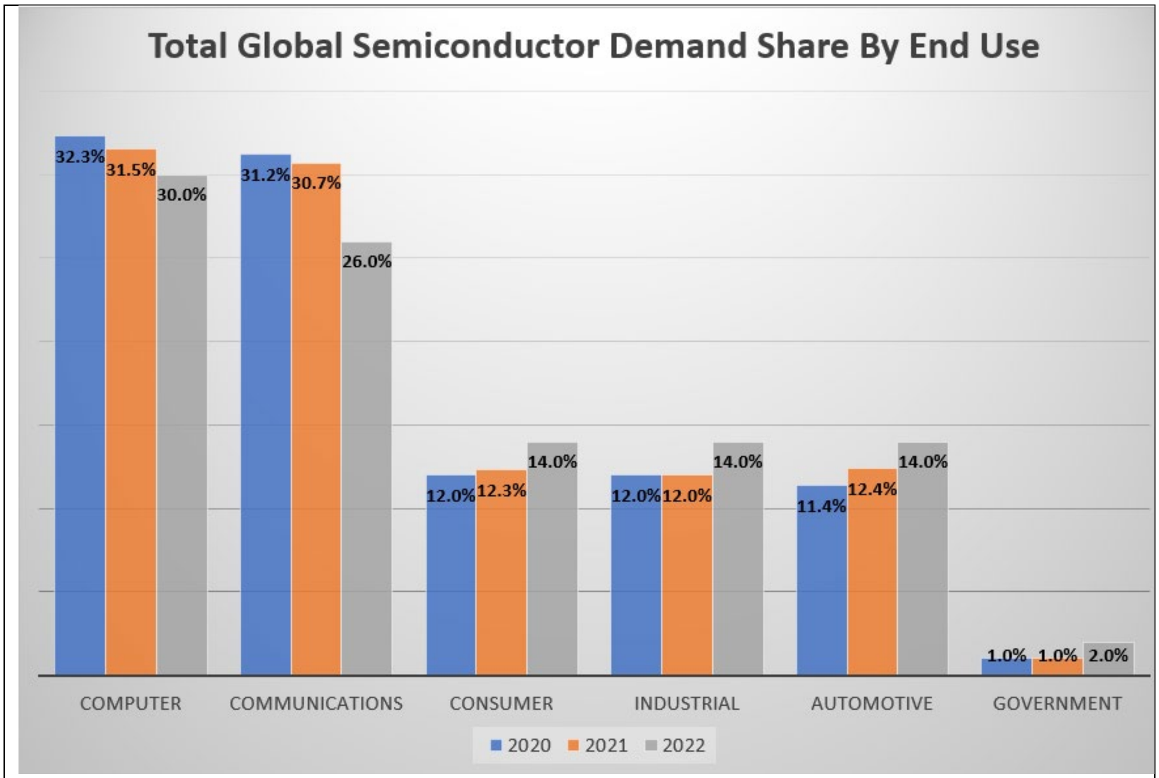

Figure 1: Semiconductor Industry Association (SIA 2020, 2021, 2022)

The low global forecasted demand for 11.40% of semiconductor chips in the automotive industry and the distance they traveled to such plants before they reached the dealership added additional time and risk. From creation to customer product, semiconductor chips can travel 31,000 miles across 70,000 international borders (Harris, 2022). According to 2020 research by the Global Semiconductor Alliance, shown above in Figure 2, before a chip eventually reaches its end user, the parts in a semiconductor can traverse well over 50,000 kilometers and more than seventy foreign borders. Since 2020, environmental uncertainty has impacted supply, demand, and manufacturing risks, resulting in a supply chain interruption. One industry affected is the automotive sector due to the semiconductor chip shortage caused by a global pandemic caused by the contiguous disease COVID-19. Therefore, designing resilient supply chains and preparing contingency plans is paramount (Katsaliaki et al., 2021).

Figure 2: Semiconductor chip tracking across the world before destination to product assembly (Harris, 2022)

The disruptive events may have a local impact on suppliers in a specific area (e.g., a labor strike brought on by new worker legislation, etc.) and individual implications (e.g., affects only one supplier, such as equipment breakdown, fire, etc.), or a global impact that affects all suppliers or supply chain (SC) echelons at once. An economic crisis, a protracted labor struggle in the transportation industry, etc., are examples of such worldwide events. All three forms (individual, local, and global) of interruption risk are possible for suppliers (Sawik, 2014). Studies on how the design of SC might be beneficial in lowering or rolling up supply chain risk exposure are abundant. For instance, researchers and industry experts claim that supplier dependence can boost the supply chain's response to risk (Blackhurst et al., 2018).

PROBLEM STATEMENT

Before COVID-19, many of the world's top automakers sourced 30% to 60% of their parts, including modules and subassemblies, from China (ETAuto, 2020; McKinsey & Company, 2019). Hence, international automakers increased their interest in producing crucial components domestically (ETAuto, 2020; McKinsey & Company, 2019). A broader nationalistic mood was aroused in other nations as trade tensions peaked with the escalation of the tariff war between the United States and China. Multinational vehicle operators were under a genuine and immediate threat from the escalation of protectionism through targeted financial trade barriers, which must be addressed.

The COVID-19 pandemic proved the automotive supply chain's vulnerability and supported the expansion of global supply methods. The abrupt shutdown of production facilities in China and the following cascading effects significantly negatively influenced the global auto industry, with the impact felt in Europe, the United States, India, and

South America. After moving their manufacturing operations offshore to low-cost nations, many automakers and suppliers are now rushing to establish a centralized management system at one point in the supply chain (ETAuto, 2020).

Returning to a centralized supply chain management system at a single site is complicated and significant, given the enormous number of required components and the various lead times for each. Additionally, original equipment manufacturers (OEMs), component suppliers, and producers of automotive subsystems are attempting to create alternate, flexible, and adaptable supply chains to reduce the susceptibility of a single source as the infection spreads. To do this, they have started reconsidering the creation of regional logistics hubs, which explores sourcing, assembly, and delivery inside the region's strategically centered management system (ETAuto, 2020).

SIGNIFICANCE OF THE PROBLEM

Automakers accept a failure rate of zero parts per billion throughout a 15-year operating lifespan and demand a 30-year supply of replacement parts. With failure rates measured in parts per million, many consumer electronics—including mobile phones—would be deemed unusable within five years. If your computer experiences a problem, restart it and give it another try. Due to their extensive history of working with component manufacturers, automakers are also subject to a unique route dependence. They rely on certain component suppliers, even when alternatives are available (Ishida, 2017). Thus, the automotive industry's parts market was a "thin market," with global decentralized management and a significant reliance on certain foreign nations as standard.

The market will become even thinner, so instead of using a decentralized management model with a structure that is unevenly distributed among different countries, it should be switched to a centralized management model that benefits from a closed-integral setup's inherent strength, with as much proximity to the producing countries as possible.

The increase of electronic vehicles (EVs) as an additional product to the firm on national and local levels will not only introduce risk from a threefold increase in semiconductor chip creation but also inventory within local automotive dealerships.

RESEARCH GAP

The priority of automotive semiconductor chips within the semiconductor industry can produce supply risk, demand risk, manufacturing risk, environmental uncertainty, contractual governance, relational governance, and a supply chain risk management plan that directly affects supply chain interruption. Many existing literature reviews have researched single-case interruptions, but no study has been conducted on multiple-risk interruptions simultaneously. The variables used in many studies include supply chain operational risk impacting supply chain performance (Chen et al.; D. I., 2013), supply risk, supply chain resilience, adaptive capabilities, technology, and supply chain resilience capabilities (Um, J., & Han, N. 2021).

RESEARCH QUESTION

What are the risk factors for supply chain interruption in the US automotive industry during the semiconductor chip shortage?

RESEARCH CONTRIBUTIONS

This study emphasizes the importance of relational governance in alleviating the impacts of supply chain interruptions, highlighting the benefits of trust-based relationships for collaboration and flexibility. It also underscores the significance of contractual governance in ensuring operational stability through adherence to standards. Contrary to conventional beliefs, the research suggests that environmental unpredictability and manufacturing risk might have less influence than previously assumed, opening avenues for further exploration in supply chain risk management. It also proposes that effectively managing demand fluctuations could help mitigate interruption, offering new strategic possibilities.

The study recommends several practical measures for supply chain administrators, including adopting comprehensive risk management frameworks, robust supplier management strategies, and advanced forecasting techniques. It also advocates for a holistic governance strategy, integrating relational and contractual mechanisms to reduce vulnerability to interruptions. This research significantly contributes to understanding supply chain interruptions and offers practical approaches for organizations to enhance their preparedness and response. Its insights are precious in navigating the complexities of modern supply chain management amidst rapid technological advancements and global networks.

II: LITERATURE REVIEW AND THEORY

According to the 2021 Semiconductor Industry Association (SIA), which monitors the state of the semiconductor industry, the US market share of global semiconductor manufacturing capacity went from 37% in 1990 to 12% in 2021. East

Asia, with China, is projected to command the largest share of global production by 2030, representing around 75% of the world's semiconductor production capacity. The US wafer capacity share has steadily decreased from 57 percent in 2013. Other leading US-headquartered front-end semiconductor wafer fabrication capacity locations were Singapore, Taiwan, Europe, and Japan. China has attracted considerably less US investment in front-end fabrication than the other central locations. The average rate of chip manufacturing output has grown five times faster overseas than in the United States over the last decade. The increase in chip output overseas is primarily due to robust incentive programs nations have implemented to attract semiconductor manufacturing. The United States must implement similar incentives to remain competitive. (2021 State of the US Semiconductor Industry)

According to an executive order signed by President Biden in April 2021 and enacted by several federal agencies, the supply chains for semiconductors, pharmaceuticals, large-capacity batteries, and six industrial bases are the subject of a year-long investigation. The agencies were asked to recommend quick government actions to address supply chain risks. The directive addressed threats to national security without considering the cost increase relative to semiconductor chips made outside the United States (Fortnam, 2021).

Car manufacturers should have judged the recovery timeframe for COVID-19, resulting in decreased inventory. The lockdowns increased the demand for electronics for work and entertainment (Financial Times, 2021). Car manufacturers felt there would not be an increase in demand for automotive vehicles during COVID-19, while the demand market for semiconductor chips was second to last. The demand share percentage is essential to have an influence and priority within semiconductor chip production (2021 State of the US Semiconductor Industry). Semiconductor chips can travel 31,000 miles across 70,000 international borders from creation to customer product (Harris, 2022). The traditional process flow of having a product go from one place to another is a fundamental concept; however, semiconductor chips have a higher level of complexity than other goods, including local vs multiple international transfers. The transportation steps noted above are an opportunity for massive risk within the supply chain flow for semiconductor chips.

Due to the high cost of making items in the United States compared to other nations, American businesses have chosen the outsourcing model for essential components, which has resulted in a decrease in manufacturing jobs here in the country. The pandemic removed the bandage on the risk of failing to control crucial aspects of risk management. In the Creating Helpful Incentives to Produce Semiconductors [CHIPS] Act, the United States sought to increase local microelectronics production and to counteract foreign dominance in the semiconductor chip industry. According to the Pentagon's Fiscal Year 2020 Industrial Capabilities Report, Beijing is expected to control the world's semiconductor output by 2030.

The US government continues to impose restrictions on technology exports to businesses that collaborate with the military of the Chinese Communist Party (CCP) and their semiconductor manufacturing. The Semiconductor Industry Association and Boston Consulting Group reported that the 10-year total cost of ownership of a new front-end fabrication facility, or fab, in the United States, is 30% higher than in Taiwan, South Korea, and Singapore and 37% in 50% higher than in China. This increase in market share indicates that the competition is challenging to overcome the high cost of making items in the United States compared to other nations; American businesses have chosen the outsourcing model for essential components, resulting in a decrease in manufacturing jobs here in the country.

The impact of the 2021 semiconductor chip shortage has revolutionized the redesign of products from manufacturers that have been shipping uncompleted units, focusing on older, lower-tech models, including cars. This has created a used car segment with increased demand, resulting in price increases. A few examples of the chip shortage are given below.

Snowmobiles shipped without large GPS screens will be installed once parts from recreational vehicle maker Polaris Inc. are available. The electric stand-up vehicle for university and airport security officer maker T3 Motion is redesigning its products to use fewer computer chips and electronics, eliminating five individual circuit boards that control features such as batteries, lighting, and sirens (Hufford, A., 2021). The short supply of vehicles resulted in 82% of new car buyers paying more than the manufacturer's suggested retail price (MSRP), according to the consumer research site Edmunds.com (Colias et al.; N., 2022).

This study offers a paradigm for evaluating supplier interruption risk based on strategy, structure, performance, and qualities as altered by turbulence in the environment (Trkman et al.; K., 2009). Given the absence of a single optimal approach to managing uncertainties and risks, firm-specific risk comparisons between supply chains stem from unique environmental requirements and characteristics. The contingency theory is the strategy's foundation for dealing with risk (Trkman et al.; K., 2009).

CONTINGENCY THEORY

This study's theoretical framework posits that a firm's external environment is the critical determinant of its optimal manufacturing strategy. In highly uncertain contexts, manufacturing companies are expected to adopt risk-averse techniques to cope with the unpredictability of their operational conditions. Conversely, in more stable economies, manufacturing companies may be more inclined to take risks to gain competitive advantages (Donaldson, 2001).

According to the structural contingency theory, the organizational structure must accommodate the three potential environmental, size, and strategy outcomes. The structure can be divisional, bureaucratic, or organic (Donaldson, 2001). The essence of contingency theory is that no management or organizational strategy is universally applicable; the best strategy is contingent upon the unique circumstances and external environment. Nembhard's (2005) supply chain model empowers manufacturers to make informed decisions about facility locations, vendors, and market sectors. The ability to adapt and shift resources quickly is a crucial aspect of this model, as it enables firms to mitigate supply risk and meet high product demand.

While logistics service providers and manufacturing enterprises perceive demand risks as the most menacing, it is noteworthy that many from both groups consider supply chain risks as the most substantial (Kersten, 2007). Supply chain interruptions triggered by natural disasters (external environmental uncertainty) profoundly impact performance, particularly when they coincide with high supply chain complexity and uncertainty (Bode & Wagner, 2015).

According to the contingency hypothesis, businesses should modify their supply chain risk management (SCRM) procedures to meet the unique requirements and difficulties of their industry, market, and product line. For instance, those in high-demand volatility industries might need to use SCRM strategies that differ from those in more stable industries. Similarly, businesses with high seasonality in their product offerings may need to use different SCRM strategies than those with more stable product demand (Zsidisin, 2003).

The contingency theory (CT) supports the effects of high environmental uncertainty (EU) (Thompson, 1967). The study will investigate how supply, demand, manufacturing risks, supply chain risk management, environmental uncertainty, relational governance, and contractual governance are direct effects to better understand how to combat future interruptions based on the projected increase in inventory demand and future product challenges in the US automotive industry.

III. THEORETICAL BACKGROUND AND RESEARCH MODEL

CONCEPTUAL FRAMEWORK

The theoretical foundation of the conceptual research model depicted in Figure 3 identifies risk factors that influence supply chain interruption in the semiconductor chip shortage in the US automotive industry. The model shown in Table 1 contains three independent variables affecting supply chain interruption, which were used in the paper by Trkman and McCormack (2009): supply risk, demand risk, and environmental uncertainty. One independent variable influencing supply interruption impact was used in the paper by Wu et al. (2006): manufacturing risk and supply chain risk management are two independent variables used in the paper by (Gurtu et al., 2021). Two independent variables, relational governance and contractual governance, were used in the paper by (Lee et al., 2023). The potential direct effects are being controlled by age, gender, number of dealership employees, employment status, state of participant, organizational role, total years of dealership experience, current years of dealership experience, and types of cars sold at the current dealership.

