1st World Congress on Industrial Engineering and Operations Management
October 09-11, 2024
Publisher: IEOM Society International, USA DOI: 10.46254/WC01.20240035
Published: October 09, 2024

Optimizing the Global Automotive Industry's Supply Chain Resilience

Tasfia Tarannum
Department of Data Analysis and Supply Chain Management
Southern Arkansas University
Magnolia, Arkansas, 71753, USA
ttarannum3228@muleriders.saumag.edu

Hayder Zghair
Department of Engineering and Physics
Southern Arkansas University
Magnolia, Arkansas, 71753, USA
hzghair@saumag.edu

Abstract

This research addresses the need for a data-driven model to improve supply chain resilience within the North American automotive industry. The model tackles geopolitical instability, trade wars, climate change, resource scarcity, and sustainability pressures. This research project developed a data-driven model integrating a human-centric approach (HCA) with a standardized supplier certification and validation process (SSCV). The SSCV is a comprehensive supplier evaluation that ensures the industry's resilience in terms of agility and sustainability. The research aims to improve key performance indicators, including pricing, lead time, and on-time delivery, by implementing the SSCV model for suppliers. The model prioritizes agility and sustainability while optimizing supplier key performance. By implementing this data-driven model, significant outcomes have been observed, including strengthened supply chain resilience, improved operational efficiency, and the ability to adapt to a rapidly changing global environment. The model supports ensuring the long-term resilience of the supply chain within the North American automotive industry in a dynamic market. The results explore how this model can strengthen North American supply chains, mitigate risks, and ensure long-term resilience in a dynamic global market.

Keywords
Supply Chain Resilience, Automotive Industry, Supplier Certification, Sustainability and Operational Efficiency.

1. Introduction
The automotive industry plays an essential role in the North American economy, making substantial contributions to GDP and industrial production, and also promoting technological progress. Nevertheless, this sector is increasingly confronted with various global challenges, such as geopolitical tensions, the COVID-19 pandemic, climate change, and developing consumer preferences. These challenges have exposed considerable weaknesses in the conventional supply chain model, which heavily depends on just-in-time (JIT) inventory systems and centralized supplier networks. The vulnerabilities of these systems have become particularly evident, especially as the industry confronts persistent semiconductor shortages and rising demand for electric vehicles (EVs).

With the increasing interconnection of global markets, the automotive industry's supply chain management needs to implement a proactive and data-driven strategy that effectively tackles these detailed risks. This paper introduces a thorough framework aimed at optimizing supply chain resilience, particularly by improving the certification and validation procedures for suppliers using advanced technologies such as AI and big data analytics. This strategy emphasizes the importance of agility, adaptability, and enhanced performance metrics, including cost efficiency, lead time, and delivery reliability. A major challenge noted is the inconsistency in supplier certification processes, which raises the industry's risk exposure. The scattered locations of suppliers, dependence on single-source suppliers for essential components such as semiconductors, and pressures from environmental and geopolitical factors further exacerbate these risks. To stay competitive in an unpredictable global market, North American automakers need to focus on strategies that minimize these vulnerabilities and strengthen the resilience of their supply chains.

By incorporating Industry 4.0 technologies, localizing supply chains, and welcoming sustainable practices, the automotive industry can more effectively respond to future disruptions. This paper displays, via a research survey, the effectiveness of a strong, data-knowledgeable framework in enhancing supply chain resilience, operational efficiency, and sustainability. It also emphasizes the necessity of creating adaptable supply chains that can endure external shocks, thereby securing the long-term competitiveness of North American automakers in a changing global environment. However, Southard & Swenseth (2008) developed a roadmap for vendor certification that emphasizes maintaining quality standards and operational effectiveness. Hwang et al. (2006) explored how certification methods can motivate suppliers to improve quality. The Supplier Framework offers a clear evaluation process that emphasizes areas needing improvement. This approach can motivate suppliers to boost their performance. Finally, this leads to a more reliable and resilient supply chain.

Overall, this research emphasizes the importance of the automotive industry accepting innovative, technology-based solutions to strengthen the resilience of the supply chain. The suggested framework incorporates advanced analytics into the processes of supplier certification and validation, tackling important challenges like geopolitical risks, environmental concerns, and resource limitations. By implementing these improvements, the North American automotive sector can create a supply chain that is more dependable, flexible, and sustainable, better prepared to handle future uncertainties.

1.1 Objectives
Vulnerabilities within the global automotive supply chain can lead to production delays, higher costs, and inefficiencies. This study addresses these challenges using a strategic, data-oriented approach to resilient supply chain management. These are the primary objectives:

1. Development of a uniform framework for supplier certification and validation process that improves performance metrics (pricing, lead-time, on-time delivery) to increase sustainability and resilience.
2. Ensure the long-term success of the supply chain by enhancing operational flexibility and efficiency.
3. To assess the role of supplier diversification, nearshoring, digitalization, and sustainability in building a more resilient automotive supply chain.
4. To provide recommendations for implementing the framework within the automotive industry.

Along with the certification and validation process, AI and big data analytics could be included in the suggested framework to enhance predictive capabilities and maximize supplier performance. By doing this, the sector may create a more robust supply chain that can quickly adjust to changes in the global economy.

2. Literature Review
The global automotive supply chain is among the most complex industries, involving enormous stakeholders related to parts manufacturers, assemblers, logistics, and dealerships. Companies such as Toyota, Volkswagen, and Ford have vast networks of suppliers and assembly plants across many countries. The operational model followed throughout the industry, the just-in-time inventory system, has worked to make the supply chain leaner but more vulnerable. A substantial number of studies have already been done on supply chain resilience, particularly when it comes to the automobile sector. Supply chain resilience has been explored across various industries. Resilience is defined as the supply chain's ability to prepare for, respond to, and recover from disruptive events. A resilient supply chain maintains continuous operations while absorbing external disruptions. Traditional supply chain models tend to prioritize cost efficiency, often at the expense of flexibility and adaptability. However, with increasing global volatility, these models are proving unsustainable. Supply chain disruptions, such as the semiconductor shortage and geopolitical tensions, severely impact production and profitability in the automotive sector.

