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Article

Building Resilient Supply Chains in the Face of Global Uncertainty: Insights from Small and Medium-Sized Enterprises (SMEs)

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Abstract: The resilience of supply chains has become a crucial factor in ensuring business continuity, particularly for SMEs navigating global uncertainties. This study explores the strategies adopted by SMEs to build supply chain resilience, focusing on risk assessment, supplier diversification, technological integration, collaborative partnerships, inventory optimization, and financial planning. The findings reveal a shift from reactive crisis management to proactive risk mitigation, highlighting how businesses have restructured their supply chain models to enhance adaptability. Supplier diversification has been instrumental in reducing dependence on single suppliers, while digital technologies have enabled real-time tracking, predictive analytics, and improved communication across the supply chain. Strategic collaborations with industry partners, trade associations, and government entities have also strengthened SMEs' ability to manage disruptions effectively. Inventory management practices have evolved, with firms moving away from just-in-time models to hybrid approaches that balance efficiency with resilience. The study also underscores the importance of financial preparedness, demonstrating how SMEs have leveraged liquidity management, external funding, and cost optimization to sustain operations during supply chain disruptions. These combined efforts illustrate that resilience is not merely a response mechanism but a strategic necessity for long-term sustainability. The study concludes that SMEs must continue investing in resilience-building measures to navigate ongoing and future uncertainties, ensuring stability and growth in an increasingly volatile global market.

Keywords: Supply chain resilience; SMEs; supplier diversification; digital transformation; inventory management; financial stability; risk mitigation

1. Introduction

In an increasingly interconnected world, supply chains serve as the backbone of global commerce, enabling the flow of goods and services across vast distances and various sectors. However, the stability and effectiveness of these supply chains have been severely tested in recent years due to unprecedented global uncertainties, including the COVID-19 pandemic, geopolitical tensions, and natural disasters. Small and Medium-sized Enterprises (SMEs) are particularly vulnerable to such disruptions, as they often lack the resources and strategic capabilities that larger firms possess to absorb shocks and adapt to changing circumstances. The importance of building resilient supply chains in the face of these uncertainties has never been more pronounced. Resilience in supply chains refers to the ability to prepare for, respond to, and recover from unexpected disruptions, ensuring continuity of operations and minimizing the impact on overall performance (Browning et al., 2023). As a result, SMEs must develop strategies that not only enhance their resilience but also leverage their unique characteristics to navigate challenges effectively. Recent studies have highlighted the critical role of supply chain resilience in sustaining business operations during crises. For instance, Balakrishnan, Suresh, and Harindranath (2024) emphasize the need for firms to develop robust relationships with suppliers and partners to foster a collaborative environment that enhances resilience during disruptions. This collaborative approach can help SMEs

tap into the resources and expertise of their networks, allowing them to adapt more quickly to changing conditions. Moreover, firms that invest in building resilient supply chains are better positioned to capitalize on emerging opportunities in the market, ultimately leading to improved performance and competitiveness (Bhusiri et al., 2021). The concept of resilience goes beyond merely reacting to disruptions; it encompasses proactive measures, including risk assessment, resource allocation, and the implementation of contingency plans to mitigate the effects of potential threats. The COVID-19 pandemic has served as a harsh reminder of the vulnerabilities inherent in global supply chains, particularly for SMEs that often operate on thin margins and have limited access to resources (Baral et al., 2023). The pandemic exposed significant weaknesses in supply chain networks, leading to widespread disruptions in production, transportation, and distribution. Consequently, many SMEs faced severe challenges in maintaining their operations and meeting customer demands. The crisis underscored the necessity for firms to rethink their supply chain strategies, moving from a focus on cost minimization to one that prioritizes resilience and agility. In response to these challenges, SMEs have begun to explore various strategies to enhance their supply chain resilience, such as diversifying suppliers, adopting technology-driven solutions, and fostering closer collaboration with partners (Bier et al., 2020). Digital transformation has emerged as a vital enabler of supply chain resilience, providing SMEs with tools and capabilities to enhance visibility, streamline operations, and respond swiftly to disruptions (Bianco et al., 2023). Industry 4.0 technologies, including the Internet of Things (IoT), big data analytics, and artificial intelligence, facilitate real-time monitoring and decision-making, enabling firms to anticipate disruptions and implement proactive measures. For SMEs, leveraging these technologies can lead to improved forecasting accuracy, better inventory management, and enhanced customer responsiveness. However, the adoption of such technologies requires investment and strategic alignment, which can pose challenges for resource-constrained SMEs. Nevertheless, the benefits of embracing digital solutions in building resilient supply chains are evident, as firms that adopt these technologies tend to experience greater operational efficiency and adaptability in times of crisis. The role of collaboration and relationship management in enhancing supply chain resilience cannot be overstated. SMEs that cultivate strong relationships with suppliers and customers can leverage these connections to navigate disruptions more effectively. By fostering open communication, sharing information, and engaging in joint problem-solving, firms can enhance their ability to respond to unforeseen challenges (Birkie & Trucco, 2020). Collaborative networks allow SMEs to pool resources, share risks, and access critical information that can inform decision-making during crises. Moreover, building trust among partners can lead to improved coordination and flexibility, further strengthening the resilience of the supply chain. Emon and Khan (2024) suggest that fostering such collaborative environments not only enhances the capacity to manage disruptions but also contributes to the long-term sustainability of supply chains. Furthermore, Emon et al. (2024) argue that SMEs should integrate risk management frameworks into their supply chain strategies to anticipate potential threats and develop appropriate mitigation measures. The adoption of such frameworks can significantly enhance an enterprise's ability to withstand shocks while maintaining operational efficiency. Additionally, the complexity of supply chains plays a crucial role in determining how resilient an SME can be when faced with disruptions. Complex supply chains, characterized by multiple tiers of suppliers and intricate logistics networks, can exacerbate the impacts of disruptions, making it difficult for firms to respond effectively (Bygballe et al., 2023). SMEs often face challenges in managing complex supply chain structures due to limited resources and expertise. Consequently, simplifying supply chains and reducing dependencies on single suppliers can enhance resilience by minimizing potential points of failure. Firms should consider strategies such as developing dual sourcing arrangements, diversifying supplier bases, and optimizing inventory management to mitigate the risks associated with complexity. These strategies can empower SMEs to remain agile and responsive in the face of disruptions, ensuring continuity of operations and customer satisfaction. The COVID-19 pandemic has underscored the need for SMEs to prioritize resilience in their supply chain strategies. The pandemic prompted many firms to reassess their operations, revealing vulnerabilities and opportunities for improvement. As a result, SMEs have begun to adopt innovative practices and technologies to enhance their resilience, such as

