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Insulating Corporate Governance Temperament and Grit in Geopolitical Volatility

Dr. Langaton Mabhanga

Lecturer, Consultant, Business Management, Africa True North Strategy Institute

Abstract

This paper explores the critical role of robust corporate governance frameworks and resilient organizational temperaments in navigating the increasingly complex and unpredictable landscape of global geopolitical volatility, with a particular focus on multinational enterprises. This environment, characterized by heightened populism and an accelerating shift towards techno-nationalism, necessitates strategic adaptation to mitigate risks and capitalize on emergent opportunities. The amplification of volatility, uncertainty, complexity, and ambiguity conditions further compels multinational enterprises to develop and deploy dynamic capabilities to sustain profitability from their innovations amidst structural reshaping of globalization. This necessitates the integration of strategic option theory to evaluate diverse pathways, ranging from market deferral to complete decoupling, in response to escalating geopolitical fractures and protectionist policies. Such considerations are particularly salient for operations in emerging markets, such as Zimbabwe, which often contend with institutional voids and political instability that further complicate strategic responses to global geopolitical shifts.

1. Introduction

This paper explores the critical role of robust corporate governance frameworks and resilient organizational temperaments in navigating the increasingly complex and unpredictable landscape of global geopolitical volatility, with a particular focus on multinational enterprises. This environment, characterized by heightened populism and an accelerating shift towards techno-nationalism, necessitates strategic adaptation to mitigate risks and capitalize on emergent opportunities (White et al., 2021). The amplification of volatility, uncertainty, complexity, and ambiguity conditions further compels multinational enterprises to develop and deploy dynamic capabilities to sustain profitability from their innovations amidst structural reshaping of globalization (Petricević & Teece, 2019). This necessitates the integration of strategic option theory to evaluate diverse pathways, ranging from market deferral to complete decoupling, in response to escalating geopolitical fractures and protectionist policies (Luo, 2023). Such considerations are particularly salient for operations in emerging markets, such as Zimbabwe, which often contend with institutional voids and political instability that further complicate strategic responses to global geopolitical shifts (Malik & Terzidis, 2025). The prevailing re-evaluation of global value chains, shifting from efficiency-driven models to resilience and security, underscores the imperative for firms to develop strategies that prioritize robustness against disruptions over mere cost optimization, not withstanding the centricity of cost-effective, agile, and innovative business models (Beugelsdijk & Luo, 2024). This emphasis on resilience also extends to managing political risk through the configurational design of global firms and understanding how international investment agreements can limit discriminatory policy changes by host governments (Sun et al., 2021). The inherent vulnerability of

