

Navigating Geopolitical Disruptions on Supply Chains: Lessons from the Russia-Ukraine War for EU Industries

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Abstract—*Geopolitical shocks can disrupt businesses on multiple fronts, such as sudden loss of buyers or suppliers, supply disruption, and demand fluctuations, wielding the power to profoundly undermine a firm's ability to meet customer demands. The imperative to grasp the repercussions of geopolitical tumult and devise effective countermeasures has drawn the attention of scholars and business leaders alike. Key findings reveal that geopolitical tensions have transformed maritime routes, caused critical material shortages, and elevated operational costs, prompting industries to reassess supply chain strategies. These strategies enhance supply chain transparency and mitigate risks. This study investigates the Russian invasion of Ukraine's extensive impact on European Union industries. It identifies disruptions to trade routes, rising energy and agricultural prices, and the vulnerabilities linked to EU dependence on Russian resources. The study enriches supply chain management literature by classifying challenges and proposing actionable strategies to enhance EU industries' adaptability and resilience.*

Keywords—*geopolitical disruptions, energy crisis, supply chain resilience, risk management, mitigation strategies.*

I. INTRODUCTION

Geopolitical disruptions—encompassing risks from threats, occurrences, and escalations of adverse events like wars, terrorism, and tensions between states or political actors that disrupt peaceful international relations—have become a defining characteristic of the modern business environment. Geopolitical disruptions have had measurable impacts on global business across various historical events. For instance, during the Gulf War in 1990-1991, oil prices surged by nearly 40%, leading to higher transportation and production costs worldwide [1]. Also, the 2018 U.S.-China trade war reduced global GDP growth by an estimated 0.5% as tariffs disrupted supply chains (SCs) and trade flows [2].

Ukraine's growing ties with the EU and NATO, contrary to Russia's strategic interests, led to escalating tensions that began with Russia's annexation of Crimea in 2014. This marked the beginning of a broader geopolitical crisis, which ultimately evolved into a full-scale war with Russia's invasion of Ukraine in February 2022. This ongoing conflict represents a major geopolitical disruption, significantly impacting Europe's energy dependency, trade routes, and SCs. It underscores how such events can trigger widespread and long-term SC disturbances.[3, 4].

For example, following the war, European natural gas

prices surged by over 300%, peaking at €339 per megawatt-hour in 2022, compared to pre-war levels around €80. This dramatic increase significantly raised operational costs for energy-intensive industries such as manufacturing, chemicals, and transportation (GIS Reports, 2023)¹. Simultaneously, the FAO reported that global food prices increased significantly, with a 33.6% year-on-year rise, driven largely by disrupted agricultural exports from Ukraine and Russia (FAO, 2022). Moreover, according to a PwC global crisis survey (2023)², over 60% of companies reported revenue disruption tied to geopolitical shocks such as the Russia-Ukraine conflict, while 37% of firms in Europe and North America began reshoring operations to mitigate exposure to high-risk regions. These disruptions highlight the critical need for adaptive strategies to navigate the volatile global landscape [5].

Based on the geopolitical risk index by Caldara and Iacoviello (2022), the Ukraine crisis ranks among the top decile of global events affecting macroeconomic indicators, notably in trade and GDP forecasts, and potentially reducing global economic growth by one-tenth to seven-tenths in the first or second quarter following the initial geopolitical risk [6]. The disruption of Ukraine's maritime routes—previously accounting for 60% of its exports—redirected critical EU trade flows through alternative ports, increasing transit times and insurance costs, especially for grain and metals. Many firms have been forced to reconsider their SC linkages with Russia, necessitating rapid reconfiguration of SC designs in Europe and elsewhere [3, 7, 8].