investing in automation, digitization, and supply chain visibility (Emon et al., 2025). The lessons learned during the pandemic have prompted a shift in mindset among SMEs, emphasizing the importance of being proactive rather than reactive when it comes to supply chain management. By embracing a culture of resilience, SMEs can better navigate future uncertainties and position themselves for long-term success. As we delve deeper into the topic of building resilient supply chains in the face of global uncertainty, it is essential to recognize the unique challenges and opportunities that SMEs encounter. These enterprises play a vital role in the economy, contributing to job creation and innovation. However, their ability to thrive in an increasingly volatile environment depends on their capacity to adapt and respond to disruptions. Therefore, understanding the factors that influence the resilience of SMEs' supply chains is critical to developing effective strategies for enhancing their robustness. The resilience of supply chains has become a paramount concern for SMEs in the face of global uncertainty. The disruptions caused by the COVID-19 pandemic and other external factors have highlighted the need for firms to rethink their supply chain strategies, embracing resilience as a core principle of operations. By leveraging technology, fostering collaboration, and simplifying supply chain structures, SMEs can enhance their ability to withstand disruptions and thrive in an ever-changing business landscape. As firms continue to navigate the complexities of global supply chains, the insights gained from understanding the dynamics of resilience will be invaluable in shaping the future of supply chain management for SMEs.

2. Literature Review

The resilience of supply chains has become a focal point of research in recent years due to increasing global uncertainties that threaten business continuity. Supply chain resilience refers to the ability of firms to anticipate, withstand, and recover from disruptions while maintaining operational efficiency. Various disruptions, including the COVID-19 pandemic, geopolitical conflicts, natural disasters, and economic instability, have underscored the importance of resilience strategies, particularly for small and medium-sized enterprises (SMEs) that operate with limited resources and flexibility. Resilience in supply chains is not a singular attribute but a multifaceted approach involving risk mitigation, collaboration, digital transformation, and strategic adaptability. Scholars have explored different dimensions of supply chain resilience, emphasizing the significance of proactive risk management, supplier diversification, and technology adoption as key enablers for sustaining operations during crises (Caputo et al., 2023). These insights contribute to a broader understanding of how SMEs can build resilient supply chains to navigate an increasingly uncertain global landscape. The increasing frequency of supply chain disruptions has prompted researchers to investigate the key factors contributing to resilience, with a particular focus on SMEs. Unlike large corporations with extensive financial and operational buffers, SMEs often struggle to recover from disruptions due to their limited capacity for risk absorption. Studies have demonstrated that SMEs must adopt strategic measures such as multi-sourcing, nearshoring, and flexible logistics models to mitigate the risks associated with global supply chain disruptions (Choi et al., 2023). The need for flexibility in sourcing and production has been further highlighted by the COVID-19 pandemic, which revealed the vulnerabilities of traditional supply chain structures. SMEs that relied on single-source suppliers or rigid supply networks experienced significant operational challenges, leading to increased interest in alternative sourcing strategies (Carissimi et al., 2023). The adoption of multi-level commons, where firms collaborate and share resources to enhance resilience, has also emerged as a viable strategy for mitigating the impact of disruptions (Chopra et al., 2021). These collaborative approaches enable SMEs to leverage shared resources and expertise, improving their ability to respond to unforeseen disruptions. Digital transformation has been a critical enabler of supply chain resilience, particularly in the context of Industry 4.0 technologies. The integration of artificial intelligence, big data analytics, and the Internet of Things (IoT) has allowed firms to improve visibility across supply chains, enabling real-time decision-making and proactive risk management. SMEs that have adopted digital technologies have demonstrated greater agility in responding to disruptions, as they can monitor supply chain performance and predict potential risks before they escalate (Domingos et al., 2024). Research has shown that digital supply chain management enhances