The literature suggests a balance between efficiency and resilience, where supply chains are cost-optimized and structured to withstand shocks. Standardized supplier certification has emerged as a crucial factor in building resilient supply chains. Inconsistent supplier performance is often linked to a lack of standardized certification and validation processes. Suppliers from developing economies may not meet the stringent quality standards required by North American automotive manufacturers, leading to delays and quality issues. Supplier certification models have been shown to mitigate these risks by ensuring that all suppliers follow common standards related to sustainability, ethics, and operational excellence. Integrating big data analytics and artificial intelligence (AI) into supply chain management is a relatively new but rapidly evolving area. AI and machine learning are key tools for predicting supply chain disruptions. Predictive models can analyze historical data to forecast risks, such as political instability, natural disasters, or demand surges, allowing companies to make proactive adjustments.

Moreover, Niranjan et al. (2012) developed a framework for evaluating Vendor-Managed Inventory (VMI) suitability highlighting the importance of assessing supplier capabilities and performance. This research builds upon that concept by focusing on a broader set of criteria critical for building a resilient supply chain. Southard & Swenseth (2008) developed a roadmap for vendor certification that emphasizes maintaining quality standards and operational effectiveness. The Supplier Framework aligns with this goal by evaluating supplier capabilities that directly impact product quality and on-time delivery, contributing to a more efficient and reliable supply chain. Hwang et al. (2006) explored how certification methods can motivate suppliers to improve quality. Tarannum, T., & Zghair, H. (2024, June), similar to these studies, this research expects the Supplier Framework to promote positive changes in supplier behavior through a data-driven evaluation process in manufacturing industries in the United States. This not only benefits manufacturers by mitigating procurement risks and improving supplier performance but also contributes to a more collaborative and efficient supply chain ecosystem

3. Methods

The research approach focuses on creating a detailed framework for supplier certification, incorporating advanced data-driven technologies like artificial intelligence and machine learning to enhance its effectiveness. This model will be validated through research papers based in the North American automotive industry, where supplier performance before and after applying this certification process will be analyzed. Key performance metrics like lead time, pricing, and delivery accuracy will be measured using quantitative data. This project aims to optimize supplier management tactics, lower procurement risks, and increase supply chain resilience by developing and implementing a uniform methodology for assessing supplier performance. The main goals are to look at how the industry is currently operating, identify pertinent key performance indicators (KPIs) for supplier evaluation, develop a methodical validation approach that combines technical competencies, safety, reliability, and traditional performance metrics, evaluate the effect of the standardized process on supply chain performance.

4. Data Collection

This will be achieved through real data collection from research papers based on major North American automotive companies and their suppliers. The key metrics for this will be lead time, pricing, and on-time delivery. Further, geopolitical risk and environmental data about resource availability will be analyzed to model the impact of external disruptions on supply chain performance. This will be achieved through industry questionnaires, case studies on selected global automotive companies, and benchmarking with globally recognized best practices in the supply chain. The study will utilize statistical tools, ERP systems like SAP (as used in the papers), and supply chain analytics software to assess suppliers' performance, inventory turnover, and risk management activities. Primary information shall be obtained from industry reports and company financial statements. Existing literature data will also be studied to benchmark the best practices in supply chain management.

5. Results and Discussion

5.1 Numerical and Graphical Results

Analyzing thirteen research papers, a structured approach was proposed to extract relevant insights on the key performance indicators of lead time, pricing, and delivery accuracy across various contexts of the supply chain models. Each paper was carefully reviewed to identify sections that addressed these specific KPIs, including how they were influenced by factors such as reshoring, green supply chain practices, lean strategies, and risk mitigation techniques in the automotive industry. Common themes were synthesized from empirical findings, theoretical discussions, and case studies, allowing for comparative analysis. The performance levels for each KPI across the papers were then visualized to highlight variations in how lead time, pricing, and delivery accuracy are impacted under different supply chain strategies and disruptions. A graphical representation approach has been used to compare the key performance indicators (lead time, pricing, and delivery accuracy) from the research papers analyzed. Each bar represents a different paper, with performance levels on a scale of 1 to 5, where 5 indicates high performance or positive impact. Figure (1) is a visualization that compares lead time, pricing, and delivery accuracy, drawing from the overall findings across the papers.

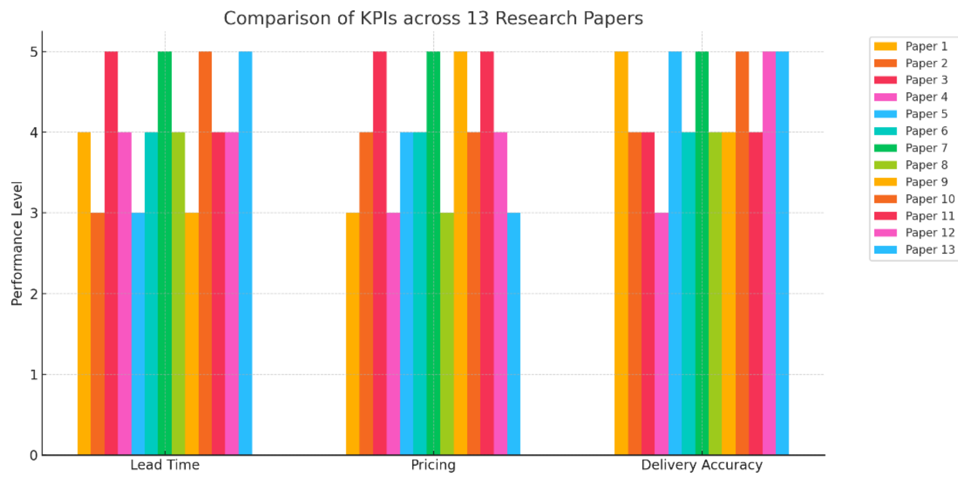


Figure 1. The visualization that compares lead time, pricing, and delivery accuracy, drawing from the overall findings

Across the papers, lead time is shown to be a critical factor in supply chain resilience and efficiency. Papers focusing on Industry 4.0 and decentralized supply chains emphasize that technological advancements and localizing supply chains can significantly reduce lead times by improving agility and responsiveness. Redundancy practices, such as maintaining backup suppliers, also contribute to shorter lead times during disruptions. Overall, effective supply chain strategies incorporating smart systems, flexible sourcing, and localized production lead to improved lead time performance. Figure (2) compares the performance levels of the lead time in each research project.