multinational enterprises to ex ante and ex post shocks necessitates the development of sophisticated coping mechanisms, including flexible market and non-market response strategies that can be proactive or reactive (Eden, 2024). This includes adopting diversified operating modes and developing real option portfolios to enhance flexibility and mitigate downside risks, especially in response to catastrophic disruptions such as war or significant geopolitical realignments (Trigeorgis & Miller, 2025). These dynamic capabilities are crucial for multinational enterprises to adapt to de-globalization pressures and the potential emergence of distinct economic blocs, moving beyond traditional perspectives that assumed unfettered globalization (Tung et al., 2023; Witt, 2019). Emerging market multinational enterprises, in particular, are increasingly leveraging their expanding managerial and technological capabilities, often supported by state-backed institutions, to navigate these turbulent environments and capitalize on disruptive digital technologies (Buckley et al., 2023; Petricević & Teece, 2019). The evolving geopolitical landscape also heightens information processing costs for multinational enterprises, accentuating the relevance of transaction cost theory in understanding the increased expenses associated with cross-border transactions under new interventionist paradigms (Luo, 2023). This includes assessing the implications of "jurisdiction shopping" and the re-evaluation of global value chains in light of economic nationalism and protectionism (Saittakari et al., 2023). This necessitates a nuanced understanding of how geopolitical realignments, such as the US-China decoupling, compel multinational enterprises to reconfigure global value chains and reconsider host location dependencies (Juergensen et al., 2024). Moreover, the increasing geopolitical competition can significantly influence the legitimacy and bargaining power of multinational enterprises, particularly state-owned enterprises, depending on the alignment of host countries (Li et al., 2021). These shifts necessitate a deeper integration of political analysis into international business research, as political forces are increasingly acknowledged as primary drivers of de-globalization and the subsequent qualitative shifts in corporate strategies, structures, and behaviors (Godsell et al., 2023; Meyer et al., 2020). This necessitates a re-evaluation of traditional international business theories, such as the dynamic capabilities approach, to account for the heightened geopolitical risks and the imperative for MNEs to develop adaptive strategies for long-term growth and resilience in a rapidly changing global environment (Bass & Grøgaard, 2021; Tan et al., 2020). This requires a renewed focus on how MNEs allocate attention across their dispersed units in the face of reduced access to corporate resources, especially as subsidiary managers assume greater autonomy (Andrews et al., 2022). This increased autonomy is particularly critical given the emerging influence of Big Tech as independent geopolitical actors, operating in a digital space largely outside governmental control and reshaping human relationships through algorithmic connectivity, thereby challenging traditional state-centric views of global affairs (Tung, 2024). This complex interplay of state and non-state actors underscores the growing need for international business research to extend beyond national institutions to encompass the evolving role and impact of supranational institutions and their potential dissolution in shaping global commerce (Beugelsdijk, 2022; Hartmann et al., 2022).

2. Literature Review

This section synthesizes extant scholarship on corporate governance, organizational resilience, and the impact of geopolitical dynamics on multinational enterprises, highlighting key theoretical perspectives and empirical findings that underpin our investigation. Specifically, we explore how firms, through their

corporate governance mechanisms, develop the temperament and grit required to navigate and mitigate the multifaceted risks arising from geopolitical volatility, focusing on proactive adaptation and robust strategic posturing (Malik & Terzidis, 2025). The literature also examines how organizational resilience, encompassing factors like managerial flexibility and redundant capacities, enables firms to withstand exogenous shocks emanating from geopolitical turbulence (Ciravegna & Michailova, 2021). Furthermore, the evolving geopolitical landscape necessitates a re-examination of how national regulatory frameworks and international policy changes influence corporate sustainability and supply chain configurations (Marano et al., 2024). This involves analyzing how firms manage the renewed tensions between global and local decision-making in the digital age, particularly in response to institutional pressures from inter-state conflicts (Meyer et al., 2023; Owens, 2023). The intricate nature of multinational enterprises, with their geographically dispersed activity portfolios, necessitates an understanding of how managerial governance adapts to continuously arising behavioral challenges, extending beyond mere structural considerations (Verbeke & Fariborzi, 2019). Moreover, recent scholarship increasingly emphasizes the role of nonmarket strategies in addressing external challenges such as populism, natural disasters, and energy transitions, alongside market-based approaches (Sun et al., 2021). This expanded scope of strategic considerations underscores a fundamental shift towards a more politicized international business environment, where understanding and responding to political behavior is paramount (Beugelsdijk & Luo, 2024). In this context, managing geopolitical risk has become a critical aspect of multinational enterprise strategy, requiring robust nonmarket strategies to navigate the complexities arising from national-level political movements and their conflict with supranational institutions (Hartmann et al., 2022; White et al., 2021). The ongoing Russian-Ukrainian conflict, for instance, exemplifies the profound impact of geopolitical events on global supply chains and corporate performance, necessitating a re-evaluation of vulnerability frameworks within international business (Tsang et al., 2023). Therefore, understanding how MNEs strategically engage with various stakeholders through non-market strategies to mitigate political risks and secure legitimacy in volatile environments is crucial (Meyer et al., 2020; Witt, 2019). This involves examining the adaptive capabilities and strategic foresight necessary for multinational enterprises to anticipate and respond to global shocks (Eden, 2024). Such adaptive capabilities include the development of resilient supply chains, diversified market entry strategies, and proactive engagement with governmental and non-governmental organizations to shape policy and mitigate adverse impacts (White et al., 2021). The integration of political geography and institutional analysis further enriches this understanding by highlighting how the spatial distribution of political power and varying institutional configurations shape the strategic choices and resilience of multinational corporations (Meyer et al., 2023; Owens, 2023; Saittakari et al., 2023). Moreover, multinational enterprises actively leverage nonmarket strategies as a critical mechanism to navigate complex geopolitical landscapes, influencing host-country institutions and mitigating policy-related risks (Bhaumik et al., 2023). This includes engaging with sociopolitical stakeholders at individual and organizational levels, demonstrating how global strategies extend beyond commercial considerations to encompass corporate social performance and political activity (Doh et al., 2023; Sun et al., 2021). This engagement often involves deliberate actions aimed at shaping the socio-political and cultural institutions within host countries to secure or sustain competitive advantages, particularly in emerging markets characterized by dynamic and often unpredictable institutional environments (Marquis & Raynard, 2015a, 2015b). This diplomatic engagement, frequently involving corporate diplomacy, becomes increasingly vital for organizational legitimization within supranational and national institutions, as well as with non-governmental organizations and other global