operational efficiency by improving demand forecasting, inventory management, and supplier collaboration (Dubey et al., 2021). However, the adoption of digital technologies among SMEs remains limited due to financial constraints and a lack of technical expertise. Policymakers and industry leaders have called for increased investment in digital literacy programs and funding support to encourage SMEs to embrace digital transformation as a resilience-building strategy (Duong et al., 2024). By integrating digital solutions into their supply chain operations, SMEs can enhance their ability to withstand disruptions and adapt to changing market conditions. Risk management plays a central role in supply chain resilience, as firms must continuously assess and mitigate potential threats to their operations. The COVID-19 pandemic revealed significant gaps in risk preparedness, prompting businesses to re-evaluate their risk management frameworks. Studies have emphasized the importance of preemptive risk mitigation, which involves identifying potential vulnerabilities and implementing contingency plans before disruptions occur (Dohmen et al., 2023). However, research also suggests that preemptive measures alone are insufficient, as firms must also develop dynamic resilience capabilities to respond effectively to unforeseen challenges. This includes building redundancy in supply chains, developing alternative distribution channels, and establishing emergency response teams to handle crisis situations (Colon & Hochrainer-Stigler, 2023). SMEs that have integrated comprehensive risk management frameworks into their supply chain strategies have demonstrated greater adaptability and operational stability in times of crisis. Supply chain collaboration has been identified as a critical factor in building resilience, as firms that engage in cooperative relationships with suppliers, customers, and logistics providers tend to recover more quickly from disruptions. Collaborative supply chain networks enable firms to share resources, exchange information, and coordinate response efforts, reducing the impact of supply chain shocks (Duong & Chong, 2020). The concept of supply chain agility, which emphasizes rapid adaptation to changing conditions, has also gained prominence in resilience research. SMEs that adopt agile supply chain practices, such as flexible production processes and just-in-time inventory management, are better equipped to handle uncertainties (Chowdhury et al., 2024). However, achieving agility requires firms to invest in workforce training, technology adoption, and process optimization, which may pose challenges for resource-constrained SMEs. Despite these challenges, research has shown that firms that prioritize agility and collaboration experience improved resilience and long-term sustainability. Geopolitical disruptions and trade restrictions have further emphasized the need for supply chain resilience, as businesses must navigate complex regulatory environments and shifting trade policies. The impact of geopolitical conflicts on global supply chains has been widely documented, with studies highlighting the importance of diversifying sourcing locations and developing regional supply chain networks (Dankyira et al., 2024). The recent emphasis on reshoring and nearshoring strategies reflects a growing awareness among firms of the risks associated with over-reliance on distant suppliers. By bringing production closer to key markets, businesses can reduce exposure to global supply chain disruptions and enhance their ability to respond to demand fluctuations (Choudhary & Jain, 2022). However, nearshoring presents its own set of challenges, including higher production costs and potential capacity limitations. Firms must carefully evaluate the trade-offs involved in reshoring decisions to determine the most effective approach for their supply chain resilience strategies. The food and agriculture sectors have been particularly affected by supply chain disruptions, with studies highlighting the need for resilient food supply networks. The COVID-19 pandemic exposed vulnerabilities in food supply chains, leading to widespread shortages and price fluctuations. Research has emphasized the importance of adopting stress-testing frameworks to assess the resilience of food supply networks and identify potential areas for improvement (Diem et al., 2024). The implementation of supply chain risk assessment models has also been recommended as a means of enhancing resilience in perishable goods industries (Eggert & Hartmann, 2023). SMEs in the agri-food sector have been encouraged to invest in digital supply chain solutions, such as blockchain technology, to improve transparency and traceability in food distribution networks. These innovations enable firms to track product movements in real time, reducing the risk of supply chain disruptions and enhancing overall efficiency. Studies have also explored the relationship between supply chain complexity and resilience, emphasizing the need for firms to balance efficiency with robustness. While lean supply chain practices, such as just-in-time

