INSTITUTE FOR HOMELAND SECURITY

SUPPLY CHAIN RISKS AT US/MEXICO BORDER

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SUMMARY

The US/Texas-Mexico border region serves as a vital artery for international trade, essential for linking markets and fueling economic growth. The region's importance extends to multiple sectors, including automotive. Managing supply chain risks pertinent to this area is integral for maintaining smooth operations. This report analyses the challenges faced along the border, from security threats to infrastructural constraints and regulatory complexities. It aims to equip supply chain managers with effective strategies and recommendations to navigate these challenges, particularly from a Texas viewpoint.

This report explores the US-Mexico border's economic, political, social, environmental, and cultural significance. It dissects the intricacies of supply chain operations and identifies potential threats leading to disruptions. To mitigate these risks, such as trade policy changes, cross-border delays, labor disputes, natural disasters, cybersecurity threats, regulatory compliance, and economic instability, the report outlines practical strategies.

These tactics include supplier diversification, technology integration, fostering strong supplier relationships, risk assessment and planning, inventory management, resilient design, robust cybersecurity measures, and financial risk management. For instance, supplier diversification and geographical dispersion diminish the impact of disruptions, while technology integration facilitates real-time tracking, predictive analytics, and efficient communication. Regulatory compliance, reinforced by robust cybersecurity measures, ensures quality and shields against potential disruptions.

The report also underscores the Texan values of resilience, collaboration, innovation, self-reliance, and preparedness and their importance in managing the US/Mexico trade. The implementation of the discussed strategies is in alignment with these values, exhibiting their relevance in handling supply chain risks.

Emphasizing the need for continuous cooperation and dialogue between the US and Mexico, the report concludes by affirming the importance of proficiently managing supply chain risks. This approach aids in preserving the prosperity of cross-border trade and contributes to the economic robustness of both nations.

Companies in the automotive industry, such as Ford and GM, have exemplified the successful implementation of these strategies, demonstrating their efficiency in minimizing disruptions and promoting the seamless flow of goods and services during events like the COVID-19 pandemic.

In conclusion, this report elucidates the applicability of various strategies in mitigating supply chain risks. These tactics, adaptable to specific needs and risk tolerance of companies, foster a resilient and secure supply chain, ensuring the uninterrupted flow of goods and services across the US/Texas-Mexico border.

INTRODUCTION

The US/Texas-Mexico border, a bustling trade conduit, stands as a testament to the deep-seated economic intertwining of the two nations. The intricate cross-border supply chain operations play a vital role in connecting markets, enabling the smooth movement of goods, and fostering the economic growth of both countries. However, these border operations are not devoid of challenges. Supply chain risks specific to the US/Texas-Mexico border region are manifold, and their proper management is paramount to sustain seamless trade operations.

This report presents an in-depth examination of the supply chain risks in the US/Texas-Mexico border region. It aims to highlight these unique challenges, ranging from security risks such as theft and vandalism to infrastructural hurdles like traffic congestion, border crossing delays, and regulatory complexities concerning cross-border trade. In doing so, we delve into the intricate dynamics of the region's supply chain operations, articulating the potential threats that can cause disruptions.

The report is divided into three key sections: an analysis of supply chain risks, the practical applicability of the analysis, and a focused exploration from the Texas perspective. Each section dissects various facets of the risks and thoroughly analyses the current scenario. This helps us frame effective strategies and recommendations for managing these challenges and ensure that supply chain operations thrive despite the inherent difficulties.

Furthermore, the report emphasizes the Texas perspective, providing insights into this border state's unique supply chain challenges and opportunities. Given Texas's pivotal role in US/Mexico trade, understanding its specific circumstances is crucial for tailoring effective supply chain strategies.

This report is designed to be accessible to a broad range of readers. We present the information in clear and easy-to-understand language, supported by visual aids such as maps, graphs, and tables, to better understand the complex interplay of supply chain risks and recommendations.

The objective of this report is to facilitate a better understanding of the supply chain risks inherent to the US/Texas-Mexico border region. We aim to empower supply chain managers with the knowledge and tools to navigate these challenges successfully. By doing so, we can ensure the continued prosperity of cross-border trade, contributing to both nations' economic growth and strength.

BACKGROUND TO US-MEXICO BORDER

US Border Business Political and Economic Overview

The US-Mexico border, spanning roughly 1,954 miles (3,145 kilometres), holds immense significance in economic, political, social, cultural, and environmental domains and is recognized as the world's most frequently traversed international boundary.

Figure 1: US-Mexico Border (Wikipedia, 2023)

Starting from the Pacific Ocean, the border follows a series of markers heading eastward, crossing four U.S. states: California, Arizona, New Mexico, and Texas, and six Mexican states: Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas. The border's eastern end is at the Gulf of Mexico.

The table below shows the number of dollars crossing each bridge on the Texas-Mexico border in 2020. As you can see, the El Paso bridges handle the most trade between Texas and Mexico, with the Bridge of the Americas being the busiest bridge in the entire state. The Laredo bridges are also very busy, with the World Trade International Bridge being the busiest in the Rio Grande Valley.

It is important to note that these figures only represent the value of goods crossing the bridges and do not include the value of services or people crossing the border. Additionally, these figures are for 2020, and the amount of trade crossing the border may have changed since then.

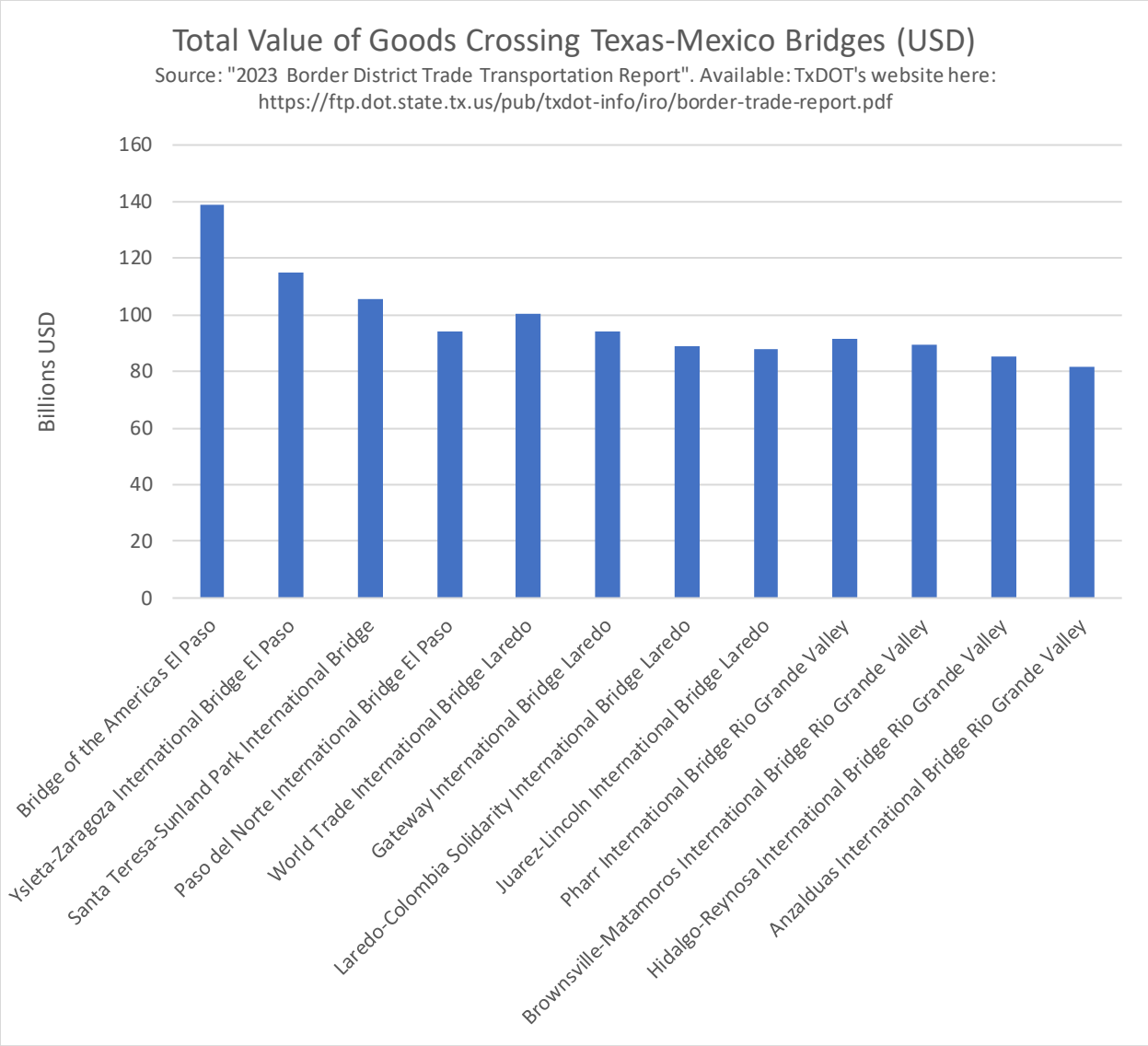

Figure 2: Total Value Of Goods Crossing Texas-Mexico Bridges (TxDOT, 2023)

In terms of economics, this border is a fundamental pillar of both nations' economies. Trade facilitated through agreements like the now-replaced North American Free Trade Agreement (NAFTA) (Office of the United States Trade Representative (USTR), 1994) and the current (United States Trade Representative, 2020) United States-Mexico-Canada Agreement (USMCA) results in exchanging goods and services worth billions of dollars annually. Border cities such as San Diego, El Paso, and Tijuana thrive due to the economic activity spurred by cross-border trade, tourism, and investments.

