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THE ROLE OF IT IN ENHANCING SUPPLY CHAIN RESILIENCE: A GLOBAL REVIEW

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ABSTRACT

In today's dynamic and interconnected global business environment, supply chain resilience has emerged as a critical factor for organizations seeking to navigate uncertainties and disruptions. This review explores the pivotal role of Information Technology (IT) in bolstering supply chain resilience on a global scale. As supply chains become increasingly complex and vulnerable to various risks, including natural disasters, geopolitical tensions, and pandemics, leveraging IT capabilities becomes imperative for organizations aiming to build and sustain resilience. The review encompasses an in-depth analysis of how IT tools and systems contribute to enhancing supply chain resilience across diverse industries and geographical regions. The integration of advanced technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and blockchain is examined, shedding light on their transformative impact on supply chain management. These technologies enable real-time visibility, predictive analytics, and secure information sharing, empowering organizations to proactively identify risks and respond swiftly

to disruptions. Furthermore, the review delves into the significance of digital platforms and cloud-based solutions in fostering collaboration and agility within supply chains. The ability to access and share critical information seamlessly among supply chain partners facilitates quick decision-making and adaptive responses to unforeseen challenges. Case studies from various global contexts provide insights into successful IT implementations that have significantly improved supply chain resilience, showcasing best practices and lessons learned. This global review underscores the indispensable role of IT in fortifying supply chain resilience. As organizations continue to grapple with an ever-evolving landscape of uncertainties, leveraging cutting-edge IT solutions emerges as a strategic imperative for building robust, adaptable, and responsive supply chains that can withstand and recover from disruptions effectively.
Keywords: IT, Supply Chain, Resilience, Review, Technology.

INTRODUCTION

Supply chain resilience is a critical aspect of modern supply chain management, encompassing the ability of a system to not only "bounce back" after an impeding event but also to adapt and transform (Wieland & Durach, 2021). The increasing complexities and risks in global supply chains have necessitated a focus on resilience, as it has been shown to enhance firm financial performance and customer value (Li et al., 2017). This highlights the importance of supply chain resilience in mitigating disruptions and maintaining operational performance.

Information technology (IT) plays a pivotal role in enhancing supply chain resilience. Integrating dynamic capabilities and a relational perspective through IT can enrich and develop the antecedents and outcomes of supply chain resilience, providing theoretical guidance for enterprises to recover from disruption shocks and enhance operational performance (Pu et al., 2023). Furthermore, the integration of Industry 4.0 technologies has been identified as a means to enhance supply chain resilience through the design of simulation scenarios, thereby validating the potential of IT in bolstering resilience (Xu et al., 2022).

The purpose of the global review is to provide a comprehensive understanding of the dimensions and outcomes of supply chain resilience, particularly in the context of dynamic capabilities, relational perspectives, and Industry 4.0 integration. This review aims to shed light on the significance of IT in fortifying supply chain resilience and its implications for operational performance and disruption mitigation. Additionally, it seeks to explore the role of IT in designing simulation scenarios to enhance supply chain resilience under uncertainty, emphasizing the need for IT-driven strategies to navigate disruptions and uncertainties in global supply chains (Pu et al., 2023; Xu et al., 2022).

In conclusion, the integration of IT in supply chain management is instrumental in bolstering supply chain resilience, as evidenced by its impact on firm financial performance, customer value, and the design of simulation scenarios. This underscores the critical role of IT in navigating the complexities and risks inherent in global supply chains, ultimately contributing to the resilience and sustainability of supply chain operations (Li et al., 2017).

Supply Chain Resilience

Supply chain resilience is a critical aspect of supply chain management, defined as the ability of a supply chain to return to normal operating performance within an acceptable period after being disturbed (Dubey et al., 2019). It involves the dynamic success capability of the supply chain, together with an appropriate risk mitigation strategy, which is crucial in the highly

uncertain global supply chain environment (Um & Han, 2020). The development of supply chain resilience is influenced by various factors, including social capital, human capital, and cognition of supply chain managers, which contribute to enhancing organizational resilience antecedents such as visibility, responsiveness, and flexibility (Nikookar & Yanadori, 2021). Additionally, the literature emphasizes the importance of alertness, agility, and adaptability as critical elements for achieving supply chain resilience (Li et al., 2017). Furthermore, the ability to withstand and return to the original state after disruption is a widely accepted definition of supply chain resilience (Mari et al., 2016).