TABLE 1: Conceptual Framework

Construct	Theory	Framework
Supply Risk	Contingency Theory	Trkman (2009)
Demand Risk	Contingency Theory	Trkman (2009)
Manufacturing Risk	Contingency Theory	Trkman (2009)
Environmental Uncertainty	Contingency Theory	Trkman (2009)
Supply Chain Risk Management	Contingency Theory	Gurtu, Amulya, and Jestin Johny (2021)
Relational Governance	Contingency Theory	Lee, C. H., Son, B. G., & Roden, S. (2023)
Contractual Governance	Contingency Theory	Lee, C. H., Son, B. G., & Roden, S. (2023)

Contingency theory is the primary theoretical framework utilized by the conceptual research model to clarify the impact of different risk factors on supply chain interruptions in the automotive sector. Effective management is contingent upon the context and circumstances encountered by the organization (Donaldson, 2001). This theory substantiates that a universal strategy for addressing organizational and environmental challenges does not exist. The model's objective is to provide a thorough understanding of how automotive companies can strategically reduce risks by adjusting their operations to address vulnerabilities in the supply chain and the external business environment. By applying the contingency theory framework, the model discerns the pivotal risks and proposes that organizations can substantially alleviate the detrimental consequences of these interruptions by implementing adaptive strategies. This strategy emphasizes the significance of adaptability and customized strategy formulation in the face of dynamic and complex market challenges.

A conceptual framework is proposed to assess the impact of supply chain interruptions. This framework is founded upon the contingency theory discussed in the preceding section and empirical research findings. Figure 3 illustrates the graphical representation of the model, which guides the generation of subsequent hypotheses.

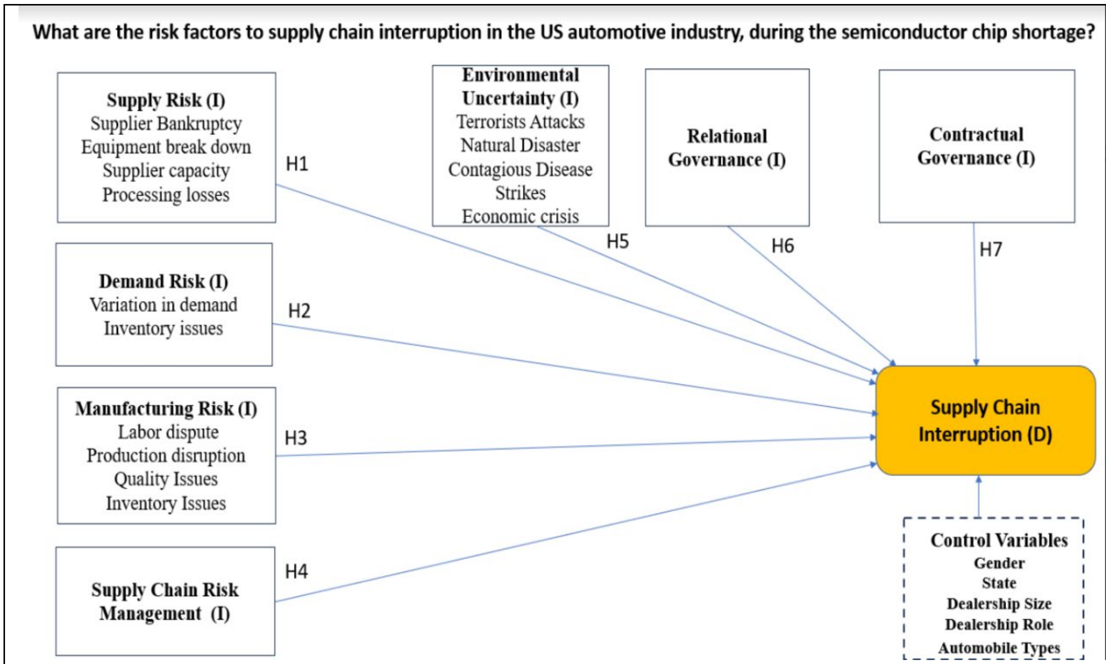

Figure 3: The Conceptual Research Model

HYPOTHESIS DEVELOPMENT

The constructs used within this study are shown in Figure 1 above and contain the following factors: SR, DR, MR, EU, SCRM, RG, and CG as independent variables—the dependent variable of SCI. (See Appendix A for the variable source list.)

SUPPLY RISK

The growing importance of supply risk is evident in both academic and practical spheres, attributed to various factors, including recent crises, globalization, and the increasing competitiveness of the marketplace. Additionally, contemporary supply chains have become more robust than traditional methods (Harland et al., 2003; Roth et al., 2008). Supply risk management is paramount for businesses to achieve economic benefits and to establish a competitive advantage. This is mainly attributable to the escalating unpredictability and reliance on the entire supply chain, encompassing every stage from suppliers to end customers (Zhu et al., 2017).

Companies face multiple risks related to the initial stages of their supply chains. Supply risks are present in various aspects, such as procurement, suppliers, supplier agreements, and supply networks. These risks can lead to supply chain interruption. For example, production was halted due to the unavailability of raw materials and labor during the COVID-19 pandemic (Upadhyay et al., 2024).

Supply risks can interrupt the supply chain due to supplier failures and single-supplier environments with no contingency. In 1997, a Toyota subsidiary named Aishin Seiki Co Ltd was the source of a faulty brake value. Toyota purchased the part from Aishin and used it in most of its cars. Many Toyota plants kept only a four-hour supply of the value, and once depleted, Toyota had to close 20 auto plants in Japan that produced a run rate of 14K vehicles per day (Li et al.; J., 2004).

Ji and Hong (2024) scrutinized supply risk and supply chain interruption within the context of a single manufacturer and supplier. Their study investigated strategies like penalty mechanisms, emergency suppliers, and strategic investments to mitigate supply chain interruption risks, each representing a different approach to risk management—transferring, diversifying, or sharing it. Through their analysis of these strategies across different interruption risk levels, the research elucidates their effects on supply chain resilience. It emphasizes the necessity of tailored risk management tactics, highlighting the pivotal role of collaborative relationships between manufacturers and suppliers in upholding resilience and stability. The study also reflects on the response to the COVID-19 pandemic, illustrating how it underscored the vulnerability of global supply chains and prompted varied coping strategies indicative of different risk attitudes—transfer, diversification, or sharing.

Some factors that can disrupt the supply market include supplier business risks, production capacity constraints, quality issues, and advancements in technology and product design (Zsidisin et al., 2000). An interruption in the supply chain impacts the bilateral relationship between a central purchasing entity, such as a dealership, and one of its suppliers. The primary emphasis is on interruptions within the "inbound logistics network" or supplier network. These interruptions, which may include issues related to increased production costs, failed deliveries, and facility fires, posed substantial risks or hindered the regular business operations of the central organization. Kraljic (1983) was one of the pioneers who highlighted the importance of enterprises actively evaluating and controlling the uncertainties in their supplier portfolio to prevent expensive supply interruptions.

The consequences of an interruption constitute pivotal data that an organization analyzes to formulate its hypotheses regarding the stability of the impacted exchange. Concern for scrutinizing prevailing behaviors, regulations, approaches, or frameworks grows in tandem with the severity of adverse incidents (Hedberg, 1981; Zakay et al., 2004).

H1: As **supply risks** increase, the **supply chain interruptions** will increase.

DEMAND RISK

Demand risk is the possibility that the anticipated demand will differ from the existing demand (Kumar et al., 2010). It is more challenging for producers to predict demand when wide variances are reflected in order changes, increasing demand risk. Order modifications may take the form of volume, expediting, or inclusion. The shifts could be brought on by new product introductions or shorter product life cycles (Ho et al., 2005; Manuj & Mentzer, 2008). They might also be "provider-induced"; customer actions like order batching and sales promotion amplify demand variations (Lee et al., 1997; Croxton et al., 2002). Additionally, the bullwhip effect can sometimes amplify demand signals and raise order variability even when market demand is stable, and the demand pattern is flat (Lee, 2002). One of the main goals of a supply chain is to match supply and demand. Unexpected changes in demand, however, reduce prediction accuracy and make it more challenging to accomplish this aim (Cohen & Kunreuther, 2007). The supply chain's efficiency and efficacy must be more consistent between actual orders and forecasts. If the forecast is more optimistic than the actual demand, the supply chain may become inefficient due to excess inventory, obsolescence, inefficient capacity use, or price markdowns (Sodhi & Lee, 2007).

If the projection is lower than the actual demand, there may be shortages on the shelves and a failure to satisfy the consumer, which makes the supply chain inefficient. Demand risk threatens the supply chain's ability to fulfill its consumers. Hence, we hypothesize that:

H2: As **demand risks** increase**,** the **supply chain interruptions** will increase.

MANUFACTURING RISK

While manufacturing risk comes from operations inside a focal firm, operations outside cause supply and demand risks. Consequently, manufacturing risk can also be brought on by external risks, as suggested by a system perspective. According to Hopp and Spearman (2000), variation spreads. Unexpected shifts in demand or customer orders cause volatility in the production process and raise manufacturing risk. To adjust for variations in demand or supply, the gross needs in an MRP system must be adjusted between periods, which ultimately causes fluctuations in the production process and increases manufacturing risk (Whybark & Williams, 1976). This is an example of the propagating effect. The “easy fix” of employing buffers to reduce supply and demand risks can likewise have this ripple effect. Inventory, capacity, or giving consumers longer lead times could be utilized as buffers (Newman et al., 1993). However, increasing inventory only further conceals the actual demand (Mason-Jones & Towill, 1998), worsens forecast accuracy, poses a more significant threat to achieving smooth operation, and thus heightens manufacturing risk. Extended lead periods may cause excessive production process congestion (e.g., Whybark and Williams, 1976) and exacerbate output variation. The highly variable outputs from suppliers or client orders become the extremely variable inputs into the manufacturer's production process (Hopp & Spearman, 2000), which supports the ripple effect. As a result, along the supply chain, the unpredictability coming from one firm might make another firm's variability greater (Germain et al., 2008). Such a ripple effect hurts a company's internal capacity to create goods and services, production quality and timeliness, and profitability (Wu et al., 2006). Hence, we hypothesize that:

H3: As **manufacturing risks** increase, the **supply chain interruptions** will also increase.

SUPPLY CHAIN RISK MANAGEMENT

Supply networks are more vulnerable to risks because of globalization, elevated customer demands, and environmental volatility (Christopher & Peck, 2004; Norrman & Jansson, 2004).

Supply chain risk management (SCRM) has become increasingly essential. SCRM is not a solitary endeavor but requires a coordinated approach among all supply chain participants, as Jüttner et al. (2003) stated. This collaborative aspect of SCRM is further reinforced in several studies (Zsidisinet al., 2000), where collaboration has been incorporated into risk reduction frameworks. A prescriptive framework for collaborative risk management, called W4RM, is introduced and used to support risk management. W4RM is a collaborative tool that fosters a culture of collaboration within and among communities, enabling ongoing risk management (Soares, 2021). The significance of information sharing and communication in collaborative risk management is examined by both (Greer, 2002) and (Rollíns,2017). Greer's analysis pertains to software engineering, while Rollíns concentrates on supply chain operations.

A thorough analysis of supply chain risk management (SCRM) procedures and a framework for risk management in international supply chains are two examples of risk reduction frameworks. In a supply chain risk environment, the two examples of risk reduction frameworks are a thorough analysis of supply chain risk management (SCRM) procedures and a framework for risk management in international supply chains. This process highlights the significance of risk identification, assessment, mitigation, and monitoring.

The application of contingency theory to supply chain risk management, specifically in supply chain interruptions, has been the subject of numerous studies (Zhang, 2016). Moreover, Sun (2016) put forth all-encompassing frameworks emphasizing contingency strategies, including virtual dual procurement and robust inventory control, to manage interruptions. Trkman (2009) and Stading (2007) underscore the significance of identifying and categorizing suppliers according to their performance and characteristics and the necessity of a framework that capitalizes on the supply chain assets to mitigate interruptions. The significance of cash-flow variability and the necessity for robust supply chains in mitigating interruption risks are topics explored by Yew (2011) and Xu (2008). Practical insights regarding implementing contingency production-inventory control policies and alleviating interruption impacts in supply chains are offered by Rozhkov (2018) and Hopp (2011). These studies and their findings suggest that SCRM often implements contingency production-inventory control, significantly reducing supply chain interruption.

Hence, we argue:

H4: As **supply chain risk management** (SCRM) intensifies, more **supply chain interruptions** will be monitored.

ENVIRONMENTAL UNCERTAINTY

Natural catastrophes such as earthquakes, tsunamis, and floods are consequences of the earth's natural risks. They result in monetary, ecological, and societal damages. The supply chain in the automobile sector was impacted by the earthquake and tsunami in Japan on March 11, 2011, and the flood in Thailand at the end of July 2011. Considering previously neglected areas of supply chain risk is imperative, particularly considering the impact experienced by numerous manufacturing factories and industrial zones in both countries due to supply chain shortages (Chen X, 2012).

Epidemic outbreaks are another type of risk, as are Ebola, swine flu, and COVID-19. Epidemic outbreaks are multilayered in complexity, branching from three drivers:

1. The presence of long-term interruptions and their unpredictable growth
2. The concurrent spread of interruptions in the supply chain (known as the ripple effect) and the spread of epidemic outbreaks in the population (known as pandemic propagation)
3. The concurrent interruptions in logistics infrastructure, supply, and demand

These historical events are examples of environmental uncertainty that leads to significant interruptions to the global supply chain. Hence, we argue that:

H5: As **environmental uncertainty** increases**, supply chain interruptions** will increase**.**

GOVERNANCE STRUCTURE

Relational governance encompasses two key aspects. Firstly, it involves a type of organizational "quasi-integration" that signifies a long-term relationship and a significant reliance on the supplier and the buyer's business performance. The relationship is demonstrated by the integration of both parties in the development of products (Blome et al., 2013). Secondly, it encompasses a process dimension that involves relational norms and trust in value co-creation (Artz & Brush, 2000). Relational norms encompass the anticipated conduct that is partially shared across a collection of decision-makers and is oriented toward achieving collective and group objectives (Heide & John, 1992). These norms encompass various aspects, such as adaptability and unity (Liu et al., 2009). Trust, which encompasses confidence in a partner's honesty, credibility, and generosity, is crucial in a relationship that involves risky exchanges (Cao & Luminau, 2015). This confidence is particularly evident when there is a need to codify data on products and processes to a greater extent and efficiently without requiring specific investments from the parties involved (Gereffi et al., 2005). The complex and ever-evolving field of supply chain interruption management is closely associated with the contingency theory of relational governance. The significance of governance mechanisms and contingency plans in efficiently monitoring interruptions has been emphasized by Wathne (2004) and Sun (2016). Sun emphasizes the criticality of implementing a comprehensive framework for emergency management (2016). Relational governance's function in managing supply chain interruptions is critical. The significance of trust and control mechanisms in reducing relational risks and improving adaptability in customer relationships is emphasized by both Zhao (2013) and Wathne (2004).