To mitigate geopolitical risk, firms increasingly adopt SC strategies that emphasize flexibility, diversification, and technological innovation. Diversification, for example, reduces dependence on a single geographic region or supplier base. This approach was evident during the U.S.-China trade war, when multinational corporations such as Apple shifted segments of their production to countries like Vietnam and India to minimize exposure to rising tariffs and political tensions. Likewise, nearshoring and reshoring—relocating production closer to domestic markets—have gained prominence as mechanisms to reduce exposure to cross-border disruptions. The Russia-Ukraine conflict has prompted European automotive manufacturers to reevaluate their global sourcing models in favor of more localized or regionally resilient configurations [9, 10]. The integration of advanced technologies such as blockchain has enhanced SC visibility and traceability. Companies like Walmart, for

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¹ https://www.gisreportsonline.com/r/european-gas-markets-post-war-oulook/?utm_source=chatgpt.com

² <https://www.pwc.com/gx/en/crisis/pwc-global-crisis-resilience-survey-2023.pdf>

instance, employ blockchain systems to monitor product movement in real time, thereby improving transparency and responsiveness to disruptions [31].

Collectively, these strategies enhance SC resilience by reducing systemic vulnerabilities and supporting operational continuity in the face of geopolitical uncertainty [11].

This paper explores lessons from the Russia-Ukraine war for EU industries, offering a framework to analyze SC disruptions, classify risks, and propose strategies to enhance resilience to future geopolitical crises. Specifically, we address key research questions: *How can geopolitical disruptions be effectively categorized based on their nature, scale, and impact on global SCs (GSCs)? What are the primary SC risks and volatilities caused by the Russia-Ukraine conflict in the EU? How have businesses responded to these challenges, and what strategies have proven most effective in mitigating the associated risks?* Through this analysis, we aim to contribute to the existing literature on SC management (SCM) by providing actionable insights and practical recommendations for firms navigating the uncertainties of a geopolitically volatile environment.

The remainder of the paper is organized as follows: Section 2 provides a comprehensive literature review, while Section 3 Methodology and approach. Section 4 introduces the proposed framework. Section 5 outlines policy recommendations for mitigating future geopolitical risks. Finally, Section 6 concludes the paper and highlights potential directions for future research.

II. LITERATURE REVIEW

A. Overview of Russia-Ukraine Conflict: Geopolitical Risks

Geopolitical risks play a critical role in shaping bilateral relations and the structure of GSCs, frequently leading to heightened vulnerabilities and systemic disruptions. The Russian invasion of Ukraine, beyond the immediate impacts, has generated far-reaching consequences, including energy crises and GSC instability, prompting transnational corporations (TNCs) and governments to re-evaluate geopolitical risks in their production and value chain strategies. Nevertheless, the reconfiguration of supply chains poses significant challenges due to the complexity of contemporary industrial systems and the urgency required for adaptive responses. Furthermore, in contexts where transparent and reliable information is scarce, geopolitical risks may lead to suboptimal or biased decision-making, highlighting the need for enhanced collaborative data-sharing among TNCs, governmental bodies, and academic institutions [12].

Caldara and Iacoviello [13] demonstrate that elevated geopolitical risk indices correlate with reduced investment levels and deteriorating business environments, with notable historical surges occurring during major conflicts such as the Ukraine crisis. This conflict ranks among the top 10% of global geopolitical risk events and exerts a pronounced impact on global economic growth, particularly during the

initial quarters. The imposition of sanctions on Russia further exacerbates these challenges, as more than 1,200 European firms maintain at least one direct supplier within the country [29]. This is particularly critical for industries reliant on specialized materials, highlighting the complex interdependencies between geopolitical risk, economic performance, and the resilience of GSCs [14]. Similarly, Lam and Fernandez [15] classify the Ukraine crisis as one of the most severe geopolitical risk events since 1900, and had predicted a decline in global economic growth by up to 0.7%, with the most acute effects manifesting within the first year.

Russia and Ukraine are critical suppliers of commodities such as titanium and palladium. SC disruptions are expected to intensify for industries reliant on these resources, including the automotive, electronics, and aerospace sectors [16]. Regarding investment Reactions to Geopolitical Risks, Kleindorfer and Saad [17] emphasize that risk mitigation strategies must align with the specific decision-making environment.