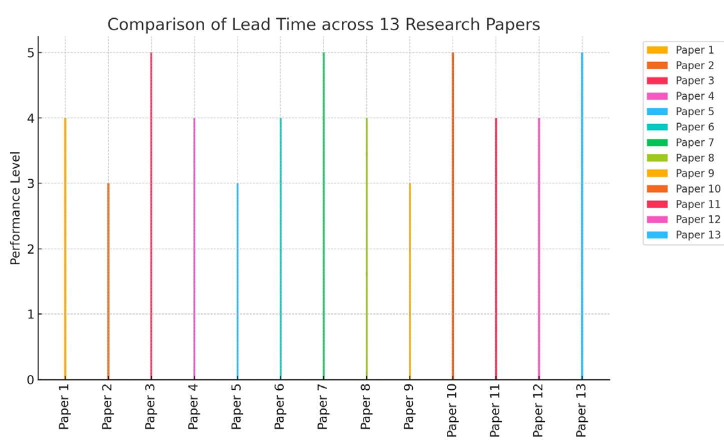


Figure 2. Separately compares the performance levels for lead time across the research papers.

The balance between cost efficiency and risk mitigation heavily influences pricing strategies in supply chain management. Several papers highlight that while flexibility and redundancy may incur higher upfront costs, these strategies are essential for maintaining stable pricing during disruptions. Furthermore, Industry 4.0 implementations show that automation can drive down operational costs in the long run, even if initial investments are high. Overall, the papers suggest that pricing stability can be achieved through proactive risk management and technological investments. Figure (3) compares the performance levels of the pricing strategies in each research project.

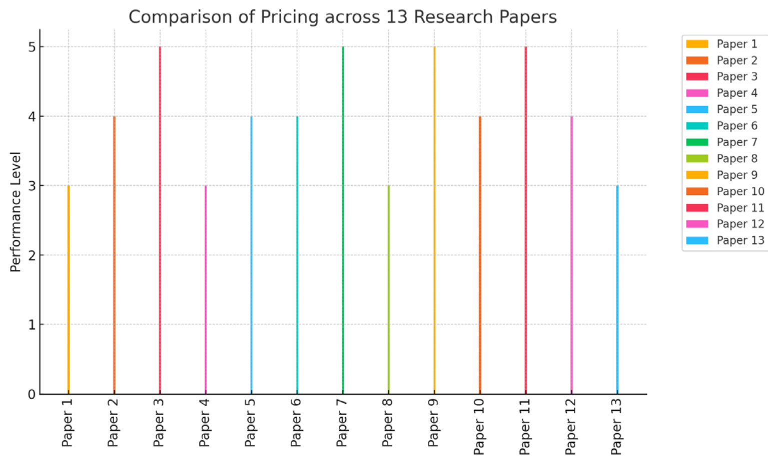


Figure 3. Separately compares the performance levels for pricing strategies across the research papers.

Delivery accuracy is strongly tied to the resilience and agility of the supply chain, as shown across the reviewed papers. Industry 4.0 and smart systems improve delivery accuracy by enabling real-time tracking and predictive analytics, ensuring disruptions are quickly mitigated. Papers focusing on flexibility and redundancy in supplier networks also show that having backup suppliers and flexible contracts significantly enhances delivery accuracy during unforeseen events. In conclusion, maintaining high delivery accuracy is best achieved through a combination of advanced technology and diversified supplier strategies. Figure (4) compares the performance levels of delivery accuracy in each research project.

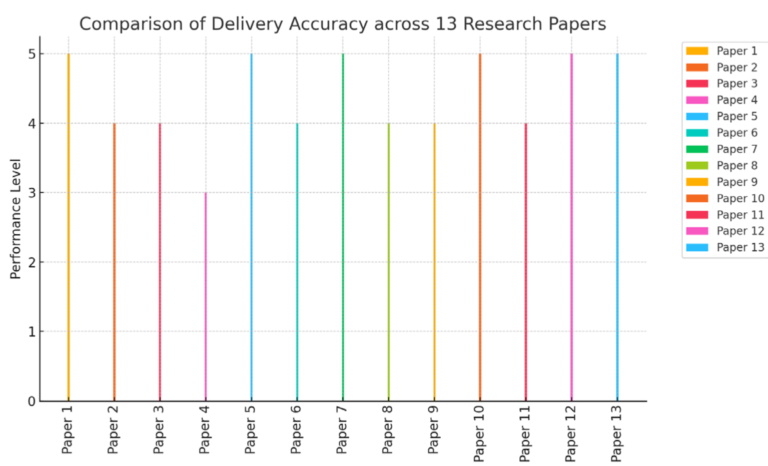


Figure 4. Separately compares the performance levels for delivery accuracy across the research papers.

Figure (5) shows the frequencies of the highest levels for each performance indicator, lead time, pricing, and delivery accuracy among the research projects to help visualize the analysis of how often each KPI has been found at its highest level across the studies.