Politically, the border is a focal point in both countries due to its association with immigration and border security. In the US, the discourse often revolves around enhancing border security to counter illegal immigration, drug trafficking, and potential threats to national security.

Mexican politics, on the other hand, tend to concentrate on migrant rights, economic opportunities, and collaborative strategies with the US on border security issues.

The US-Mexico border is also a vibrant social and cultural junction that witnesses a unique amalgamation of Mexican and American traditions, languages, and cuisines. It binds families on both sides, who maintain close connections and frequently cross to meet. It also serves as an entrance for immigrants aspiring for a better life in the United States.

Furthermore, the border is the epicenter of a burgeoning humanitarian crisis, with many migrants and asylum-seekers attempting to cross into the US each year. Most of these individuals are fleeing violence, persecution, or extreme poverty. Addressing this crisis is essential to safeguard human rights, provide humanitarian aid, and explore long-term solutions to the root causes of migration.

From an environmental standpoint, the border area hosts a diverse ecosystem and several protected natural areas and wildlife refuges, necessitating careful preservation efforts. Challenges such as water scarcity, pollution, and habitat loss require cross-border collaboration. The added complications from climate change make the environmental cooperation between the US and Mexico even more crucial.

In summary, the US-Mexico border is a dynamic area that serves as an economic hub, a political hotbed, a cultural melting pot, a focal point for humanitarian issues, and an environmentally significant region. Continuous cooperation and dialogue between both nations are essential to address the multifaceted challenges present in this area.

STEEPLE Analysis

A STEEPLE analysis examines the various factors that affect a particular subject by looking into Social, Technological, Economic, Environmental, Political, Legal, and Ethical aspects. Here's a detailed STEEPLE analysis of the US-Mexico border:

	Social	Technical	Economical	Environmental	Political	Legal	Ethical
1	The border region is characterized by a mix of Mexican and American cultures, with common bilingualism and biculturalism.	Surveillance and security technologies, such as drones, cameras, and biometric systems, are used to monitor and control border crossings.	The US-Mexico border is a critical driver of economic activity, with billions of dollars in trade occurring annually.	The border region is home to diverse ecosystems and protected natural areas that require conservation and sustainable management.	Immigration and border security are prominent issues in the political discourse of both countries.	Legal frameworks, such as the USMCA, govern trade and economic relations between the US and Mexico.	Addressing the humanitarian crisis at the border involves protecting the human rights of vulnerable individuals, providing humanitarian assistance, and finding long-term solutions to the root causes of migration.
2	Family ties often span the border, with members living on both sides.	Electronic systems are employed to facilitate trade and customs procedures, improving efficiency and reducing wait times.	Border cities benefit from the economic activity generated by cross-border trade, tourism, and investments.	Environmental challenges include water scarcity, pollution, and habitat loss, requiring cross-border collaboration to address them effectively.	US politicians may focus on securing the border to combat illegal immigration, drug trafficking, and potential national security threats.	Immigration laws and policies dictate the process and requirements for people attempting to cross the border, whether for work, study, or asylum.	Balancing the need for border security with the rights of migrants and asylum-seekers ensures that policies and practices do not discriminate or violate human rights.
3	Migrants and asylum-seekers at the border may face significant social challenges, such as integration into the local community and access to education, healthcare, and employment opportunities.	Digital platforms and social media have shaped public opinion on border-related issues and provided support networks for migrants and border communities.	The USMCA has facilitated trade and economic	Climate change exacerbates existing environmental issues, necessitating greater cooperation and action on both sides of the border.	Mexican politicians may address issues related to migrant rights, economic opportunities, and cooperation with the US on border security.	Cross-border collaboration on law enforcement and security requires agreements and cooperation between the two countries to combat organized crime and drug trafficking.	Ensuring that environmental policies and practices in the border region are sustainable and promote the well-being of both human and natural communities.

Figure 3 US-Mexico Border SEEPLE Analysis

Analysis of the Interplay Between STEEPLE Elements

The social factors are intertwined with economic and political aspects. The mixed Mexican American culture shaped by strong family ties and migration influences economic activities as migrants seek new opportunities. Their struggle to integrate, in turn, becomes a significant political issue. Legal and ethical aspects also come into play, as the migrants' rights and access to various opportunities are governed by laws and require a just approach.

Technological advancements are largely connected with political and legal elements. The technology used for border surveillance impacts immigration policies and the political discourse around border security. It's also tied to ethical considerations, with the need to balance security and migrants' rights. Meanwhile, digital platforms play a role in shaping cultural perceptions and fostering community support.

The border region's economy is closely tied to legal and political factors, with trade agreements like the USMCA significantly influencing economic activities. This, in turn, is influenced by social factors, as migration affects the labor market and cross-border commerce. Environmental factors also impact the economy, as environmental challenges may threaten sustainable economic growth.

Environmental concerns are tied to the economy (via impacts on commerce and tourism), and to ethical considerations, as sustainable practices are crucial to conserving the region's ecosystems. They're also linked to politics, as climate change and environmental management often require governmental initiatives and international cooperation.

Political decisions are shaped by social, economic, and technological factors and impact nearly every other area. Immigration policies, for instance, stem from social realities but can influence economic conditions and are both influenced by and a factor in technological development for border security. Additionally, politics play a central role in addressing environmental issues.

Legal frameworks govern economic, social, and political relationships. They regulate economic practices like the (United States Trade Representative, 2020) agreement and set migration rules, affecting social dynamics. They also interact with ethical considerations, as laws should ideally reflect principles of justice and equality.

Ethical considerations touch upon every other aspect: respect for migrants' rights (social), the use of surveillance technology (technological), promoting economic equality (economic), conserving ecosystems (environmental), policy decisions (political), and legal fairness (legal).

Overall, the border situation is a complex network of interconnected factors, with each component influencing and being influenced by the others. These connections illustrate the complex challenges of managing such situations and highlight the need for holistic approaches.

AUTOMOTIVE SUPPLY CHAIN AND TRANSPORTATION

The US-Mexico border is a significant link in the automotive industry's transportation and supply chain, thanks to the integration of the two economies through NAFTA and its successor, the USMCA. This integration has led to substantial growth in the automotive sector, highlighting the border's vital role in this industry.

The Manufacturing and Production Perspective

The US and Mexico automotive industry has grown significantly, largely due to the manufacturing cost advantages offered by Mexico. These benefits include lower labor costs, access to skilled workers, and favorable trade policies (KPMG, 2016). Consequently, numerous US and foreign automakers have established manufacturing facilities in Mexico, producing vehicles and components for the US and other global markets (Canas, Coronado & Gilmer, 2011). The manufacturing process often necessitates cross-border transport of these components and finished products, with parts sometimes crossing the border multiple times before the final assembly (Villarreal & Fergusson, 2014).

The Trade and Logistics Importance

The US-Mexico automotive trade is a vital economic driver for both countries. In 2022, the value of automotive trade between the two countries was estimated at $200 billion (International Trade Administration, 2022), making it the world's largest bilateral automotive trade relationship. The US-Mexico border is a critical node in the global automotive supply chain, with billions of dollars' worth of vehicles, parts, and components crossing the border each year.

Efficient border crossing and customs procedures are essential for maintaining the smooth flow of goods across the border (U.S. Department of Transportation, 2019). Any disruptions to the supply chain can have significant impacts on production timelines and costs. In recent years, there have been concerns about the potential for increased border security measures to disrupt the automotive trade. However, the US and Mexico have taken steps to ensure the border remains open and efficient for trade.

A robust logistics infrastructure is also essential for supporting the US-Mexico automotive trade. This includes highways, rail systems, and ports that can efficiently move goods between the two countries. Strategic infrastructure investments are needed to ensure the logistics infrastructure can keep pace with the growing automotive trade.

The US-Mexico automotive trade is a win-win for both countries. It creates jobs, boosts economic growth, and enhances the competitiveness of both economies. By working together to maintain a smooth and efficient border crossing and logistics infrastructure, the US and Mexico can continue to reap the benefits of this vital economic relationship.

The Integration of Supply Chains

The North American automotive industry has heavily integrated supply chains, with US and Mexican companies deeply reliant on each other. This integration offers numerous advantages, including cost savings and access to specialized manufacturing. However, it also presents challenges as disruptions in one country can significantly impact the other (Center for Automotive Research, 2017). Events like natural disasters, labor disputes, or trade disputes can cause component availability disruptions, leading to production delays or cost increases.

Advancements in Innovation and Technology

The US-Mexico border region is a crucial hub for innovation and technological advancements in the automotive industry, playing a key role in developments such as electric vehicles and autonomous driving technology (Deloitte, 2020; Chatterjee & Hillebrand, 2019). It also serves as a testing ground for innovative transport and logistics technologies, like automated border crossings, which aim to streamline customs procedures and reduce operational costs. These technological advancements emphasize the region's importance beyond its role as a supply chain link.

Essential Knowledge for Supply Chain Managers Utilizing the Mexico Border Crossings

For smooth operations, supply chain managers using the US-Mexico border crossings must consider various factors (see table below). These factors include the crossing hours of operation, crossing fees, crossing times, customs procedures, trade agreement compliance, security issues, transport infrastructure quality, regulatory changes, potential disruptions, language and cultural understanding, use of technology for process streamlining and real-time shipment tracking, relationships with border agencies, and awareness of cargo restrictions.