This conflict stems from a complex interplay of historical, political, and economic factors since Ukraine's independence in 1991. In particular, economic drivers such as competition over energy transit routes, access to Black Sea ports, and control of resource-rich regions have significantly contributed to the escalation of tensions [7]. Economically, Ukraine—often referred to as the "breadbasket of Europe"—has historically depended on its agricultural output, industrial base, and natural gas imports from Russia, creating structural vulnerabilities. The war has significantly disrupted industrial and agricultural activity in eastern Ukraine, while sanctions imposed by the United States, the European Union, and their allies have economically isolated Russia, further complicating global trade dynamics. [21].

Armed conflicts of this scale generate a cascading effect across global supply networks by disrupting production and transportation, elevating operational costs, and exposing systemic vulnerabilities. Sanctions, trade restrictions, and blockades further exacerbate these disruptions. The heavy reliance on single-source suppliers, such as Ukrainian agricultural exports and Russian energy, has amplified supply shocks, resulting in widespread shortages, price volatility, and logistical bottlenecks across multiple industries.

To mitigate these risks, companies are adopting strategies like regionalization, backshoring, supplier diversification, and advanced technologies such as AI and blockchain to enhance flexibility and transparency. Ultimately, geopolitical disruptions compel businesses to innovate and build resilient, agile supply chains to navigate an increasingly volatile global landscape [10, 11]. Table 1 illustrates how geopolitical disruptions have unevenly impacted EU industries. The energy sector, for instance, was most directly affected and faced immediate shocks due to an 80% drop in Russian gas imports, leading to a surge in prices and a reorientation toward LNG and renewables. Meanwhile, the manufacturing and automotive sectors suffered delays and raw material

TABLE 1. SECTORAL IMPACTS OF GEOPOLITICAL DISRUPTIONS ON EU INDUSTRIES

Sector	Challenges	Pre-War Status	Post-War Impact	Impacts	Reference
Energy Sector	Heavy reliance on Russian natural gas, supply cuts, and sanctions.	Russia supplied ~40% of the EU	Russian gas imports dropped by 80%; natural gas prices in Europe rose by over 200% in 2022, and increased investments in renewable energy sources	Skyrocketing energy prices, supply shortages, and industrial and household energy use disruptions.	[18]
Manufacturing and Raw Materials	Shortages of critical raw materials (e.g., steel, titanium, palladium), supply chain delays, and increased costs.	Stable supply of parts from Ukraine and Russia	Disrupted raw material supply, delayed procurement cycles, increased raw material costs, and shifts toward alternate suppliers in Asia or Africa.	Production delays, reconfigured supply chains, and heightened vulnerability for resource-dependent industries.	[14]
Automotive Industry	Supply chain interruptions, particularly in parts like wire harnesses, and rising energy and material costs.	Ukraine supplied ~7% of global wire harnesses.	Wire harness production dropped by 70% in early 2022; palladium prices rose by ~45%; EU automotive exports fell by 15% due to material shortages.	Increased production costs, overhauled supply chain strategies, and reduced dependency on global suppliers.	[16]
Agriculture and Food Supply	Reduced availability of grain, edible oil, and fertilizers from Ukraine and Russia, rising food insecurity and costs.	Ukraine supplied ~50% of global sunflower oil.	Wheat prices surged by 60%; sunflower oil costs doubled; EU fertilizer imports from Russia dropped by 50%, increasing production costs for farmers.	Higher food prices, shortages, and severe impacts on food security for EU consumers and industries.	[19]
Other Critical Sectors	Disruptions in chemicals, cement, glass, healthcare, pharmaceuticals, aerospace, and technology.	Efficient transit routes via Black Sea ports	Reduced access to critical inputs, diversification of suppliers outside the conflict region, and increased costs for raw materials	Instability in transportation, communication, and consumer goods, with broad economic repercussions.	[20]

shortages. These sectoral impacts reveal the EU's structural vulnerability to overconcentrated suppliers and highlight the need for diversification and strategic stockpiling.

