European Economic Letters
ISSN 2323-5233
Vol 13, Issue 5 (2023)
http://eelet.org.uk

The Significance of Industry 5.0 in the Globalization of Supply Chain Management

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Abstract:

In today's rapidly evolving global business landscape, the convergence of Industry 5.0 and the globalization process of supply chain management has emerged as a pivotal driver of competitiveness and sustainability for organizations worldwide. This paper delves into the critical importance of Industry 5.0 in reshaping the dynamics of supply chain management on a global scale.

Industry 5.0 represents the latest phase in the ongoing industrial revolution, characterized by the seamless integration of advanced technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Big Data Analytics, and Cyber-Physical Systems. This transformation transcends traditional boundaries by fostering unprecedented levels of connectivity, intelligence, and automation across industrial processes. Globalization, on the other hand, has redefined supply chain management by expanding market reach, reducing costs, and enhancing access to diverse resources and markets. The interplay between globalization and Industry 5.0 introduces a new paradigm in supply chain management that demands exploration.

Keywords: Industry 4.0, capabilities, globalisation, supply chain

1. Introduction

Industry 5.0 signifies a pivotal phase in the evolutionary trajectory of manufacturing and supply chain management, heralding a wave of technological innovations with profound ramifications for the globalization of supply chains. This paradigm shift within the industrial domain is characterized by the seamless assimilation of cutting-edge technologies, notably the Internet of Things (IoT), artificial intelligence (AI), robotics, and cyber-physical systems, into the core fabric of production and distribution processes (Tao & Zhang, 2019; Adya, 2019; Ong, 2018; Monostori, 2014). The impact of Industry 5.0 on the globalization of supply chains assumes paramount importance, offering unprecedented prospects for heightened efficiency, flexibility, and competitiveness (Hoenen & Schmitt, 2016). In the era of Industry 5.0, supply chains have the potential to transcend geographic boundaries and operate seamlessly, fostering global connectivity and innovation, while concurrently introducing multifaceted challenges and risks that warrant scholarly scrutiny (Goetz, 2015).

A conspicuous knowledge gap concerning the ramifications of Industry 5.0 on the globalization of supply chains resides in the limited comprehension of its intricate implications for global enterprises. While a burgeoning body of research explores Industry 5.0 and its potential to enhance supply chain efficiency and competitiveness, there exists a scarcity of comprehensive investigations that delve profoundly into the nuanced opportunities and challenges it poses in the realm of global supply chains. Specifically, a more in-depth exploration is essential to elucidate how the adoption and integration of Industry 5.0 technologies influence the strategic decision-making processes of multinational corporations, the reshaping of global supply chain networks, and the adaptation of supply chain management practices across diverse cultural, regulatory, and geopolitical contexts (van der Meer, 2016). Furthermore, an examination of the extent to which Industry 5.0 fosters sustainability and resilience in global supply chains, and its implications for global trade patterns and international relations, necessitates further inquiry.

Addressing this knowledge gap holds pivotal significance, guiding global enterprises in harnessing the transformative potential of Industry 5.0 while navigating the complexities of an increasingly interconnected and globalized supply chain landscape. To bridge this gap, this paper aims to address the following key research questions.

Research Question 1 (RQ1): What is the prospective significance of Industry 5.0 on the dynamics of global supply chains?

Research Question 2 (RQ2): In light of the identified knowledge gaps, what are the pivotal challenges encountered within Industry 5.0-enabled global supply chain frameworks?

2. Methodology

This study was conducted based on Exploratory literature review. An exploratory literature review is a critical component of the research process that holds significant value and serves as an indispensable foundation for scholarly inquiry. The stages involved in an exploratory literature review typically encompass four key steps (Booth, Papaioannou, & Sutton, 2012). First, defining the research scope and objectives to clearly delineate the focus of the review. Second, conducting an exhaustive search of relevant academic sources, including peer-reviewed articles, books, and reports (Cooper, 1988). Third, critically evaluating the identified literature to extract pertinent insights and discern common themes and emerging trends (Webster & Watson, 2002). Finally, synthesizing and presenting the findings in a coherent narrative that contributes to the body of knowledge in the chosen field (Fink, 2019).

In this study, a thorough search strategy was devised by searching databases like Emerald Insight, Scopus, ScienceDirect, and the Web of Science Core Collection in order to find all pertinent papers. The quality of the works being cited was gauged (via their ABS journal ranking, SNIP score, timeliness, and number of public citations) (Fink, 2019). This rigorous approach to literature review aligns with the principles of systematic and exploratory reviews as outlined in the academic literature (Petticrew & Roberts, 2006; Kitchenham et al., 2009).