The complexity of border operations necessitates a well-informed team capable of responding quickly to unexpected situations. Companies can mitigate disruptions and maintain an efficient automotive supply chain across North America through proactive risk management and a resilient supply chain.

	Factor	Description
1	Hours of Operation	Not all border crossings operate 24/7. Understand the hours of operation for each bridge and plan logistics accordingly.
2	Crossing Fees	Most crossings charge fees, which can vary by vehicle type and size.
3	Crossing Times	Crossing times can vary greatly, influenced by factors such as time of day, day of the week, customs inspections, security checks, and holidays. Regularly monitor border crossing wait times to plan schedules efficiently.
4	Customs Procedures	Ensure you understand the customs procedures, necessary paperwork, and import/export regulations for each country. Non-compliance can result in delays and penalties.
5	Compliance with Trade Agreements	Be aware of the rules of the USMCA (the replacement to NAFTA), as well as any other relevant trade agreements, and ensure your business is in compliance.
6	Security Concerns	Some border areas may have higher levels of crime or security issues. Be aware of these concerns and plan for necessary security measures.
7	Transport Infrastructure	The quality and availability of roads, rail systems, and ports on either side of the border can affect transport times and logistics planning. Understand the transport infrastructure for each crossing.
8	Regulatory Changes	Be alert to changes in regulations or procedures that could affect your operations. This includes changes to trade agreements, import/export regulations, or customs procedures.
9	Potential Disruptions	Events such as labor strikes, political instability, severe weather, or changes in policy can disrupt operations. Have contingency plans in place for potential disruptions.
10	Language and Culture	Understanding language and cultural nuances can facilitate smoother operations and negotiations with partners or authorities on either side of the border.
11	Technology and Data Management	Use technology to streamline processes, track shipments in real-time, and predict and manage potential disruptions.
12	Relationships with Border Agencies	Building strong relationships with customs and border patrol agencies can facilitate smoother operations and faster resolution of issues.
13	Cargo Restrictions	Be aware of any restrictions or special requirements for transporting certain types of goods across the border.

Table 4 - US-Mexico border crossings Factors To Manage

Innovation and Technology

The area bordering the United States and Mexico has evolved into a significant nexus of innovation and technological advancement within the automotive industry. This international region has developed a highly collaborative environment where businesses from both countries converge on cutting-edge research and development (R&D) initiatives (Martinez and Canales, 2018; Calderón, 2020; Hamann, 2020).

At the core of these R&D efforts are significant technological breakthroughs within the automotive sector. For example, the industry is making impressive strides in developing electric vehicles, representing a sustainable shift from traditional fossil fuels. The region also plays a key role in pursuing autonomous driving technology (Osorio, 2019; Reyes, 2022). With their efforts focused on perfecting sensor capabilities, machine learning algorithms, and safety protocols, these advancements stand to redefine transportation's future. Furthermore, they're propelling forward advanced manufacturing techniques that are shaping next-generation vehicle production.

The US-Mexico border region is not only a hub for R&D but also a real-world testing ground for innovative transportation and logistics technologies. Consider automated border crossings, a technological solution that has emerged in this region to streamline customs procedures. By automating the complex processes of border checks, the technology aims to augment efficiency, mitigate human error, and substantially reduce operational costs. This innovation is instrumental in optimizing the movement of goods across the border, significantly improving the logistics ecosystem (Lewis and Swartz, 2019).

The importance of the US-Mexico border region extends beyond its role as an innovation hub, reaching deep into the heart of the automotive industry's transportation and supply chain mechanisms. The integration of these two economies has given rise to a robust and highly interdependent supply chain (Moreno, 2021; Gonzalez, 2021). This interconnected system relies heavily on the seamless cross-border flow of goods and services, propelling the automotive industry's growth and enhancing its competitive edge.

The border region's dual function as a bastion of technological innovation and a vital cog in the industry's supply chain highlights the importance of maintaining a strong, cooperative partnership between the United States and Mexico. Continued diplomatic and business relations are essential for fostering an environment conducive to technological advancement and optimizing the automotive sector's growth within North America. This region's significance is expected to rise as these nations continue to leverage technology to revolutionize the automotive landscape.

Automotive Supplier Tier Segmentation

The automotive supply chain is often divided into various tiers. These tiers classify the types of suppliers in the chain, with each tier providing different products and services to the next. Let's examine how the tiers typically break down:

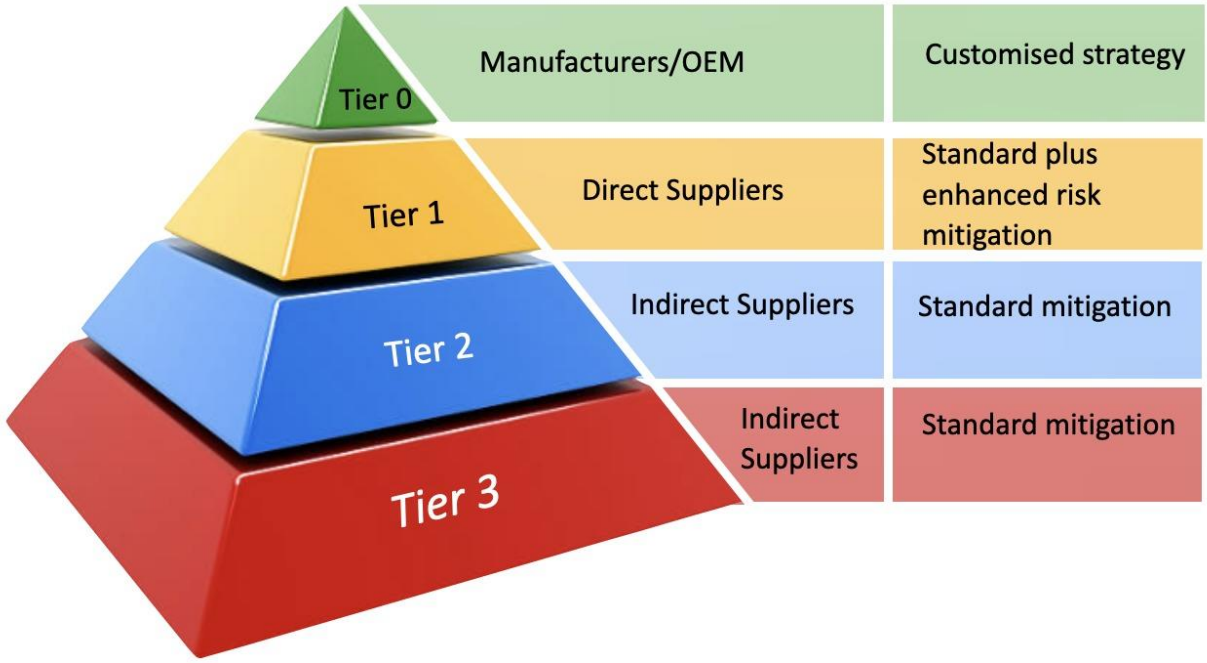

Figure 4 Automotive Supplier Tiers

Tier 0: Vehicle Manufacturers

Although vehicle manufacturers are not traditionally part of the "tier" classification, they are technically at the top of the supply chain. These companies assemble and sell the finished vehicles to the end customers (Dicken, 2015).

Tier 1 Suppliers

Tier 1 suppliers are direct suppliers to the OEMs (Original Equipment Manufacturers - the vehicle manufacturers). These companies supply OEMs with complete systems or subsystems that can be directly installed into a vehicle (OECD, 2013). They are the ones who assemble parts from Tier 2 and Tier 3 suppliers into larger car components.

Examples of products that Tier 1 suppliers might provide include infotainment systems, engine parts, brake systems, seating, and other interior components.

Tier 2 Suppliers

Tier 2 suppliers are the direct suppliers to Tier 1 suppliers (MacDuffie, 2013). These companies manufacture and supply parts or components used by Tier 1 suppliers to create complete

systems or subsystems. These parts or components might not be usable in a car by themselves but are critical to the operation of the vehicle.

Examples of products that Tier 2 suppliers might provide include individual electronic components for infotainment systems, pistons for engines, or parts of brake assemblies.

Tier 3 Suppliers

Tier 3 suppliers are typically the suppliers to the Tier 2 suppliers. These companies provide raw materials or basic components used to create the parts supplied by Tier 2 suppliers.

For example, a Tier 3 supplier might provide metals, plastics, or other materials used by a Tier 2 supplier to manufacture specific parts for a Tier 1 supplier (Dicken, 2015; OECD, 2013).

The categorization can even go deeper to Tier 4, where suppliers provide even more basic inputs, like rubber for tires or iron ore for steel production. Still, this level of classification is not commonly used.

The tier system helps manage and understand the complex relationships and interdependencies in the automotive supply chain, which involves hundreds or thousands of different companies.

IDENTIFICATION OF AUTOMOTIVE SUPPLY CHAIN RISKS

Risks From the Perspective of Automotive Supplier Tiers

Understanding risk in the context of Supplier Tiers is a highly effective approach in the supply chain landscape. The level of risk, from Tier 1 to Tier 2, can vary considerably, given their unique positions within the chain.