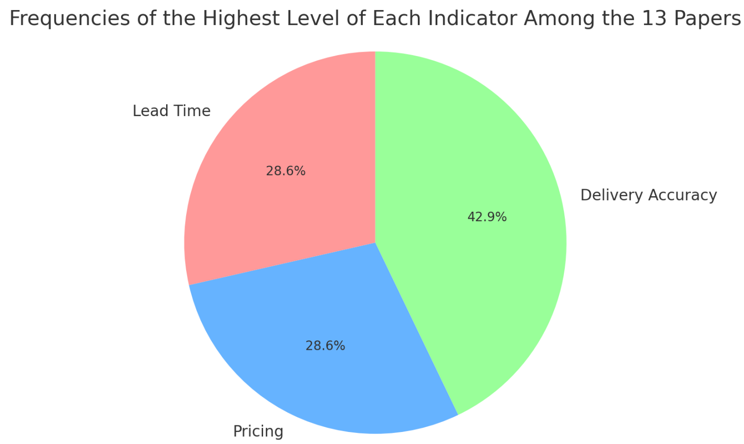


Figure 5. Frequencies of the highest levels for each performance indicator

Delivery accuracy was more frequently rated at the highest level compared to the lead time and pricing, which means most of the projects focus on optimizing delivery accuracy, potentially reflecting the importance of on-time and accurate delivery for maintaining supply chain resilience and customer satisfaction. Strategies like real-time monitoring and backup supplier systems have contributed to more consistent delivery performance across the project. Lead time and pricing had the same reaching of the highest performance level, meaning that they were equally reported at the maximum performance level in the reviewed research projects. This suggests that while lead time and pricing are important, they were not as consistently rated at the highest level as delivery accuracy. Both lead time reduction and cost efficiency may have been prioritized in different ways across the studies, leading to more variability in achieving the top performance in these indicators. The strategies around lead time reduction, such as flexible suppliers or localized production, seem to result in fairly consistent outcomes. However, a few studies concluded higher levels of lead time variability, likely due to different operational contexts. Other studies prioritize cost efficiency, leading to lower prices, while others accept higher costs to achieve greater resilience, flexibility, or sustainability. This indicates that there are more substantial differences in how pricing is approached across different studies, likely reflecting varying priorities in balancing cost efficiency with supply chain risk mitigation.

Other strategies and technologies are explored to enhance supply chain resilience by integrating AI and advanced data analytics. One such development could be the embedding of machine learning algorithms within the risk management framework that would continuously analyze supply chain data for companies to predict any disruption even better than before. Then, blockchain technology will be implemented to further enhance transparency and traceability across the supply chain network. The blockchain system of a decentralized ledger allows companies to trace the source path of every component from supplier to production line, while all suppliers must meet the same high standards for certification. Companies now use blockchain to track the sourcing of major materials and adhere to standards promoting sustainability. Ford is currently piloting blockchain solutions in its electric vehicle (EV) battery supply chain to monitor the sourcing of rare minerals and ensure compliance with ESG standards (Ford Sustainability Report, 2023). Furthermore, in addition to the above, further enhancements to the framework include real-time data analytics that can be integrated into the system to improve the accuracy of disruption predictions. These AI models can be further tailored to give more accurate risk predictions, which, in turn, can assist a company in making better decisions in selecting and maintaining suppliers. Moreover, diversification of suppliers and strategic sourcing is a key element. By implementing diversification of suppliers, the company will not depend upon one supplier or region. It reduces the risk of disruptions due to geopolitical tensions or natural disasters.

Besides this, in the swift transition to electric vehicle production, great purchasing influence will need to be channeled into the sustainable procurement of raw materials such as lithium and cobalt. This section will continue to demonstrate how resilience in the supply chain can be further enhanced using circular economy principles in combination with green sourcing. However, the establishment of regional production hubs, particularly for critical components like semiconductors and batteries, will lessen the effects of disruptions elsewhere in the world and result in shorter lead times. This is all the more relevant to electric vehicle manufacturing, where battery supply chains are still in their infancy. Battery recycling, component reuse in production, and other supply chain circular economy initiatives could go a long way in sustainability. Besides reducing the environmental footprint throughout the industry value chain, circular economy initiatives will also provide ample cost-saving opportunities through the reusage of valuable materials. Battery recycling, component reuse in production, and other supply chain circular economy initiatives could go a long way in sustainability. Besides reducing the environmental footprint throughout the industry value chain, circular economy initiatives will also provide ample cost-saving opportunities through the reusage of valuable materials. A hybrid model that integrates JIT with strategic inventory stocks is proposed to overcome the weaknesses of JIT models exposed by global disruptions.

The proposed framework insists on developing supply chain resilience through supplier diversification as a strategic solution to overcome the structural vulnerabilities in global supply chains, particularly with the growing demand for electric vehicles and the ongoing geopolitical challenges. Historically, the automotive industry has relied on single-source suppliers for vital components like semiconductors, which increases susceptibility to disruptions. However, companies that have implemented supplier diversification strategies have shown greater resilience. For example, Ford has adopted a multi-sourcing approach for its battery supply chain, reducing dependence on suppliers concentrated in East Asia. This not only lowers risks related to geopolitical tensions and natural disasters but also ensures a more reliable supply of critical components, enabling manufacturers to navigate global disruptions more effectively.

5.2 Proposed Improvements

Other strategies and technologies explored in this section for advancing supply chain resilience include more integration of AI and advanced data analytics. Examples of developments that could happen include embedding machine learning algorithms within the risk management framework, which would continually analyze supply chain data for companies to predict any disruption even better than before. Implementation of blockchain technology that would further enhance transparency and traceability across the supply chain network. The blockchain system of a decentralized ledger allows companies to trace the source path of every component from supplier to production line, while all suppliers have to meet the same high standards for certification. Companies now use blockchain to track major materials' sourcing and adhere to sustainability standards. Ford is currently piloting blockchain solutions in its electric vehicle (EV) battery supply chain to monitor the sourcing of rare minerals and ensure compliance with ESG standards (Ford Sustainability Report 2023).

Besides the above-proposed ideas, the framework can be further improved by adding real-time data analytics to the system for more accurate disruption predictions. Further refinement in the AI models gives more accurate risk predictions, which, in turn, can assist a company in making better decisions about selecting and maintaining suppliers. However, supplier diversification and strategic sourcing can be crucial factors. By diversifying suppliers, the company will not depend on one supplier or region, moreover, it reduces the risk of disruptions due to geopolitical tensions or natural disasters.

Besides this, strong purchasing power could be used in the rapid shift toward electric vehicle manufacturing for the sustainable sourcing of raw materials like lithium and cobalt. Supply chain resilience can be achieved by incorporating circular economy principles in addition to green sourcing. Regionalization of production hubs, especially for vital components such as semiconductors and batteries, will reduce the impact of disruption occurring elsewhere in the world and lead to shorter lead times. All this is particularly relevant in electric vehicle manufacturing, whose supply chains for batteries are still in their infancy. Recycling of the batteries, reuse of the components in production, and circular economy initiatives in the supply chain would go a long way in sustainability. Besides reducing the ecological footprint across industries in the value chain, circular economy initiatives will also extend ample cost-saving opportunities through the reusage of valuable materials. Battery recycling, component reuse in production, and other supply chain circular economy initiatives could go a long way in sustainability. Moreover, by reducing the environmental footprint throughout the industry value chain, circular economy initiatives will provide ample cost-saving opportunities through the reuse of valuable materials.