The research also highlights the role of redundancy in building and improving resilience by providing a buffer against the risk of supply chain disruption (Yin & Ran, 2022). Moreover, it is suggested that supply chain resilience can be strengthened through effective management of supply chain risks, including the use of Internet-of-Things and stakeholder engagement (Al-Ayed & Al-Tit, 2023). The importance of supply chain agility in enhancing resilience has been supported by previous research, indicating a positive effect of supply chain agility on supply chain resilience (Pratondo et al., 2021). Furthermore, the study of supply chain resilience has expanded to include various industries such as the mineral resources industry, tantalum supply chain, and garment supply chain, indicating the broad applicability of resilience concepts across different sectors (Jiang et al., 2023; Mancheri et al., 2018).

In conclusion, supply chain resilience is a multifaceted concept that encompasses the ability of a supply chain to withstand and recover from disruptions. It involves a dynamic success capability, risk mitigation strategies, and the development of organizational antecedents such as visibility, responsiveness, and flexibility. The literature emphasizes the importance of factors such as social capital, human capital, cognition, alertness, agility, adaptability, redundancy, and stakeholder engagement in building and enhancing supply chain resilience.

Overview of Supply Chain Resilience

Supply chain resilience is a critical aspect of modern business operations, defined as the capacity of a supply chain to persist, adapt, or transform in the face of change (Wieland & Durach, 2021). It encompasses various components such as alertness, agility, and the ability to recover from disruptions (Li et al., 2017). The growing vulnerability of global supply chains due to environmental uncertainties and outsourcing tendencies emphasizes the importance of supply chain resilience (Thị et al., 2023). Supply chain resilience refers to the ability of a supply chain to cope with the risk of disruption and quickly return to its original performance after a disruption (Yin & Ran, 2022). It is also associated with dynamic capabilities and relational perspectives, providing a comprehensive understanding of its antecedents and outcomes (Pu et al., 2023).

Several factors contribute to supply chain vulnerabilities, including natural and man-made disasters, such as the recent COVID-19 pandemic, which has increased attention to supply chain vulnerability (Sharma et al., 2021). Additionally, the flexibility of primary production, rapid material substitution, and increasing availability of waste and scrap contribute to observed supply chain resilience (Mancheri et al., 2018). The reliability of suppliers, the number of transport vehicles, and the risk control ability of employees are identified as the main factors restricting the resilience of agricultural supply chains (Dong, 2020).

In a dynamic business environment, the need for supply chain resilience is paramount. It allows for the immediate return to normal business operations and the maintenance of continuity of

operations at the desired level of connectedness and control over structure and function (Zavala-Alcívar et al., 2023). Furthermore, by combining capabilities with the upcoming technologies of Industry 4.0, supply chain resilience can be achieved (Gružauskas & Vilkas, 2017). The ability to withstand and return to its original state after being disrupted is crucial for the sustainable and resilient design of supply chain networks (Mari et al., 2016). Quantitative metrics are used to analyze supply chain resilience and associated costs, emphasizing the importance of recoverability and system reliability (Zavala et al., 2018).

In conclusion, supply chain resilience is essential for businesses to persist, adapt, and recover in the face of unexpected events and disruptions. It involves various components and factors that contribute to vulnerabilities, highlighting the need for resilience in a dynamic business environment.

The Evolving Landscape of Information Technology in Supply Chains

The introduction of Information Technology (IT) in supply chain management has a historical perspective that spans over the last 30 years, with the introduction of information and communication technology (ICT) being a major change during this period (Håland, 2011). Furthermore, the emergence of advanced technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and Blockchain has significantly impacted supply chain dynamics. Research has highlighted the need to understand the dynamics of supply-side forces in the introduction of new technologies, emphasizing the importance of modeling supply-side dynamics of IT components, products, and infrastructure (Adomavicius et al., 2012). Additionally, the integration of IT has enhanced supply chain visibility and agility, with the introduction of information and communication technologies (ICT) significantly changing the organization of knowledge generation, reducing knowledge absorption costs, and improving knowledge interactions (Antonelli, 2017). Moreover, the legal issues and prospects of using Blockchain in public governance have become a focal point, signifying the increasing relevance and adoption of advanced technologies in various sectors, including supply chain management (Marchenko, 2021).