Tier 1 Suppliers

Tier 1 suppliers are at the forefront, providing directly to Original Equipment Manufacturers (OEMs). Consequently, they experience immense pressure to meet rigorous standards of quality, delivery, and cost set forth by the OEMs. If a Tier 1 supplier were to miss the delivery deadline for crucial components, it could halt the production line at the OEM, which could lead to significant financial penalties and potential loss of future business. These suppliers must also successfully navigate design alterations and product life cycles and be ready to adapt to demand increases or new product rollouts from the OEMs.

Tier 2 Suppliers

Although tier 2 suppliers do not deal directly with the OEMs, they face their own significant challenges. They must meet the requirements of Tier 1 customers, which can be as demanding as those set by the OEMs, but with less direct control over the final product. Moreover, the success of Tier 2 suppliers is closely tied to the Tier 1 suppliers they serve. These suppliers must also manage a diverse supplier base (Tier 3 suppliers) and ensure they meet the standards of quality, delivery, and cost.

Tier 3 Suppliers

While tier 3 suppliers might seem more insulated from the direct demands of OEMs, they face their own unique challenges. Changes in demand can impact them, though the Tier 2 suppliers often cushioned the impact. They must also manage their supply chain effectively, often dealing with even more upstream suppliers (such as Tier 4) for raw materials. While they usually don't face the same financial penalties for disruptions as Tier 1 suppliers, they must uphold their delivery commitments to avoid causing further disruptions in the supply chain.

Each tier within the automotive supply chain has unique challenges, responsibilities, and risks. Tier 1 suppliers are the most exposed to the OEMs' demands and potential financial penalties. Still, every tier plays a critical role in the smooth functioning of the overall supply chain.

As we delve further into the topic, we'll explore the general risks applicable across all supply chain tiers. It's important to remember the interconnected nature of risks across the supply chain, with the shared aim of ensuring continuity, quality, and efficiency. We will first address general risks applicable to all tiers. However, we will also dedicate a section of this report to more detailed and specific risk considerations for Tier 1 suppliers.

Risks From Trade Policy Changes

Changes in trade policies, tariffs, or international trade agreements often bring about considerable uncertainty, impacting the stability of international trade relationships and the predictability of business environments (Bradford, 2020; Burfisher, Lambert and Usmen, 2019). These shifts can alter the costs of goods, the competitiveness of markets, and the compliance rules, presenting significant challenges to businesses, especially those operating in global supply chains.

For instance, the transition from the North American Free Trade Agreement (NAFTA) to the United States-Mexico-Canada Agreement (USMCA) had profound implications for industries across North America, notably the automotive sector (Fergusson, Villarreal, Jones and Brown, 2020; Lovato, 2020). NAFTA, in effect since 1994, had aimed to remove trade barriers between the US, Canada, and Mexico, creating one of the world's largest free-trade zones. However, the renegotiation into USMCA aimed to modernize the existing treaty to address contemporary trade issues and rebalance North American manufacturing.

One key change under the USMCA on July 1, 2020, was the "rules of origin" regulations for the automotive sector. These rules dictate the percentage of a vehicle's content that must be sourced from within the USMCA region to qualify for zero tariffs. Under NAFTA, the requirement was that 62.5% of a car's content needed to be manufactured in North America. However, USMCA increased this figure to 75%, meaning that to avoid tariffs, three-quarters of a car's parts must be made in either the US, Mexico, or Canada.

This change aimed to boost automotive production within North America, but it also required automotive manufacturers to re-evaluate and modify their supply chains (Fergusson, Villarreal, Jones and Brown, 2020; Lovato, 2020). Companies had to ensure more components were sourced locally, affecting their relationships with foreign suppliers. For example, a car manufacturer might have previously sourced inexpensive parts from Asia. Still, due to the USMCA, they might now need to source more expensive parts from within North America to meet the new rule of origin requirement.

The situation exemplifies how trade policy and agreement changes can introduce uncertainty and necessitate significant adjustments in business operations (Gomez, 2021). Companies must remain agile and adaptable, ready to navigate the evolving landscape of international trade agreements and policies.

Risks From Cross-Border Delays

Border crossings serve as critical junctures in international supply chains, particularly in sectors like automotive manufacturing that heavily rely on the timely delivery of parts for production (Alcala and Gonzalez, 2018). However, these crossings can often be delayed due to customs inspections, extensive paperwork, and increased security measures. Although such holdups might seem minor in isolation, they can accumulate over time, leading to significant supply chain disruptions and impacting the overall efficiency of industries reliant on seamless logistics (Mendoza, 2016; Wilson, Castillo, and Schrank, 2021).

For example, automotive manufacturing often employs a just-in-time (JIT) delivery system for parts and components. Under JIT, the components needed for assembling a vehicle are not stored in inventory for long periods. Instead, they arrive exactly when they are needed in the production process. This system significantly reduces inventory costs and improves efficiency. However, it also makes the production process highly sensitive to delays, as even minor interruptions at border crossings can cause production stoppages, creating ripple effects down the line.

Historical events can illustrate the effects of such delays on the automotive industry. Following the terrorist attacks on September 11, 2001, security measures at the US-Mexico border were heightened considerably. This led to more rigorous and time-consuming customs inspections, resulting in extended wait times at border crossings. The automotive industry, with its reliance on JIT delivery, was hit hard by these delays. Many manufacturers faced slowed production and increased costs due to these unanticipated interruptions in their supply chains.

A more recent example occurred in 2019, during the Trump administration. Due to an increase in migrant crossings, customs officers who typically handled cargo inspections at ports of entry were reassigned to manage the surge. This resulted in fewer officers being available for cargo inspections, leading to extended wait times for commercial vehicles at the border. Such delays significantly impacted the flow of goods, causing disruptions in industries like automotive manufacturing that heavily relied on components crossing the border in a timely fashion.

These examples underscore the critical importance of efficient border-crossing procedures for maintaining smooth supply chains. They also highlight the need for industries to consider these potential delays when designing their supply chains and develop contingency plans to mitigate the effects of unexpected disruptions.

Risks From Supply Chain Disruptions

The interconnected nature of today's global supply chains means that disruptions in one region can create a domino effect, causing disturbances that ripple throughout the entire system (Ivanov and Dolgui, 2020). When an unexpected event halts production in one part of the world, it can significantly impact manufacturers and consumers far removed from the initial disruption, revealing potential vulnerabilities within the supply chain.

A stark example of this phenomenon is how the COVID-19 pandemic impacted the automotive supply chain. As the virus spread globally, governments worldwide implemented lockdown measures, forcing many factories to shut down temporarily (Choi, 2020; Jabbour et al., 2020). These shutdowns were not limited to one country or region; they occurred across the globe, causing significant interruptions in the production and distribution of automotive parts.

China’s lockdown in early 2020 caused a significant disruption. As the world's largest supplier of auto parts, China's shutdown had a massive impact on the global automotive industry. For instance, parts like wiring harnesses, which are primarily produced in China's Hubei province—the initial epicenter of the outbreak—were suddenly in short supply. This resulted in manufacturing delays for automakers far from China, who relied on these components for their own production lines.

Similarly, the pandemic caused significant disruptions in Europe's automotive sector. Italy, a significant hub for auto parts and a major manufacturer of high-performance vehicles, was hard hit by the virus. The country's strict lockdown measures forced many factories to cease production, resulting in supply shortages that affected car manufacturers across Europe and beyond (Ivanov and Dolgui, 2020; Jabbour et al., 2020).

In the US, automakers like General Motors and Ford had to halt production due to a lack of critical parts sourced from affected regions. These supply shortages exposed the vulnerability of

relying heavily on just-in-time manufacturing practices, which aim to reduce inventory costs but can leave companies ill-prepared for sudden disruptions in supply.

The COVID-19 pandemic, therefore, brought to light the vulnerability and complexity of the global automotive supply chain. It emphasized the need for manufacturers to build more resilient and diversified supply chains, capable of withstanding unexpected disruptions. This could mean fostering stronger relationships with a broader range of suppliers, investing in advanced forecasting and tracking technology, and holding larger inventories of critical components.

Risks From Labor Disputes/Strikes

Labor issues, including strikes or disputes, can interrupt supply chains. This is particularly relevant in the automotive industry, where skilled labor is crucial at many supply chain stages.

Examples of labor disputes are the 2019 Maquiladora Strikes in Matamoros, Mexico: Workers in the maquiladora (manufacturing) industry in Matamoros, Tamaulipas, went on strike demanding better wages and working conditions (Reuters, 2019). This led to significant disruptions in the supply chain, especially affecting the automotive and electronics industries which rely heavily on these factories.

While the US Government Shutdown in 2018-2019 was not a strike, the longest government shutdown in US history led to significant understaffing at US Customs and Border Protection (CBP), causing long delays at border crossings (Santos, 2019). This had a ripple effect on supply chains that depended on timely border crossings.

The 2002 West Coast Port Lockout did not directly impact the US-Mexico border but significantly affected North American logistics (Bonacich and Wilson, 2008). With the ports locked out due to a labor dispute, many companies rerouted their goods overland, causing increased pressure on border crossings and inland transportation networks.

Risks From Natural Disasters

The region is susceptible to natural disasters such as hurricanes, flooding, or extreme heat, disrupting transportation routes and delaying deliveries.

Examples of these are Hurricane Harvey (2017), One of the costliest natural disasters in US history, Hurricane Harvey affected a large area of Texas (Kollewe, 2017). This led to widespread flooding, causing severe disruptions to supply chain operations, including delays at the Port of Houston, one of the busiest in the country. Roads were flooded and logistics facilities were damaged, disrupting overland routes and making it difficult to transport goods across the border.