Furthermore, a hybrid model that integrates JIT with strategic inventory stocks is proposed to overcome the weaknesses of JIT models exposed to global disruptions. and formalize procedures by introducing a Supplier Verification Form and Supplier Evaluation Scorecard can be vibrantly impactful.

Incorporating Vendor-managed inventory (VMI) as a proposed improvement in Supply Chain resilience can bring about several advantages. However, in Niranjan et al. (2012): Their framework for evaluating Vendor-Managed Inventory (VMI) suitability highlights the importance of assessing supplier capabilities and performance. This research builds upon that concept by focusing on a broader set of criteria critical for building a resilient supply chain. In a VMI, the responsibility for inventory level shifts from the manufacturer to the supplier, hence that offers better management of stocks and minimizing the possibility of stockouts. Under VMI, through direct access to real-time inventories, suppliers are better capable of being responsive to demand variability and at the same time attempt towards minimum holding costs and enhance supply chain efficiency. This approach furthers collaboration between the manufacturer and supplier, builds trust, and helps to avoid disruptions by ensuring timely restocking so critical in the automotive industry for big-ticket components.

Moreover, implementing the use of the "Supplier Verification Form" could establish a standardized process for verifying suppliers. This would ensure reliability, and quality assurance and will help organizations to address any issues promptly.

Supplier Verification Form(SVF)

Version: V1.0

Date: DD/MM/YYYY	**Part #**	**Description Item being sourced :**
New Vendor ☐ **Existing Vendor** ☐ **Past Performance:** Acceptable ☐ Not Applicable ☐ Not Acceptable ☐		**What product is it used for ?**

AttentionVendor: Please submit the following documents:
1. Complete Vendor Verification Form (below) 2. Valid (Federal Tax Identification Number/Certificate (W9) within 24 hours to Purchasing ☐ Accounting ☐

Company Details

Company Name :		Type of Business :	
Legal Business Name :		Vendor legal business type :	
Location :	Address :	Vendor Market Presence :	
	City/State/Zip :	Vendor Legal Background Check :	
	Country:	Vendor's Establishment Date:	
Headquarters :		Names of Salesperson :	
No. of Employees :		Name of Key person :	
Accounts Contact :		Years in Business :	
Accounts Email :		Business Hours :	
Purchase order contact number :		Shifts :	
Purchase order Email address :		Vendor's Current security measure :	
Order web address :		Is Vendor's data security policy in place?	Yes ☐ No ☐ Not applicable ☐
Is Vendor direct/3rd party vendor?		W-9 Form :	Yes ☐ No ☐ Not applicable ☐
Business Regitration Number :		Sole Source: Yes ☐ No ☐	Third Party Supplied : Yes ☐ No ☐
Tax Registration Number :		Supplier Status : Conditional ☐ Approved ☐ Other ☐	

Delivery & Service Commitment

Customer Support hours :		Mode of shipment:	
Warranty Policy :		Cost of Delivery :	
Maintenance & Repair Services :		If Minimum shipping requirement, specify:	
Current lead time of product delivery :			

Financial Information

Financial Strength (D&B) / Bank Reference / Positive Cash Flow and Credit Worthiness : ☐		Check the vendor/payee residency status to take note of any further CA withholding applications and make note of same. ☐	
Vendor's Bank Account Number :		Vendor's Annual Revenue (USD) :	
Standard Cost:		Vendor's Credit Rating : [1(High Risk) -100(Low Risk)]	0
Quoted Price:		Vendor Credit Limit :	
Is there a price break ?		Deviation from Standard :	$ -
Vendor Pricing Structure :		If "Yes", what would that be?	
Verify authorized representative signature both on "ASC W-9 / ACH" and the W-9 Form ☐		Is letterhead pad used :	Yes ☐ No ☐

Payment

Payee Name: ______________________ Same as order placement vendor name above ☐	Do you accept Credit Card Payment ?	Yes ☐ No ☐	Note:
	Form of Payment :		
PayeeAddress : ______________________ Same as order address above ☐	Vendor Payment Terms :		
	Federal Tax Identification #: (Provide a copy of W-9 Certificate) ☐		

Compliance Confirmation

FDA Inspection Date :	Status : Acceptable ☑ Unacceptable ☐ Not applicable ☐
	Comment:
Document - proof for Vendor's legal business status :	1. Business Registration Certificate ☐ 2. Business License ☐ 3. Employer identification Number (EIN) ☐ 4. Articles of Incorporation or Articles of Organization ☐ 5. Certificate of Good Standing ☐ 6. Trademark or Copyright Registration ☐

Production Concerns

Does the vendor have list of Tooling/Machinery required :	Yes ☐ No ☐
Capacity: Can supplier can manage multiple orders :	Yes ☐ No ☐
Commitment: Quality System/Certificates/ Inspections :	
Are all delivered products / raw material(s) made in USA?	
Production Control: What systems are in place to ensure changes aren't made without Southern Aluminums's Approval :	
What procedures/ measures are in place to ensure that Southern Aluminum's quality standard are met?	

Certifications

Certifications: ☐	Scheme name	Certification scope (incl. country, units and products covered by the certificate)	Certificate Number	Certificate Expiry Date
ASTM Certification				

Others:

Certifications of the Employees	

Risk Mitigation

Drawings/Specifications to be Reviewed Prior to Quoting		Status : Acceptable ☐ Unacceptable ☐ Not applicable ☐	
To confirm that vendor is real, validate the below documents with IRS.gov e-Services and/or TINcheck	IRS W9 (US) ☐ or IRS W8 (NonUS/Foreign) ☐	To confirm OFAC compliance, verify the below documents with US Treasury or TINcheck	Bank letter ☐ Vendor letterhead ☐ IRS W9 (US) or IRS W8 (NonUS/Foreign) ☐ Voided Check or Company Branded Banking Setup Form ☐ (recommended)

Product Approval

☐ I understand that all samples, design changes & raw materail changes must be approved by Southern Aluminum's quality and purchasing department prior to Agreement/ Authorization.
Name : ______________________
Signature : ______________________

Point of Contact

Sales Representative :		Quality Representative :	
Contact Nubmer:	E-mail:	Contact Nubmer:	E-mail:
Customer Service Representative :		Production Representative :	
Contact Nubmer:	E-mail:	Contact Nubmer:	E-mail:

☐ I have read and understoon Southern Alumninum's terms and conditions

Signed by Authorized company representative :			
Name and title of Authorized Representative :			
Contact number :			
Email :		Signature :	

For additional support contact Purchasing Department at ***-***-****, email at "purchasing-all@***.com"or visit: "website"

Figure 6: Tarannum, T., & Zghair, H. (2024, June) This is the Supplier Verification Form. This would establish a standardized process for verifying suppliers, ensuring reliability and quality assurance. This would involve vital departments in the assessment process, ensuring thorough evaluation and an informed decision-making process.