Table 2 summarizes the transformation of the EU energy sector following the war. It shows how severe disruptions in gas supply and energy prices accelerated renewable energy transitions, and the EU's energy structure became more diversified and resilient in response to systemic geopolitical risks.

TABLE 2. COMPARATIVE ANALYSIS OF IMPACTS ON THE EU ENERGY SECTOR BEFORE AND AFTER THE RUSSIA-UKRAINE WAR

Area	Pre-War status	Key Challenges	Post-War Status
Natural Gas Dependency	40% of EU gas from Russia (Germany: 65%)	Overdependence on Russian pipelines and infrastructure.	Reduced to ~20%; diversification through LNG and alternative sources
Energy Prices	Stable energy prices (~€20/MWh)	Increased gas prices by over 200% for households and industries.	Peaked at ~€300/MWh in 2022; long-term volatility remains
Renewable Transition	Renewables ~37% of Energy mix (2020)	Need to accelerate investments in renewable energy due to reduced Russian gas.	Accelerated renewable investment; aim ~50% by 2030

B. Supply Chain Resilience Strategies for Geopolitical Crises

SCM integrates core operations from suppliers to end users, ensuring the delivery of goods, services, and information. Disruptions can arise from internal factors, such as machinery faults or quality issues, or external factors, such as natural disasters and geopolitical conflicts [10]. Table 3 presents a structured categorization of SC strategies designed to mitigate geopolitical disruptions. These strategies fall into four main areas: (I) Diversification and localization: includes approaches such as multi-sourcing, nearshoring, and dual SCs, which reduce regional dependency and enhance operational continuity. (II) Enhancing SC agility and visibility focuses on dynamic planning, contingency preparation, agile logistics, and real-time monitoring systems to allow rapid and flexible adaptation to evolving disruptions. (III) Leveraging technology for risk management emphasizes the use of advanced technologies such as artificial intelligence (AI), blockchain, and IoT to enable predictive analytics, improve traceability, and support

decentralized, data-driven decision-making. (IV) Strengthening regional and international collaboration involves joint risk-sharing agreements, stakeholder engagement, and regulatory coordination that foster transparency, shared resilience efforts, and aligned responses to geopolitical challenges.

Together, these four categories form a comprehensive resilience framework for GSCs operating in uncertain geopolitical environments [22, 23].

III. METHODOLOGY AND APPROACH

This study follows a qualitative research design, guided by the Research Onion framework developed by Saunders et al. [30], to examine how SCM strategies mitigate the impacts of the Russia-Ukraine war on European industries. At the philosophical level, the study adopts an interpretivist paradigm, recognizing that understanding complex, socially constructed phenomena—like geopolitical risk and organizational response—requires contextual insight. A deductive-inductive hybrid approach was applied: first, a deductive review of existing literature identified key disruptions and response patterns; then, an inductive thematic analysis helped categorize and interpret SCM strategies in response to the conflict. Using secondary data collection, the study drew from peer-reviewed articles, policy papers, and industry reports. Through qualitative content analysis, key themes were identified around risk mitigation, resilience-building, and adaptive SC design. The methodology supports the development of a conceptual framework linking geopolitical disruptions to SCM responses in the European context.

IV. LESSONS AND POLICIES FROM THE RUSSIAN INVASION OF UKRAINE

The Russian invasion of Ukraine has exposed major vulnerabilities in GSCs, including geopolitical risk, sectoral fragility, and insufficient technological agility. Political tensions have disrupted the flow of goods and labor, revealing critical dependencies on high-risk regions. In response, strategies such as crisis-adaptive SC design, supplier diversification, and regional sourcing have gained prominence. These approaches help mitigate shortages, contain costs, and maintain access to essential goods through