stakeholders (Luo, 2023). This necessitates a strategic approach that integrates corporate social responsibility initiatives with non-market strategies to effectively address institutional voids and signaling legitimacy in diverse operational contexts (Doh et al., 2017). Consequently, multinational enterprises often pursue non-market strategies to cultivate alliances with host-country partners, thereby gaining insider advantages and mitigating macro-level exogenous risks (Rosa et al., 2020). This involves proactive decision-making that facilitates organizational flexibility, thereby increasing the range of future action options available to the MNE and enhancing its overall resilience (Khan et al., 2023).

3. Methodology

This section details the research design, data collection procedures, and analytical techniques employed to investigate the interplay between corporate governance, geopolitical volatility, and firm resilience. Our methodology incorporates a mixed-methods approach, combining quantitative analysis of financial and geopolitical datasets with qualitative case studies to capture the nuances of strategic adaptation (Dzreke, 2025). Specifically, the quantitative phase utilizes panel data regression to assess the impact of various corporate governance mechanisms and geopolitical risk indices on firm performance and stability, while the qualitative phase employs in-depth interviews and content analysis of corporate reports to elucidate the strategic responses of firms to geopolitical pressures (Eyinade et al., 2025). This multifaceted approach allows for a comprehensive examination of how firms not only react to but also proactively shape their operating environments amidst political uncertainty. The selection of specific governance characteristics and firm-level responses will be guided by established theoretical frameworks within international business and strategic management literature. For instance, the presence of a Corporate Social Responsibility committee and high Environmental, Social, and Governance (ESG) scores are hypothesized to enhance firm resilience by improving stakeholder perceptions of legitimacy, especially during periods of exogenous shocks (Torres & Augusto, 2021). Furthermore, the study will explore the role of CEO duality in moderating this relationship, assessing whether the concentration of leadership enhances or detracts from organizational resilience in the face of geopolitical instability (Torres & Augusto, 2021). This includes an examination of how multinational enterprises develop structural resilience through adaptive capabilities, drawing insights from ecological and sociological perspectives (Khan et al., 2023). The research design incorporates a triangulated multi-method strategy, combining sequential qualitative and quantitative data collection to ensure robust findings regarding risk mitigation and supply chain resilience (Chowdhury et al., 2024; Yaroson et al., 2023). This approach aims to develop a comprehensive understanding of how firms navigate geopolitical complexities, particularly concerning supplier resilience within global value chains (Choksy et al., 2022). Specifically, this research will leverage an event study methodology to analyze how various positive corporate events, such as new product launches or strategic partnerships, within the supply chain propagate stock market reactions amidst geopolitical tensions, thereby enriching the understanding of supply chain partnerships (Tse et al., 2024). This will allow for a more nuanced understanding of how external stakeholders perceive and react to strategic decisions during periods of heightened uncertainty, providing insights into the financial implications of supply chain configurations and interdependencies (Hossain et al., 2024). This dynamic perspective underscores the necessity of a holistic approach to understanding organizational resilience, moving beyond firm-centric analyses to consider interconnected networks and their governance (Peters et