The Role of Artificial Intelligence (AI) in Supply Chain Resilience

The role of Artificial Intelligence (AI) in supply chain resilience is increasingly significant, particularly in risk identification and mitigation, as well as predictive analytics for proactive decision-making. AI has gradually brought about a new paradigm shift, leading to automated systems that can harness knowledge and data to improve decision-making within supply chains (Baryannis et al., 2018). Despite its widespread acceptance as a decision-aid tool, AI has seen limited application in supply chain management (SCM) (Min, 2009). However, literature indicates that AI algorithms have been used for different applications in upstream and downstream supply chains (Grover et al., 2020; Njemanze et al., 2008). AI can play an important role in the post-COVID-19 world to proactively enable the identification, assessment, and mitigation of supply chain risks as well as provide managerial insights for responding to those risks (Kanti et al., 2022).

Furthermore, AI has led to the investigation of machine learning techniques and their applicability in supply chain risk management, offering the potential for predicting supply chain risks using machine learning techniques (Baryannis et al., 2019; Akagha and Epie, 2022). This is crucial as disruptions in the supply chain planning process reflect the significance of disruptions and the need for the revision of pre-disruption decision variables (Ali et al., 2018).

Additionally, AI can enable the identification, evaluation, and management of supply chain-related risks to reduce overall supply chain vulnerability (Chang et al., 2015). The global pandemic COVID-19 has unveiled the need to transform the supply chain to be more resilient against unprecedented events, highlighting the significance of AI in managing agricultural supply chain risk to counter the impacts of the COVID-19 pandemic (Nayal et al., 2021).

Successful AI implementations in supply chain resilience are evident in various case studies. For instance, AI has been applied to build an antifragile supply chain that sees disorder as an opportunity to learn and grow, moving beyond robustness and resilience (Akagha et al., 2023; Priyadarshini et al., 2022). Moreover, the adoption of AI in managing supply chain risks has been emphasized, with organizations benefitting immensely from AI adoption in managing supply chain risks, especially in the face of growing complexity, geopolitical events, and pandemics (Paul et al., 2020).

In conclusion, AI plays a crucial role in supply chain resilience by enabling risk identification and mitigation, predictive analytics for proactive decision-making, and successful AI implementations in various case studies. The application of AI in supply chain resilience is increasingly significant, offering opportunities to improve decision-making and mitigate risks in supply chain management.

Leveraging the Internet of Things (IoT) for Real-time Visibility

Leveraging the Internet of Things (IoT) for real-time visibility has significantly transformed supply chain management by providing enhanced tracking and monitoring capabilities, improving communication and coordination, and offering successful integration examples globally. IoT-enabled tracking and monitoring in supply chains have revolutionized the management of supply chains, providing increased visibility, real-time tracking, and seamless connectivity between all stakeholders involved (Hasan & Habib, 2023). The IoT seamlessly integrates supply chain and logistics processes, enhancing the overall performance and organizational capabilities (Vass et al., 2018). Furthermore, the use of Blockchain database and IoT technologies has been found to significantly improve transparency in volatile agri-food supply chains, enabling real-time tracking of the provenance of food products (Hasan et al., 2022). Additionally, IoT-enabled supply chains for perishable food with two-echelon supply hubs have been modeled to address challenges based on real-time data acquired by IoT devices (Zhang et al., 2017).

Enhancing communication and coordination through IoT has been exemplified in the application of IoT and Blockchain technology in supply chain management, enabling companies to observe, track, and monitor products, activities, and processes within their respective value chain networks (Rejeb et al., 2019). Real-time communication and tracking through 5G-enabled IoT and interconnected devices have been identified as crucial for realizing the concept of smart logistics (Alashjaee et al., 2022). Moreover, the application of IoT technology to the optimization of e-commerce supply chains has been shown to enable real-time monitoring and management of logistics systems, thereby enhancing communication and coordination within the supply chain (Zhu, 2020).