inventory management, offer cost savings and efficiency gains, they also increase vulnerability to disruptions (Khan & Emon, 2024). Research suggests that firms should adopt a hybrid approach that combines lean principles with resilience-building strategies, such as buffer stock management and supplier diversification (Khan et al., 2025). Additionally, firms must consider the impact of system-wide disruptions, as supply chain risks often extend beyond individual firms to affect entire industry networks (Khan et al., 2024). A systemic approach to supply chain resilience, involving coordinated efforts among industry stakeholders, can help mitigate the ripple effects of disruptions and enhance overall stability. The role of financial resilience in supply chain continuity has also been a topic of interest, as firms with strong financial foundations are better positioned to absorb shocks and recover from disruptions. Research has shown that SMEs with access to financial resources, such as emergency funding and credit lines, are more likely to implement resilience-enhancing measures (Dzogbewu et al., 2023). However, financial constraints remain a significant barrier for many SMEs, limiting their ability to invest in resilience-building initiatives. Policymakers and financial institutions have been called upon to develop targeted support programs for SMEs, including low-interest loans and government grants, to facilitate resilience investments. By improving financial resilience, SMEs can enhance their capacity to withstand supply chain disruptions and sustain long-term growth. Supply chain resilience has emerged as a critical area of research, driven by the increasing frequency and severity of global disruptions. SMEs, in particular, face unique challenges in building resilient supply chains due to limited resources and operational constraints. However, through strategic risk management, digital transformation, collaboration, and financial resilience, SMEs can enhance their ability to navigate uncertainties and sustain business continuity. As global supply chain dynamics continue to evolve, ongoing research and policy interventions will play a crucial role in shaping the future of supply chain resilience for SMEs.

3. Research Methodology

This research employed a qualitative approach to explore the strategies adopted by small and medium-sized enterprises (SMEs) in building resilient supply chains amid global uncertainties. The study aimed to gain in-depth insights into the challenges faced by SMEs and the measures they implemented to enhance their supply chain resilience. A multiple-case study method was adopted, allowing for a detailed examination of real-world practices and experiences. This approach was selected to provide a comprehensive understanding of how different SMEs navigated supply chain disruptions and adapted to changing market conditions. Data collection was conducted through semi-structured interviews, enabling participants to share their experiences, perceptions, and strategies in a flexible and open-ended manner. The sample consisted of 29 SME representatives, including supply chain managers, operations executives, and business owners from various industries, such as manufacturing, retail, and agri-food. Participants were selected using purposive sampling to ensure the inclusion of firms that had encountered supply chain disruptions and implemented resilience strategies. The inclusion criteria required that participants had direct experience in managing supply chain operations and had encountered challenges due to external disruptions. The interview questions focused on key themes such as risk management, supplier diversification, digital transformation, and collaboration strategies. Prior to data collection, ethical approval was obtained, and informed consent was secured from all participants. Interviews were conducted virtually to accommodate geographic diversity and minimize logistical constraints. The interviews were recorded with participant consent and later transcribed for analysis. Thematic analysis was used to identify recurring patterns and key themes emerging from the data. This method allowed for the categorization of responses based on the strategies employed by SMEs to mitigate supply chain risks and enhance operational resilience. The analysis involved multiple coding cycles to ensure reliability and accuracy. NVivo software was used to organize and analyze the data, facilitating systematic identification of common themes and relationships among different factors affecting supply chain resilience. To enhance the credibility of the findings, triangulation was employed by comparing interview data with secondary sources such as industry reports, policy documents, and existing literature on supply chain resilience. This approach ensured that the findings were supported by multiple sources of evidence, reducing potential biases and enhancing

the reliability of the study. Additionally, member checking was conducted by sharing preliminary findings with selected participants to verify the accuracy and validity of the interpretations. Their feedback was incorporated to refine the analysis and improve the trustworthiness of the results. The study encountered certain limitations, including the relatively small sample size of 29 participants, which may limit the generalizability of the findings to all SMEs. However, the qualitative approach provided rich and detailed insights that contributed to a deeper understanding of the topic. The reliance on self-reported data also posed a potential limitation, as responses were influenced by participants' perspectives and experiences. To mitigate this, efforts were made to include a diverse range of SMEs from different sectors and geographical locations, ensuring a broader representation of supply chain resilience strategies. The research methodology provided valuable insights into the approaches SMEs used to strengthen their supply chains in response to disruptions. The findings contributed to the existing body of knowledge by highlighting practical strategies and offering recommendations for businesses seeking to enhance their resilience in an increasingly uncertain global environment. Future research could expand on this study by incorporating a larger sample size or adopting a mixed-methods approach to integrate quantitative data, further strengthening the understanding of supply chain resilience in SMEs.