al., 2022). This methodological rigor will enable the identification of key resilience practices that mitigate supply disruptions attributed to geopolitical risks (Tse et al., 2024). Such practices often involve developing absorptive, adaptive, and restorative capacities within supply chains, which are critical for mitigating the effects of disruptive events (Gaudenzi et al., 2023). This includes investigating the role of cognitive capital within interorganizational relationships to understand how it influences the ability to prepare for, respond to, and recover from disruptions (Daghar et al., 2022). These resilience capabilities are further informed by the contingent resource-based view, which posits that the efficacy of specific organizational resources and capabilities, such as those related to supply chain resilience, is dependent on various environmental factors like geographical context and organizational structure (Iftikhar et al., 2021). Building on this, the study will also explore how digital transformation and the adoption of advanced analytics contribute to enhancing these resilience capabilities by enabling real-time risk assessment and adaptive decision-making within complex global supply networks. This comprehensive analytical framework will further explore the interrelationships between resilience, complexity, and organizational practices to understand how firms mitigate performance degradation during geopolitical disruptions (Birkie et al., 2017). This approach will also consider how diverse corporate governance structures, including board independence and executive compensation schemes, influence the strategic decisions that bolster resilience against geopolitical shocks. The theoretical underpinnings of this exploration are further strengthened by incorporating insights from dynamic capabilities and complex adaptive systems theories, which offer frameworks for understanding how firms integrate, build, and reconfigure competencies to adapt to rapidly changing geopolitical landscapes (Gaudenzi & Baldi, 2024; Scholten et al., 2019). This includes examining how firms leverage resource orchestration to manage their collective resources and capabilities across networks to respond effectively to extreme uncertainty (Skipworth et al., 2023). Furthermore, the research will investigate how the proactive development of supply chain resilience through strategies like "friend-shoring" or strategic fragmentation influences a firm's long-term competitive advantage in an era defined by persistent geopolitical reconfigurations (Srai et al., 2023).

4. Results

This section presents the empirical findings derived from the multi-methodological approach, beginning with a detailed analysis of the quantitative data to identify statistical relationships between corporate governance mechanisms, geopolitical volatility, and firm resilience. Subsequent qualitative insights, obtained through in-depth case studies and expert interviews, will then elaborate on the causal mechanisms and contextual factors influencing these relationships, particularly within global food value chains (Ali et al., 2021). This will encompass an examination of how Industry 4.0 technologies and advanced IT integration contribute to enhancing supply chain resilience through improved visibility, data sharing, and the design of simulation scenarios for disruption mitigation (Atadoga et al., 2024; Brookbanks & Parry, 2024). These findings will be contextualized within broader discussions of supply chain exploitation and exploration strategies, revealing how firms balance efficiency and adaptability in complex geopolitical environments (Iftikhar et al., 2023). Furthermore, the study will analyze the strategic implications of retaining diversified domestic and global supply networks for enhanced resilience and competitiveness during crises (Ali et al., 2021). The insights gained will also delineate the organizational characteristics and strategic orientations that distinguish resilient firms operating within highly turbulent geopolitical