Wildfires (Multiple Occasions): The US-Mexico border region, particularly in California, is prone to wildfires. These fires have occasionally forced key highways to be closed for transporting goods across the border, disrupting supply chains (CBC News, 2017).

Mexico is located in a seismically active region, and earthquakes can disrupt infrastructure and transportation, leading to supply chain interruptions. For instance, the 8.1 magnitude earthquake in southern Mexico in September 2017 damaged infrastructure and led to temporary logistics disruptions.

Extended periods of drought in the region, often linked to climate change, can indirectly affect supply chains. For example, they can reduce agricultural production, impact the water supply needed for manufacturing and other operations, and exacerbate wildfires (McSweeney and Allen, 2018).

Both sides of the border have experienced severe flooding that has temporarily shut down border crossings, impacting trade and supply chain operations.

Risks From Cybersecurity

As supply chains become more digital, the risk of cyberattacks increases. An attack that disrupts logistics or manufacturing systems could seriously impact supply chains.

There have been several instances of ransomware attacks on government systems that can delay or disrupt customs operations. For example 2019, a ransomware attack affected the city government of Laredo, Texas, a major port of entry (Taylor, 2019). Although the city was able to maintain border operations, such attacks potentially pose significant risks to customs and border control systems.

Transport and logistics companies are frequent targets of cyberattacks, which can disrupt their operations and cause delays. For example, in 2017, the shipping company Maersk suffered a significant ransomware attack that disrupted its global operations, highlighting the potential impact such attacks could have on supply chains (Greenberg, 2018).

Data breaches can expose sensitive data, such as shipping manifests or other commercial information, which can disrupt operations and lead to significant financial and reputational damage. For example, in 2018 the US Customs and Border Protection suffered a data breach in which tens of thousands of images of travelers and license plates were stolen (Bazzell, 2019).

Risks From Regulatory Compliance

The automotive industry is heavily regulated due to the safety-critical nature of its products (Kim & Ivy, 2020). Automotive components must meet rigorous safety and quality requirements to ensure the well-being of consumers. Non-compliance with these standards can lead to

severe consequences, including costly product recalls and reputational damage, which can significantly disrupt operations.

When automotive manufacturing involves cross-border trade, as in the case of the US, Mexico, and Canada, the complexity of compliance increases manifold. Manufacturers must navigate the regulatory landscapes of multiple countries, each with its unique set of rules and standards. Failure to comply with these international regulations can result in border delays, fines, and other disruptions that could impact the supply chain adversely.

A recent example of such regulatory complexities can be seen in the transition from the North American Free Trade Agreement (NAFTA) to the United States-Mexico-Canada Agreement (USMCA) in 2020. The USMCA imposed new rules of origin requirements for the automotive industry, which mandated higher levels of North American content in cars and trucks to qualify for zero tariffs.

These new rules of origin stipulated that 75% of auto content must be made in North America, an increase from NAFTA's 62.5% requirement. In addition, the USMCA introduced a new labor value content rule, requiring that between 40-45% of auto content be made by workers earning at least $16 per hour.

The introduction of these new rules posed significant challenges for many businesses. Companies had to scramble to understand and meet the new regulations, often leading to delays and disruptions in the supply chain. Some manufacturers had to redesign their supply chains to increase North American content, a time-consuming and costly process. Others struggled to meet the labor value content requirement, particularly those operating in regions with lower wage rates.

These examples underscore the importance of regulatory compliance in the automotive industry and the potential challenges manufacturers can face cross-border. They also highlight the need for manufacturers to stay abreast of regulatory changes and have robust compliance mechanisms to ensure smooth operations.

Risks From Economic Instability

Economic instability in the U.S. or Mexico could impact exchange rates, labor costs, or automobile demand, affecting the entire supply chain.

The 2008-2009 economic downturn resulted in a significant decrease in consumer demand in the US, which led to a drop in imports from Mexico. This impacted Mexican manufacturers, especially those in industries like automotive and electronics, which relied heavily on exports to the US.

Fluctuations in the value of the Mexican Peso relative to the US Dollar can create challenges for cross-border supply chains. For instance, the significant devaluation of the Peso during the

1994-1995 Mexican Peso Crisis increased the cost of imported goods for Mexican consumers and businesses, disrupting supply chains and causing economic instability.

The trade war between the US and China caused some businesses to reevaluate their supply chains, with some looking to shift production from China to Mexico to avoid tariffs. This sudden demand increase in Mexico's manufacturing capacity may have caused short-term disruptions and strained existing supply chains.

The US and Mexico are major oil producers, and fluctuations in global oil prices can impact the cost of transportation and logistics, affecting the overall cost of managing cross-border supply chains.

Mitigating these risks often involves diversifying supply sources, increasing supply chain visibility, developing flexible logistics strategies, and ensuring robust cybersecurity measures.

MANAGEMENT OF SUPPLY CHAIN RISKS

Handling risks within the supply chain, especially within the multifaceted automotive manufacturing sector, necessitates an all-encompassing and preemptive approach. When considering the tiered nature of the automotive supply chain, the varying levels of risk exposure for Tier 1, Tier 2, and Tier 3 suppliers must be integrated into the risk management strategies. Here are some general techniques that can be utilized:

Supplier Diversification

Spreading the risk by diversifying suppliers, logistics providers, and even geographic locations can reduce the impact of disruptions at a single point in the supply chain. Ford also diversifies its suppliers to ensure a consistent supply of components. GM and Ford were able to leverage their diversified supplier network during the COVID-19 pandemic to minimize disruption to their production.

Technology Integration

The use of technology can help businesses to manage supply chain risks in several ways. By using technology to track goods in real-time, predict potential disruptions, and communicate effectively with all stakeholders, businesses can improve their ability to respond quickly and make better decisions.

The use of GPS tracking technology can provide businesses with real-time updates on the location of goods. This information can be used to monitor delivery times, identify potential delays, and track the movement of goods across borders. For example, DHL's Track and Trace system allows customers to monitor the location and status of their shipments in real time.

Predictive analytics can be used to identify potential disruptions in the supply chain. By analyzing historical data and current trends, businesses can identify factors that could lead to a disruption. This information can then be used to take preventative action, such as rerouting shipments or adjusting schedules. For example, IBM's Supply Chain Insights uses machine learning and AI to predict potential disruptions in the supply chain.

Effective communication is essential for managing supply chain risks. By communicating effectively with all stakeholders, businesses can ensure that everyone is aware of potential risks and that there is a plan in place to mitigate them. For example, Walmart uses a cloud-based platform to share information with its suppliers and partners. This platform allows them to track shipments, identify potential disruptions, and collaborate on solutions.

Blockchain technology can be used to provide transparency and traceability in the supply chain. This can help ensure that goods are sourced ethically and meet all regulatory requirements. For example, De Beers uses blockchain technology to track the journey of diamonds from the mine to the consumer. This ensures that the diamonds are conflict-free and that they have been mined ethically.

In addition to the technologies mentioned above, several other technologies can be used to manage supply chain risks. These include:

- Artificial intelligence (AI) can be used to automate tasks, identify patterns, and make predictions.
- Machine learning can be used to analyze data and identify trends.
- The Internet of Things (IoT) can be used to connect devices and collect data.
- Cloud computing can be used to store and analyze data.

The use of technology to manage supply chain risks is an ongoing process. As new technologies emerge, businesses will need to continue to adapt and adopt them to stay ahead of the curve. However, the benefits of using technology to manage supply chain risks are clear. By using technology effectively, businesses can improve their ability to respond quickly and make better decisions, which can help protect their supply chains from disruptions and ensure that they can meet customer demand.

Supplier Relationships

Building strong relationships with suppliers and maintaining open lines of communication can help in risk mitigation. Close cooperation can result in shared risk management strategies and more resilient supply chains.

GM has a long history of investing in supplier relationships to build a resilient supply chain. GM runs a 'Supplier of the Year' award program, which aims to incentivize suppliers to exceed the company's requirements and expectations. This not only improves the quality and reliability of

the supply chain, but also encourages suppliers to provide support in times of disruption. GM has many suppliers based in Mexico, a key part of its North American manufacturing operations.

Ford Motor Company operates manufacturing facilities in both the US and Mexico. They have actively fostered collaborative relationships with their suppliers, running programs to help suppliers improve their processes and quality. Ford's Aligned Business Framework (ABF) is a notable example, which selects certain suppliers for long-term relationships, involving them more deeply in Ford's strategic plans and offering them a greater share of Ford's business in return for commitments on innovation, quality, and competitive pricing. This approach promotes mutual success and enables more effective risk management.

Risk Assessment and Planning

Regular risk assessments can identify potential vulnerabilities and allow for the creation of contingency plans. This could involve scenario planning for different types of disruptions (natural disasters, political changes, etc.)