TABLE 3. SUPPLY CHAIN STRATEGIES AGAINST GEOPOLITICAL DISRUPTIONS

Category	Strategies	Description	References
Diversification and localization of supply chains	<i>Supplier diversification</i>	Expanding the supplier base across regions ensures continuity during disruptions.	[11]
	<i>Multi-sourcing and supplier redundancy</i>	Maintaining alternative suppliers enables quick activation when disruptions occur.	[25]
	<i>Geographical diversification</i>	Spreading sourcing, manufacturing, and logistics across multiple countries reduces regional reliance.	[23]
	<i>Nearshoring and reshoring</i>	Relocating operations closer to end markets shortens supply chains and mitigates risks tied to distant geopolitical events.	[11]
	<i>Regionalization</i>	Positioning production in lower-wage economies near demand centers optimizes costs and reduces disruption risks.	[25]
	<i>Dual supply chains</i>	Utilizing multiple routes for the same goods enhances resilience against transportation risks.	[11]
	<i>Reevaluating supply networks</i>	Adjusting manufacturing and distribution networks in response to geopolitical tensions.	[2]
Enhancing supply chain agility and visibility	<i>Contingency planning</i>	Identifying and pre-qualifying backup suppliers and routes, with regular testing for effectiveness.	[26]
	<i>End-to-end visibility</i>	Implement digital solutions for real-time monitoring of goods, materials, and information.	[21]
	<i>Dynamic planning</i>	Scenario-based strategies allow quick adaptation to geopolitical changes.	[6]
	<i>Agile sourcing and logistics</i>	Quickly shifting sourcing, transport modes, and distribution channels in response to disruptions.	[2]
	<i>Supply chain alertness and resource orchestration</i>	Ensuring readiness and resource optimization in highly volatile contexts.	[26]
Leveraging technology for risk management	<i>Data Analytics</i>	Provides insights into managing risks and optimizing supply chain processes using big data analytics.	[23]
	<i>Developing new technologies to improve transparency and traceability</i>	Blockchain can improve transparency and traceability, and IoT can monitor real-time goods, transport, and environmental conditions.	[24]
	<i>Predicting future disruptions and customers' demand</i>	Using AI solutions to predict disruptions and optimize supply and demand management.	[5]
	<i>Modular production technologies</i>	Tools like 3D printing allow cost-effective, localized manufacturing.	[27]
	<i>Data-driven transparency</i>	Improving real-time decision-making on stock levels.	[10]
	<i>Partner cooperation</i>	Ensures alignment of interests, priorities, and tasks for mutual benefits.	[10]
Strengthening regional and international collaboration	<i>Information Sharing</i>	Facilitate transparency and decision-making across supply chains.	[6]
	<i>Joint risk-sharing agreements</i>	Strengthens relationships with suppliers through collaborative mitigation efforts.	[28]
	<i>Stakeholder engagement</i>	Drives innovation in sustainable technologies by involving diverse actors.	[28]
	<i>Regulatory coordination</i>	Aligns international trade policies to reduce geopolitical disruptions	[21]

buffer inventories and strategic relocation away from conflict zones [11, 22].

In addition to managing risks, war has underscored the importance of technology and collaboration in building resilient SCs. Leveraging real-time monitoring systems allows for improved visibility and faster responses to evolving challenges. Agile SC networks, designed for flexibility, enhance resilience by enabling businesses to adapt quickly to disruptions. Also, ethical sourcing and environmental, social, and governance (ESG) principles have gained prominence, as sustainability-driven procurement reduces environmental impacts while fostering social responsibility during crises. Finally, collaborative reconfiguration efforts, such as cross-sector partnerships and resilient network redesign, minimize exposure to high-risk regions and ensure continuity through alternative trade corridors. According to Table 4, these lessons collectively provide actionable insights for enhancing global SC stability amid ongoing geopolitical uncertainties [12, 24].