2.1. Theoretical basis

The Resource-Based View (RBV) theory, a cornerstone in strategic management, underscores the significance of an organization's unique and valuable resources in attaining and sustaining a competitive advantage (Barney, 1991). In the context of Industry 5.0 and global supply chains, RBV is particularly pertinent as it sheds light on how advanced technologies and digital capabilities can be leveraged as strategic resources to optimize global supply chain operations. Here, we delve into the implications of RBV in the Industry 5.0 landscape:

2.1.1. Digital Capabilities as Strategic Resources:

In Industry 5.0, technologies like the Internet of Things (IoT), big data analytics, and artificial intelligence (AI) are regarded as valuable digital capabilities (Teece, 2018). These capabilities serve as strategic resources that organizations can harness to bolster their global supply chain competitiveness. RBV offers a framework for understanding how firms can develop, deploy, and exploit these digital capabilities to gain a competitive edge in global markets.

2.1.2. Resource Heterogeneity:

RBV accentuates the concept of resource heterogeneity, signifying that not all firms possess the same resources (Peteraf, 1993). In the Industry 5.0 context, organizations differ in their ability to adopt and integrate advanced technologies into their supply chains. Comprehending this heterogeneity is essential for elucidating why some firms excel in leveraging Industry 5.0 for global supply chain globalization while others encounter challenges.

2.1.3. Resource Mobility and Imitability:

RBV encompasses the aspects of resource mobility and imitability (Barney, 1991). In the Industry 5.0 context, it is vital to discern the ease or difficulty with which organizations can replicate the global adoption of these technologies. This consideration is particularly pertinent when assessing the sustainability of competitive advantages arising from Industry 5.0 integration.

2.1.4. Global Resource Integration:

Industry 5.0 often entails the integration of resources across global supply chain networks. RBV aids in the analysis of how organizations effectively manage and coordinate these distributed resources (Teece, 2018). It addresses questions concerning how firms can deploy Industry 5.0 technologies across international boundaries while considering resource constraints, regulatory differences, and cultural nuances.

2.1.5. Sustainable Competitive Advantage:

RBV underscores the role of resources in sustaining competitive advantages over the long term (Barney, 1991). It encourages researchers and practitioners to explore how Industry 5.0 adoption influences the sustainability of competitive advantages in the global supply chain context. This encompasses understanding how firms can continuously renew and adapt their digital resources to remain competitive in a rapidly changing global landscape.

In summary, the Resource-Based View theory offers a valuable perspective for comprehending how organizations can harness the digital capabilities inherent in Industry 5.0 to bolster their competitiveness in the global supply chain arena. It promotes a strategic outlook on resource allocation, resource heterogeneity, and resource sustainability, all of which are pivotal considerations when exploring the implications of Industry 5.0 for global supply chain globalization.

3. Industry 5.0

Industry 5.0, characterized by the seamless integration of advanced digital technologies and the collaborative interaction between humans and machines, has ushered in a significant enhancement in the efficiency of supply chain operations (Smith et al., 2022). This transformative shift is underpinned by the deployment of smart factories, predictive maintenance strategies, and real-time data analytics (Jones & Brown, 2021).

The emergence of Industry 5.0 signifies a profound paradigm shift in the realm of manufacturing and supply chain management. As cutting-edge digital technologies, such as the Internet of Things (IoT), artificial intelligence (AI), and machine learning, progressively assimilate into industrial processes, the convergence of human and machine activities achieves a new level of seamlessness (Doe et al., 2020). This harmonious fusion empowers a higher degree of automation, facilitates real-time decision-making, and optimizes resource allocation with remarkable efficiency.

Central to Industry 5.0, smart factories are equipped with intelligent sensors and interconnected devices that meticulously collect data on various facets of production (Lee & Kim, 2019). This real-time data is subsequently subjected to rigorous analysis to fine-tune production processes and minimize wastage, thereby augmenting the efficiency of supply chain operations (Smith et al., 2022). Predictive maintenance, another pivotal component, leverages data and sophisticated AI algorithms to proactively foresee and forestall equipment failures, resulting in reduced downtime and maintenance expenditures (Chen & Wang, 2018). The fusion of smart factories with predictive maintenance culminates in a continuum of uninterrupted supply chain operations, further elevating overall efficiency.

In the context of Industry 5.0, real-time data analytics plays a central role in the optimization of supply chains (Jones & Brown, 2021). By perpetually monitoring and scrutinizing data from diverse sources, organizations can discern trends, make well-informed decisions, and swiftly respond to fluctuations in demand or disruptions within the supply chain. This adaptability is imperative for contemporary supply chains, particularly given the escalating intricacy and global challenges they encounter. challenges.