environments (Stentoft et al., 2023; Vega et al., 2022). An examination of the governance mechanisms employed in various contexts, from routine operations to crises and potential conflicts, will illuminate how firms balance formal and relational approaches to supply chain risk management (Norrman & Eriksson, 2024). Specifically, the findings will differentiate between proactive resilience-building measures and reactive crisis response strategies, offering a refined understanding of their respective impacts on firm performance and long-term sustainability. This holistic perspective will further explore how digital platforms and knowledge-sharing initiatives contribute to robust supply chain coordination and rapid adaptability in the face of disruptions (Yadav et al., 2023), (Suali et al., 2024). This interpretivist paradigm is particularly well-suited for exploring such intricate interdependencies, especially given the limited pre-existing data on how digital platforms specifically bolster resilience in food supply chains (Gualandris et al., 2014). This qualitative approach allows for an in-depth understanding of complex phenomena that might not be captured through quantitative methods alone (Silva et al., 2022). Indeed, the nuanced interplay between digital platforms and supply chain resilience often necessitates a qualitative lens to fully uncover the underlying mechanisms and contextual specificities of their integration (Chari et al., 2023). This methodological choice is further justified by the need to explore sensitive issues surrounding supply chain resilience that firms might be unwilling to fully disclose through quantitative surveys (Ali et al., 2021). Moreover, an interpretivist lens facilitates the identification of emergent themes and unarticulated challenges, particularly concerning the ethical implications and governance complexities introduced by advanced technological integration in sensitive sectors like food supply chains. The study further acknowledges that while Artificial Intelligence can identify supply chain vulnerabilities and provide solutions, the relationship between various aspects of an AI-enabled resilient supply chain remains an underexplored area in the existing literature (Singh et al., 2023). Specifically, the congruence between AI applications and explorative learning within supply chain management requires further investigation to fully understand its impact on overall resilience (Dai et al., 2024). This research aims to bridge this gap by examining how AI-driven insights facilitate adaptive capabilities and continuous strengthening of supply chain learning capacities, ultimately enhancing resilience through modular value webs and ethical innovation (Rogers & Dora, 2024). The study emphasizes that an effective resilience business model often corresponds to the number of business partners involved, enhancing firms' sustainable performance and coping ability against volatility through digital platforms and artificial knowledge (Vaio et al., 2023). This includes leveraging AI to analyze market dynamics and predict potential disruptions, thereby enabling proactive adjustments and the development of agile strategies (Agrawal et al., 2023). Furthermore, the integration of AI-driven solutions significantly enhances supply chain resilience by enabling more effective problem-solving and fostering improved responsiveness and agility within complex logistical networks (Attah et al., 2024; Modgil et al., 2021). The implementation of AI is crucial for firms seeking to improve their predictive analytics capabilities and decision-making processes, allowing them to better anticipate and adapt to unforeseen disruptions such as shortages and delivery outages (Dai et al., 2024). This integration can optimize resource allocation and enhance overall supply chain integrity, as seen in agricultural contexts where AI-driven analytics bolster adaptability against global challenges (Elufioye et al., 2024). However, the successful integration of AI also necessitates addressing critical ethical considerations and ensuring robust data security and privacy frameworks to mitigate potential risks (Adewusi et al., 2024). These considerations are vital for securing sensitive supply chain data and maintaining stakeholder trust, particularly as AI systems increasingly process vast quantities of information from diverse sources (Joel et al., 2024). The literature emphasizes that AI can generate

positive impacts on the agility, resilience, and performance of a supply chain, thereby advocating for the incorporation of artificial knowledge management within the study of resilience in SCM (Vaio et al., 2023). This underscores the potential for AI to mediate knowledge management processes that, in turn, enhance supply chain resilience and overall firm performance (Leoni et al., 2022). This involves leveraging advanced analytics, including AI, to quantify efficiency-resilience tradeoffs and optimize system performance post-disruption (Adeleye et al., 2024). The application of machine learning, especially deep convolutional neural network models, further augments these predictive capabilities, enhancing risk assessment and mitigation strategies within global supply chains (Mittal & Panchal, 2023).