V. POLICY RECOMMENDATIONS FOR MITIGATING FUTURE RISKS

To effectively navigate the complexities of geopolitical disruptions, businesses and governments must adopt proactive strategies that address vulnerabilities in GSCs and enhance overall resilience. These disruptions expose critical industry weaknesses, leading to supply shortages, increased costs, and operational inefficiencies. Focusing on forward-looking policies and collaborative efforts makes it possible to mitigate risks and build SCs that are more adaptable to unforeseen crises [5]. The following policy recommends

outlining actionable steps to minimize future risks and safeguard SC stability in an increasingly volatile global environment:

- *Diversify and localize SCs*: To reduce vulnerability to geopolitical disruptions, businesses must prioritize diversifying and localizing their SCs. Expanding supplier bases by sourcing from multiple locations helps mitigate the risks associated with over-dependence on a single supplier or region. Additionally, nearshoring or reshoring production closer to key markets minimizes exposure to geopolitical risks linked to distant locations, shortens lead times, and enhances SC resilience in volatile environments [23, 29]. During the COVID-19 pandemic, pharmaceutical companies like Pfizer and BioNTech collaborated globally to streamline vaccine production and distribution, sharing critical SC data to ensure the timely delivery of life-saving products. [22].
- *Leverage technology*: Adopting advanced technologies is critical for enhancing SC agility and visibility in the face of disruptions. Investments in digital solutions such as AI, IoT, blockchain, and SCM systems enable real-time monitoring, data integration, and proactive risk management. These tools also provide data-driven insights, allowing businesses to track inventory, logistics, and environmental conditions, ensuring more informed and agile decision-making during crises [10, 28].
- *Strengthen collaboration*: Strengthening collaboration among SC stakeholders is essential for building resilience. Collaborative risk-sharing agreements with suppliers foster trust and continuity during disruptions, while public-private partnerships drive innovation by combining resources, particularly in sustainable technologies. Encouraging knowledge sharing, cross-border information

TABLE 4. KEY LESSONS AND CHALLENGES FROM THE RUSSIA-UKRAINE WAR

Key challenges	Related strategies	Implications for supply chains	Reference
Geopolitical risks and supply chain disruptions	Crisis-responsive supply chain design	Geopolitical conflicts disrupt personnel, suppliers, logistics, and trade, necessitating adaptive supply chain structures	[7]
	Supplier diversification	Reducing dependence on specific suppliers in conflict zones mitigates the risks of shortages and increased costs.	[29]
Critical sector fragility	Management Inventory	Maintaining reserves of essential goods (e.g., food, energy, raw materials) ensures continuity during crises.	[21]
	Regional supply base development	Diversifying supply bases away from high-risk regions helps safeguard against trade restrictions and sanctions.	[2]
Technology and agility	Real-Time Monitoring and Automation	Leveraging AI, IoT, and blockchain enables improved visibility, faster response times, and greater resilience in supply chains.	[11]
	Agile supply chain networks	Establishing flexible supply chain networks allows businesses to adapt to disruptions in real-time.	[30]
Ethical Sourcing and ESG	Sustainability-driven procurement	Integrating ESG principles into procurement ensures ethical sourcing, reduces environmental impacts, and promotes social responsibility, enhancing resilience during crises.	[23]
Collaborative reconfiguration	Cross-sector collaboration	Strengthening partnerships across industries facilitates shared resources and coordinated crisis responses.	[11]
Sectoral and regional impacts	Resilient network redesign	Relocating manufacturing and optimizing trade routes minimizes exposure to high-risk geopolitical zones	[20]
	Alternative trade corridors	Shifting maritime routes and diversifying logistics options ensure continuity in the face of regional inefficiencies.	[23]

exchange, and establishing trade agreements enhances preparedness and ensures smooth operations during geopolitical tensions, creating a stable foundation for global commerce [1].