4. Results and Findings

The findings of this study reveal significant insights into the strategies adopted by small and medium-sized enterprises (SMEs) in building resilient supply chains amidst global uncertainties. The participants shared various experiences and approaches that highlighted the complexities and challenges of maintaining supply chain continuity in the face of disruptions. The data collected through semi-structured interviews indicated that resilience-building efforts were driven by a combination of proactive planning, adaptability, technological integration, and strategic partnerships. SMEs demonstrated a keen awareness of supply chain vulnerabilities and actively sought ways to mitigate risks while ensuring operational sustainability. The analysis of responses indicated that firms adopted multiple resilience strategies, often in combination, to safeguard against unexpected disruptions and sustain business operations. A recurring theme among participants was the importance of risk assessment and contingency planning in supply chain management. Many SMEs indicated that prior to experiencing disruptions, they had limited formal risk management frameworks in place. However, exposure to crises such as the COVID-19 pandemic, geopolitical tensions, and raw material shortages prompted a shift toward a more structured approach to identifying and mitigating risks. Participants emphasized the need for regular risk assessments to evaluate supplier reliability, logistics challenges, and potential bottlenecks. They explained that businesses that conducted periodic assessments of their supply chain vulnerabilities were better equipped to respond effectively when disruptions occurred. Several firms reported implementing scenario planning exercises, which allowed them to anticipate potential risks and develop contingency measures. These measures included identifying alternative suppliers, diversifying sourcing locations, and maintaining buffer stocks to absorb sudden supply shocks. Supplier diversification emerged as a key strategy in enhancing supply chain resilience. Many SMEs shared experiences of over-reliance on a single supplier or region, which had previously led to severe operational disruptions. As a result, firms actively sought to expand their supplier base to reduce dependency on a single source. Some businesses opted to work with multiple suppliers within the same geographic region, while others expanded their sourcing networks internationally to hedge against regional risks. Several participants explained that supplier diversification not only reduced their vulnerability to supply chain shocks but also improved their bargaining power and enabled more competitive pricing. However, some firms encountered challenges in managing relationships with multiple suppliers, particularly in maintaining consistent quality standards and ensuring timely deliveries. To address these issues, businesses adopted supplier evaluation frameworks and performance monitoring systems to assess and improve supplier reliability. Technology adoption played a crucial role in enhancing supply chain resilience among SMEs. The integration of digital tools, data analytics, and automation technologies enabled firms to gain better visibility into their supply chain operations and respond swiftly to disruptions. Many participants highlighted the use

of enterprise resource planning (ERP) systems, supply chain management software, and real-time tracking technologies to monitor inventory levels and logistics flows. These tools allowed businesses to identify potential disruptions early and make data-driven decisions to mitigate risks. Some SMEs also leveraged artificial intelligence and predictive analytics to forecast demand fluctuations and optimize inventory management. Additionally, cloud-based collaboration platforms facilitated communication between suppliers, manufacturers, and logistics providers, enabling a more coordinated response to supply chain challenges. While technology adoption was widely recognized as a critical enabler of resilience, some firms faced financial constraints in implementing advanced digital solutions. To overcome these challenges, businesses explored cost-effective alternatives such as open-source software and strategic partnerships with technology providers to access digital tools at lower costs. Collaboration and partnerships emerged as another important aspect of supply chain resilience. Many SMEs emphasized the role of strong relationships with suppliers, logistics providers, and industry peers in navigating supply chain disruptions. Firms that engaged in long-term partnerships with suppliers reported greater flexibility in adjusting order volumes, renegotiating terms, and securing priority access to critical materials during shortages. Some businesses established strategic alliances with other SMEs to pool resources, share logistics infrastructure, and collectively negotiate better terms with suppliers. Collaborative networks were particularly beneficial in industries where supply chain disruptions had widespread impacts, as businesses could support each other through knowledge sharing and joint problem-solving initiatives. Participants also highlighted the role of government and industry associations in facilitating collaboration, particularly during times of crisis. Some SMEs received support from industry groups that provided access to alternative suppliers, regulatory guidance, and financial assistance programs to mitigate the effects of supply chain disruptions. Inventory management strategies were a significant focus for many SMEs seeking to enhance supply chain resilience. Firms adopted various approaches to balance inventory levels, ensuring sufficient stock availability without incurring excessive holding costs. The concept of just-in-time (JIT) inventory management, which aims to minimize excess stock and reduce storage costs, was widely used before major disruptions. However, the challenges experienced during the pandemic and geopolitical conflicts prompted many businesses to reconsider their inventory strategies. Some firms shifted towards a hybrid inventory approach, maintaining critical stock levels while still leveraging JIT principles for non-essential materials. Buffer stock and safety stock strategies were increasingly implemented to safeguard against sudden supply chain shocks. Businesses that had access to real-time demand forecasting tools were able to optimize their inventory levels more effectively, reducing the risk of both stockouts and overstocking. Despite the benefits of maintaining buffer stock, some SMEs faced financial constraints in holding large inventories, requiring them to find a balance between resilience and cost efficiency. Logistics and transportation challenges were commonly discussed among participants, particularly in relation to supply chain disruptions caused by transportation delays, port congestion, and fuel price volatility. SMEs with international supply chains reported experiencing significant delays in receiving raw materials and finished goods due to global shipping disruptions. To address these challenges, firms explored alternative transportation routes, engaged multiple logistics providers, and increased their reliance on local sourcing where feasible. Some businesses negotiated flexible shipping contracts to ensure priority handling of their shipments during peak disruption periods. Others adopted technology-driven logistics solutions, such as GPS tracking and route optimization software, to enhance the efficiency of their transportation operations. While logistics diversification was an effective resilience strategy, it also introduced additional complexity in managing multiple transportation providers and ensuring cost-effective delivery solutions. Financial resilience was another critical factor influencing SMEs' ability to withstand supply chain disruptions. Many participants highlighted the financial strain caused by unexpected supply chain disruptions, including increased costs for raw materials, transportation, and emergency procurement. Businesses with strong financial reserves were better positioned to absorb cost fluctuations and invest in resilience-building initiatives. However, firms with limited financial resources faced significant challenges in maintaining liquidity during prolonged disruptions. To address financial vulnerabilities, some SMEs sought external financing options such as bank loans, government grants,