Here is an example of a Risk Mitigation Questionnaire that may be helpful in understanding the variables in your supply chain:

	Company Name: [Insert Company Name],	Date: [Insert Date]
#	**Section One: Supplier Dependence:**	**Response**
1	Number of suppliers for key components or materials:	[Insert Number]
2	Do you have alternative suppliers for key components or materials?	(Yes/No): [Insert Yes/No]
3	Have you experienced any major disruptions from a supplier in the past year?	(Yes/No): [Insert Yes/No]
	Section Two: Geographical Risks:	
4	Number of countries involved in your supply chain:	[Insert Number]
5	Have any regions involved in your supply chain experienced political instability, natural disasters, or other disruptive events in the past year? (Yes/No):	[Insert Yes/No]
6	Do you have a contingency plan if a disruption occurs in a key region of your supply chain? (Yes/No):	[Insert Yes/No]
	Section Three: Regulatory Compliance:	
7	Are all your suppliers compliant with relevant regulations and standards? (Yes/No):	[Insert Yes/No]
8	How do you monitor and ensure regulatory compliance throughout your supply chain?	[Insert Response]
9	Have you faced any regulatory issues in the past year that disrupted your supply chain? (Yes/No):	[Insert Yes/No]
	Section Four: Transportation and Logistics:	
10	Do you rely on a single mode of transport for your goods, or do you use multiple modes (e.g., air, sea, rail, road)?	
11	Have you experienced any significant logistics disruptions in the past year? (Yes/No):	[Insert Yes/No]
12	How do you monitor the status of goods in transit?	[Insert Response]
	Section Five: Technology and Cybersecurity:	
13	How do you protect your supply chain data from cybersecurity threats?	[Insert Response]
14	Have you ever experienced a cybersecurity incident that impacted your supply chain? (Yes/No):	[Insert Yes/No]
15	Do you have a plan in place to respond to cybersecurity incidents? (Yes/No):	[Insert Yes/No]
	Section Six: Inventory Management:	
15	Do you utilize just-in-time inventory practices, or do you maintain safety stock for key components or materials?	[Insert Response]
16	How do you determine the optimal amount of inventory to hold?	[Insert Response]
17	Have you ever experienced stockouts of key components or materials in the past year? (Yes/No):	[Insert Yes/No]
	Note: Please provide detailed and accurate information to ensure an effective assessment of your supply chain risks.	

Figure 5 Risk Mitigation Questionnaire

Inventory Management

While just-in-time manufacturing has advantages, keeping a strategic stock of critical components can buffer against supply chain disruptions. Safety stock levels can be determined through careful analysis of lead times, demand variability, and the criticality of each component.

The shift from JIT to JIC, often termed as a new wave in supply chain management, has been triggered by various factors (Ivanov & Dolgui, 2020; Linton & Vakil, 2020). Major supply chain disruptions, such as the COVID-19 pandemic and geopolitical uncertainties, have highlighted

the vulnerability of the JIT model and pushed many companies to rethink their supply chain strategies.

The shift towards JIC represents a broader trend towards risk mitigation and resilience in supply chain management. It is important to note that it does not represent a one-size-fits-all solution. Each company must balance the potential costs and benefits based on their particular situation and risk tolerance.

Resilient Design

Designing the supply chain to be flexible and adaptable can help it withstand shocks. This can include multi-sourcing strategies, flexible manufacturing systems, and adaptable logistics solutions.

Given the USMCA's rules of origin, which require a significant percentage of a vehicle's components to be manufactured in North America, some companies have moved to regional supply chains. This can reduce the risk of disruptions from international trade disputes and can also reduce lead times and transportation costs.

Companies need contingency plans for different types of disruptions, such as natural disasters, political instability, trade policy changes, and cyberattacks. These plans should detail alternative sourcing strategies, emergency response procedures, and communication protocols.

Regulatory Compliance

Ensuring that all supply chain elements comply with the relevant regulations and standards can prevent costly disruptions and maintain the quality of products. One way to achieve this is to have regular training and education sessions for all personnel involved in the supply chain can ensure that they understand and comply with relevant regulations. This is particularly important for regulations that change frequently or are complex in nature.

Regular compliance audits can help identify any areas of the supply chain that do not comply with relevant regulations. This can involve checking paperwork, inspecting facilities, or interviewing staff.

There are numerous software solutions available that can help manage and track compliance across the supply chain. These tools can automatically check for compliance issues, generate reports, and even automate some aspects of the compliance process.

Working with suppliers who have achieved relevant certifications can ensure that they comply with regulations. For example, a supplier might have a certification indicating that they comply with environmental regulations or labor laws.

For complex or unclear regulations, seeking advice from legal experts can be valuable. This can help ensure that the supply chain is not only in compliance with the letter of the law, but also with the spirit of it.

Finally, developing contingency plans for potential non-compliance issues can help mitigate the impact of any disruptions resulting from non-compliance.

Cybersecurity Measures

As supply chains become more digital, the risk of cyberattacks increases. This is why businesses must implement robust cybersecurity measures (Islam, Sussan & Mujahid, 2020). These measures should include:

- Secure data handling includes using strong passwords and encryption and limiting access to sensitive data.
- Data should be stored securely in a cloud-based or on-premises data center.
- Businesses should regularly check their systems for vulnerabilities and update their software to the latest versions.

One widely accepted cybersecurity framework is the NIST Cybersecurity Framework (CSF) (National Institute of Standards and Technology, 2018). The CSF is a set of guidelines that can be used to manage and mitigate cybersecurity risk. It is divided into five functions:

- **Identify:** Identify assets and systems important to the business and assess their cybersecurity risks.
- **Protect:** Implement controls to protect assets and systems from cyberattacks.
- **Detect:** Detect and respond to cybersecurity incidents promptly.
- **Respond**: Respond to cybersecurity incidents and recover from them quickly.
- **Recover:** Restore systems and operations to normal after a cybersecurity incident.

The CSF is a valuable resource for businesses of all sizes. By following the guidance of the CSF, businesses can better understand their current cybersecurity risk, set goals for cybersecurity risk management, and establish a plan for improving or maintaining cybersecurity risk management.

Here are some additional examples of cybersecurity measures that businesses can implement (Kumar, Park & Subramaniam, 2008; Ghose & Tran, 2019):

- Use two-factor authentication (2FA): 2FA adds an extra layer of security to logins by requiring users to enter a code from their phone in addition to their password.
- Implement data loss prevention (DLP): DLP software can help to prevent sensitive data from being leaked or stolen.
- Monitor social media: Businesses should monitor social media for mentions of their brand or products and any potential threats or vulnerabilities.

- Train employees: Employees should be trained on cybersecurity best practices, such as how to spot phishing emails and create strong passwords.

By implementing these and other cybersecurity measures, businesses can help to protect themselves from cyberattacks and keep their supply chains secure.

Financial Risk Management

Hedging strategies can be used to protect against currency and commodity price fluctuations (Hull, 2012; McDonald, 2006). This could involve financial instruments such as futures and options (Baranoff, 2013). For example, suppose a US company expects to receive payment in Mexican Pesos for goods or services provided to a Mexican company in six months. In that case, the US company faces the risk that the Peso could depreciate against the US Dollar. To hedge this risk, the US company could buy Peso futures contracts, locking in today's exchange rate for a transaction in the future. Similarly, they could buy Peso put options, giving them the right, but not the obligation, to sell Pesos at a specified exchange rate in the future.

Automotive and industrial companies require various metals such as steel, aluminum, and copper. The prices of these commodities can be volatile. To hedge against this risk, a company could buy futures contracts for these metals, locking in today's future delivery price (Bessembinder, 1992; Black, 1976). Alternatively, they could buy call options, giving them the right to buy the metal today, even if the price rises significantly in the future.

Industrial companies often have high energy consumption, and automotive companies need to consider the cost of fuel in their logistics operations. These companies can hedge against fluctuations in energy prices by purchasing oil or natural gas futures contracts (Miffre & Oldfield, 2014). This guarantees a set price for future delivery. Alternatively, the company could buy oil or gas call options to secure the right to purchase fuel at a certain price in the future, protecting against potential price increases.

There is no one-size-fits-all strategy for supply chain risk mitigation. The best approach depends on the specific characteristics of the company, its supply chain, and the broader economic and regulatory environment. An effective risk management strategy usually involves a combination of the abovementioned approaches tailored to each company's specific needs.

MANAGING SUPPLY CHAIN RISKS WITHIN THE TIER 1 SUPPLIER CONTEXT

Given the complex landscape of the automotive supply chain, Tier 1 suppliers bear a significant level of risk exposure. Therefore, strategies to manage this risk should be appropriately tailored and consider additional factors. For instance:

Supplier Diversification

A Tier 1 supplier should consider diversifying border crossing points while maintaining a diverse sub-supplier network. This reduces over-reliance on a single crossing point and mitigates the risk of significant delays or stoppages due to stringent border control measures.

Here are some more details and examples that illustrate how Tier 1 suppliers can accomplish this:

Strategic Sourcing and Supplier Relationships: Establishing a diverse network of suppliers with access to different border crossing points can be beneficial. For example, a Tier 1 supplier in the automotive industry could work with sub-suppliers near border crossings in the United States and Mexico. This approach provides flexibility to shift production and supply chain logistics based on border conditions.

Alternate Transportation Routes and Modes: Exploring alternate transportation routes and modes can help avoid potential chokepoints. For instance, if road freight across a particular border crossing point becomes challenging due to stricter control measures, suppliers can look into rail or air freight options that may be less impacted.

Logistics Partnerships: Collaborating with multiple logistics partners who operate at different border crossings can provide additional flexibility. For example, a supplier might typically use a trucking company that operates through a border crossing in San Diego/Tijuana. But it could also establish relationships with companies that operate through crossings at Laredo/Nuevo Laredo or El Paso/Ciudad Juarez, allowing it to switch routes if necessary.

Advanced Scheduling and Planning: Understanding border crossing schedules, peak times, and regulations can help plan shipments to avoid delays. For instance, certain border crossing points may have less traffic during off-peak hours, making them attractive for scheduling shipments.