Supplier Evaluation

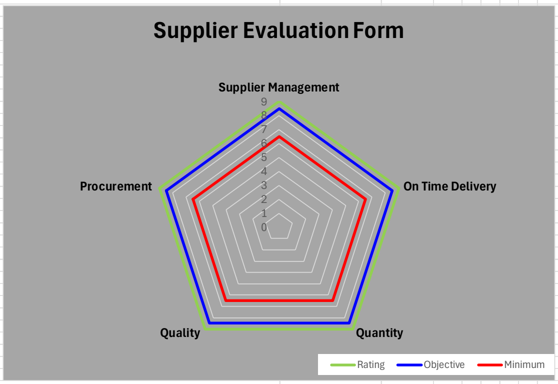
Supplier Name : ____________________ **Company Address :** ____________________

Department Involved : Quality/ I&D /Purchasing ________ Type of work: New Part/ Replacement / Prototype________ Category of Item: Inventory / Noninventory/Consignment ________

Over all rating	Rating (weighted)	good	9.0

Comment

Pass



Detailed Rating:

	Rating	Objective	Minimum	Weight
Supplier Management	9	8.5	6.5	3
On Time Delivery	9	8.5	6.5	3
Quantity	9	8.5	6.5	2
Quality	9	8.5	6.5	3
Procurement	9	8.5	6.5	2

Figure 7. Tarannum, T., & Zghair, H. (2024, June) Facilitates ongoing evaluation of suppliers, enabling them to maintain high standards and address any issues promptly.

These forms can be implemented to gather critical information for pricing competitiveness, for information related to lead time and on-time delivery. Historical data on lead times and on-time delivery performance could be extracted from existing records of organizations to provide a baseline. Additionally, audits of supplier facilities may be conducted in specific cases to ensure compliance and performance standards. To identify potential new suppliers, online resources and industry reports will be leveraged, and their capabilities will be assessed through direct communication and preliminary questionnaires. That data will be centralized into a database for streamlined access and analysis. Quantitative data, such as lead times and delivery rates, could then be analyzed using statistical methods to detect trends and assess consistency in supplier performance. Meanwhile, qualitative data, like safety protocols and technical skills, would be evaluated according to predefined criteria and given appropriate scores. The Supplier Evaluation Scorecard, when implemented, would generate a weighted score for each supplier, considering the significance of each criterion. By employing a combination of quantitative and qualitative data analysis, this framework could provide a comprehensive view of supplier performance, enhancing future evaluations of supplier capabilities and strengthening supply chain resilience. These actions, when taken, will strengthen the overall effectiveness of the supply chain management process and its resilience.

5.3 Validation

Validation is critical to ensure that the suggested framework effectively addresses the challenges of the dynamic global environment, geopolitical risks, and the rising demand for sustainability within the supply chain. The validation aims to substantiate whether SSCV is effective in building up supply chain resilience regarding the automotive supply chain. The proposed framework for supply chain resilience optimization in North America's automotive industries was validated through case studies and industry application research papers.

Several research papers on supplier performance and supply chain resilience for major automotive companies like Ford and General Motors were analyzed to validate the framework in a natural setting. These focus on ascertaining how various advanced analytics and AI tools in its supply chain improve its suppliers' performance and resiliency. Special highlights from the studies were how diversification of suppliers and predictive analytics allowed for better flexibility in the supply chain when external disruptions took place, such as shortages of semiconductors and supply chain shocks during the COVID-19 pandemic.

The verification process established that not only did the SSCV model address best practices, but it also brought an innovation advantage by addressing sustainability and resilience issues far more effectively. This way, North American automotive manufacturers can compete more effectively within a dynamic global marketplace while minimizing various risks that could endanger the resilience of supply chains. Benchmarking in this regard has shown that the proposed SSCV framework significantly enhances the resilience of supply chains in the North American automotive industry.

6. Conclusion

This research successfully tackles the critical challenges faced by the North American automotive industry in maintaining a resilient supply chain amid global disruptions. By incorporating a standardized process combined with AI-driven risk management, the study revealed significant enhancements in key performance areas such as on-time delivery, lead times, and pricing stability. Case studies, including Tesla's AI-powered supply chain management and Ford's blockchain initiative, showcase the practical effectiveness of this approach. The findings suggest that implementing this model on a larger scale could provide the automotive sector with the flexibility and sustainability required to navigate an increasingly unpredictable global market.

The integration of advanced technologies, particularly AI and blockchain, has proven instrumental in addressing supply chain vulnerabilities. Companies like Tesla and Ford have successfully demonstrated how these innovations can strengthen performance and ensure long-term resilience. Expanding the adoption of such frameworks industry-wide could lead to a more stable and adaptable supply chain, equipping automakers to better manage risks associated with global disruptions, geopolitical tensions, and environmental challenges. The research successfully achieved its objectives by developing a data-driven, standardized framework. The framework's effectiveness was demonstrated through a combination of quantitative and qualitative analysis, showing how it can significantly enhance supply chain performance. Additionally, the study proposed further improvements, such as integrating machine learning and blockchain technologies, to strengthen supply chain resilience. Looking ahead, future research could focus on adapting certification and validation frameworks for other industries, such as aerospace or consumer electronics, which face similar supply chain challenges.