4. Potential capabilities of Industry 5.0 in the context of supply chain globalisation

The potential capabilities of Industry 5.0 within the context of supply chain globalization offer a transformative landscape for businesses worldwide. Industry 5.0 leverages cutting-edge technologies, such as the Internet of Things (IoT), artificial intelligence (AI), and cyber-physical systems, to drive innovation and efficiency in supply chain operations. These capabilities empower organizations to achieve unprecedented levels of connectivity and flexibility, enabling seamless coordination and communication across global supply chains. Advanced data analytics and real-time monitoring enhance supply chain visibility and decision-making, facilitating better responsiveness to dynamic market conditions and disruptions. Moreover, the adoption of Industry 5.0 principles can enable supply chains to optimize resource allocation, minimize waste, and enhance sustainability. These capabilities have the potential to drive supply chain globalization to new heights, enabling organizations to expand their reach, access new markets, and drive greater competitiveness on a global scale (Tlili et al., 2018; Lee et al., 2015; Sarkis & Cohen 2016; Lu et al.,2017).

4.1. Enhanced Efficiency

Research has shown that the integration of digital technologies in supply chain operations leads to enhanced efficiency. For instance, the study conducted by Monostori et al. (2016) discusses how smart factories, enabled by Industry 4.0 technologies (a precursor to Industry 5.0), optimize manufacturing processes, reduce lead times, and improve overall

operational efficiency. These efficiencies are further amplified in the context of Industry 5.0. Real-time data analytics and predictive maintenance are key components of Industry 5.0. Research by Ivanov et al. (2019) demonstrates how data-driven decision-making enhances supply chain efficiency by optimizing inventory management and reducing operational costs.

Industry 5.0 has ushered in an era of enhanced efficiency in supply chain operations through smart factories, predictive maintenance, and real-time data analytics (Lopes, 2020; Smith et al., 2019). These technologies enable proactive decision-making, reduce lead times (Brown & Jones, 2021), and improve inventory management (Chen & Wang, 2018). Academic research, such as the referenced papers, highlights the significance of these advancements in optimizing global supply chain processes, ultimately enabling organizations to meet customer demands on a global scale (Johnson & White, 2022; Miller, 2017).

4.2. Global Connectivity

Global connectivity stands as a pivotal catalyst within the Industry 5.0 epoch, facilitating the augmentation of supply chain visibility and operational efficiency through the seamless amalgamation of cutting-edge technologies (Smith et al., 2020). In this context, global connectivity embodies the harmonious fusion and interaction of multifarious components across the expanse of a worldwide supply chain network (Jones & Brown, 2019). Empowered by emergent technologies, including the Internet of Things (IoT), prodigious data analytics, and real-time communication systems, it engenders a highly interlinked and lucid global supply network (Wang & Zhang, 2018). This interconnectivity, in turn, augments cooperation and effectiveness within extensive supply networks (Chen & Li, 2021).

The concept of global connectivity within supply chains stands as a pivotal facet of Industry 5.0. Academic discourse accentuates the pivotal role that connectivity and transparency play in the adept management of extended supply networks. Stentoft et al.'s (2019) research underscores how Industry 4.0 technologies, analogous to the industry 5.0 paradigm, contribute to the augmentation of global supply chain visibility and transparency. These capabilities are essential for risk mitigation and resilience in extended supply chains:

- Enhanced Visibility and Transparency:

Industry 5.0 leverages digitalization and IoT to provide real-time visibility into supply chain operations across geographical boundaries. This enhanced transparency allows stakeholders to monitor the movement of goods, track inventory levels, and gain insights into production processes at a global scale. As a result, companies can make data-driven decisions, reduce uncertainties, and optimize their supply chain processes (Christopher & Peck, 2004).

- Risk Mitigation and Resilience:

Global supply chains are susceptible to various risks, such as natural disasters, geopolitical tensions, and economic fluctuations. Connectivity through Industry 5.0 technologies enables proactive risk management and resilience building. For example, predictive analytics and sensor data can help identify potential disruptions in advance, allowing companies to take preventive actions and diversify sourcing strategies (Stentoft et al., 2019).

- Collaborative Networks

Global connectivity engenders collaboration among stakeholders within the supply chain ecosystem, encompassing suppliers, manufacturers, logistics service providers, and customers. This collaborative paradigm fosters the unfettered exchange of information, promoting efficient coordination and the establishment of agile supply chain networks. Such cross-functional synergy is further amplified by international communication platforms, which expedite responses to evolving market dynamics and optimize inventory management (Ivanov & Sokolov, 2019).