Leveraging Technology: Tools like real-time tracking systems and predictive analytics can help Tier 1 suppliers proactively adjust their logistics plans based on current and predicted conditions at various border crossings. For example, real-time tracking could show that a preferred crossing point is experiencing significant delays, prompting the supplier to reroute a shipment to a different crossing point.

Building Redundancies: Creating backup plans and redundancies in supply chains can cushion the impact of disruptions. For instance, a supplier might keep a safety stock of critical components in multiple locations so production can continue even if shipments are delayed at a particular border crossing.

Scenario Planning: Suppliers can engage in comprehensive scenario planning exercises to anticipate possible issues at border crossing points and develop appropriate responses. For

example, they might prepare a plan for a situation where increased security measures at a certain border crossing drastically slow shipment time.

Technology Integration

In the case of Tier 1 suppliers, predictive analytics could be further refined to account for potential cross-border delays, considering factors such as border control policy changes, historical customs clearance times, and geopolitical situations.

Supplier Relationships

Building strong relationships with customs authorities could benefit Tier 1 suppliers, as it may facilitate smoother border crossings. Enhanced collaboration with these authorities can aid in expediting the clearance process, which is critical in maintaining the JIT delivery system.

Risk Assessment and Planning

While regular risk assessments are crucial, Tier 1 suppliers should particularly focus on risk assessment around border crossing delays. Contingency plans should also consider solutions for severe border crossing disruptions, such as airlifting critical parts, although this may come at a higher cost.

Inventory Management

Tier 1 suppliers, despite relying on JIT principles, should consider holding minimal safety stock for critical components. This is a buffer against significant production disruptions due to unexpected border crossing delays.

Expanded use of Safety Stock for Tier 1 Suppliers

Using safety stock for critical components provides a cushion to absorb potential disruptions in the supply chain (Chopra & Meindl, 2016; Silver, Pyke & Peterson, 1998). By strategically identifying which components are crucial for uninterrupted production and ensuring a reserve inventory of these components, Tier 1 suppliers can safeguard against unexpected delays at border crossings. This can include delays due to customs inspections, paperwork issues, security measures, or any other factors that may impact the flow of goods across the border.

The safety stock level for critical components should be determined through careful analysis and consideration of various factors. These factors may include historical data on border crossing delays, lead times for component replenishment, the criticality of the component in the production process, and the potential impact of disruption on overall production timelines and costs (Heizer, Render & Munson, 2017; Simchi-Levi, Kaminsky & Simchi-Levi, 2008).

Holding minimal safety stock aims to balance the benefits of JIT principles and the need for contingency plans. Tier 1 suppliers can leverage supply chain visibility, communication with logistics partners, and real-time information on border conditions to assess the appropriate safety stock level for critical components.

It's worth noting that maintaining safety stock does come with associated costs, such as inventory holding costs, storage space requirements, and potential obsolescence risks. Therefore, Tier 1 suppliers should carefully evaluate the trade-offs and weigh the potential risks and benefits of holding safety stock for critical components.

Collaboration and communication with other supply chain partners, including Tier 2 suppliers and OEMs, are crucial for effective safety stock management. Sharing information on production schedules, inventory levels, and potential disruptions can help align expectations, coordinate contingency plans, and ensure a timely response to unexpected events.

Regulatory Compliance

Maintaining compliance with customs regulations is critical for Tier 1 suppliers, as non-compliance can lead to delayed border crossings. Regular training and education for personnel involved in cross-border logistics are crucial to ensure understanding and compliance with changing border control policies and customs regulations.

Cybersecurity Measures

Given the sensitivity of Tier 1 supplier operations, robust cybersecurity measures are even more vital. Regular system checks and updates and secure data handling can prevent data breaches and protect sensitive supplier and logistics information.

Regular system checks and updates are essential to identify and address supplier systems and infrastructure vulnerabilities. This involves periodic assessments of hardware, software, and network configurations to ensure they are up to date and fortified against emerging cybersecurity threats. By promptly applying security patches, software updates, and firmware upgrades, Tier 1 suppliers can address known vulnerabilities and strengthen their defenses against potential attacks.

Furthermore, secure data handling practices are crucial to protect sensitive supplier and logistics information. This involves employing robust encryption algorithms to protect data both at rest and in transit. Encryption ensures that even if unauthorized individuals gain access to the data, they cannot decipher it without the encryption keys. Secure data handling also includes implementing strong access controls, authentication mechanisms, and user permissions to limit data access to authorized personnel only.

Implementing secure data storage practices, such as utilizing secure servers or cloud storage with encryption and access controls, adds an additional layer of protection. Regular backups of critical data should also be performed to mitigate the impact of potential data loss or corruption due to cyber incidents.

Tier 1 suppliers should also consider implementing multi-factor authentication (MFA) for user access to sensitive systems and data to enhance cybersecurity measures. MFA adds an extra layer of protection by requiring users to provide multiple forms of verification, such as passwords and one-time verification codes, reducing the risk of unauthorized access even if credentials are compromised.

Employee training and awareness programs are crucial to reinforce cybersecurity best practices within the organization. By educating employees about phishing attacks, social engineering techniques, and the importance of following secure data handling procedures, Tier 1 suppliers can reduce the likelihood of human error leading to security breaches.

Regular internal and external audits, vulnerability assessments, and penetration testing can also help identify any security weaknesses or potential entry points for attackers. By proactively identifying and addressing vulnerabilities promptly, Tier 1 suppliers can strengthen their cybersecurity posture and reduce the likelihood of successful cyberattacks.

It is worth noting that cybersecurity is an ongoing process that requires continuous monitoring, evaluation, and improvement. Threat landscapes evolve rapidly, and new attack vectors emerge regularly. Therefore, Tier 1 suppliers should stay current with the latest cybersecurity practices, collaborate with industry partners and cybersecurity experts, and remain vigilant in addressing potential vulnerabilities to protect their operations and the integrity of the automotive supply chain.

Financial Risk Management

For Tier 1 suppliers with cross-border operations, hedging against currency fluctuations is essential to protect against unexpected financial losses due to currency devaluation or appreciation.

While general risk management strategies form the foundation, Tier 1 suppliers should implement additional measures to mitigate risks particular to their operations, especially those related to cross-border logistics. This requires a comprehensive, multi-faceted approach to ensure a continuous and efficient production flow. Here are some specific measures that Tier 1 suppliers with cross-border operations can take:

Currency Hedging: Tier 1 suppliers should use currency forwards, futures, options, or swaps to protect themselves against potential losses due to currency volatility. Having a clear understanding of how these financial instruments work and how they can be applied strategically can create a solid layer of financial protection for the organization.

Developing a Global Treasury Function: This function would oversee cash flow and liquidity management, currency exposure and risk management, and capital structure strategy. An effective global treasury team can manage financial risks proactively, plan for contingencies, and ensure the company can meet its obligations under different scenarios.

Supply Chain Diversification: Relying heavily on a single region or country for supplies or operations can put the company at risk in the face of geopolitical instability or localized economic downturns. By diversifying its supply chain, a company can mitigate this risk and ensure the continuity of supplies.

Currency Risk Clauses in Contracts: Incorporating clauses in contracts that address currency fluctuations can mitigate the potential impact. These clauses might define who bears the risk of currency fluctuations or specify an agreed upon exchange rate for certain transactions.

Investing in Technology and Analytics: With the right tools, companies can analyze and predict market and currency trends. This can aid in decision-making and strategic planning. Using predictive analytics, machine learning, or artificial intelligence can provide insights into future trends and enable more informed decision-making.

Training and Education: Regular training for employees involved in cross-border transactions can help in understanding the intricacies of currency risk and ways to mitigate it. This can be part of a larger risk management training program.

Regulatory Compliance: Different countries have different laws and regulations relating to cross-border transactions and currency exchanges. It's critical that Tier 1 suppliers understand and comply with these regulations to avoid legal complications that could disrupt their operations or lead to financial penalties.

Establishing Local Operations or Partnerships: Setting up local operations or partnerships can be an effective way to manage currency risk. This approach can reduce the exposure to currency risk by offsetting costs and revenues in the same currency. In addition, local partnerships can provide additional market insight and help in navigating local regulations.

Maintaining Strong Relationships with Financial Institutions: Banks and other financial institutions are key in currency management and hedging strategies. Maintaining strong relationships with these entities can provide more favorable terms, improved access to information, and more options for managing currency risk.

Regular Reviews and Audits: Market conditions and currency values can change rapidly, making regular reviews of currency risk management strategies critical. These reviews should include audits of internal processes, reassessment risk exposure, and adjustment of hedging strategies as necessary.

THE PRACTICAL APPLICABILITY OF THIS ANALYSIS TO REDUCE SUPPLY CHAIN RISK

The strategies mentioned above have practical applicability to reducing supply chain risks. Here's a breakdown of their practicality:

Supplier Diversification:

Diversifying suppliers, logistics providers, and geographic locations can reduce disruptions in the supply chain. The example of Ford and GM leveraging their diversified supplier networks during the COVID-19 pandemic demonstrates the practicality and effectiveness of this approach.

Technology Integration:

Utilizing technology for real-time tracking, predictive analytics, and efficient communication can significantly enhance response times and decision-making in supply chain management. The examples of GPS tracking, predictive analytics solutions like IBM's Supply Chain Insights, and blockchain technology demonstrate the practical applicability of technology integration in reducing risks.