Obi (2020) provides additional evidence supporting this notion, demonstrating that relational governance benefits supply chain performance, specifically regarding information sharing and quality, improving the monitoring of the impact of interruptions. (Wang, 2007). Moreover, Müller (2014) emphasizes the significance of information transparency and adaptability in the management of interruptions, with Wang placing particular emphasis on the function of relational governance within this framework. Based on the above logic, we hypothesize:

H6: Relational governance will enhance the monitoring of **supply chain interruptions**.

Contractual-based governance has the potential to monitor and mitigate the risks associated with alliance partnerships, improve alliances' overall performance, and promote the transfer of knowledge (Sheng et al., 2018; Lee et al., 2006; Wang et al., 2020). Firms may exhibit a preference for arm's-length contractual agreements to exercise control over the nature and quantity of information exchanged, mitigate the potential dangers associated with knowledge transfer surpassing the intended boundaries set by the parent company, and establish the groundwork for future trust between firms (Lee et al., 2006). With such knowledge, firms may improve their ability to monitor the impact of supply chain interruptions.

Contractual governance in the context of supply chain interruption has highlighted its role in shaping firms' responses to interruptions. Liu (2021) found that a balance between contractual and relational governance can enhance firms' bridging responses to interruptions, with this effect being moderated by cultural distance (Ata, 2016), emphasizing the need for risk management as part of supply chain governance to enhance resiliency (Neboh, 2022).

Moreover, Sun (2005) underscored the importance of supply chain resilience and agility, explicitly focusing on supply chain contracts' role in coordinating responses to cost interruptions (Thorne, 2016). Moreover, Salminen (2016) discussed the role of private and contract-boundary-spanning governance mechanisms in managing supply chain risks. Lastly, Liu (2019) and Ya-hong (2005) provided insights into the coordination problem in supply chains and the different forms of supply chain governance and contracts, respectively. In sum, firms may improve their ability to monitor the impact of supply chain interruptions by closely monitoring contractual relationships. Hence, we argue:

H7: Contractual governance will enhance the monitoring of **supply chain interruptions**.

IV: RESEARCH METHODOLOGY

RESEARCH DESIGN

This study used a quantitative survey method to examine individual intentions and perceptions of the risks within the automotive dealership industry during a semiconductor chip shortage (Creswell, 2016). Quantitative research primarily aims to investigate variations and transformations in one or more variables in correlation with one or more supplementary variables. A crucial prerequisite for deriving accurate inferences from our data is determining which changes in variables accurately reflect genuine changes in the entities and qualities they represent, and which changes are superficial, transient, or merely a result of inaccurate measurements (Aidley, 2018, p. 45). To gain a deeper understanding of the intricate connections inherent in contemporary research endeavors within social science, there is a growing imperative to employ advanced techniques for multivariate data analysis (Sarstedt, et al., 2021, p2). Multivariate analysis utilizes statistical techniques to examine multiple variables concurrently. The variables denote parameters linked to individuals, corporations, occurrences, undertakings, circumstances, and similar entities. Measurements are commonly acquired through surveys or observations, which gather primary data. However, they can also be derived from secondary databases (Ibid).

POPULATION

Sample size is one of the critical data characteristics of PLS-SEM, as well as distribution, missing values, and scale of measurement. Sample size addresses the data characteristics of neglectable identification issues with small sample sizes and achieves high statistical power with them. Larger sample sizes increase PLS-SEM estimations' precision (i.e., consistency) (Sarstedt et al., 2021, p2).

This study's population was employees who work at an automotive dealership that sells new or new/used cars in the United States (US). Employees must have at least two years' experience in a US automotive dealership. Employees missing any of the qualifications were not included in the scope of this study. The employee demographic information captured included age, gender, number of dealership employees, employment status, state, organizational role, race, educational status, total years of dealership experience, current years of dealership experience, and types of cars sold at the current dealership.

This study utilized two survey samples: one for the pilot study (100 participants) and one for the main study (539 participants). The sample size was sufficient for a primary pilot based on the survey instrument and internal consistency reliability of variables via previously validated instruments. A minimum sample size of 30 participants will be sufficient to assess the reliability of the survey (Bujang et al., Y. K, 2024). The main study's sample size calculation is based on the statistical power estimate. I used the National Automobile Dealers Association (NADA) measurement of the number of US dealerships, 16,835 in 2023, based on the NADA website (https://www.nada.org/media/4695/download?inline). With a 95-percent confidence level and a 5-percent margin of error, an ideal sample size of 376 will give the required statistical power (Sarstedt et al., 2021, p. 27).

INSTRUMENT DEVELOPMENT

Preexisting instruments from prior research were utilized to assess all constructs with one-word clarity modifications (Strauch et al., 2004). The verified measurement items were utilized, guaranteeing both face and content validity. The wording of the survey questions was revised to account for contextual specifics related to an automotive dealership environment while remaining based on the questions outlined in previous research. The survey tool allowed the survey to be distributed to participants in the automotive industry only. Each construct of the model was measured with reflective items on a seven-point Likert scale. Supply risk (SR) had ten items for the construct adopted from Wagner, S.M. and Bode, C. (2008), Muhammad Saeed Shahbaz; Raja et al.; MD Fauzi Bin Ahmad (2019) and Kumar, V., Bak, O., Guo, R., Shaw, S. L., Colicchia, C., Garza-Reyes, J. A., & Kumari, A. (2018). Demand risk (DR) had seven items for the construct adopted from Wagner, S.M. and Bode, C. (2008), Atuahene-Gima, Kwaku, and Haiyang Li (2004) and Jie Chen, Amrik S. Sohal & Daniel I. Prajogo (2013). Manufacturing Risk (MR) had ten items for the construct adopted from Kumar, V., Bak, O., Guo, R., Shaw, S. L., Colicchia, C., Garza-Reyes, J. A., & Kumari, A. (2018). Supply Chain Risk Management (SCRM) had seven for the construct items adopted from Wagner, S.M. and Bode, C. (2008). Relational Governance (RG) had twelve items for the construct adopted from Sheng, S., Zhou, K.Z., Li, J.J (2018). Contractual Governance (CG) had seven items for the construct adopted from Sheng, S., Zhou, K.Z., Li, J.J (2018). Environmental Uncertainty (EU) had twelve items for the construct adopted from Wagner, S.M. and Bode, C. (2008), Inman, R Anthony, & Kenneth W Green (2022). Punniyamoorthy, M., Thamaraiselvan, N., & Manikandan, L. (2013), Muhammad Saeed Shahbaz; Raja Zuraidah RM Rasi; MD Fauzi Bin Ahmad (2019). Supply Chain Interruption (SCI) had nine items for the construct adopted from Bode, Christoph, Stephan M. Wagner, and Kenneth J. Petersen (2011).

The questionnaire survey also includes demographic questions such as age range, gender, number of dealership employees, employment status, state of the participant, organizational role, race, education status, total years of dealership experience, current years of dealership experience, and types of cars sold at the current dealership and the following three screening questions to ensure that only qualified participants can take the survey: The first screening question confirmed the participate had two years minimum automotive dealership experience. The second screening question confirmed the participant does not hold the dealership's foreman or administrative role. The third screening question confirmed that the automotive dealership sells new or new/used cars. The rationale for the screening questions was to make sure the survey participants' were directly in dealership roles related to supply chain risk operations internally. The complete questionnaire utilized in this research is presented in Appendix E.

DATA COLLECTION

The Pollfish web survey platform was used to conduct the study for a probability-based sample for hypothesis testing (Yeager, 2011). A benefit of using the web survey method is that online surveys are typically the least expensive survey delivery method because they can be sent to respondents without incurring the expense of hiring interviewers. The second benefit to using online surveys is that they allow the usage of graphics in questions, such as tables, charts, or maps, and you can randomly select questions and response categories. The third benefit of online surveys is that they may reduce measurement errors (D. et al., 2019). One example of measurement errors is that respondents are more likely to answer sensitive questions if an interviewer is not truly present (Lind et al., 2013; Currivan et al., 2004).

Participants were initially presented with the terms of the survey platform, and informed consent was obtained. Participants were then presented with three screening questions to ensure that only those with direct knowledge of the automotive industry took the survey. If qualified, survey participants were presented with the questions described in Appendix E in sequence. After answering the relevant questions, an attention check was administered. Upon completing the survey in Pollfish, the participants were thanked for their participation and dismissed (Schreuder, 2001).

PRETEST STUDY

Pretesting approaches can identify issues with the phrasing of questions and the selection of responses. By enlisting the assistance of subject matter experts (SMEs) to present a predetermined questionnaire to a limited sample of participants who closely resemble those to be included in a research study, it is possible to detect potential challenges that may contribute to hesitancy or confusion (Schutt, R.K., 2019). A pretest study was completed with the Qualtrics survey instrument before executing the pilot study for quality control. The objectives of the pretest were to test the clarity of questions, estimate the time needed to complete the survey and confirm the format of the questions on various platforms and media, including mobile and laptop.

The Qualtrics survey instrument was initially examined by a team of 15 SMEs consisting of peers and research experts. The SMEs were provided with the study consent, intent, construct definitions, construct questions, and a feedback area to capture thoughts and questions about the construct within each section. The SME group assessed and provided evidence of face validity for the nine constructs and was able to complete questions in the areas of supply risk (SR), demand risk (DR), and manufacturing risk (MR) (independent variables), including moderating variables of supply chain risk management (SCRM), environmental uncertainty (EU), relational governance (RG), and contractual governance (CG) with the dependent variable of supply chain interruption (SCI).

The SMEs gave direct insights into how to improve the survey for participants in Table 2. The first suggestion was to remove the instructional tense of using the term negative impact. The second suggestion was to add definitions for specific terms, such as relational, to ensure the survey participants understand the terms. The third suggestion was to give clear and direct instructions to the survey participants. The fourth suggestion to reverse-code items to eliminate acquiescence bias was proposed, as well as item modification, removing negative connotations. The final suggestion was to clarify the construct definition for targeted clarification before presenting the question. Adjustments were made to the question structure formatting for all inquiries to enhance the instrument's clarity.

TABLE 2: Pretest Study Subject Matter Experts Comments

Construct Name	**Subject Matter Experts (SME) Comments**
Supply Risk (SR)	Price and cost verbiage needs to be clarified.
	Quality from purchasing verbiage could be more precise.
	Supplier dependency vs. dependency on a single supplier needs to be clarified.
	Consider dropping the first congratulatory paragraph, which adds to the cognitive load.
Demand Risk (DR)	Demand fluctuations and volatile customer demands are very similar.
	I need help understanding reputation risk.
	Do you mean reputation risk impacting demand?
	Consider rewording a negative impact on demand risk to an increase in demand risk.
	Clarify whose reputation you are referring to in the last item.
	Shouldn't the question be ... a negative impact ON demand risk?
Manufacturing Risk (MR)	"variability in process" - I think you need to specify which process and whose process (internal processes? Supplier process? etc.)
	Specify which organization you are referring to in the last item. (manufacturer, supplier, or customer).
	Vague inspection and acceptance procedures by whom? The manufacturer or dealer? Should these procedures be codified?
Environmental Uncertainty (EU)	Uncertainty due to government laws/regulations - is this specific to the US government or overseas? I would add other international disruptions, such as military coups or other instability (e.g., Ukraine/Russia).
	Administrative barriers from whom or where?
	Environmental uncertainty - macroeconomic uncertainty - what would this mean to an employee at a car dealership? What type of employee are you targeting: sales, finance, service, general management? All types?
Relational Governance (RG)	Will the typical person in the automotive sector know what relational governance is?
	Flexible in response to your partner's request for changes - who is flexible? Which partners? For example, do you want to know whether it is the car manufacturers or other suppliers?
Contractual Governance (CG)	You do not need to do so in the first two responses.
	The phrasing of the second question could be more comfortable. I suggest deleting the 4th question. What happens in the case of unplanned events?

Supply Chain Risk Management (SCRM)	The word *our* seems out of place in some of these responses. . . I feel like some are unnecessary, and others might be best to use *your* since this is from the perspective of the specific car dealership.
	Supply chain managers at the corporate office, then I would have the requisite visibility to answer these questions.
Supply Chain Disruption (SCD)	These seem clear.
	Please check the Section 8 header; it was not displaying the header. I recommend checking the Likert scale's font and distribution since they seem too close.

Based on the SMEs' feedback, the pilot test study was improved in the following areas. Subsequently, the instrument was made available for pilot testing, catering to a target sample size of 100 participants through the Pollfish distribution system.

PILOT TEST STUDY

The pilot study, launched in October 2023 using Pollfish, took one day to reach the target of 100 participants, as shown in Appendix B. Ninety responses were validated through data cleaning, which consisted of time- and attention-check measures. Appendix C summarizes the demographics of the pilot study respondents. It shows that 52% of the respondents were male and 48% were female. Approximately 37% of the respondents were between ages 35 and 44, 28% were between ages 45 and 54, 27% were between ages 25 and 34, 7% were greater than 54, and 2% were between 18 and 24.

Regarding the number of dealership employees, 26% reported 251–500, 19% reported 101–250, 18% reported 51–100, 16% reported 501–1000, 8% reported 26–50, 4% reported more fabulous than 5000, 3% reported 1001–5000, 2% reported 1 and 1% reported zero. 86% of the respondents reported being employed for wages, 10% reported being self-employed, and 1% reported being a student, unemployed looking, unemployed not looking, or retired. Regarding education status, 38% reported having a university degree, 27% reported having a vocational technical college, 21% reported having a high school diploma, and 14% reported having postgraduate education. Approximately 21% of the respondents had an organizational role in senior management; 16% reported supervisor; 10% reported middle management; 7% reported other non-management and foreman; 4% reported owner/partner and sales staff; 3% reported president CEO chairperson, chief financial officer, chief technical officer, human resources (HR) manager, and supply manager; 2% reported director, faculty staff, and project management; 1% reported executive, not working. Product manager, 0% reported craftsman, prefer not to say and technical staff.

In the state location of the participant, a total of 32 states were represented in the study. Florida had the most significant participation of 9% reported; California had the second highest participation of 7%; Georgia, Maryland, New York, North Carolina, and Texas reported 6%; Illinois, Missouri, New Jersey, Pennsylvania reported 4%; Michigan reported 3%; Arizona, Connecticut, Indiana, Louisiana, New Mexico, Oklahoma, Ohio, Rhode Island, South Carolina, Tennessee, Virginia, and Washington reported 2%; Alabama, Arkansas, Kentucky, Minnesota, Mississippi, Nebraska, Nevada reported 1%.

Regarding race, 33% were White, 20% were Black, 18% were Hispanic, 13% were Latino, 8% were Arab, 4% were Asian, 2% were Multiracial, and 1% were Other.

Based on the participants' current location, the types of cars sold at the current dealership reported that 33.3% had gas-powered and electric hybrids of the same model; 26% reported gas-powered only; 21.1% reported gas and electric cars (not the same car model);18.9% reported electric vehicles only; and zero percent reported not working at a dealership.