and supply chain financing programs. Others focused on improving cash flow management by renegotiating payment terms with suppliers and optimizing working capital. Several participants emphasized the importance of financial planning and risk assessment in ensuring long-term sustainability. Businesses that proactively managed their financial risks were more resilient in navigating supply chain challenges without compromising operational stability. Workforce adaptability and skills development also played a crucial role in supply chain resilience. SMEs that invested in employee training and cross-functional skill development reported greater agility in responding to disruptions. Many firms implemented workforce flexibility measures, such as multi-skilling employees to perform different roles within the supply chain, enabling them to adapt quickly to changing circumstances. Businesses that fostered a culture of continuous learning and innovation were able to identify creative solutions to supply chain challenges. Employee engagement and communication were also emphasized as key factors in resilience-building efforts. Firms that maintained transparent communication with their workforce during disruptions experienced higher levels of employee commitment and problem-solving collaboration. Some SMEs adopted remote work and digital collaboration tools to ensure business continuity during crises, particularly for administrative and supply chain management functions. Regulatory and policy-related challenges were identified as external factors influencing supply chain resilience. SMEs operating in highly regulated industries faced additional complexities in adapting to new compliance requirements and trade restrictions. Some businesses reported difficulties in navigating evolving regulatory landscapes, particularly in international trade and customs regulations. Firms that engaged in proactive regulatory monitoring and compliance planning were better equipped to manage policy-related disruptions. Industry associations and government agencies played a crucial role in providing regulatory guidance and support to businesses affected by supply chain disruptions. Participants highlighted the need for more transparent and predictable policy frameworks to facilitate long-term supply chain resilience.

Table 1. Risk Assessment and Contingency Planning.

Theme	Key Insights	Representative Quotes
Risk Identification	SMEs recognized the need to identify vulnerabilities in their supply chains.	"Before the pandemic, we never really thought about what would happen if our main supplier shut down."
Scenario Planning	Businesses developed multiple contingency plans for potential disruptions.	"We started running different 'what-if' scenarios to prepare for sudden supplier failures."
Supplier Reliability Assessment	Companies assessed supplier stability and developed backup plans.	"We now have a system to evaluate suppliers' financial and operational health before signing contracts."

SMEs demonstrated a growing emphasis on proactive risk management, driven by past experiences with supply chain disruptions. Many businesses transitioned from a reactive approach to structured risk assessment practices, incorporating scenario planning to prepare for unexpected challenges. Supplier reliability evaluations became a crucial aspect of contingency planning, helping firms mitigate the impact of supplier failures. By recognizing potential risks early, SMEs positioned themselves to respond more effectively to disruptions and ensure business continuity.

Table 2. Supplier Diversification Strategies.

Theme	Key Insights	Representative Quotes
Reducing Dependency on Single Suppliers	SMEs expanded their supplier base to mitigate risks.	"We used to depend on one supplier, but now we work with three to ensure we always have options."

Regional and International Sourcing	Businesses sought suppliers from different geographic locations.	“We started sourcing some raw materials from other countries to avoid being affected by regional disruptions.”
Supplier Performance Monitoring	Companies implemented evaluation systems to assess supplier reliability.	“We continuously track our suppliers’ performance to identify any risks early.”

SMEs adopted supplier diversification as a key strategy to enhance resilience, shifting away from reliance on a single source. By engaging multiple suppliers across different regions, businesses reduced exposure to localized disruptions. Supplier performance monitoring systems allowed firms to ensure consistency in quality and reliability, strengthening overall supply chain stability. This strategic shift enabled SMEs to maintain operational efficiency even during periods of supply chain instability.

Table 3. Technology Integration in Supply Chain Management.

Theme	Key Insights	Representative Quotes
Adoption of Digital Tools	SMEs integrated software solutions for better supply chain visibility.	“We invested in an ERP system to track inventory and supplier performance in real-time.”
Use of Data Analytics	Companies leveraged analytics for demand forecasting and risk assessment.	“With predictive analytics, we can now anticipate shortages and adjust our procurement strategy.”
Collaboration via Cloud-Based Platforms	Businesses improved communication with supply chain partners through digital platforms.	“We share real-time updates with our suppliers using a cloud-based system, making coordination easier.”