Supplier Relationships:

Building strong relationships with suppliers and maintaining open communication is practical and valuable in risk mitigation. GM's 'Supplier of the Year' award program and Ford's Aligned Business Framework exemplify successful approaches to fostering cooperative relationships with suppliers, resulting in improved supply chain quality, reliability, and support during disruptions.

Risk Assessment and Planning:

Regular risk assessments and contingency planning are essential practices for identifying vulnerabilities and preparing for potential disruptions. Scenario planning for different types of disruptions further enhances preparedness. This approach is practical and widely adopted in supply chain management.

Inventory Management:

The shift from just-in-time (JIT) to just-in-case (JIC) inventory practices has gained momentum due to the vulnerability exposed by major disruptions like the COVID-19 pandemic. Keeping a strategic stock of critical components can buffer against supply chain disruptions. Analyzing lead times, demand variability, and component criticality can help determine optimal safety stock levels. This shift towards JIC represents a practical and resilient approach to inventory management.

Resilient Design:

Designing flexible and adaptable supply chains through multi-sourcing strategies, flexible manufacturing systems, and adaptable logistics solutions is a practical approach to withstanding shocks. The example of regional supply chains adopted to mitigate disruptions from trade disputes demonstrates the applicability and benefits of resilient design.

Regulatory Compliance:

Ensuring compliance with relevant regulations and standards is crucial to prevent disruptions and maintain product quality. Regular training, compliance audits, software solutions, and partnerships with certified suppliers are practical measures to achieve regulatory compliance and mitigate risks.

Cybersecurity Measures:

With the growing digitalization of supply chains, implementing strong cybersecurity measures is crucial to reduce potential risks. The NIST Cybersecurity Framework, an established guideline, offers valuable direction on managing and decreasing cybersecurity threats. This Framework can be applied across a wide range of organizations and industries to help safeguard their operations.

Financial Risk Management:

Hedging strategies using financial instruments like futures and options can protect against currency and commodity price fluctuations. The examples provided highlight the practicality of such strategies for managing financial risks in automotive and industrial sectors.

In conclusion, the strategies presented in the text demonstrate practical applicability to reducing supply chain risks. However, it is important to note that there is no one-size-fits-all solution, and companies should tailor their risk management strategies based on their specific needs, characteristics, and risk tolerance.

THE TEXAS PERSPECTIVE

From a uniquely Texan perspective, the strategies discussed for managing supply chain risks in the automotive industry align with the state's emphasis on resilience, innovation, and self-reliance. Texas, being home to major automotive manufacturing plants and a robust logistics industry, recognizes the importance of diversifying suppliers, logistics providers, and geographic locations to reduce disruptions in the supply chain. The Texan spirit of independence and adaptability drives the integration of technology, such as GPS tracking and blockchain, for real-time monitoring, predictive analytics, and transparent traceability, ensuring efficient decision-making and risk mitigation.

Building strong supplier relationships resonates with Texas's emphasis on collaboration and cooperation. Programs like GM's 'Supplier of the Year' award and Ford's Aligned Business

Framework reflect the Texan values of recognizing and incentivizing excellence, fostering long-term partnerships, and encouraging support during challenging times.

Conducting regular risk assessments and contingency planning aligns with Texas's proactive approach to addressing challenges. The Texan resilience, shaped by facing natural disasters and unpredictable circumstances, emphasizes preparedness through scenario planning, identifying vulnerabilities, and creating alternative sourcing strategies.

In terms of inventory management, the shift from just-in-time to just-in-case practices reflects Texas's pragmatic approach. With a rich history in energy production, Texas understands the importance of maintaining a strategic stock of critical components, considering lead times, demand variability, and component criticality. This shift towards just-in-case inventory aligns with Texas's belief in being prepared and self-sufficient.

The Texan commitment to compliance and ethics is highlighted in discussions about regulatory compliance. Texas recognizes the significance of adhering to relevant regulations and standards, ensuring quality and preventing disruptions. Through training, audits, and partnerships with certified suppliers, the Texan commitment to doing business responsibly shines through.

Cybersecurity measures resonate strongly with Texas's focus on protecting valuable assets. As a hub for technology and innovation, Texas understands the importance of robust cybersecurity measures to safeguard sensitive data, prevent disruptions, and maintain trust in supply chain operations. Following frameworks like the NIST Cybersecurity Framework aligns with Texas's commitment to excellence and staying at the forefront of technological advancements.

Finally, managing financial risks through hedging strategies corresponds with Texas's proactive and resourceful nature. Being a leader in industries like oil and gas, Texas is familiar with managing commodity price fluctuations and currency risks. Utilizing financial instruments like futures and options aligns with the Texan spirit of leveraging innovative solutions to protect against financial uncertainties.

CONCLUSIONS

The U.S.-Mexico border is a critical hub in the automotive industry's supply chain, bolstered by the economic integration of NAFTA and its successor, the USMCA. Low labor costs, a skilled workforce, and advantageous trade policies have spurred growth in the automotive sectors of both countries, with many manufacturers establishing facilities in Mexico. The sizable import of automotive goods from Mexico to the U.S. underlines the importance of this trade corridor.

Efficient border crossings and customs processes are necessary to ensure the smooth flow of goods and prevent supply chain disruptions. An excellent infrastructure, including highways, rail systems, and ports, is crucial for efficient transportation. The supply chains of the U.S. and Mexican automotive industries are deeply integrated, with disruptions in one country significantly affecting the other.

The U.S.-Mexico border region has become a hotbed for innovation and technological advances in the automotive industry. The region also serves as a testing ground for logistics technologies. The automotive supply chain typically involves several tiers, each providing distinct products and services.

A robust partnership between the U.S. and Mexico is essential for maintaining technological growth within North America's automotive sector. Each supply chain tier faces unique challenges, and policy changes can disrupt operations, especially for industries like automotive manufacturing relying on Just-In-Time (JIT) delivery.

Global events like the COVID-19 pandemic and labor disputes can severely disrupt the supply chain. Therefore, resilience is essential and can be achieved through diversification, strong supplier relationships, investment in advanced technology, and holding larger critical component inventories.

The automotive industry faces stringent regulations, and non-compliance can result in severe repercussions. Cross-border trade and changes in trade agreements can complicate regulatory compliance, requiring businesses to stay updated about changes and establish robust compliance mechanisms.

Economic instability and events like recessions, currency fluctuations, trade wars, and global oil price changes can impact the supply chain. Therefore, comprehensive and preemptive risk management strategies are vital, such as diversification, technology integration, strong supplier relationships, regular risk assessments, and contingency planning.

Companies are adopting more resilient supply chain strategies in response to increased disruptions. Also, considering USMCA's rules of origin, many are moving towards regional supply chains. Regulatory compliance, cybersecurity measures, and financial risk management strategies are also integral to preventing disruptions and ensuring product quality. Effective risk

management should be a tailored combination of approaches considering specific company needs and the broader economic and regulatory landscape.

RECOMMENDATIONS

1. **Facility Localization:** Given the importance of the US-Mexico corridor for the automotive industry, consider setting up or expanding production facilities in Mexico. This reduces transport times and costs, enables easier access to the U.S. market, and takes advantage of lower labor costs.
2. **Improve Customs Processes:** Work closely with customs authorities to streamline procedures and minimize potential delays at the border. This includes understanding regulatory changes, ensuring accurate documentation, and using technology to expedite processes.
3. **Invest in Infrastructure and Technology:** Invest in or leverage existing infrastructure like highways, rail systems, and ports for efficient transportation of goods. Explore innovative logistics technologies to optimize supply chain processes.
4. **Supply Chain Diversification:** Diversify your supply chain by engaging multiple suppliers for critical parts, spreading risk and making your supply chain more resilient to disruptions.
5. **Strengthen Supplier Relationships:** Foster strong relationships with suppliers. Collaborative relationships can result in shared risk management strategies, improving supply chain resilience.
6. **Regular Risk Assessment:** Conduct routine risk assessments to identify potential vulnerabilities and design contingency plans for disruptions such as labor disputes, natural disasters, policy changes, or cyberattacks. Essential to make the risk assessment a core business process rather than an added extra or “nice to have” option.
7. **Resilient Inventory Management:** Consider transitioning from a JIT inventory system to a just-in-case (JIC) model or maintaining strategic stock to buffer against supply chain disruptions.
8. **Regulatory Compliance:** Maintain strict compliance with cross-border regulations to avoid penalties, recalls, or reputational damage. Stay updated about changes in trade agreements and establish robust compliance mechanisms.
9. **Cybersecurity Measures:** As digitization increases, implement robust cybersecurity measures to protect sensitive data. Use established frameworks such as the NIST Cybersecurity Framework to manage cybersecurity risks.
10. **Financial Risk Management:** Implement strategies like hedging using futures and options to safeguard against currency and commodity price fluctuations.
11. **Invest in R&D:** Participate in collaborative R&D initiatives in the region to stay ahead of technological advancements and create innovative solutions to industry challenges.
12. **Adapt to Policy Changes:** Stay informed of changes in international trade agreements and adjust your supply chain operations accordingly to avoid disruptions and seize opportunities.

13. **Create a Resilient Supply Chain Strategy:** Combine various approaches, such as multi-sourcing, flexible manufacturing systems, and adaptable logistics solutions, to design a robust and resilient supply chain strategy
14. **Strategic Governance:** Assign responsibility for supply chain risk management to a senior member of the board to ensure it is recognized as a critical component of the organization's strategy.

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