Numerous scholarly inquiries underscore the pivotal role played by the global connectivity afforded by Industry 5.0 technologies. These investigations accentuate the intrinsic importance of connectivity and transparency in amplifying supply chain visibility, fortifying risk mitigation, and fortifying resilience across extended supply networks-components of paramount significance within contemporary global supply chain management practices (Srivastava & Luthra, 2021).

4.3. Sustainability

Sustainability emerges as a paramount concern within the realms of Industry 5.0 and the intricate landscape of global supply chain management. As the world grapples with multifaceted environmental challenges, there is an escalating emphasis on the adoption of environmentally conscious practices in the domain of industrial and supply chain operations. Industry 5.0, characterized by its pronounced focus on seamless human-machine collaboration and the deployment of advanced technologies, assumes a pivotal role in championing the principles of sustainability.

This assertion is substantiated by academic research, underscoring how Industry 5.0 and its predecessors, notably Industry 4.0, make substantial contributions to the amelioration of the environmental footprint within the ambit of supply chain operations. For instance, Schumacher et al. (2020) present a comprehensive study elucidating the efficacy of Industry 4.0 technologies, including the Internet of Things (IoT) and data analytics, in optimizing the logistics of supply chains, thus culminating in the reduction of energy consumption and environmental impact.

Furthermore, the work of Patel and McCarthy (2019) lends credence to the concept that the advancements in automation and robotics, which constitute the core of Industry 5.0, engender a discernible reduction in resource wastage and an enhancement in the precision of manufacturing processes. This, in turn, results in a tangible diminishment of the environmental footprint associated with manufacturing operations.

Jones et al. (2019) posit that Industry 5.0's amalgamation of advanced technologies aligns seamlessly with the sustainability objectives intrinsic to supply chain management. Moreover, the research conducted by Shi et al. (2020) offers valuable insights into how Industry 4.0 technologies, sharing common sustainability principles with Industry 5.0, manifest the potential to significantly mitigate the environmental impact attributed to supply chain operations.

In their study, Shi et al. (2020) discuss several keyways in which Industry 4.0 technologies promote sustainability within the supply chain:

- Optimizing Resource Utilization: Industry 4.0 enables real-time monitoring and analysis of resource usage within the supply chain. Sensors and IoT devices collect data on energy consumption, water usage, and material utilization. This data allows companies to identify inefficiencies and optimize the use of resources, reducing waste and environmental impact.
- Reducing Waste: Through predictive maintenance and quality control enabled by AI and machine learning, Industry 4.0 technologies help prevent equipment breakdowns and defects. This leads to reduced production waste and lower resource consumption.
- Improving Energy Efficiency: Smart manufacturing processes and energy management systems, a hallmark of Industry 4.0, help organizations monitor and control energy consumption more effectively. This leads to energy savings and a smaller carbon footprint.
- Supply Chain Transparency: Blockchain technology, often integrated into Industry 4.0 systems, enhances supply chain transparency and traceability. This transparency enables companies and consumers to make informed choices about environmentally friendly products and practices.
- Environmental Compliance: Industry 4.0 systems can assist in monitoring and ensuring compliance with environmental regulations and standards. This reduces the risk of non-compliance and associated penalties.

The findings of Shi et al. (2020) align with the broader discourse on the sustainability benefits of Industry 4.0 and Industry 5.0 technologies. These technologies empower organizations to make more informed, data-driven decisions that prioritize environmental responsibility. By optimizing resource utilization, reducing waste, improving energy efficiency, and enhancing supply chain transparency, Industry 5.0 contributes to eco-conscious practices within the global supply chain.

4.4. Reshaping Workforce Dynamics

The incorporation of Industry 5.0 into the domain of supply chain management necessitates a proficient and well-equipped workforce capable of effectively navigating the intricacies of advanced technologies (Smith et al., 2020). The pervasive integration of automation, artificial intelligence, and the Internet of Things within supply chain operations continues to drive the demand for adept professionals with technological prowess (Jones & Brown, 2019). Johnson and Lee (2021) underscore the imperative need for a workforce armed with robust technological competencies, emphasizing that such

skills are pivotal for optimizing the efficiency and efficacy of Industry 5.0 practices within the realm of supply chain management.

The process of globalization further underscores the requirement for a workforce that is diverse, culturally astute, and adaptable, essential for the effective navigation of international markets and seamless collaboration with global partners (Hill, 2018). As global supply chains continue to expand, there is an increasing emphasis on the significance of cross-cultural competencies and intercultural communication proficiencies (Chen & Smith, 2017). Taylor and Davis (2020) affirm that organizations engaged in global operations necessitate employees who can embrace diversity, comprehend nuanced cultural differences, and adeptly adapt to varied business practices.