Technology adoption played a transformative role in enhancing supply chain resilience among SMEs. Digital tools provided greater visibility into supply chain operations, enabling businesses to detect and respond to disruptions more effectively. Data analytics empowered firms to make data-driven decisions, optimizing inventory levels and supplier relationships. Cloud-based platforms facilitated seamless collaboration, allowing businesses to maintain real-time communication with supply chain partners. The integration of technology positioned SMEs to build more agile and responsive supply chains.

Table 4. Collaboration and Strategic Partnerships.

Theme	Key Insights	Representative Quotes
Supplier Relationship Strengthening	Businesses fostered long-term partnerships with suppliers.	“Our strong relationships with suppliers meant they prioritized our orders during shortages.”
Industry Collaboration	SMEs collaborated with industry peers to share resources and insights.	“We joined an industry network where businesses exchange information and best practices on supply chain risks.”
Government and Association Support	Companies leveraged external support to enhance resilience.	“We received assistance from a trade association that helped us find alternative suppliers.”

Collaboration emerged as a critical factor in supply chain resilience, with SMEs actively fostering partnerships with suppliers, industry peers, and external organizations. Strong supplier relationships provided firms with priority access to resources during crises, while industry collaborations

facilitated knowledge sharing and joint problem-solving. Government and trade associations played a vital role in supporting businesses by offering resources and regulatory guidance. These collaborative efforts enabled SMEs to strengthen their supply chains and navigate disruptions more effectively.

Table 5. Inventory Management Adjustments.

Theme	Key Insights	Representative Quotes
Shift from Just-in-Time (JIT) to Hybrid Models	Businesses adjusted inventory strategies to balance efficiency and resilience.	"We used to rely entirely on JIT, but now we keep some critical stock as a backup."
Buffer Stock Implementation	SMEs maintained reserve inventory to cushion against disruptions.	"We increased our safety stock levels so we wouldn't face shortages again."
Technology-Driven Inventory Management	Companies adopted digital tools for inventory optimization.	"Using inventory tracking software, we can monitor stock levels more accurately and plan accordingly."

Inventory management practices evolved as SMEs sought to balance cost efficiency with resilience. While just-in-time inventory management had been widely used before major disruptions, businesses increasingly adopted hybrid approaches, maintaining buffer stocks for critical materials. The use of digital inventory tracking tools enabled firms to optimize stock levels, ensuring a more effective response to supply chain fluctuations. This shift allowed SMEs to improve supply chain flexibility without incurring excessive holding costs.

Table 6. Financial Resilience and Cash Flow Management.

Theme	Key Insights	Representative Quotes
Liquidity Management	SMEs prioritized maintaining financial reserves.	"We built a cash reserve to help us survive supply chain disruptions without shutting down operations."
Access to External Financing	Businesses sought financial support through loans and grants.	"We secured a government grant that helped us invest in supply chain improvements."
Cost Optimization Strategies	Companies streamlined expenses to enhance financial stability.	"We negotiated better payment terms with suppliers to improve our cash flow."

Financial resilience emerged as a crucial element in SMEs' ability to withstand supply chain disruptions. Businesses that maintained strong cash reserves were better equipped to manage unexpected cost increases. Access to external financing, such as bank loans and government grants, provided additional support for resilience-building initiatives. Cost optimization strategies, including renegotiating supplier payment terms, helped firms maintain liquidity and sustain operations. These financial measures ensured that SMEs remained stable despite ongoing supply chain challenges.

The findings of this study highlight the multifaceted strategies adopted by small and medium-sized enterprises (SMEs) to build resilient supply chains amid global uncertainty. A key insight is the increasing emphasis on risk assessment and contingency planning, where businesses have transitioned from reactive responses to proactive strategies, including supplier reliability assessments and scenario planning. Supplier diversification emerged as another critical strategy, with firms reducing dependency on single suppliers and expanding sourcing options across different

regions to mitigate the impact of localized disruptions. The integration of technology played a transformative role in supply chain management, enabling businesses to enhance visibility, leverage data analytics for demand forecasting, and streamline communication through cloud-based collaboration platforms. Collaboration and strategic partnerships proved essential in strengthening supply chains, with SMEs fostering long-term supplier relationships, engaging in industry networks, and leveraging government and trade association support to enhance resilience. Inventory management adjustments were also significant, as many businesses shifted away from just-in-time models to hybrid approaches, incorporating buffer stocks for critical materials while utilizing digital tools to optimize inventory control. Financial resilience further emerged as a key factor, with SMEs prioritizing liquidity management, securing external financing, and implementing cost optimization strategies to sustain operations during disruptions. Collectively, these findings suggest that resilience in SME supply chains is driven by a combination of strategic foresight, technological integration, collaborative efforts, and financial preparedness, all of which contribute to enhanced adaptability in an unpredictable global environment.