Global examples of successful IoT integration for resilience include the exponential rise in adoption of IoT devices and technologies in agriculture and food supply chains, leading to substantial research and innovation interest in developing reliable, auditable, and transparent traceability systems (Pincheira et al., 2018). Furthermore, the proposed Internet of Things-based

Blockchain framework for tracking and tracing drugs through the entire supply chain demonstrates successful IoT integration for resilience in the pharmaceutical industry (Singh et al., 2020). Additionally, the application of IoT technology has improved the visualization and transparency of the agricultural supply chain, reducing uncertainty and enhancing intelligence in supply chain management (Mao & Zhang, 2023).

Blockchain Technology and Secure Information Sharing

Blockchain technology indeed plays a crucial role in ensuring data integrity and transparency, particularly in supply chain management. emphasize the facilitation of information sharing through a supply chain using blockchain technology (Saberi et al., 2018). This is further supported by , who highlight the ability of blockchain to provide transparency in the supply chain (Babaei et al., 2023). Additionally, discuss how the features of blockchain technology impact supply chain transparency through the lens of the information security triad (Xu et al., 2021). These studies collectively underscore the significance of blockchain in ensuring transparency and data integrity within supply chains.

Smart contracts are another essential aspect of blockchain technology, enabling streamlined and secure transactions. discuss the pioneering approach of inter-firm relationships using blockchain and smart contracts, emphasizing their potential in enhancing business interactions (Baron & Chaudey, 2019). Furthermore, highlight the potential of blockchain technology to enforce trust, transparency, and patient empowerment in clinical trial data management through the use of smart contracts (Mak et al., 2021). These studies demonstrate the effectiveness of smart contracts in various domains, including inter-firm relationships and healthcare, showcasing their role in ensuring secure and efficient transactions.

Global case studies further illustrate the effectiveness of blockchain in supply chains. For instance, discuss the application of blockchain technology in agricultural products' traceability systems, emphasizing its positive impact on data sharing, information integrity, and operational efficiency (Yan et al., 2021). Similarly, present a theoretical model suggesting that real-time transparency and cost savings secured by blockchain technology improve the profitability and competitiveness of manufacturing firms, ensuring sustainability in the manufacturing industry (Ko et al., 2018). These case studies provide real-world examples of how blockchain enhances transparency and efficiency in supply chains globally.

In conclusion, blockchain technology plays a pivotal role in ensuring data integrity and transparency, particularly in supply chain management. It facilitates information sharing, provides transparency, and enhances the efficiency of transactions through smart contracts. Global case studies further demonstrate its effectiveness in improving supply chain operations and sustainability.

Digital Platforms and Cloud-based Solutions

Collaborative platforms for information sharing have become increasingly important in various domains. Research by Hamari et al. (2015) delves into the motivations behind people's participation in collaborative consumption, shedding light on the factors driving individuals to engage in information sharing. Additionally, Spagnoletti et al. (2015) discuss the implications of their research on digital platforms supporting online communities, emphasizing the role of design theory in enhancing information sharing and collective action. These studies underscore the significance of collaborative platforms in facilitating information exchange and collective endeavors.

Cloud-based solutions have significantly enhanced accessibility and scalability in diverse settings. Zhang et al. (2014) highlight the importance of secure information and resource sharing in cloud infrastructure as a service, emphasizing the need for robust access control and authorization mechanisms. Furthermore, Wang et al. (2019) explore the development and application of a mining technology collaboration platform theory to support China's digital mine construction, showcasing the practical implementation of cloud-based solutions to foster collaboration and innovation. These studies underscore the pivotal role of cloud-based solutions in promoting accessibility, security, and technological advancement.

Several organizations have reaped substantial benefits from digital platforms. For instance, Kark et al. (2022) emphasize the necessity of sharing lessons of success and failure to address challenges, highlighting the practical advantages gained through collaborative platforms. Moreover, Souza et al. (2017) discuss how digital platforms based on design principles contribute to enlarging the possibilities of information sharing and collaboration, showcasing the tangible benefits realized by organizations leveraging digital platforms. These studies provide concrete examples of organizations benefiting from digital platforms, thereby emphasizing their practical utility and impact.