Reflective measurement models were assessed on an indicator level (indicator reliability), construct level (internal consistency reliability (Cronbach's alpha and composite reliability), validity assessment (convergent validity, average variance extracted), and discriminant validity (HTMT) (Sarstedt et al., 2021, p. 116). In Table 3, Cronbach Alpha measured scale reliability, expressing the degree of internal consistency and overall inter-correlation between items (Aldley, 2018, p. 331). Cronbach's alpha assumes equal indicator loadings, meaning all the indicators have equal outer loadings on the construct, which is one weakness. Cronbach's alpha can be sensitive to the number of items in a scale, sometimes leading to underestimating internal consistency dependability.

Hence, Cronbach's alpha can serve as a more cautious indicator of internal consistency reliability (Sarstedt et al., 2021, p. 119). According to Hair Jr et al. (2021), Cronbach's alpha is considered a conservative measure of reliability. On the other hand, composite reliability tends to overestimate the internal consistency reliability, leading to relatively higher reliability estimates. Comparable to coefficient alpha, composite reliability (CR) estimations yield an internal consistency reliability coefficient that quantifies the extent to which the test components account for the whole variation of the composite test score (Hair Jr et al., 2021).

In Table 3, validity can be broken down into two distinct categories: convergent and discriminant. In assessing convergent validity, the extent to which measurements that exhibit a robust correlation with a shared component are interconnected. The average variance extracted (AVE) metric will be utilized to assess convergent validity; indicators must exceed a threshold of 0.5 in the AVE value to pass the convergent validity test (Fornell-Larcker, 1981, p. 46). To determine the study's acceptability, it is essential to assess the reliability and validity of the latent and indicator variables included in the pilot study. Table 3 shows the reliability and validity results. The Cronbach alpha values for contractual governance, demand risk,

environmental uncertainty, manufacturing risk, relational governance, supply chain interruption, supply chain risk management, and supply risk are above the acceptable value of 0.70.

In Table 3, the composite reliability of each construct can be collected by summing the squares of completely standard factor loadings divided by the sum plus the total variance of the error term for the indicators. The composite reliability values above 0.7 are acceptable (Fornell-Larcker, 1981). The composite reliability for all variables was also above .70, indicating the internal consistency in the scale items. The values of CG, DR, EU, MR, RG, SCI, SCRM, and SR had AVE values exceeding 0.5, indicating that the latent construct explains at least 50% of the indicator variance and hence convergent validity (Fornell-Larcker, 1981, p. 46).

TABLE 3: Pilot Study Construct Reliability and Validity

	Cronbach's alpha	**Composite reliability (rho_a)**	**Composite reliability (rho_c)**	**Average variance extracted (AVE)**
CG	0.754	0.756	0.859	0.670
DR	0.791	0.792	0.878	0.706
EU	0.712	0.713	0.839	0.635
MR	0.807	0.807	0.873	0.633
RG	0.821	0.824	0.875	0.583
SCI	0.722	0.723	0.844	0.643
SCRM	0.736	0.755	0.850	0.654
SR	0.716	0.733	0.838	0.634

We further assessed the construct validity via the heterotrait-monotrait ratio of correlations (HTMT) approach in Table 4. If the HTMT value is below 0.90, it indicates a high level of discriminant validity (Hair et al., 2021). Evidence that measures of constructs that theoretically should not be substantially linked with one another are not found to be highly correlated serves as proof of discriminant validity. Convergent validity coefficients should be considerably more significant than discriminant ones (Hair et al., 2021). When different measurements of the same construct are grouped or converge on a single statistical factor, this is known as convergent validity. Subsamples are randomly selected (with replacement) from the initial data set throughout the bootstrapping process. The model is then estimated using each subsample until many random subsamples, typically approximately 10,000, have been produced, and this process is repeated.
The standard errors for the estimations are calculated using the estimated parameters from the subsamples (for example, the HTMT statistic) (Hair et al., 2021). The data is used to calculate a bootstrap confidence interval. The interval is the range into which the HTMT population figure will fall, assuming a specific confidence level (95%) (Hair et al., 2021). Discriminant validity is the extent to which a construct is genuinely distinct from other constructs in the model. An HTMT value above 0.90 suggests a lack of discriminant validity (Hair et al., 2021). Table 4 shows the constructs' discriminant validity as HTMT ratios are below 0.90.

TABLE 4: Pilot Study Discriminant Validity – Heterotrait-Monotrait (HTMT) Ratio – Matrix

	CG	**DR**	**EU**	**MR**	**RG**	**SCI**	**SCRM**
CG							
DR	**0.545**						
EU	0.864	**0.851**					

MR	0.576	0.864	**0.899**				
RG	0.765	0.672	0.576	**0.629**			
SCI	0.881	0.799	0.833	0.772	**0.886**		
SCRM	0.767	0.727	0.876	0.624	0.562	**0.780**	
SR	0.378	0.855	0.641	0.832	0.328	0.677	**0.464**

Factor analysis is a statistical technique used in multivariate research to examine a single collection of variables. It aims to identify logical subsets within a set of largely independent variables (Noora, 2021). Confirmatory factor analysis was utilized to determine the factor structure of the primary study data. This approach was chosen due to well-established measures in the existing literature that supported validity.

The validity of construct items was evaluated by examining their loading strength on intended constructs and assessing any cross-loadings with unwanted constructs. Only the constructs that maintained at least two components were preserved (Arefi, Nahid., 2024). The factor analysis results generated a revised conceptual model, which was then utilized for hypothesis testing (Hair et al., 2022). Table 5 shows that all loadings for the constructs of CG, DR, EU, MR, RG, SCI, SCRM, and SR were significant and above 0.7, demonstrating convergent validity after low-loading items were dropped. The factor analysis in Table 5 indicates that these items were effective measures of their respective constructs, confirming their appropriateness for the study. So, this study moved to primary data collection.

TABLE 5: Pilot Study Outer Loading Matrix – Factor Analysis

	CG	DR	EU	MR	RG	SCI	SCRM	SR
CGQ11.2	0.824							
CGQ11.3	0.816							
CGQ11.7	0.816							
DRQ4.1		0.819						
DRQ4.6		0.819						

DRQ4.7		0.881						
EUQ6.3			0.786					
EUQ6.7			0.770					
EUQ6.8			0.834					
MRQ5.10				0.796				
MRQ5.3				0.764				
MRQ5.4				0.830				
MRQ5.5				0.791				
RGQ10.1					0.716			
RGQ10.10					0.769			
RGQ10.4					0.746			
RGQ10.5					0.767			
RGQ10.9					0.817			
SCDIQ9.1						0.791		
SCDIQ9.2						0.833		
SCDIQ9.3						0.781		
SCRMQ7.2							0.763	
SCRMQ7.3							0.857	
SCRMQ7.4							0.803	
SRQ3.3								0.803
SRQ3.5								0.842
SRQ3.6								0.741

In summary, the pilot study supported construct reliability and validity for all the constructs H1–H7. Hence, the main study contained the same survey questions with a larger sample size.

MAIN STUDY

This section will provide comprehensive details on participant demographics for the primary study. Following this, the data analysis chapter provides the scrutinized data's reliability and convergent and discriminant validity assessments. These evaluations pave the way for examining results derived from the path model analysis.

Pollfish was used for the main study's data collection. In the instrument from Appendix D, 539 responses were collected. Data cleaning, consisting of time and attention check measures, validated 519 responses. Appendix D summarizes the demographics of the respondents in the main study. It shows that 62.8% of the respondents were male and 37.2% were female. Approximately 31% of the respondents were between ages 25 and 34, 25.2% between 35 and 44, 18.7% were greater than 54, 15.6% between ages 45 and 54, and 9.4% between 18 and 24. Regarding number of dealership employees, 22.5% reported 501–1000, 19.1% reported 251–500, 14.1% reported 101–250, 10.4% reported 51–100, 12.5% reported 1001–5000, 7.1% reported 26–50, 4.2% reported more significant than 5000, 3.5% reported 6–10, 2.5% do not work 1.5% reported 2–5, .8% reported prefer not to say, 1% reported 1, and 0.8% reported 11–25.

Seveny-four-point-four percent of the respondents reported their employment status as employed for wages, 17.5% reported self-employed, 3.2% reported unemployed looking, 1.3% reported student, 1.9% reported other, 0.6% reported retired, and 0.4% reported homemaker/unable to work, and 0.2% reported unemployed not looking. Regarding education status, 35.5% reported having post-graduate education, 32.2% reported having a university degree, 15.8% reported having a vocational technical college, and 16.6% reported having a high school diploma.

Approximately 13.7% of the respondents have an organizational role in senior management; 13.5% reported middle management; 7.3% reported other non-management; 6.7% reported human resources (HR) manager; 6.4% reported sales staff; 5.6% reported supervisor; 4.2% reported owner/partner and technical staff; 3.7% reported craftsman, faculty staff, project management, and president CEO chairperson; 3.5% reported director and not working; 2.9% reported preferred not to say and administrative clerical; 2.1% reported business administrator; 1.9% reported C-level executive; 1.7% reported chief technical officer; 1.5% reported product manager; 1.3% reported chief financial officer; 1.2% reported foreman; 1% reported buyer purchasing agent; and 0.2% reported supply manager.

In the participant's state location, 44 states were represented in the study. California had the most significant participation of 13.1%; Texas had the second highest participation at 8.7%; 7.7% reported Florida ; 6.2% reported New York; 6.4% reported Ohio; 3.5% reported New Jersey; 5% reported Idaho; 4.8% reported Georgia; 3.5% reported Michigan; 3.7% reported Illinois; 2.9% reported Pennsylvania; 3.3% reported South Carolina; 2.1% reported Colorado; 1.7% reported Maryland; 1.9% reported North Carolina; 1.7% reported Massachusetts; 2.3% reported Virginia and Missouri; 1.2% reported Mississippi, Alabama, Arizona, Indiana, Kansas, Kentucky, Louisiana, Utah, Washington; 0.8% reported Rhode Island; 1% reported Connecticut, Nevada, and Oregon; 0.6% reported Iowa; 0.8% reported Minnesota and Wisconsin; 0.4% reported Delaware, Nebraska, New Hampshire, New Mexico, Oklahoma and Tennessee; 0.2% reported Arkansas, Montana and Maine.

Regarding race, 71.5% were White, 10.0% were Black, 7.1% were Asian, 5% were Hispanic, 3.5% were Arab, 1.9% were Other, 0.4% were Multiracial and 0.2% were Latino.

Based on the participants, types of cars sold at the current dealership were reported: 46.6% reported gas and electric cars (Hybrid same car model), 26% reported gas-powered models and electric cars (not the same car model) only, 16.2% reported gas-powered, 7.3% reported electric cars only, and 3.9% reported not working at a dealership.

V: DATA ANALYSIS

OVERVIEW

Partial least squares (PLS) software was used for data analysis. PLS-SEM (Structural Equation Modeling) has a high level of statistical power, handles constructs measured with single and multi-item measures, incorporates the relationship between constructs and indicators, which in this case is a reflective measurement model, and is appropriate to reduce the amount of unexplained variance and maximizes the R square values (Hair et al., 2021).

Since PLS-SEM is based on ordinary least squares regression. Most of the statistical properties understood from ordinary least squares regression are assumed to apply to PLS-SEM. The PLS-SEM algorithm seeks to maximize the amount of endogenous constructs' variance that can be explained by a route model, which is supported by thorough causal justifications.

The construct scores are the first essential outcomes of the PLS path model estimate. Since these scores are used as exact replacements for the measurement models' indicator variables, they incorporate all the variance that can be used to explain endogenous structures. Additionally, they make it easier to estimate every relationship in the PLS path model (Hair et al., 2021).

Model estimation gives empirical measures of the relationships between the indicators (measurement models) and between the constructs (structural models). The estimates enable us to evaluate the quality of the measures and assess whether the model provides satisfactory results in explaining and predicting the target constructs. The model evaluation follows a two-step process for the measurement and structural models. Following the two-stage approach, we assessed construct reliability and validity before testing the path model (Hair et al., 2020).

MEASUREMENT MODEL

The evaluation of reflective measurement models encompasses the assessment of the reliability and validity of the measures, encompassing both indicator reliability and internal consistency reliability at the concept level. The assessment of validity pertains to evaluating two distinct types of validity. One aspect to consider is the convergent validity of each measure, which may be assessed using AVE. Discriminant validity compares all construct measures inside a given model by assessing HTMT values (Hair et al., 2021, p117).

Table 6 shows the reliability and validity results of the main study. The measure of Cronbach's alpha is acceptable as a preferred measure (> 0.700) in the contractual governance (0.705), environmental uncertainty (0.710), relational governance (0.763), supply chain interruption (0.835), manufacturing risk (0.662), and supply chain risk management (0.816) constructs. The manufacturing risk construct reported close to 0.700 at 0.662, the minimum acceptable level of 0.6 (Bagozzi & Yi, 1998)—the measures for supply risk at 0.515. However, Cronbach's alpha value is low, with a value of 0.50 compared to the best range of 0.70 -0.90. Nevertheless, when faced with lower Cronbach alpha values, numerous studies still refer to the previous stance advocated by Nunnally (1967), which states that values as low as 0.50 are deemed appropriate for the initial phases of the study. Some studies have contended that reliabilities as low as 0.40 are acceptable for extensively defined conceptions (e.g., Van de Venn and Ferry, 1980). Hence, we argue that Cronbach's alpha values for supply risk are above 0.5 and acceptable.

The composite reliability (rho_a and rho_c) should be 0.700 or above. In exploratory research, 0.6 or greater is acceptable (Bagozzi & Yi, 1998). The measure of rho_a is more significant than 0.700 for all constructs except supply risk at 0.526: contractual governance (0.706), environmental uncertainty (0.738), manufacturing risk (0.673), relational governance (0.763), supply chain interruption (0.835), and supply chain risk management (0.816) constructs. Supply risk at 0.526 is below the minimum acceptable level of 0.6 in exploratory research (Bagozzi & Yi, 1998). However, all composite reliability (rho_c) values are more significant than 0.7, indicating the internal consistency of all constructs. Hence, we argue that the reliability of the constructs is primarily established.

CONVERGENT VALIDITY

Convergent validity is a concept used in research to assess the degree to which different methods or measures of the same construct produce similar results. In other words, it evaluates whether multiple measures that are supposed to measure the same underlying concept converge or come together, yielding consistent outcomes. Convergent validity ensures that these different measures, despite their variations, all converge or point in the same direction, providing evidence that they are indeed tapping into the same underlying construct. For example, researchers studying job satisfaction might use various survey items related to satisfaction with pay, benefits, working conditions, and relationships with colleagues. Convergent validity would be demonstrated if responses to these different items consistently indicated high levels of overall job satisfaction.

Researchers typically assess convergent validity using statistical techniques such as factor analysis, which examines the extent to which different measures load onto the same factor or dimension. High factor loadings across multiple indicators suggest strong convergent validity, indicating that the measures effectively capture the intended construct.

Ensuring convergent validity is crucial in research because it provides confidence that the findings are robust and reliable. Suppose multiple measures of the same construct do not converge. In that case, it may indicate problems with the measurement instruments or conceptualization of the construct, leading to questions about the validity of the results. Therefore, establishing convergent validity is an essential step in validating research instruments and ensuring the accuracy and credibility of research findings. CG, DR, EU, MR, RG, SCI, SCRM, and SR values had AVE values exceeding 0.5, thus establishing the convergent validity (Fornell-Larcker, 1981).