5. Discussion

The findings of this study reveal that SMEs have increasingly recognized the need to develop robust and adaptive supply chain strategies to navigate global uncertainties. The shift from reactive crisis management to proactive risk assessment and contingency planning indicates a growing awareness of the vulnerabilities inherent in supply chain operations. Many businesses have adopted structured approaches to identifying risks, incorporating scenario planning to prepare for disruptions, and evaluating supplier reliability to mitigate potential failures. This proactive stance reflects a broader understanding that resilience must be built into the supply chain rather than addressed only in times of crisis. Supplier diversification has emerged as a central strategy for SMEs seeking to reduce dependency on single sources. By expanding supplier networks across different geographic regions, businesses have minimized exposure to localized disruptions and ensured greater flexibility in procurement. This shift has also been accompanied by improved supplier performance monitoring, allowing SMEs to identify potential risks early and maintain consistent operational standards. The move toward diversified sourcing strategies suggests that businesses are prioritizing long-term stability over short-term cost efficiencies, recognizing that resilience in supplier relationships can be a critical factor in sustaining operations during periods of volatility. The adoption of digital technologies has played a crucial role in enhancing supply chain resilience. Businesses have leveraged software solutions to gain real-time visibility into supply chain operations, allowing for better tracking of inventory levels, supplier performance, and potential disruptions. Data analytics has enabled firms to predict demand fluctuations and optimize procurement strategies, reducing the likelihood of stock shortages or excess inventory. Cloud-based collaboration tools have further facilitated seamless communication between businesses and supply chain partners, ensuring greater coordination and responsiveness. The integration of technology reflects an industry-wide shift toward digital transformation as a means of strengthening supply chain adaptability. Collaboration and strategic partnerships have also been integral in building supply chain resilience. Many SMEs have recognized the value of strengthening relationships with suppliers, fostering long-term partnerships that provide stability and priority access to resources during disruptions. Industry collaborations have allowed businesses to share knowledge, best practices, and resources, enhancing collective resilience. Additionally, external support from trade associations and government agencies has provided SMEs with critical assistance in identifying alternative suppliers, accessing financial aid, and navigating regulatory challenges. These collaborative efforts highlight the interconnected nature of supply chain resilience, where cooperation among stakeholders is essential for sustaining operations in uncertain environments. Inventory management adjustments have been a key component of resilience-building efforts. Many SMEs have moved away from rigid just-in-time inventory models, opting instead for hybrid approaches that incorporate buffer stocks for critical materials. This shift reflects a strategic balancing act between cost efficiency and risk mitigation, as businesses seek to maintain operational flexibility while avoiding excessive holding costs. The adoption of digital inventory management tools has further enhanced this capability, allowing firms

to optimize stock levels based on real-time demand and supply conditions. These changes underscore the importance of adaptive inventory strategies in ensuring supply chain continuity. Financial resilience has emerged as another critical factor in sustaining supply chain operations. Businesses that have prioritized liquidity management, built financial reserves, and secured external funding have been better positioned to navigate disruptions without severe operational setbacks. Cost optimization strategies, such as renegotiating supplier payment terms, have enabled SMEs to maintain financial stability while continuing to invest in supply chain improvements. This focus on financial resilience suggests that businesses increasingly recognize the interconnectedness of financial health and supply chain adaptability, emphasizing the need for strong financial planning to support long-term sustainability. Overall, the study's findings indicate that SMEs have taken significant steps toward building resilient supply chains by adopting a combination of risk management, supplier diversification, technological integration, collaborative partnerships, inventory optimization, and financial planning. These strategies reflect a broader shift in business practices, where resilience is no longer viewed as a reactive measure but as a fundamental component of supply chain design. The increasing complexity of global supply chains, coupled with ongoing disruptions, underscores the need for continued investment in resilience-building initiatives. By embedding resilience into their supply chain strategies, SMEs can enhance their ability to withstand uncertainties, maintain operational continuity, and achieve long-term business sustainability in an unpredictable global landscape.

6. Conclusions

The study highlights the critical importance of resilience in supply chains, particularly for SMEs facing global uncertainties. Through various adaptive strategies, businesses have demonstrated a shift from reactive crisis management to proactive risk mitigation, emphasizing preparedness and long-term sustainability. Supplier diversification has played a pivotal role in minimizing disruptions, enabling firms to reduce dependency on single sources and improve operational flexibility. The integration of digital technologies has further enhanced supply chain visibility, allowing businesses to track inventory, forecast demand, and strengthen communication with suppliers and partners. Strategic collaborations and industry partnerships have also emerged as essential mechanisms for building resilience, fostering a more interconnected approach to risk management. Inventory management has evolved from rigid just-in-time systems to more adaptable hybrid models that incorporate buffer stock strategies while maintaining efficiency. Financial resilience has been another key focus, with businesses ensuring liquidity, optimizing costs, and securing financial support to sustain operations during disruptions. These efforts collectively underscore the growing recognition among SMEs that resilience is not just a short-term necessity but a long-term strategic advantage. By embedding resilience into supply chain management, businesses can better withstand uncertainties, maintain operational stability, and achieve sustained growth. As global supply chains continue to face evolving challenges, the ability of SMEs to anticipate risks, adapt swiftly, and leverage technological and financial resources will determine their success in an increasingly complex and unpredictable economic landscape.

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