- *Enhancing SC agility and visibility:* This involves the capacity of a SC to swiftly adapt to disruptions or changes while maintaining real-time transparency into the movement of goods, materials, and information. Agility focuses on flexibility, responsiveness, and adaptability, allowing quick decision-making in dynamic conditions. Conversely, visibility emphasizes end-to-end tracking and real-time data sharing, fostering stakeholder transparency [2, 20]. These capabilities strengthen risk mitigation, boost operational efficiency, and enable opportunities in an ever-evolving business landscape [26].
- *Address ethical concerns and promote ESG:* Incorporating ethical and sustainable practices into SCM is increasingly critical for achieving long-term resilience, especially in the context of geopolitical disruptions. ESG frameworks encourage companies to prioritize responsible sourcing, carbon footprint reduction, labor rights, and ethical supplier engagement. These practices are not only reputationally advantageous but are also becoming essential due to growing regulatory pressure. Governments and international bodies are implementing compliance requirements, such as the EU's corporate sustainability reporting directive (CSRD), that require firms to demonstrate transparency and due diligence across their SCs. In this context, traceability systems, often supported by technologies like blockchain and IoT, allow firms to monitor the origin and movement of goods in real time. Similarly, compliance algorithms can automate the screening of suppliers against legal, environmental, and ethical standards, ensuring regulatory alignment and risk reduction. By embedding ESG criteria into procurement and SC operations, firms not only meet regulatory expectations but also build more agile and crisis-resilient networks. [11, 23].
- *Enhance government support and policies:* Governments are crucial in mitigating SC vulnerabilities. Establishing robust regulatory frameworks that facilitate smooth trade flows, even during disruptions, is essential. Policymakers

should also prioritize protecting seafarers by implementing policies that ensure their financial security, physical safety, and mental well-being, particularly in high-risk zones critical to global trade. [1].

- *Consider geopolitical risks in investments:* Businesses must consider geopolitical risks when making investment decisions. Companies perceived as less exposed to such risks often enjoy higher investor confidence. Adopting risk-adjusted investment strategies ensures financial stability and operational security, enabling firms to withstand the uncertainties of geopolitical disruptions better while maintaining a competitive edge [5].

Disruptive geopolitical challenges in the GSC are likely to occur in the future. Rising tensions in the Asia-Pacific region, particularly over Taiwan and the South China Sea, threaten vital shipping routes and the semiconductor SC, given the region's dominance in chip production. Similarly, the global energy transition has intensified competition for critical minerals like lithium and rare earth elements, as nations like China control significant portions of their supply, increasing the risk of export restrictions. At the same time, political instability in emerging economies exacerbates vulnerabilities in raw material sourcing and labor-dependent manufacturing sectors. These challenges underscore the critical need for the resilience strategies noted above.

VI. CONCLUSION AND FUTURE RESEARCH

The Russian invasion of Ukraine has highlighted critical vulnerabilities in GSCs, emphasizing the systemic risks of geopolitical disruptions. For the European Union, the conflict exposed over-reliance on Russian energy and the fragility of essential SCs, particularly in agriculture and raw materials. These shocks have heightened global inflation, reduced GDP growth, and driven industries to reevaluate their dependencies and adopt strategies like SC diversification, technological advancements, and reshoring to enhance resilience. Governments have also played a vital role by implementing policies to mitigate risks and foster cooperation, ensuring economic stability in times of crisis.

Businesses must embrace proactive strategies to build robust SCs capable of withstanding geopolitical shocks.

Diversification and localization of supply networks, combined with nearshoring and reshoring, reduce reliance on single-source dependencies and enhance SC flexibility. Integrating advanced technologies—such as AI, IoT, and blockchain—improves real-time monitoring, enhances decision-making, and strengthens risk management frameworks. Fostering collaboration through public-private partnerships, cross-border cooperation, and knowledge-sharing initiatives promotes innovation and operational continuity amid crises. Adopting ethical SC practices and ESG principles further reinforces sustainability, builds investor confidence, and contributes to long-term stability. Moreover, government support remains crucial in establishing resilient regulatory frameworks, safeguarding critical infrastructure, and protecting global trade flows, particularly in high-risk regions.

While the framework proposed in this study is conceptually grounded, its practical effectiveness requires further validation. Future research should incorporate firm-level case studies, modeling, and simulations to assess the trade-offs of resilience strategies. Integrating control theory, AI-based forecasting, and real-time data-sharing can also enhance understanding of how SCs can remain sustainable and secure in an increasingly fragmented geopolitical landscape. Resilience must now be seen as a core principle of SC strategy, not a discretionary feature.

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