TABLE 6: Main Study Reliability and Validity

	Cronbach's alpha	**Composite reliability (rho_a)**	**Composite reliability (rho_c)**	**Average variance extracted (AVE)**
CG	0.705	0.706	0.836	0.629
DR	0.712	0.819	0.830	0.622
EU	0.710	0.738	0.817	0.528

MR	0.662	0.673	0.813	0.593
RG	0.763	0.763	0.849	0.584
SCI	0.835	0.837	0.884	0.604
SCRM	0.816	0.817	0.872	0.576
SR	0.515	0.526	0.742	0.494

DISCRIMINANT VALIDITY

Discriminant validity is a concept used in research to assess whether constructs that are supposed to differ are distinct and separate. In other words, it examines whether measures of one construct do not overlap or correlate too highly with measures of other, theoretically distinct constructs. When designing a study, researchers often include multiple constructs to capture the phenomenon's complexity under investigation.

Discriminant validity ensures that these constructs are truly unique and not simply different manifestations of the same underlying concept. For example, in a study examining job satisfaction and organizational commitment, discriminant validity would ensure that job satisfaction (e.g., satisfaction with pay, work-life balance) is distinct from measures of organizational commitment (e.g., loyalty, identification with the organization). If the measures of job satisfaction and organizational commitment were highly correlated, it would suggest that they are not genuinely separate constructs but rather variations of a single underlying concept.

Researchers typically assess discriminant validity using statistical techniques such as confirmatory factor analysis or correlation analysis. Confirmatory factor analysis evaluates how items designed to measure different constructs load onto separate factors or dimensions. Low cross-loadings suggest good discriminant validity, indicating that each item is primarily associated with its intended construct and not others. Similarly, correlation analysis examines the correlations between different constructs. Low correlations between constructs provide evidence of discriminant validity, demonstrating that they are distinct and not highly related to each other.

Establishing discriminant validity is important because it ensures that the studied constructs are genuinely distinct and that the findings accurately reflect their relationships.

Without discriminant validity, researchers may erroneously conclude that constructs are related when measuring the same underlying concept, leading to flawed interpretations and conclusions. Therefore, demonstrating discriminant validity is essential in validating research instruments and ensuring the validity of study findings.

The Fornell-Larcker (1981) criterion assesses discriminant validity by comparing the square root of the AVE values with the latent variable correlations. The logic is that the construct shares more variance with its associated indicators than any other construct.

The Fornell-Larcker criterion was applied based on the diagonal value, which should be more significant than all values in the same row and column (Fornell-Lacker, 1985). The square root of each construct's AVE is more significant than its highest correlation with any other construct, as shown in Table 7, confirming the discriminant validity of the constructs.

TABLE 7: Main Study – Discriminant Validity Fornell-Larcker Criterion

	CG	**DR**	**EU**	**MR**	**RG**	**SCI**	**SCRM**	**SR**
CG	**0.793**							
DR	0.194	**0.789**						
EU	0.412	0.533	**0.727**					
MR	0.388	0.460	0.605	**0.770**				
RG	0.628	0.132	0.412	0.447	**0.764**			
SCI	0.545	0.071	0.374	0.395	0.698	**0.777**		
SCRM	0.566	0.280	0.598	0.578	0.620	0.588	**0.759**	

SR	0.367	0.303	0.451	0.480	0.406	0.438	0.489	**0.703**

Cross-loadings are an indicator's correlation with other constructs in the model. Cross-loading occurs when an observed variable has a high loading (correlation) on more than one factor, indicating that multiple latent variables influence it (Hair et al., 2021, p117). Complex factors have many cross-loading variables, making them difficult to interpret and name. Factors such as cross-loading and complex variables can diminish the clarity and simplicity of the factor solution, making it more challenging to interpret the meaning of the factors and variables. The criteria for elimination were close to 0.7 for loadings and 0.4 for cross-loadings (Hair et al., 2021, p117). The removal of several items resulted in the items in Table 8.

TABLE 8: Main Study Cross Loadings

	CG	DR	EU	MR	RG	SCI	SCRM	SR
CGQ12.2	**0.773**	0.169	0.348	0.320	0.460	0.428	0.456	0.283
CGQ12.5	**0.805**	0.157	0.302	0.289	0.512	0.435	0.419	0.303
CGQ12.6	**0.801**	0.136	0.331	0.314	0.522	0.434	0.473	0.288
DRQ5.5	0.135	**0.726**	0.408	0.377	0.069	0.036	0.201	0.235
DRQ5.6	0.136	**0.746**	0.418	0.356	0.102	0.045	0.221	0.240
DRQ5.7	0.180	**0.885**	0.450	0.379	0.127	0.074	0.242	0.252
EUQ7.12	0.361	0.313	**0.781**	0.464	0.385	0.361	0.518	0.400
EUQ7.5	0.303	0.482	**0.736**	0.504	0.264	0.232	0.429	0.305
EUQ7.6	0.259	0.393	**0.699**	0.399	0.280	0.221	0.383	0.251
EUQ7.8	0.250	0.419	**0.686**	0.394	0.230	0.230	0.375	0.323
MRQ6.3	0.358	0.316	0.430	**0.795**	0.384	0.357	0.483	0.435
MRQ6.8	0.204	0.433	0.471	**0.737**	0.286	0.255	0.385	0.324
MRQ6.9	0.313	0.335	0.512	**0.776**	0.351	0.285	0.455	0.334
RGQ11.10	0.463	0.123	0.278	0.340	**0.764**	0.539	0.469	0.289
RGQ11.5	0.458	0.133	0.364	0.367	**0.742**	0.544	0.479	0.362
RGQ11.8	0.506	0.097	0.307	0.328	**0.778**	0.546	0.490	0.272
RGQ11.9	0.494	0.046	0.309	0.331	**0.772**	0.502	0.456	0.317

SCDIQ10.4	0.416	0.057	0.270	0.273	0.542	**0.779**	0.458	0.277
SCDIQ10.5	0.431	0.027	0.302	0.317	0.547	**0.778**	0.465	0.314
SCDIQ10.7	0.403	0.025	0.238	0.300	0.555	**0.771**	0.452	0.354
SCDIQ10.8	0.467	0.054	0.338	0.326	0.553	**0.823**	0.489	0.369
SCDIQ10.9	0.397	0.115	0.303	0.317	0.514	**0.732**	0.419	0.388
SCRMQ8.2	0.448	0.212	0.435	0.395	0.461	0.419	**0.747**	0.340
SCRMQ8.3	0.428	0.172	0.486	0.412	0.467	0.454	**0.767**	0.407
SCRMQ8.4	0.381	0.201	0.451	0.463	0.475	0.462	**0.761**	0.362
SCRMQ8.5	0.436	0.250	0.454	0.468	0.485	0.464	**0.772**	0.402
SCRMQ8.6	0.460	0.230	0.441	0.453	0.467	0.430	**0.747**	0.340
SRQ4.1	0.288	0.154	0.294	0.294	0.302	0.369	0.338	**0.777**
SRQ4.10	0.153	0.360	0.374	0.415	0.176	0.164	0.281	**0.569**
SRQ4.7	0.298	0.223	0.340	0.375	0.344	0.336	0.408	**0.744**

CG – Contractual Governance DR – Demand Risk
EU- Environmental Uncertainty MR- Manufacturing Risk
RG- Relational Governance SCI – Supply Chain Interruption
SCRM – Supply Chain Risk Management SR – Supply Risk

HYPOTHESIS TESTING AND RESULTS

After assessing the measurement model, we estimated the structural model. Figure 4 depicts the estimation results, and Table 9 summarizes the hypothesis test results.

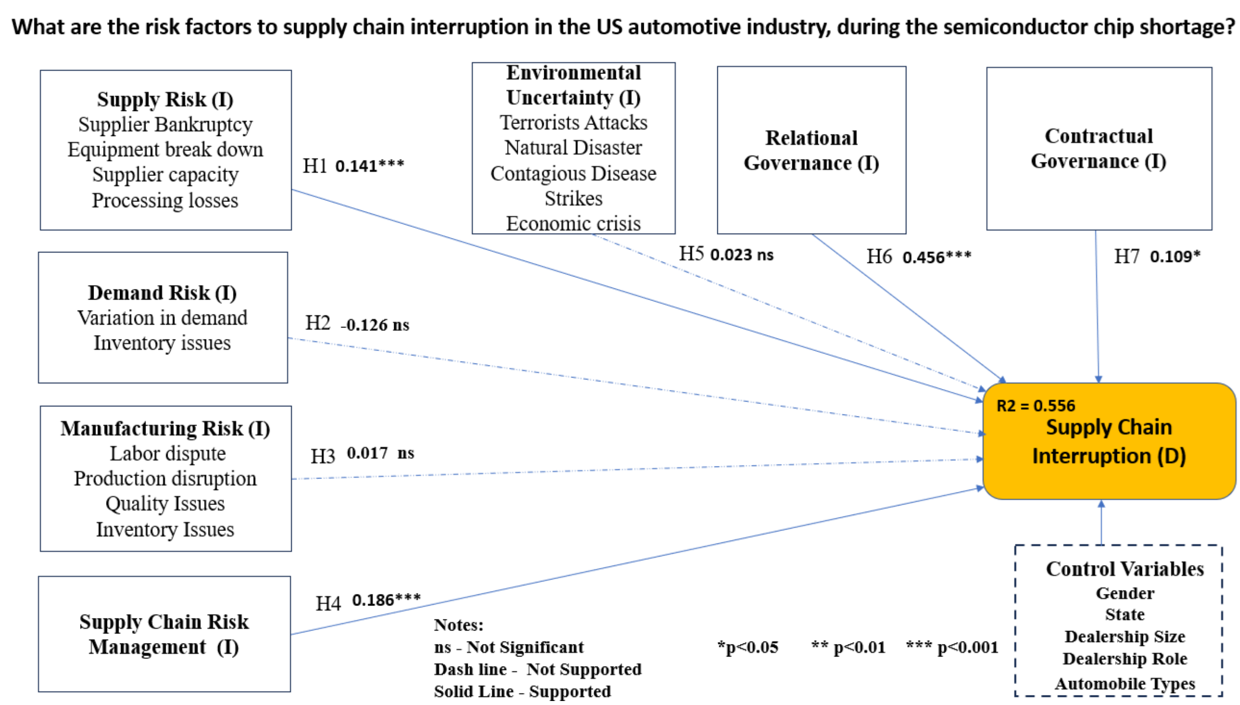

Figure 4: Results of Structural Model Estimation

HYPOTHESIS 1

Hypothesis 1 was, "As **supply risks** increase, **supply chain interruptions** will increase." As Table 9 demonstrates, supply risk (SR) positively impacts supply chain interruption (SCI). The t-value and p-value for SR predicting SCI were 3.350 and 0.001, respectively. The path coefficient was 0.141, which showed positive significance, and H1 was supported.

HYPOTHESIS 2

Hypothesis 2 was, "As **demand risks** increase, **supply chain interruptions** will increase." Demand risk (DR), as demonstrated in Table 9, negatively impacts supply chain interruption (SCI). The t-value and p-value for DR predicting SCI were 2.960 and 0.003, respectively. However, the path coefficient was -0.126, which showed an inverse or negative relationship. Therefore, H2 was not supported.

HYPOTHESIS 3

Hypothesis 3 was, "As **manufacturing risks** increase, the **supply chain interruptions** will increase." H3 suggested that manufacturing risk, including labor disputes, production interruptions, quality issues, and inventory challenges, would be positively associated with supply chain interruptions. However, the results from Table 9 indicate that the path coefficient of 0.017 for manufacturing risk (MR) predicting supply chain interruption (SCI) was not statistically significant, with a t-value of 0.422 and a p-value of 0.673. Therefore, H3 was not supported.

HYPOTHESIS 4

Hypothesis 4 was, "As **supply chain risk management** intensifies, more **supply chain interruptions** will be monitored." As demonstrated in Table 9, supply chain risk management (SCRM) is positively related to monitoring the impact of supply chain interruption (SCI). The path coefficient was 0.186, which showed positive significance, with a t-value of 3.483 and a p-value of 0.000. Hence, H4 was supported.

HYPOTHESIS 5

Hypothesis 5 was, "As **environmental uncertainty** increases**, supply chain interruptions** will increase**.**" The result did not support Hypothesis 5. Environmental uncertainty, including threats like terrorist attacks, natural disasters, contagious disease outbreaks, and economic crises, did not show a significant positive association with supply chain interruptions. However, the results from Table 9 indicate that the path coefficient of 0.023 for environmental uncertainty (EU) predicting supply chain interruption (SCI) was not statistically significant, with a t-value of 0.023 and a p-value of 0.614. Therefore, H5 was not supported.

HYPOTHESIS 6

Hypothesis 6 was, "**Relational governance** will enhance the monitoring of **supply chain interruptions**." As demonstrated in Table 9, relational governance (RG) improves the monitoring of supply chain interruptions (SCI). The path coefficient was 0.456. The t-value and p-value for RG predicting SCI were 9.614 and 0.000, respectively. Thus, H6 was supported.

HYPOTHESIS 7

The seventh hypothesis was, "**Contractual governance** will enhance the monitoring of **supply chain interruptions**." Contractual governance (CG), as demonstrated in Table 9, improves the monitoring of supply chain interruption (SCI). The t-value and p-value for CG predicting SCI were 2.421 and 0.015, respectively. The path coefficient was 0.109. Hence, H7 was supported.

VI: DISCUSSION AND IMPLICATIONS

The study examines the factors that can influence and monitor interruption in the supply chain. Central to this examination are various factors, including risks inherent in the supply chain, strategies for risk management, and the role of governance structures. Integral to this examination is utilizing the supply chain interruption (SCI) instrument, which encompasses nine essential items. These items gauge the extent to which dealerships have experienced the repercussions of supply chain interruptions over the past two years, and they encompass diverse aspects, ranging from procurement costs and delivery reliability to the overall efficiency of operations and the impact on sales forecasts. By examining these facets, one can gain insights into the multifaceted impacts of supply chain interruptions on dealership operations and performance. This instrument is vital in elucidating the intricate relationship between interruptions and their consequences, providing a robust foundation for the subsequent analysis of study results.

The results in Table 9 largely support the proposed research model—four out of seven hypotheses were supported. In detail, relational governance was one of the most critical factors influencing the impact of supply chain interruption, with the highest path coefficient. The findings align with prior research on the effect of relational governance. For example, research found that IT resources, such as hardware, software, and humans, can enhance the management of supply chain relationships and contracts, reducing partners' potential for opportunistic behavior (Zhang, 2019). The findings also support the contingency theory, showing the need for more than one supplier to assist in the supply risk of capacity and processing losses.

Past research further suggests that relational governance comprises information sharing, solidarity, trust, and flexibility as essential elements that can drive desired outcomes in supply chain management, mainly when interruptions occur (Griffith & Myer, 2005; Liu et al., 2009; Carey & Lawson, 2011; Yeh, 2015). Combining this study with our findings, we recommend that companies develop management strategies and governance structures that enable relationship-building with supplier partners. Research also shows that the efficiency of relational governance solutions differs based on the supply chain's operational and environmental conditions (Bonatto et al., 2020). Companies must know this and develop adaptive relational governance for different conditions.

The study’s findings validate that supply risk significantly influences supply chain interruption. Based on our findings, we recommend that companies develop early detection systems connected to the supplier's transparency of inventory levels. This will prevent the unknown of the status of capacity levels and protect the firm's assets during a supply chain interruption.