Case Studies from Global Contexts

To enhance supply chain resilience, successful IT implementations have been observed in diverse industries. For instance, the implementation of Total Quality Management (TQM) has been shown to improve the competitive abilities of organizations and provide strategic quality advances (MANNAI et al., 2017). Additionally, the successful implementation of Just-in-Time (JIT) and Total Quality Control (TQC) has led to operational benefits such as the reduction of set-up times, work-in-progress inventories, and floor space requirements (Hum, 1991). Furthermore, the use of Business Process Reengineering (BPR) in the banking industry has been aimed at improving competitive positions and enhancing customer satisfaction (Cheng & Chiu, 2008).

Organizations with resilient supply chains have provided valuable lessons. For instance, the successful implementation of TQM has been shown to alleviate typical problems encountered in industrial production, such as underutilization of capacity, poor quality, and shortage of skilled workers and raw materials (Mersha, 1997). Additionally, the influence of employees' motivational factors has been found to have a high impact on TQM implementation in the construction industry, highlighting the importance of human factors in building resilient supply chains (Ansah & Tekpe, 2022).

In terms of regional approaches to IT integration, a comparative analysis can be made based on the success factors identified in different contexts. For example, a critical success factors model for effective implementation of risk management processes in construction projects has been developed, which could provide insights into regional variations in risk management strategies (Qammaz & AlMaian, 2020; Ezeigweneme et al., 2024). Moreover, the successful implementation of Enterprise Resource Planning (ERP) in the Pakistan pharmaceutical sector reflects the search for a perfect paradigm to achieve balance in sustainability, function, network, and profit, which could be compared with approaches in other regions (Uzougbo et al., 2023; Aleem, 2021).

In conclusion, successful IT implementations in diverse industries, lessons learned from organizations with resilient supply chains, and comparative analysis of regional approaches to IT integration provide valuable insights into the role of IT in enhancing supply chain resilience.

Challenges and Considerations of IT in enhancing Supply Chain

Implementing IT for supply chain resilience presents several common challenges. These include the willingness of partner companies to share information for mutual benefits (Jharkharia & Shankar, 2005), the lack of consideration about social concerns such as child labor and personal development (Uddin et al., 2022), and the need for ethical supply chain leadership and environmental orientation to make a difference in corporate sustainability performance (Agyabeng-Mensah et al., 2023). Additionally, there is a global trend towards IT enablement of supply chains (Jharkharia & Shankar, 2004), and the emergence of ethical consumerism is reinforcing the tendency of consumers to be sensitive to supply chain transparency (Ko et al., 2022).

To overcome these barriers, strategies such as promoting ethical behavior of leaders in supply chains to promote ethical values across supply chains (Agyabeng-Mensah et al., 2023), better implementation of workplace ethics to contribute positively to supply chain management (Harun et al., 2019), and the use of supply chain transparency as a signal of ethical production Ko et al. (2022) can be employed. Furthermore, the success of IT-enabled supply chains lies in the willingness of partner companies to share information for mutual benefits (Jharkharia & Shankar, 2005), and the ethical practices in corporations' internal and external activities within the supply chain are believed to enhance economic and social performance (Billah et al., 2023). Ethical and security considerations in IT-enabled supply chains are crucial. Transparency in supply chain management is studied mainly regarding information asymmetry among suppliers (Park & Ryu, 2022), and ethical supply chains have become vital to organizational success, with companies now competing as supply chains rather than as individual entities (Yusuf et al., 2014). Moreover, the ethical judgments in supply chain management are linked to key factors such as inter-organizational trust and collaboration (Ha & Nam, 2016), and the mere writing down rules of cooperation may not be enough, especially if the supply chain is complex and knowledge of the individual links is limited (Rudnicka, 2017).

In conclusion, the challenges in implementing IT for supply chain resilience can be addressed through strategies such as promoting ethical behavior, enhancing workplace ethics, and ensuring supply chain transparency. Ethical and security considerations are vital in IT-enabled supply chains, and the ethical judgments in supply chain management are linked to key factors such as trust and collaboration. Overall, the successful implementation of IT in supply chains requires a comprehensive understanding of the ethical and security considerations, as well as the willingness of partner companies to share information for mutual benefits.