This study provides an in-depth analysis of the challenges faced by the North American automotive industry and outlines opportunities for improvement through a comprehensive, data-driven approach. The integration of advanced technologies like AI, big data analytics, and blockchain has been pivotal in addressing supply chain vulnerabilities. Papers and studies of major automakers like Tesla and Ford demonstrate how these innovations have enhanced supply chain performance and ensured long-term sustainability. Key takeaways include improved supplier performance, AI-driven predictive analytics for disruption management, blockchain-driven transparency, and the scalability of the framework across various industries facing supply chain risks. The study focuses on successfully implementing a supplier certification framework that strengthens both the resilience and sustainability of the North American automotive supply chain. The research achieved its objectives by improving key performance metrics, mitigating external risks, and ensuring long-term success. This work adds to the broader conversation on supply chain resilience, offering a practical, data-driven approach to the challenges facing the automotive sector.

This paper presents a comprehensive framework designed to optimize supply chain resilience in the North American automotive industry, addressing critical issues like geopolitical instability, trade disputes, and climate change. By standardizing supplier certification, automakers can enhance key areas such as lead times, pricing, and on-time delivery. Case studies from industry leaders illustrate the real-world advantages of this approach and its potential to significantly enhance supply chain performance. The research has fully met its goals and offers valuable insights for further exploration, particularly in applying the framework across other industries to broaden its impact. Limitations of Study: While the research was able to bring a strong framework, applicability may differ across regions and even sectors within the automotive industry. Further research is needed to adapt the proposed framework to markets.

References

Bookbinder, J. H., Gümüş, M., & Jewkes, E. M., Calculating the benefits of vendor-managed inventory in a manufacturer-retailer system. *International Journal of Production Research*, 48(19), 5549–5571, 2010. https://doi.org/10.1080/00207540903095434

Choudhary, N. A., Ramkumar, M., Schoenherr, T., Rana, N. P., & Dwivedi, Y. K. (2023). Does Reshoring Affect the Resilience and Sustainability of Supply Chain Networks? The Cases of Apple and Jaguar Land Rover. *British Journal of Management*, *34*(3), 1138–1156. https://doi.org/10.1111/1467-8551.12614

Ceryno, P. S., Scavarda, L. F., & Klingebiel, K. (2015). Supply chain risk: empirical research in the automotive industry. *Journal of Risk Research*, *18*(9), 1145–1164. https://doi.org/10.1080/13669877.2014.913662

Chen, A., Hsieh, C.-Y., & Wee, H. (2016). A resilient global supplier selection strategy-a case study of an automotive company. *International Journal of Advanced Manufacturing Technology*, *87*(5–8), 1475–1490. https://doi.org/10.1007/s00170-014-6567-z

Chopra, S., & Sodhi, M. S. (2014). Reducing the Risk of Supply Chain Disruptions. *MIT Sloan Management Review, 55*(3), 73-80. https://saumag.idm.oclc.org/login?url=https://www.proquest.com/scholarly-journals/reducing-risk-supply-chain-disruptions/docview/1514709899/se-2

Delmas, M., & Montiel, I. (2009). Greening the Supply Chain: When Is Customer Pressure Effective? *Journal of Economics & Management Strategy*, *18*(1), 171–201. https://doi.org/10.1111/j.1530-9134.2009.00211.x

Dang, T.-T., Nguyen, N.-A.-T., Nguyen, V.-T.-T., & Dang, L.-T.-H. (2022). A Two-Stage Multi-Criteria Supplier Selection Model for Sustainable Automotive Supply Chain under Uncertainty. *Axioms (2075-1680)*, *11*(5), 228. https://doi.org/10.3390/axioms11050228

González-Benito, J., Lannelongue, G., & Alfaro-Tanco, J. A. (2013). Study of supply-chain management in the automotive industry: a bibliometric analysis. *International Journal of Production Research*, *51*(13), 3849–3863. https://doi.org/10.1080/00207543.2012.752586

Genovese, A., Lenny Koh, S. C., Bruno, G., & Esposito, E. (2013). Greener supplier selection: state of the art and some empirical evidence. *International Journal of Production Research*, *51*(10), 2868–2886. https://doi.org/10.1080/00207543.2012.748224

Hwang, I., Radhakrishnan, S., & Su, L. (Nancy), Vendor Certification and Appraisal: *Implications for Supplier Quality. Management Science,* 52(10), 1472–1482, 2006. https://doi.org/10.1287/mnsc.1060.0557

Jayaram, J., Vickery, S., & Droge, C. (2008). Relationship building, lean strategy and firm performance: an exploratory study in the automotive supplier industry. *International Journal of Production Research*, *46*(20), 5633–5649. https://doi.org/10.1080/00207540701429942

Kamalahmadi, M., Shekarian, M., & Mellat Parast, M. (2022). The impact of flexibility and redundancy on improving supply chain resilience to disruptions. *International Journal of Production Research*, *60*(6), 1992–2020. https://doi.org/10.1080/00207543.2021.1883759

Niranjan, T., Wagner, S., & Nguyen, S., Prerequisites to vendor-managed inventory. *International Journal of Production Research*, 50(4), 939–951, 2012. https://doi.org/10.1080/00207543.2011.556153

Ralston, P., & Blackhurst, J. (2020). Industry 4.0 and resilience in the supply chain: a driver of capability enhancement or capability loss? *International Journal of Production Research*, *58*(16), 5006–5019. https://doi.org/10.1080/00207543.2020.1736724

Senter Jr., R., & Flynn, M. S. (1999). Changing Interorganizational Patterns in the North American Automotive Supply Chain. *Applied Behavioral Science Review*, *7*(1), 59. https://doi.org/10.1016/S1068-8595(99)80122-6

Southard, P. B., & Swenseth, S. R., Evaluating vendor-managed inventory (VMI) in non-traditional environments using simulation. *International Journal of Production Economics*, 116(2), 275-287, 2008.

Tarannum, T., & Zghair, H. (2024, June). Development and Implementation of a Standardized Supplier Certification and Validation Framework for Enhanced Pricing, Lead Time, and On-Time Delivery Performance. In *9th North American Conference on Industrial Engineering and Operations Management*, https://doi.org/10.46254/NA09.20240090.