Supply chain risk management (H4) was a significant predictor of SCI. The findings align with prior research (Finnman, 2002; Zsidisin, G.A., L.M. Ellram,1999; Zhang, T., 2019). Based on our findings, we suggest companies develop supply chain risk management strategies, following the literature. Finnman (2002) proposes a supply risk management framework and a way to evaluate risks to help the supplier selection process. Zsidisin and Ellram (1999) proposed a 10-step approach for risk assessment by giving equal importance to eight identified risk factors and using a five-point nominal risk scale. The maximum factorial risk is assigned as the overall risk of a project. The nominal risk scale is implemented using a scorecard based on best practices. This method has evolved into a formal supply risk classification system that identifies critical risk factors. Management can utilize this process as part of the corporate culture and share local, regional, and global findings. Supply chain risk management highlights the significance of thorough risk strategies in mitigating the effects of interruptions.

Relational governance (H6) was a significant predictor of SCI based on the findings in Table 9. Relational governance encourages collaborative approaches to problem-solving. Collaborators who adhere to comprehensive relational governance principles can rapidly unite to devise resolutions during interruptions. By adopting a collaborative approach, interruptions can be effectively managed and their adverse effects on the supply chain mitigated. Stable economic conditions, effective communication, and high-quality relationships facilitate positive outcomes of relational governance (Cousins et al., 2011). By integrating these components, organizations can create resilient supply chains that can withstand disruptions. The importance of these attributes is underscored in the studies conducted by Heide & John (1992) and Griffith (2006), which contend that organizations must tailor their relational governance practices to their specific circumstances to attain the most favorable outcomes.

Contractual governance (H7) was also a significant predictor of SCI based on the findings in Table 9. Based on our findings, in contract design, practical, explicit clauses should comprise an extensive array of particulars and faithfully reflect the intentions of all parties involved. Each party will consequently recognize their respective obligations and privileges. Thorough deliberation guarantees that the contingencies are safeguarded to the maximum degree feasible. By formulating the two types of clauses, both parties can predict forthcoming collaboration and receive appropriate compensation. A party engaging in opportunistic conduct will fully understand the consequences, including losing rewards and cooperation (Zhang, T., 2019).

Demand risk (H2) was found to be negatively associated with SCI, contrary to the hypothesized positive relationship. This negative path coefficient diverges from existing literature, suggesting a more complex interplay than previously acknowledged. One explanation is that the effect of a negative demand risk is multifaceted and influenced by numerous variables not fully captured in earlier studies or in this study. Therefore, future research is essential to dissect these complexities and to provide a clearer understanding of how negative demand risk impacts supply chain operations. Secondly, the transparency of the supply chain flow, mainly from consumer to manufacturing to suppliers, might also play a key role in comprehending these relationships.

Thirdly, Sodhi (2005) highlighted that demand risk could manifest positively and negatively. According to Sodhi, demand risk refers to sudden changes in order volumes that force companies to adjust their inventory levels. Negative demand risk occurs when the end customer's demand exceeds the available inventory, leading to surplus stock. This situation ties up capital in unsold goods and increases storage and obsolescence costs, exacerbating supply chain disruptions. On the other hand, positive demand risk involves demand outstripping supply, leading to stockouts and lost sales opportunities. The intricate nature of demand risk underscores the need for a nuanced approach to supply chain management. Dealerships must develop strategies to enhance supply chain transparency and agility to anticipate better and to respond to demand fluctuations.

For H3, the insignificance of manufacturing risk as a predictor of supply chain interruption could be multifaceted. Firstly, the semiconductor chip shortage, a primary focus of the study, might have overshadowed the influence of manufacturing risk. This shortage likely exerted a more immediate and pronounced impact on supply chain interruptions than internal manufacturing challenges. Moreover, automotive firms may have fortified their manufacturing processes with robust contingency protocols, thereby mitigating the effects of internal risks and reducing their predictive power about supply chain interruption (Lee & Tang, 1997).

The lack of significance observed for manufacturing risk as a predictor of supply chain interruption prompts a closer examination. The inventory shortage during the past two years may have contributed to the need for more evidence. This suggests that internal manufacturing challenges have less influence than external risks. It is conceivable that automotive manufacturers have adeptly implemented internal safeguards or contingencies, effectively reducing the repercussions of manufacturing variations on the supply chain.

This discovery underscores organizations' need to evaluate the adequacy of their internal contingency protocols, including adaptable manufacturing systems and robust process design, in withstanding external interruptions.

Similarly, in H5, environmental uncertainty did not significantly predict supply chain interruption. A possible explanation is that if a dealership has effectively aligned its strategies, processes, and structures with the environmental uncertainties it faces, this alignment might neutralize the expected negative impacts. The support for H4 indicated that dealerships may utilize the supply chain management system to monitor environmental uncertainties and neutralize their negative impacts, resulting in the insignificance of environmental uncertainties. It is also plausible that factors such as relational governance and contractual arrangements played a more pivotal role in mitigating the impact of external disturbances on supply chain interruption, thus diminishing the predictive power of environmental uncertainty (Weick, 1993).

The insignificance of environmental uncertainty as a predictor of supply chain interruption prompts a reconsideration of automotive firms' strategies. This observation suggests the presence of a resilient framework within these organizations, foreseeing substantial consequences arising from external disturbances. It advocates for a nuanced understanding of environmental uncertainties and emphasizes the importance of flexibility to achieve greater operational performance in the face of dynamic conditions (Laguir et al., 2023).

The lack of significance for H2, H3, and H5 also underscores the dominance of other variables, such as supply risk, supply chain risk management, contractual governance, and relational governance, in influencing supply chain interruption during the semiconductor chip shortage. It emphasizes the need to consider the specific context and dynamics of the semiconductor chip shortage when analyzing the impact of different factors on supply chain interruption.

TABLE 9: Summarization of Hypotheses Test

Hypotheses	**Hypotheses Paths**	**Path Coefficients (O)**	**T Values**	**P Values**	**Result**

H1	**SR -> SCI**	**0.141**	**3.350**	**0.001**	**Supported**
H2	DR -> SCI	-0.126	2.960	0.003	Not Supported*
H3	MR -> SCI	0.017	0.422	0.673	Not Supported
H4	**SCRM -> SCI**	**0.186**	**3.483**	**0.000**	**Supported**
H5	EU -> SCI	0.023	0.505	0.614	Not Supported
H6	**RG -> SCI**	**0.456**	**9.614**	**0.000**	**Supported**
H7	**CG -> SCI**	**0.109**	**2.421**	**0.015**	**Supported**

*Note. H2 shows significance in the path coefficient but has a negative sign, which is opposite to what was hypothesized.

THEORETICAL IMPLICATION

Traditionally, supply chain interruption has been associated with game and complex theories. The study makes a significant theoretical contribution by being one of the first to investigate supply chain interruption using contingency theory. Secondly, this study's theoretical implications underscore the significance of contingency theory in understanding the dynamics of supply chain interruption based on the risk factors of SR and SCRM and the role of governance mechanisms, including RG and CG. Thirdly, the direct effect of supply chain risk management on supply chain interruptions significantly contributes to improving the automotive industry and the contingency theory. Supply chain risk management can reveal the need for excellent monitoring at supplier and customer levels to identify risks and to mitigate supply interruptions.

Relational governance significantly influences the efficacy of supply chain interruption. Relational governance promotes joint problem-solving approaches. When disruptions occur, partners who have solid relational governance practices can quickly come together to identify solutions.

This study reveals the importance of contractual governance and supply chain interruption contextual variables delineated by contingency theory. Effective contractual governance reduces disruptions in the supply chain by establishing defined roles. By establishing clear and precise obligations and duties for all involved parties, precisely defined contracts diminish the probability of misinterpretations and mistakes that may result in disturbances. Transparent contractual obligations streamline operations and promote accountability. This effectiveness depends on the clarity and complexity of contractual arrangements. Organizations may tailor contractual governance to the specific conditions at hand to mitigate disruptions and to enhance the resilience of their supply chains. To achieve the most favorable outcomes, the governance strategies proposed by (Poppo & Zenger, 2002) are customized to suit the specific conditions of each organization.

PRACTICAL IMPLICATIONS

This study underscores several practical implications for enhancing supply chain management, particularly in interruptions such as semiconductor chip shortages. Firms are encouraged to develop robust supplier risk management strategies that diversify supplier bases and strengthen supplier collaboration, which is essential for mitigating supply shortage risks.

This study illuminates the crucial intricacies of supply chain interruptions within the United States automotive sector amidst the shortage of semiconductor chips. The results hold considerable practical value, providing practical advice that can be implemented by various stakeholders, such as manufacturer suppliers, automotive dealers, governmental entities, and industry regulators.

The study findings show that increased supply risks lead to increased supply chain interruptions. The literature suggests that the primary risk components in supply risks include the availability of products and services, technical capability, and capacity fluctuations of suppliers (Wagner & Bode, 2008; Kumar et al., 2018). Hence, to reduce the impact of supply risks on supply chain interruptions, we recommend that automotive dealerships reduce risks related to the availability of products and services. Automotive dealerships may develop the technology capability for effective inventory management. Research shows that by integrating state-of-the-art technologies with suppliers, automotive dealerships can enhance communication and operational efficiency, leading to prompt issue resolution and effective monitoring of fluctuations in product availability (Mandala V., 2024). As a result, automotive dealerships may develop adaptability into their supply chain risk management to accommodate changes in inventory management, ensure steady product availability, and thus reduce supply risks.

To increase their technical capability in managing supply risks, we recommend that automotive dealerships regularly evaluate suppliers' technical capabilities to ensure their compliance with quality and technical requirements; this will prevent interruptions caused by inadequate performance. Research shows that the technological readiness level can give insight into the importance of understanding technology quality and standards (Matopoulos et al., 2017). As a result, automotive dealerships may want to add technical capabilities as part of their supplier evaluation to prevent interruptions due to sub-par performance.

To address supplier capacity fluctuations and to manage supply risks, we recommend that automotive dealerships create robust risk mitigation strategies. These strategies, which include maintaining safe stock and diversifying suppliers, are vital to managing capacity fluctuations and ensuring continuous supply availability. By implementing these strategies, automotive dealerships can feel secure about their supply chain management, knowing they are prepared for potential interruptions. Research shows that implementing risk mitigation policies can improve capacity fluctuations of suppliers with downstream emergency stock as a strategy for unreliable suppliers (S. Rezapour, 2017). As a result, automotive dealerships may develop risk mitigation strategies in their supply chain risk management to accommodate supplier capacity changes, ensure steady product availability, and thus reduce supply risks.

The study findings show that supply chain risk management intensifies the more supply chain interruptions are monitored. The literature suggests that the primary risk components in supply chain risk management include regular monitoring of suppliers, monitoring customer demand, and reviewing and updating contingency plans to address identified supply chain risks (Wagner & Bode, 2008). Hence, to intensify the impact of supply chain risk management on supply chain interruptions, we recommend that automotive dealerships reduce risks related to regularly monitoring suppliers. Automotive dealerships may develop early risk detection systems to monitor suppliers. Research shows that incorporating a monitoring system can help uncover supplier risk indices that can be tracked over time to detect trends indicating increasing risk levels, and that automotive dealerships can enhance communication and operational efficiency, leading to prompt issue resolution and effective monitoring of fluctuations in product availability (Blackhurst et al., 2008). As a result, automotive dealerships may establish control limits with supplier risk to accommodate fluctuations before corrective measures are taken, thus reducing supply chain risks.

Another finding from the study shows that customer demand for monitoring can intensify supply chain risk management the more supply chain interruptions are monitored. The literature suggests that other risk components in supply chain risk management include regularly monitoring customer demand with accurate forecasting to be aware of demand trends and to align inventory with customer needs. Hence, to intensify the impact of supply chain risk management on supply chain interruptions, we recommend that automotive dealerships reduce risks related to regularly monitoring customer demand forecasting accuracy. Automotive dealerships may develop demand-forecasting systems to monitor customer demand. Studies indicate that the inclusion of a monitoring system can combine dashboards for real-time analysis of demand trends to enhance customer interaction (R, A. et al., 2024). As a result, automotive dealerships may establish dashboards for predictive and real-time monitoring of customer demand to accommodate demand forecasting accuracy before adjustments are taken, thus reducing supply chain risks.

To increase their transparency in the supply chain and information sharing with partners, we recommend that automotive dealerships develop centralized data platforms so up-to-date information is shared, reducing information silos and enhancing coordination. Sharing information enables partners to enhance predictions, align production schedules, and coordinate inventory decisions (Tang et al., 2011; Ramanathan & Ramanathan, 2021). As a result, automotive dealerships may enable effective collaboration, cooperative problem-solving, and business intelligence with transparency and information-sharing.

To address reviewing and updating contingency plans and to manage supply chain risk management, we recommend that automotive dealerships audit contingency plans regularly to ensure they adapt to changes and remain effective while addressing new risks. The audit would ensure comprehensive continuity plans and ensure preparedness for interruptions. By implementing these strategies, automotive dealerships can feel secure about their supply chain risk management, knowing they are prepared for potential interruptions. Research shows that regularly updating contingency plans ensures they remain practical in addressing new risks (Hatton & Brown, 2021). As a result, automotive dealerships may develop comprehensive continuity plans in their supply chain risk management to accommodate readiness to reduce downtime and ensure product availability, thus reducing supply chain risks.

The study findings show that relational governance will enhance the monitoring of supply chain interruptions. The literature suggests that the primary risk components in relational governance include proprietary information sharing, frequent information exchange, joint responsibility for problems, and commitment to relationship-wide improvements (Sheng al., 2018). Hence, to enhance the impact of relational governance on supply chain interruptions, we recommend that automotive dealerships enhance proprietary information sharing. Automotive dealerships may develop proprietary information sharing via enhanced collaboration. Research shows that sharing proprietary information promotes profound collaboration, optimizing processes and product offerings. Successful collaboration in automotive dealerships can be enhanced by careful partner selection and protecting intellectual property rights (Li & Nguyen, 2017). As a result, automotive dealerships may develop adaptability relational governance to accommodate access to proprietary information, drive innovation and performance improvements, and ensure stronger collaboration partnerships, thus reducing risks.

To enhance frequent information exchange in relational governance, we recommend that automotive dealerships regularly evaluate the alignment of goals to ensure that objectives and strategies enhance overall performance. Research shows that the alignment of goals can positively impact performance (Hochrein et al., 2017). As a result, automotive dealerships may want to generate regular communication to promote information exchange, streamline operations, and reduce delays.

To address joint responsibility for problems and to manage relational governance, we recommend that automotive dealerships invest in advanced monitoring systems to detect early signs of potential interruptions. Research indicates that the exchange of digitized information between original equipment manufacturers (OEMs) and suppliers might be beneficial in evaluating improvements in quality and reducing the risks associated with product recalls (Liotta & Chaudhuri, 2016). Automotive dealerships may implement shared risk management strategies in their relational governance to address joint responsibility and distribute risks. This approach promotes a balanced and resilient relationship, lowering supply chain risks.

To address commitment to relationship-wide improvements and the intensification of relational governance, we recommend that automotive dealerships investigate collective growth strategies with suppliers to drive shared commitment while driving collective growth and enhancing competitiveness. Research shows that Toyota collaborates with its suppliers through a partnership that involves shared investment in supplier associations (for general sharing of information), learning teams (on-site sharing of know-how within small groups), and consulting groups (workshops, seminars, and on-site assistance from Toyota) (Dyer & Hatch, 2004). Automotive dealerships may increase their relationship investment through collective growth while building loyalty and demonstrating commitment while lowering supply chain risks.