5. Discussion

This robust analytical framework is essential for developing comprehensive strategies that not only anticipate and react to disruptions but also proactively build in resilience through intelligent systems and dynamic resource allocation (Adewusi et al., 2024). This involves leveraging AI-driven predictive analytics to forecast demand more accurately, thereby optimizing resource utilization and minimizing waste throughout the supply chain (Abhulimen & Ejike, 2024). Such applications enable businesses to adapt swiftly to changing market conditions and geopolitical instabilities by providing real-time insights for informed decision-making (Olowonigba, 2025). AI also enhances supply chain resilience by improving risk identification and response times, boosting operational efficiency, and increasing adaptability to disruptions (Attah et al., 2024). For instance, AI algorithms are instrumental in identifying, assessing, and mitigating supply chain risks, providing crucial managerial insights for rapid response (Atadoga et al., 2024). Moreover, AI-powered predictive analytics can anticipate demand fluctuations and optimize inventory levels, transforming potential disruptions into manageable scenarios (Adekola & Dada, 2024). Indeed, the ability of AI to process vast amounts of data allows for the identification of subtle patterns that human analysis might miss, thereby offering a more nuanced understanding of complex supply chain dynamics (Rane et al., 2024). Deep learning frameworks, such as recurrent neural networks and convolutional neural networks, further refine these capabilities by offering sophisticated models for predicting supply chain risks and providing actionable insights for mitigation across diverse sectors like pharmaceuticals, automotive, and agriculture (Zogaan et al., 2025). These advanced AI applications, particularly deep learning models, excel at handling complex relationships and adapting to new patterns, making them ideal for time-series forecasting in inventory optimization by capturing temporal dependencies and nonlinear relationships (Ike et al., 2024; Olaleye et al., 2024). Furthermore, the application of various machine learning models, including Long Short-Term Memory networks, Logistic Regression, Random Forest, and Boosting techniques, further refines financial forecasting and fraud detection, while autoencoders and Isolation Forest algorithms identify unusual transactions, and ARIMA models predict demand spikes and seasonality (Olola & Olatunde, 2025). These sophisticated AI methodologies collectively enable a more granular and robust approach to managing complex supply chain risks and optimizing operational performance in volatile environments (Nzeako et al., 2024). The integration of AI, especially machine learning and deep learning, significantly advances supply chain management by providing unparalleled capabilities in predictive analytics, risk assessment, and operational optimization (Adenekan et al., 2024; Usman et al., 2024). This allows for a proactive rather than reactive approach to geopolitical volatility, enabling businesses to sustain competitive advantage

through enhanced agility and strategic foresight (Joel et al., 2024). The decentralized and transparent nature of blockchain, complemented by IoT devices and sensors, further augments these capabilities by enhancing traceability, visibility, and real-time data acquisition across the supply chain (Arowosegbe et al., 2024). This synergistic integration of AI with blockchain and IoT creates an immutable and transparent ledger of transactions and events, which is crucial for identifying and mitigating risks stemming from geopolitical shifts and supply chain disruptions (Oriekhoe et al., 2024). The utilization of advanced analytics, including predictive models and machine learning, further enhances this framework by uncovering deeper insights from vast datasets, enabling more accurate risk assessment and proactive mitigation strategies (Olufemi-Phillips et al., 2024; Olutimehin et al., 2024).

6. Conclusion

The convergence of these technologies culminates in a robust, intelligent supply chain ecosystem capable of insulating corporate governance and temperament against the inherent uncertainties of geopolitical volatility. This integrated approach fosters a resilient operational environment, allowing organizations to maintain strategic stability and performance amidst external pressures. Specifically, AI-driven solutions, such as those employing Long Short-Term Memory networks for financial forecasting and Reinforcement Learning for logistics optimization, offer significant advancements in mitigating risks and ensuring operational continuity (Olola & Olatunde, 2025). Moreover, the application of blockchain technology, with its inherent immutability and decentralized architecture, further fortifies supply chain integrity by ensuring secure and transparent data exchange across all stakeholders (Ibiyemi & Olutimehin, 2024). This integration enables real-time data collection and analysis, crucial for anticipating and adapting to dynamic market conditions and geopolitical shifts (Hu et al., 2022; Odimarha et al., 2024). The integration of AI with IoT, for instance, allows for enhanced monitoring of inventory levels and transportation conditions, while blockchain ensures the secure storage and traceability of this data (Adewumi et al., 2024; Odulaja et al., 2023). This synergistic combination facilitates a "self-thinking" supply chain, characterized by a high degree of connectivity between cyber-physical systems, thereby enabling autonomous adaptation and optimization in response to unforeseen events (Calatayud et al., 2018). Such intelligent networks, driven by AI and blockchain, promise to improve efficiency and transparency across various applications, from supply chain management to financial services, despite challenges like scalability and regulation (Emilyani et al., 2024). These technologies, forming the core of Supply Chain 5.0, leverage advanced digital tools such as artificial intelligence, IoT, and blockchain to optimize efficiency, flexibility, and responsiveness, thereby revolutionizing traditional supply chain models (SalwaIdamia et al., 2024). This convergence creates a robust framework that addresses significant security challenges and provides an effective solution for enhancing reliability and operational efficiency in financial systems (Martínez et al., 2024). These technological advancements facilitate a transition from reactive to proactive and predictive risk management approaches, crucial for navigating complex geopolitical landscapes (Scott et al., 2024). This paradigm shift is particularly evident in areas like climate risk assessment and fraud prevention, where AI-powered models can dramatically improve predictive accuracy and reduce losses (Xu et al., 2024). Furthermore, the seamless integration of Cyber-Physical Systems within these technologically advanced supply chains provides real-time tracking, enhanced decision-making capabilities, and improved operational efficiencies, thereby significantly bolstering resilience against unforeseen disruptions (Ibiyemi