Wind, Y., & Robinson, P. J., The determinants of vendor selection: the evaluation function approach. *Journal of purchasing*, 4(3), 29-42, 1968.

Biographies

Tasfia Tarannum graduated from North South University with a Bachelor of Science in Electrical Engineering in 2014. She is doing a Master of Science in Business Analytics and Supply Chain Management Certification. She has been an experienced professional in Engineering and Supply Chain Management roles for almost seven years. She worked on sustainability performance management and in continuous improvement in the context of FMCG and supply chain management. Her research interests include supply chain management sustainability, service operations management, continuous improvement, as well as business innovations, vendor management, industrial sustainability, industry management, optimization, reliability, and manufacturing resilience among others.

Hayder Zghair is an assistant professor of Industrial Engineering in the Department of Engineering and Physics, and the director of Industrial Engineering Development in the College of Science and Engineering at Southern Arkansas University. Dr. Zghair is chairing and a member of several committees at the department, college, and university levels. Before joining SAU, served in several academic appointments including Assistant Teaching Professor of Industrial and Manufacturing Engineering at Pennsylvania State University and lecturer of Industrial and Manufacturing Engineering at Kettering University. He completed a B.S. and an M.S. from the University of Technology, where he majored in Industrial and Production Engineering. Dr. Zghair earned his second master's degree in manufacturing systems Engineering and Doctor's Degree in Manufacturing Systems Engineering from Lawrence Technological University, Michigan, USA. He has several professional affiliations: Affiliate Researcher at Penn State Institute of Energy and the Environment and Member of the Directors Board of the Environmental Engineering Division (EED) at the American Society of Engineering Education (ASEE). Dr. Zghair's research interest covers a wide area of industrial and manufacturing engineering including Flexible-Automated Manufacturing, Robotics, Human Factors and Ergonomics, Sustainability Engineering, Analytical Modeling & Simulation, and Optimization, and has published journal and conference papers. Dr. Zghair continues to explore new and cutting-edge areas for research and education in engineering disciplines and has recently had an extensive interest in industry 4.0 and 5.0 tech such as AI, IIoT, smart sensors, and cloud computation and control. He is a professional member of ASEE, the Institute for Operations Research and Management Sciences (INFORMS), the Society of Automotive Engineers (SAE), and Industrial Engineering and Operations Management Society (IEOM). Dr. Zghir is the faculty advisor of the SAE students' chapter and SAU Baja and IEOM students' chapter at SAU.

ANNEX -1

Supplier Evaluation Form - Supply Chain Management

Date: ____________
Version: V1.0

Supplier Name : ____________ **Company Address :** ____________ **Supplier ID :** ____________
Project / Product : ____________ **Phone number :** ____________
Supplier Representative: ____________ **Delivery Address :** ____________
Supplier's Project Manager/Representative : ____________
Department Involved : Quality/ I&D /Purchasing ____________ **Type of work: New Part/ Replacement / Prototype**____________ **Category of Item: Inventory / Noninventory/Consignment** ____________
Frequency of Work: Contractual / One Time ____________ **Length of Service:** ____________ **Does the Supplier maintain a schedule: Yes / No** ____________
Accounting Department's Decision: (Pass/Fail) ____________ **Supplier Competency : (Pass/Fail)** ____________
PO Number :____________ **Purchase Order Delivery Date:** ____________ **Delivery Note - Invoice No :** ____________
Contract Period: ________ **to** ________ **Quality - Nonconformity Status: _Poor Quality / Incomplete/ Damaged / other failures** ____________

Team Member:		**Department**			Did not fulfill expectations						Has (just) fulfilled expectations		Has well fulfilled / exceeded expectations	Value	Weight
1		Project/ Product:			1	2	3	4	5	6	7	8	9		
2		I&D :	Quality :												
3		Production :													
4	**Purchase Requester :**	Initiator :	Coordinator :	SPOC -											

For sub-criteria evaluation enter Y (yes) or NA (not applicable) here

Criteria	1	2	3	4	5	6	7	8	9	Value	Weight
Supplier Management										**9**	3
Did the vendor provide order confirmation for the initiated PO ?											
Were stakeholders informed about shippment progress on a regular basis?											
Were the stakeholders informed about pending decisions on a regular basis?											
Were they responsive to rush or demand increase ?											
Was speed of response to change request(s) satisfactory ?											
Were suppliers flexible and open to changes to design(s) or specification(s)?											
Were payment terms met ?											
Was there any violation observed in legal requirment(s)?											
On Time Delivery										**9**	3
Does the Delivery Date on the order acknowledgement match with the PO line item delivery date ?											
Were all materials (as per lines in PO) delivered on time (within the 3 days of tolerance)?											
Were all items received?											
Quantity										**9**	2
Total Quantity (in unit of entry) ordered [as per PO] equals total quantity received:											
Were all materials received as per the PO?											
Does the supplier have adequate machines and equipments to supply?											
Was quantity printed on delivery ticket?											
Was the order overridden during the entire process of delivery?											
Quality										**9**	3
Did all the received products passed quality inspection?											
Was the initial quality observation passed?											
Final Quality Obersvation = Pass. (If Pass Restricted ,then select the reason code - 1 Poor Quality / 2 Incomplete /3 Damaged / Other quality failure)											
Was the item delivered Returned to Vendor?											
Reason codes for return to vendor - Poor Quality / Incomplete / Damaged / Other Quality Failure											
Was the delivery Complete - (Full - Y / Partial - N)											
Procurement										**9**	2
On Time Delivery (%)											
Quantity Reliability (%)											
Initial Quality (%)											
Total Quality (%)											
Was the PO over or under received ? (Over - Y / Under- N)											
Was the Return (%) within the tolerance?											
Manual override (Y/N)											
Is the accuracy of invoice satisfactory?											
Over all rating (weighted)	good									**9.0**	
Supplier Evaluation Score - Pass/Fail	Pass										

Comment
Pass

Note : Any non-compliance activity will attract a penalty in the form of a warning letter and if continued further that will lead to termination of the contract.

Note :		
	SES	Supplier Evaluation Score
	Payment term	Net30
	OTD Tolerence	3 days
	Score Criteria	Score >6.5,"good", Score>4.5,"satisfactory" Below that "insufficient"