The study findings show that contractual governance will enhance the monitoring of supply chain interruptions. The literature suggests that the primary risk components in contractual governance include supplier-defined responsibilities of each party, disagreement resolution, and supplier actions of unplanned events (Sheng et al., 2018; Lee et al., 2023; Wang et al., 2020). Hence, to intensify the impact of contractual management on supply chain interruptions, we recommend that automotive dealerships reduce risks related to the suppliers and define the responsibilities of each party. Automotive dealerships may develop performance monitoring indicators for service performance monitoring and quality control effectiveness. Research shows that "effectiveness indicators will raise any issues about the contract since it is usually tied to payments or services" (Dean et al., 2002). As a result, automotive dealerships may establish performance monitoring to determine quality monitoring practices and to create corrective measures to reduce supply chain risks.

To address dispute resolution mechanisms and to manage contractual governance, we recommend that automotive dealerships define escalation procedures to address conflicts adequately to address disputes within contract flexibility and adaptability as a part of conflict resolution. Research indicates that contractual governance is a framework for disputes constituted by a governance structure (GS) and a governance mechanism (GM). The rigid GS possesses an advantage due to a stable foundation, whereas the GM is well-suited to coordinate disputes as a part of dispute resolution (Tang al., 2023). Automotive dealerships may implement risk management strategies in their contractual governance to address dispute resolution, deal with conflict, and maintain supply chain reliability.

To address contingency planning for unplanned events and to manage contractual governance, we recommend that automotive dealerships document a clear contingency plan to enhance preparedness for interruptions, allowing quick adaption to help mitigate risks and ensuring business continuity with quarterly audits to ensure the plan is up to date. Research shows that planning must consider uncertainty by considering multiple scenarios and developing contingency plans. This involves creating analysis models that speculate on the behavior of various variables that could impact the firm in both short- and long-term scenarios (Rodrigues, 2021). Automotive dealerships may implement predefined responses and operational procedures, including automated reports, to mitigate risks and maintain, allowing for quick adaptation for smoother operations.

VII: LIMITATIONS, FUTURE STUDIES, AND CONCLUSIONS

LIMITATIONS

The current study includes limitations, including endogeneity and potential common method bias (CMB), given its reliance on survey data (Guide & Ketokivi, 2015; Sande & Ghosh, 2018). In detail, survey-based data collection, while valuable, comes with inherent limitations, such as response biases and errors in self-reported information. Despite efforts to ensure the reliability and accuracy of the data, the subjective nature of survey responses can sometimes obscure underlying patterns or causal relationships. Barr (1986) and Greenwald (1986) underscore the possibility of response biases and inaccuracies in self-reported data, with Greenwald highlighting the influence of survey design and presentation on response rates. Marquis (1986) and Hufnagel (1994) address the issue of response bias in sensitive subjects and user assessments, with Hufnagel offering suggestions for improving survey questions. Díaz (2005) proposes the randomized response approach as a potential solution. Furthermore, recent anonymous studies conducted in 2019 acknowledge the possibility of observer bias and outline measures to mitigate its impact.

As noted above, this study's limitations may include potential response bias, possible issues with data accuracy, and potential errors in self-reported data. However, the study implemented measures to address these concerns and ensure the validity of its findings. Additionally, the study recognized the potential benefits of utilizing longitudinal or multi-informant data from a single firm to mitigate endogeneity and CMB. Future research could further enhance the study's external validity by incorporating extensive data analysis and other methodological approaches (Wamba et al., 2018).

Additional limitations may result from where data was collected using Pollfish. Although Pollfish provided a probability-based sample, the sample population could still have an inherent bias. For example, specific demographics might be overrepresented or underrepresented, leading to skewed results.

FUTURE STUDIES

This quantitative study contributes to understanding supply chain interruption using a direct effect model based on the contingency theory model. However, future studies based on the findings of this research may further such understanding in the areas of mixed methods, product segmentation, and the integration of technology risk.

Mixed Methods Study: A qualitative study focusing on direct insights into US automotive industry risks will serve as a baseline for the quantitative study. The mixed methods study will give a holistic view of risk interruption.

Product Segmentation: Based on the main study demographics table (Appendix D), the types of vehicles represented in this study were a mix of gas-powered, electric, and hybrid (different models). Specialized research on hybrid or EV vehicles may produce more significant insights into the risks within a specialized automotive segment.

Integration of Technology Risk: A new construct called technology risk would be added with risk questions involving digital, digital twins, blockchain, AI, and cybersecurity technologies. The integration of digital technology is a variable component in organizational performance, as its effectiveness depends on how well it matches the company's operational needs and capabilities.

Technologies like artificial intelligence (AI) for predictive analytics, digital twins for real-time monitoring, blockchain for safe and transparent transactions, and cybersecurity will significantly improve the automobile industry's ability to withstand interruption, including technology risk. Future research may incorporate these technological factors and examine their impact on supply chain interruption.

CONCLUSIONS

In conclusion, the study provides valuable insights into the relationship between various factors and supply chain interruptions. The findings show that as supply risks (H1) increase, supply chain interruptions indeed increase. Additionally, the study validates H4, demonstrating that intensifying supply chain risk management leads to more effective monitoring of supply chain interruptions. Furthermore, both relational governance (H6) and contractual governance (H7) enhance the monitoring of supply chain interruptions, highlighting the importance of governance mechanisms in mitigating interruptions.

Demand risk (H2) results indicate a significant inverse relationship between demand risk and supply chain interruption, but the hypothesis wording was positive instead of negative, which was unsupported. However, the findings do not support manufacturing risk (H3) and environmental uncertainty (H5), suggesting that H3 and H5 do not necessarily lead to increased supply chain interruptions. These results underscore the complexity of supply chain dynamics and the need for comprehensive risk management strategies to ensure resilience and continuity in the face of uncertainties.

This research comprehensively examines the challenges associated with supply chain interruptions in the US automotive industry, particularly considering semiconductor chip shortages. By systematically analyzing factors such as manufacturing risk, environmental uncertainty, supply risk, demand risk, and the roles of relational and contractual governance, this study significantly advances our understanding of supply chain management, both theoretically and practically.

The findings underscore the critical role of relational governance in mitigating the impacts of supply chain interruptions. Establishing resilient, trust-based relationships throughout the supply chain fosters collaboration via information sharing, joint responsibilities, flexibility, and commitment to relationship-wide improvements. Similarly, contractual governance ensures the importance of monitoring, dispute resolution mechanisms, and contingency planning for unplanned events.

Moreover, the study challenges conventional notions regarding environmental unpredictability and manufacturing risk, suggesting their influence may be less significant than previously thought or need to be divided into subcategories. This presents opportunities for further research and improvement in supply chain risk management (Sato, 2018).

Furthermore, the research highlights the potential mitigating effect of demand risk on interruption extent, offering new avenues for strategically managing demand fluctuations to enhance supply chain adaptability (Paul et al., 2018).

The study offers several suggestions for supply chain administrators, including adopting comprehensive risk management frameworks, robust supplier management strategies, and advanced forecasting techniques to enhance supply chain resilience (Limbare et al., 2023). Additionally, it advocates for a holistic governance strategy integrating relational and contractual mechanisms to reduce vulnerability to interruptions (Gheidar-Kheljani & Halat, 2024).

This study contributes significantly to understanding supply chain interruptions and offers practical approaches to help organizations enhance their preparedness and response. In an era of rapid technological advancement and complex global networks, the insights derived from this research are invaluable for guiding future practices and investigations in supply chain risk management.

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APPENDICES

Appendix A – VARIABLE DEFINITIONS

Variable	Definition	Authors
Supply Risk (Independent)	The probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the purchasing firm's inability to meet customer demand or cause threats to customer life and safety.	Zsidisin (2003, 222)
Demand Risk (Independent)	A mismatch between the availability of final products and customer demand poses risks, including excess stocks, the mistaken introduction of new products, and variations in demand.	Ghadge et al. (2012), Diabat et al. (2012), Mentzer & Manuj (2008)
Manufacturing Risk (Independent)	Risks that affect a company's ability to produce profitable, timely goods and services that meet quality goals through their production activities.	Wu et al., (2006)
Supply Chain Risk Management (SCRM) (Independent)	An inter-organizational collaborative endeavor that utilizes quantitative and qualitative risk management methodologies to identify, evaluate, mitigate, and monitor unexpected macro- and micro-level events or conditions that might adversely impact any part of a supply chain.	William Ho, Tian Zheng, Hakan Yildiz & Srinivas Talluri (2015)
Environmental Uncertainty (Independent)	Risks that are outside the supply chain, such as economic crises, strikes, and pandemics.	Pfohl et al. (2010), Jüttner (2005), Trkman, P. and McCormack, K. (2009)
Relational Governance (Independent)	The extent to which the relationship is governed by trust, flexibility, solidarity, information exchange, fairness, and informal rules and procedures.	Abdi and Aulakh (2012), Poppo and Zenger (2002)
Contractual Governance (Independent)	The extent to which roles, obligations, responsibilities, contingency adaptation, and legal penalty are specified or well-detailed in formal agreements.	Abdi and Aulakh (2012), Luo (2005)
Supply Chain Interruption (Dependent)	A negative consequence due to a disturbance or problem of an event, activity, or process that serves the supply function.	Bode, Christoph, Stephan M Wagner, and Kenneth J Petersen (2011)

Gender (Control)	Sexual orientation of the participant	Male or Female
State (Control)	US state of the participant	US States
Dealership Size (Control)	Number of employees at the US dealership	0-100, 101-500, 501-999, 1000 – greater
Dealership Role (Control)	Formal job title of the participant	Executive, Senior Management, Manager, Individual Contributor
Automotive Types (Control)	Type of automobile	Gas-Powered Only, Electric Only, Both Gas-Powered and Electric Cars (Hybrid, Same Model), Both Gas-Powered Models and Electric Cars (Not the Same Car Model)

Appendix B – SURVEY SUMMARY and SOURCES

Construct Name	Number of Questions	Source	Type of Variable
Supply Risk	10	Wagner, S.M. and Bode, C. (2008) Muhammad Saeed Shahbaz; Raja Zuraidah RM Rasi; MD Fauzi Bin Ahmad (2019) Kumar, V., Bak, O., Guo, R., Shaw, S. L., Colicchia, C., Garza-Reyes, J. A., & Kumari, A. (2018)	Independent
Demand Risk	7	Wagner, S.M. and Bode, C. (2008) Atuahene-Gima, Kwaku, and Haiyang Li (2004) Jie Chen, Amrik S. Sohal & Daniel I. Prajogo (2013)	Independent
Manufacturing Risk	10	Punniyamoorthy, M., Thamaraiselvan, N., & Manikandan, L. (2013)	Independent
Supply Chain Risk Management	7	Wagner, S.M. and Bode, C. (2008)	Independent
Relational Governance	12	Sheng, S., Zhou, K.Z., Li, J.J (2018)	Independent
Contractual Governance	7	Sheng, S., Zhou, K.Z., Li, J.J (2018) Lee, C. H., Son, B. G., & Roden, S. (2023) Wang, Y., & Liu, F. (2020).	Independent
Environmental Uncertainty	12	Wagner, S.M. and Bode, C. (2008) Inman, R Anthony, and Kenneth W Green. (2022) Punniyamoorthy, M., Thamaraiselvan, N., & Manikandan, L. (2013) Muhammad Saeed Shahbaz; Raja Zuraidah RM Rasi; MD Fauzi Bin Ahmad (2019)	Independent
Supply Chain Disruption	5	Bode, Christoph, Stephan M. Wagner, & Kenneth J. Petersen (2011). *Questions not used in the Pilot and Main Study.	Dependent
Supply Chain Interruption	9	Bode, Christoph, Stephan M. Wagner, and Kenneth J. Petersen (2011)	Dependent

Appendix C – PILOT STUDY DEMOGRAPHICS (n=90)

Age Range	**n**	**%**
18-24	2	2.2
25-34	24	26.7
35-44	33	36.7
45-54	25	27.8
> 54	6	6.7

Gender	**n**	**%**
Male	47	52.2
Female	43	47.8

Number of Dealerships employees	**n**	**%**
0	1	1.1
1	2	2.2
2-5	0	0.0
6-10	2	2.2
11-25	1	1.1
26-50	7	7.8
51-100	16	17.8
101-250	17	18.9
251-500	23	25.6
501-1000	14	15.6
1001-5000	3	3.3
> 5000	4	4.4

Employment Status	**n**	**%**
Employed for Wages	77	85.6
Retired	1	1.1
Self-Employed	9	10.0
Student	1	1.1
Unemployed, Looking	1	1.1
Unemployed, Not Looking	1	1.1

Education Status	n	%
High School	19	21.1
Postgraduate	13	14.4
University	34	37.8
Vocational Technical College	24	26.7

State of Participant	**n**	%
Alabama	1	1.1
Arizona	2	2.2
Arkansas	1	1.1
California	6	6.7

Organizational Role	**n**	%
Administrative Clerical	0	0.0
Business Administrator	4	4.4
Buyer Purchasing Agent	0	0.0
C Level Executive	1	1.1

Connecticut	2	2.2
Florida	8	8.9
Georgia	5	5.6
Idaho	1	1.1
Illinois	4	4.4
Indiana	2	2.2
Kentucky	1	1.1
Louisiana	2	2.2
Maryland	5	5.6
Michigan	3	3.3
Minnesota	1	1.1
Mississippi	1	1.1
Missouri	4	4.4
Nebraska	1	1.1
Nevada	1	1.1
New Jersey	4	4.4
New Mexico	2	2.2
New York	5	5.6
North Carolina	5	5.6
Oklahoma	2	2.2
Ohio	2	2.2
Pennsylvania	4	4.4
Rhode Island	2	2.2
South Carolina	2	2.2
Tennessee	2	2.2
Texas	5	5.6
Virginia	2	2.2
Washington	2	2.2

Chief Financial Officer	3	3.3
Chief Technical Officer	3	3.3
Craftsman	0	0.0
Director	2	2.2
Faculty Staff	2	2.2
Foreman	6	6.7
HR Manager	3	3.3
Middle Management	9	10.0
Not Working	1	1.1
Other Non-Management	6	6.7
Owner Partner	4	4.4
Prefer Not to Say	0	0.0
President CEO Chairperson	3	3.3
Product Manager	1	1.1
Project Management	2	2.2
Sales Staff	4	4.4
Senior Management	19	21.1
Supervisor	14	15.6
Supply Manager	3	3.3
Technical Staff	0	0.0

Race	**n**	**%**
Arab	7	7.8
Asian	4	4.4
Black	18	20.0
Hispanic	16	17.8
Latino	12	13.3
Multiracial	2	2.2
Other	1	1.1
Prefer Not to Say	0	0.0
White	30	33.3

Total Years of Dealership Experience	**n**	**%**
0	0	0.0
1-3 Years	24	26.7
4-6 Years	43	47.8
7-9 Years	18	20.0
10+	5	5.6

Current Years of Dealership Experience	**n**	**%**
0	0	0.0
1-3 Years	43	47.8
4-6 Years	30	33.3
7-9 Years	15	16.7
10+	2	2.2