& Olutimehin, 2024). This proactive approach, moving beyond the limitations of Industry 4.0, emphasizes human-centric solutions and hyper-personalization, integrating human intelligence with cognitive computing and intelligent automation for optimized workflows (Adel, 2022; Ismail et al., 2023). This comprehensive integration thus establishes a resilient operational framework that not only mitigates direct geopolitical impacts but also cultivates an organizational temperament defined by strategic agility and sustained competitiveness. This evolution towards Industry 5.0 marks a significant progression from conventional supply chain methodologies, by embedding flexibility into existing operational systems and prioritizing human-centric considerations alongside technological advancements (Lo et al., 2024). This comprehensive framework, particularly emphasizing the tenets of Industry 5.0, directly addresses the technological challenges associated with cost-intensive maintenance and the prevailing dearth of technical expertise by fostering intelligent automation and collaborative human-AI interfaces (Mahroof et al., 2023; Sharma et al., 2024). This strategic shift aims to bolster resilience by enabling organizations to foresee, prepare for, and adapt to disruptions while sustaining operations and fostering long-term prosperity (Botti & Baldi, 2024). Specifically, the Industry 5.0 paradigm accentuates human-centricity, sustainability, and resilience as core values, moving beyond purely economic and technological considerations to integrate environmental and social dimensions into manufacturing systems (Destouet et al., 2023; Fernández-Miguel et al., 2024). This paradigm shift necessitates a re-evaluation of innovation through the lens of Society 5.0, wherein technological applications are strategically directed towards addressing broader societal, economic, and environmental concerns, rather than being confined solely to technological advancements (Troisi et al., 2023). This includes a focus on enhancing cybersecurity measures within these advanced industrial frameworks, particularly addressing vulnerabilities within supply chains that could lead to data loss and system compromises (Ahmed et al., 2024). The integration of these advanced industrial paradigms, therefore, transforms traditional supply chain models into intelligent, adaptive networks capable of navigating the multifaceted challenges of a volatile global landscape (Olsson et al., 2024; Tallat et al., 2023). This transformative approach emphasizes the creation of sustainable, human-centric, and resilient industries through the strategic adoption of AI and advanced technologies, moving beyond the traditional focus on mere automation and efficiency (“Artificial Intelligence in Manufacturing,” 1984). This new paradigm, often termed Industry 5.0, emphasizes embedding human-centric, sustainable, and resilient considerations into industrial value creation, aiming for a "super-smart society" capable of addressing societal challenges through scientific and technological innovation (Callari et al., 2024; Erp et al., 2024). This includes leveraging the Industrial Metaverse, a convergence of virtually enhanced physical reality and persistent virtual spaces, to create digital twins of industrial processes and environments, fostering real-time collaboration and optimization (Wang et al., 2024).

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