Future Trends and Recommendations of IT in enhancing Supply Chain

Emerging trends in IT and supply chain management encompass various aspects such as resilience, sustainability, and the integration of advanced technologies. The development of a managerial agenda for the identification and management of supply chain risk is crucial for improving the resilience of supply chains (Christopher & Peck, 2004). Effective supply chain practice and information sharing have been identified as key factors in enhancing the current supply chain management environment (Zhou & Benton, 2007). Additionally, the application of sustainability standards within supply chains fosters sustainability-related supply chain risks

conceptualization and management (Hofmann et al., 2013). Furthermore, the use of big data in supply chain management has been shown to make market forecasts more effective and enterprise decision-making more accurate and reasonable (Zhang et al., 2020). The integration of digital twin technology in operations and supply chain management has also been identified as a significant trend (Bhandal et al., 2022). Moreover, strengthening supply chain management has become a general trend, with a focus on leveraging artificial intelligence and blockchain multi-channel technology (Wang & Yu, 2023).

Recommendations for organizations aiming to enhance resilience in supply chain management include the need to consider sustainability practices to improve supply chain activities (Paul et al., 2020). As supply chains become increasingly global, sustainability and vulnerability simultaneously become more important, emphasizing the need for organizations to integrate sustainability practices into their supply chain management strategies (Christopher & Gaudenzi, 2018). Additionally, the development of emergency supply chains, as exemplified by Jingdong's emergency supply chain in the context of unconventional emergencies, provides valuable insights and studies for organizations aiming to improve their urgent supply chain management (Cao & Jiang, 2021).

Potential areas for further research in IT and supply chain management include the implications of additive manufacturing on supply chain and logistics, which is still an emerging field and requires further study (Velázquez et al., 2020). Furthermore, the intellectual structure of supply chain management and the bibliometric analysis of research on supply chain risk management present opportunities for future research to advance the understanding of supply chain dynamics and risk management strategies (Charvet et al., 2008; "A bibliometric analysis of research on Supply Chain Risk Management", 2019). Additionally, exploring e-business trends with a supply chain management perspective offers potential for further research to understand the continued developments in recent web generations and their impact on supply chain solutions (Shaikh et al., 2014).

RECOMMENDATION AND CONCLUSION

This global review has uncovered crucial insights into the dynamic relationship between Information Technology (IT) and the resilience of global supply chains. Key findings include the pivotal role of advanced technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and blockchain in providing real-time visibility, predictive analytics, and secure information sharing. Additionally, the review highlighted the significance of digital platforms and cloud-based solutions in fostering collaboration and agility within supply chains.

The comprehensive analysis underscores the critical role that IT plays in building and sustaining global supply chain resilience. In an era marked by unprecedented uncertainties and disruptions, the integration of cutting-edge technologies empowers organizations to proactively identify risks, respond swiftly to challenges, and ultimately fortify their supply chains against a myriad of threats. The transformative impact of IT goes beyond mere efficiency; it is a strategic imperative for organizations striving to create robust, adaptable, and responsive supply chains capable of withstanding the unpredictable nature of the global business environment.

In light of these findings, there is a clear and urgent call to action for organizations worldwide to prioritize IT integration in their resilience strategies. The digital transformation of supply chain management is no longer a choice but a necessity. Organizations must invest in the adoption and optimization of AI, IoT, blockchain, and other relevant technologies to ensure a

resilient and future-proof supply chain. Collaboration among supply chain partners, facilitated by digital platforms and cloud-based solutions, should be actively pursued.

The lessons learned from successful IT implementations in diverse global contexts should serve as inspiration for organizations seeking to enhance their supply chain resilience. This is not just a technological evolution; it is a strategic shift in organizational mindset and approach. By embracing IT as a core component of their resilience strategies, organizations will not only navigate disruptions more effectively but also position themselves at the forefront of innovation in the evolving landscape of global supply chain management. The time to act is now, as the symbiotic relationship between IT and supply chain resilience is poised to define the success of organizations in the years to come.

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