Types of Cars Sold at the Current Dealership	**n**	**%**
Gas-Powered Cars Only	24	26.7
Electric Cars Only	17	18.9
Both Gas-Powered and Electric Cars (Hybrid, Same Model)	30	33.3
Both Gas-Powered Models and Electric Cars (Not the Same Car Model)	19	21.1
Do Not Work at a Dealership	0	0.0

Appendix D – MAIN STUDY DEMOGRAPHICS (n=519)

Age Range	**n**	**%**
18-24	49	9.4
25-34	161	31
35-44	131	25.2
45-54	81	15.6
> 54	97	18.7

Gender	**n**	**%**
Male	326	62.8
Female	193	37.2

Number of Dealerships Employees	**n**	**%**
Prefer Not to Say	4	0.8
Do Not Work	13	2.5
1	5	1.0
2-5	8	1.5
6-10	18	3.5
11-25	4	0.8
26-50	37	7.1
51-100	54	10.4
101-250	73	14.1
251-500	99	19.1
501-1000	117	22.5
1001-5000	65	12.5
> 5000	22	4.2

Employment Status	**n**	**%**
Employed for Wages	386	74.4
Homemaker	2	0.4
Other	10	1.9
Self-Employed	91	17.5
Student	7	1.3
Retired	3	0.6
Unable to Work	2	0.4
Unemployed, Looking	17	3.3
Unemployed, Not Looking	1	0.2

State of Participant	n	%
Alabama	5	1.0
Arizona	7	1.3
Arkansas	1	0.2
California	68	13.1
Colorado	11	2.1
Connecticut	5	1.0
Delaware	2	0.4
Florida	40	7.7
Georgia	25	4.8
Hawaii	2	0.4
Idaho	26	5.0
Illinois	19	3.7
Indiana	8	1.5
Iowa	3	0.6
Kansas	5	1.0
Kentucky	6	1.2
Louisiana	4	0.8
Maine	1	0.2
Maryland	9	1.7
Massachusetts	9	1.7
Michigan	18	3.5
Minnesota	4	0.8
Mississippi	6	1.2
Missouri	12	2.3

Organizational Role	n	%
Administrative Clerical	15	2.9
Business Administrator	11	2.1
Buyer Purchasing Agent	5	1.0
C-Level Executive	10	1.9
Chief Financial Officer	7	1.3
Chief Technical Officer	9	1.7
Craftsman	19	3.7
Director	18	3.5
Faculty Staff	19	3.7
Foreman	6	1.2
HR Manager	35	6.7
Middle Management	70	13.5
Not Working	18	3.5
Other Non-Management	38	7.3
Owner Partner	22	4.2
Prefer Not to Say	15	2.9
President CEO Chairperson	19	3.7
Product Manager	8	1.5
Project Management	19	3.7
Sales Staff	33	6.4
Senior Management	71	13.7
Supervisor	29	5.6
Supply Manager	1	0.2
Technical Staff	22	4.2

Nebraska	2	0.4
Nevada	5	1.0
New Hampshire	2	0.4
New Jersey	18	3.5
New Mexico	2	0.4
New York	32	6.2
North Carolina	10	1.9
Ohio	33	6.4
Oklahoma	2	0.4
Oregon	5	1.0
Pennsylvania	15	2.9
Rhode Island	4	0.8
South Carolina	17	3.3
Tennessee	2	0.4
Texas	45	8.7
Utah	6	1.2
Virginia	12	2.3
Washington	6	1.2
Wisconsin	4	0.8

Race	n	**%**
Arab	18	3.5
Asian	37	7.1
Black	52	10.0
Hispanic	26	5.0
Latino	1	0.2
Multiracial	2	0.4
Other	10	1.9
Prefer Not to Say	2	0.4
White	371	71.5

Education Status	n	%
High School	86	16.6
Postgraduate	184	35.5
University	167	32.2
Vocational Technical College	82	15.8

Total Years of Dealership Experience	**n**	**%**
0	0	0.0
1-3 Years	124	23.9
4-6 Years	171	32.9
7-9 Years	149	28.7
10+	75	14.5

Current Years of Dealership Experience	**n**	**%**
0	21	4.0
1-3 Years	182	35.1
4-6 Years	203	39.1
7-9 Years	84	16.2
10+	29	5.6

Types of Cars Sold at the Current Dealership	**n**	**%**
Gas-Powered Cars Only	84	16.2
Electric Cars Only	38	7.3
Both Gas-Powered and Electric Cars (Hybrid, Same Model)	242	46.6
Both Gas-Powered Models and Electric Cars (Not the Same Car Model)	135	26
Do Not Work at a Dealership	20	3.9

Appendix E – SURVEY INSTRUMENT

SUPPLY CHAIN RISK FACTORS AND INTERRUPTION SURVEY

Qualifying Questions:

All three questions must be answered yes to start the survey:

- Do you work for a US automotive dealership that sells new cars? Yes/No
- Do you have a minimum of 1-year experience with a US dealership? Yes/No
- Is your employee level one of the following: Executive, Senior Management, Manager, or Individual Contributor? Yes/No

Instruction:

The following survey will ask about your company's supply chain management in the past two years. Please answer all questions using the seven-point scale:

1= Not at all, 2= To a very small extent, 3= To a small extent, 4= To a moderate extent, 5= To a fairly great extent. 6= To a great extent 7= To a very great extent

Read each question carefully and provide your answer.

Supply Risk (SR1-10) **Variable Type - Independent**

To what extent has your dealership, in the past two years, experienced the following risks related to suppliers:

1. The availability of products and services. [3]
2. Late deliveries of products. [3]
3. Cost fluctuations of products. [3]
4. Supplier quality problems. [3]
5. Transportation failure. [1]
6. Multiple supplier dependency. [3]
7. Technical capability. [3]
8. Export or import restrictions. [1]
9. Dependency on a single supplier for critical time [2]
10. Capacity fluctuations of suppliers. [2]

Resources:

1. Wagner, S.M. and Bode, C. (2008)
2. Muhammad Saeed Shahbaz; Raja Zuraidah RM Rasi; MD Fauzi Bin Ahmad (2019)
3. Kumar, V., Bak, O., Guo, R., Shaw, S. L., Colicchia, C., Garza-Reyes, J. A., & Kumari, A. (2018)

Demand Risk (DR1-7) **Variable Type - Independent**

To what extent has your dealership, in the past two years, experienced the following risks related to demand:

1. Volatile customer demands. [2]
2. Customer change specifications (time, quality, quantity). [2]
3. Loss due to customers' faults (a mistake from the customer). [2]
4. Frequent delays in delivery to customers. [2]
5. Demand fluctuations for our products from customers. [1]
6. Insufficient or distorted information that informs our demand projections. [1]
7. Reputation risk in demand. [3]

Resources:

1. Wagner, S.M. and Bode, C. (2008)
2. Atuahene-Gima, Kwaku, and Haiyang Li (2004)
3. Jie Chen, Amrik S. Sohal & Daniel I. Prajogo (2013)

Manufacturing Risk (MR1-10) **Variable Type - Independent**

To what extent has your dealership, in the past two years, experienced the following risks related to manufacturing:

1. Disruption in production. [1]
2. Variability in process. [1]
3. Variability of product cycle time. [1]
4. Inadequate production capability. [1]
5. Inflexibility in capacity. [1]
6. Frequent product recall process. [1]
7. Labor (strike, incident). [1]
8. Vague inspection and acceptance procedures from the supplier. [1]
9. Hesitation in sharing of design and other documents with supplier. [1]
10. Improper handling/maintenance of strategic warehouses. [1]

Resources:

1. Kumar, Vikas & Bak, Ozlem & Guo, Ruizhi & Shaw, Sarah & Colicchia, Claudia & Garza-Reyes, Jose Arturo & Kumari, Archana. (2018**)**

Supply Chain Risk Management (SCRM1-7)   Variable Type - Independent

To what extent has your dealership, in the past two years, experienced the following risks related to supply chain risk management:

1. Adequate human resources for supply chain risk management (SCRM). [1]
2. Regularly monitor your suppliers to identify supply chain risks. [1]
3. Regularly monitor your customer demand to identify supply chain risks. [1]
4. Working on transparency of your supply chain and sharing information with partners. [1]
5. Adequate business continuity or contingency plans to address identified supply chain risks. [1]
6. Review and update your business continuity or contingency plans for identified supply chain risks. [1]
7. Proactive in reviewing your business continuity or contingency plans to minimize potential impact. [1]

Resources:

1. Wagner, S.M. and Bode, C. (2008)

Relational Governance (RG1-12) **Variable Type – Independent**

To what extent has your dealership, in the past two years, characterized between your dealership and suppliers based on your relationship (relational governance) to specify:

1. The flexibility in response to your suppliers' requests for changes. [1]
2. The ability to adjust to cope with changing circumstances in the ongoing relationship. [1]
3. The ability to work out a new deal rather than hold each other to the original terms when unexpected situations arise. [1]
4. The openness to changes in fixed prices that are not ruled out by the suppliers, if necessary. [1]
5. The ability to provide proprietary information if it can help the other party. [1]
6. The ability to inform each other about events or changes that may affect the other party. [1]
7. The ability to share supply and demand forecasts. [1]
8. The ability to frequently exchange information in this relationship. [1]
9. The ability to treat problems during this relationship as joint rather than individual responsibilities. [1]
10. The ability to commit to improvements that may benefit the relationship as a whole, not just the individual parties. [1]
11. We do not mind owing each other favors in this relationship. [1]
12. The ability to take joint responsibilities with suppliers to get things done. [1]

Resources:

1. Sheng, S., Zhou, K. Z., Li, J. J., & Guo, Z. (2018).

Contractual Governance (CG1-7) **Variable Type – Independent**

To what extent has your dealership, in the past two years, in dealing with your supplier, relied on the formal written contract agreements (as opposed to shared understanding) to specify:

2. The supplier defined the role of each party. [1]
3. The supplier defined the responsibilities of each party. [1]
4. The supplier stated how each party was to perform. [1]
5. The supplier stated the legal ramifications for failure to perform. [2]
6. The supplier stated how disagreements would be resolved. [1]
7. The supplier stated what would happen in the case of events occurring that were not planned. [2]
8. The supplier precisely stated the standard for the service. [3]

Resources:

1. Sheng, S., Zhou, K. Z., Li, J. J., & Guo, Z. (2018).

2. Lee, C. H., Son, B. G., & Roden, S. (2023).

3. Wang, Y., & Liu, F. (2020).

Environmental Uncertainty (EU1-12) **Variable Type – Independent**

To what extent has your dealership, in the past two years, experienced the following risks related to environmental uncertainty:

1. Uncertainty due to government laws/regulations. [3]
2. Diseases or epidemics (e.g., SARS, COVID-19). [4]
3. Natural disasters (e.g., earthquakes, flooding, extreme climate, tsunamis). [2]
4. International terror attacks (e.g., 2022 Russia/Ukraine). [1]
5. Necessity in making major changes in this organization's production processes. [1]
6. The actions of your dealership competitors are unpredictable. [1]
7. Macroeconomic uncertainty (inflation, fiscal policy, national income, and international trade). [2]
8. Unnecessarily making major changes in my dealership's production process. [4]
9. Non availability of non-skilled workforce for the job. [4]
10. Non availability of skilled workforce for the job (strikes). [4]
11. Administration barriers for the setup or operation (US customs). [4]
12. Technological changes. [4]

Resources:

1. Wagner, S.M. and Bode, C. (2008)
2. Inman, R Anthony, and Kenneth W Green. (2022)
3. Punniyamoorthy, M., Thamaraiselvan, N., & Manikandan, L. (2013)
4. Muhammad Saeed Shahbaz; Raja Zuraidah RM Rasi; MD Fauzi Bin Ahmad (2019)

Supply Chain Disruption (SCD1-5) **Variable Type - Dependent**

To what extent has your dealership, in the past two years, experienced (directly or indirectly) the following related to supply chain disruption:

1. Need to get alerts for possible supply chain disruptions. [1]
2. Supply chain disruptions show us where we can improve. [1]
3. Recognize that supply chain disruptions are always looming. [1]
4. Think about how disruption could have been avoided. [1]
5. A supply chain disruption occurred, and it is was analyzed thoroughly. [1]

Resources:

1. Bode, Christoph, Stephan M. Wagner, and Kenneth J. Petersen (2011)

Supply Chain Interruption (SCI 1-9) **Variable Type – Dependent**

To what extent has your dealership, in the past two years, experienced (directly or indirectly) the following related to supply chain disruption impact:

1. Procurement costs/prices for the purchased item. [1]
2. Procurement delivery for purchased items. [1]
3. Overall efficiency of your operations. [1]
4. Quality of the items we sell. [1]
5. Quality of your service products. [1]
6. Responsiveness to customer demands. [1]
7. Delivery reliability (on-time delivery). [1]
8. Delivery reliability (order accuracy). [1]
9. Dealership sales forecast. [1]

Resources:

1. Bode, Christoph, Stephan M. Wagner, and Kenneth J. Petersen (2011)

AGE RANGE **Variable Type – Control**

18-24 25-34 35-44 45-54 > 54

GENDER **Variable Type – Control**

Male Female

NUMBER OF DEALERSHIP EMPLOYEES **Variable Type – Control**

Prefer Not to Say	Do Not Work	1
2-5	6-10	11-25
26-50	51-100	101-250
251-500	501-1000	1001-5000
>5000		

STATE OF PARTICIPANT **Variable Type – Control**

ORGANIZATIONAL ROLE **Variable Type – Control**

Administrative Clerical Business Administrator Buyer Purchasing Agent

C Level Executive	Chief Financial Officer	Craftsman
Director	Faculty Staff	Foreman
HR Manager	Middle Management	Not Working
Other Non-Management	Owner Partner	Prefer Not to Say
President, CEO Chairperson	Product Manager	Project Management
Sales Staff	Senior Management	Supply Manager
Technical Staff		

Race **Variable Type – Control**

Arab	Asian	Black
Hispanic	Latino	Multiracial
Other	Prefer Not to Say	White

TOTAL YEARS OF AUTOMOTIVE EXPERIENCE (TYAE1) Variable Type – Control

How many total years of experience do you have in the automotive dealership industry?

0 1-3 Years 4-6 Years 7-9 Years 10+

YEARS AT CURRENT DEALERSHIP (YAC1) Variable Type – Control

How many years of experience do you have with your current dealership?

0 1-3 Years 4-6 Years 7-9 Years 10+

TYPE OF CAR (TOC1) **Variable Type – Control**

What types of cars are sold at your current dealership?

None - I currently do not work at a dealership

Gas-powered cars only

Electric cars only

Both gas-powered and electric cars (hybrid, same model)

Both gas-powered models and electric cars (not the same car model)

VITA

RACQUEL ROBINSON JONES

1990-1995	B.Sc. Information Systems Rochester Institute of Technology Rochester, New York
1995 – 1998	Systems Engineer Electronic Data Systems (EDS) Rochester, New York
1998- 2002	Motorola Corporation Software Engineer Phoenix, Arizona
2002-2004	M.Sc. Information Systems University of Phoenix Phoenix, Arizona
2004-2005	City of Phoenix Information Tech Analyst Programmer III Phoenix, Arizona
2005-2020	Intel Corporation Engineering Program Manager Phoenix, Arizona, Columbia, South Carolina, Austin, Texas
2020- 2024	VMware Inc. Technical Program Manager
2021-2024	Doctorate in Business Administration Florida International University Chapman Graduate School of Business Miami, Florida