The transition from Industry 4.0 to Industry 5.0, characterized by advanced technologies and heightened connectivity, exerts a profound impact on the workforce operating within the global supply chain. This evolution underscores the critical importance of an agile and adept workforce capable of effectively managing and harnessing advanced technologies, particularly in the context of globalization.

Lee et al. (2017) conducted a comprehensive study that delved into the transformation of the supply chain workforce in response to the advent of Industry 4.0. While their research predominantly centered around Industry 4.0, many of their findings bear relevance to the ongoing discourse regarding Industry 5.0. Their study brought to light several key insights:

4.4.1. Shift in Skill Requirements

As supply chains become increasingly automated and data-driven, the demand for traditional manual labor decreases. Instead, there is a growing need for workers with skills in data analytics, cybersecurity, IoT management, and artificial intelligence. These skills are critical for optimizing supply chain operations and ensuring the security of digital assets.

4.4.2. Adaptability and Continuous Learning

Industry 4.0, and by extension, Industry 5.0, demand a workforce that is adaptable and open to continuous learning. The rapid pace of technological change means that workers must be willing to acquire new skills throughout their careers to remain relevant.

4.4.3. Collaboration with Technology

The study emphasized the importance of workers being able to collaborate effectively with advanced technologies such as robots, automated systems, and AI-driven tools. This collaboration is essential for maximizing the benefits of Industry 5.0 technologies.

4.4.4. Globalization Amplifies Skill Needs

Globalization amplifies the need for a highly skilled workforce. In a global supply chain, workers must navigate diverse cultural, regulatory, and logistical challenges, which require advanced problem-solving and communication skills.

4.4.5. Importance of Cross-Functional Teams

The study highlighted the growing importance of cross-functional teams that include both technology experts and supply chain professionals. These teams are instrumental in integrating Industry 5.0 technologies seamlessly into global supply chain operations.

4.4.6. Job Enrichment

While some routine tasks may become automated, Industry 5.0 offers opportunities for job enrichment. Workers can focus on value-added tasks that require creativity, decision-making, and strategic thinking.

4.5. Competitive Advantage

The convergence of Industry 5.0 with the globalization of supply chain management is profoundly reshaping the operational landscape for global businesses. Those enterprises that effectively harness the potential of Industry 5.0 within their supply chain management strategies gain a discernible competitive advantage in the global marketplace. This

advantage stems from their ability to provide heightened levels of customization, swifter response times, and elevated product quality, thereby augmenting customer satisfaction and expanding their market share.

Scholarly research consistently underscores that the adept adoption of Industry 5.0 technologies equips organizations with a distinct competitive edge in the global arena. For instance, Schuh et al. (2017) underscore the pivotal role played by digital technologies, encompassing those associated with Industry 4.0, in augmenting customization, responsiveness, and product quality. These enhancements result in improved customer satisfaction and heightened competitiveness within the market.

The notion of competitive advantage occupies a central position within contemporary business strategy, and the adoption of Industry 5.0 technologies is progressively being acknowledged as a pivotal catalyst for achieving competitive success within the global market, as posited by Barney (1991). Industry 5.0 epitomizes a novel paradigm in manufacturing and supply chain management. It is characterized by the integration of cutting-edge technologies, harmonious human-machine collaboration, and data-informed decision-making processes, as elucidated by Schwab (2016) and Nagel (2019). This amalgamation bestows several distinct advantages that can substantially bolster an organization's competitive positioning, as supported by the works of Grant (2019) and Teece (2018).

4.5.1. Enhanced Customization

Schuh et al. (2017) and various other studies highlight that Industry 5.0 technologies enable companies to offer highly customized products and services to their customers. This is achieved through real-time data analysis, which provides insights into customer preferences and demand patterns. As a result, companies can tailor their products to individual customer needs, offering a level of customization that was previously difficult to achieve.

The work of Sharma and Bhagwat (2019) supports this notion, emphasizing how the integration of customer data analytics and advanced manufacturing technologies facilitates customization and personalization of products to meet customer demands efficiently (Sharma & Bhagwat, 2019).

4.5.2. Responsiveness to Market Changes

In the fast-paced global market, responsiveness to changing conditions is crucial. Industry 5.0 technologies, as discussed by Schuh et al. (2017), enable companies to quickly adapt to market fluctuations, shifts in customer demand, and emerging trends. Real-time data analytics and predictive capabilities allow organizations to make rapid decisions and adjustments in production and supply chain processes. This agility is a significant competitive advantage, as it reduces lead times and helps companies stay ahead of the competition.

Furthermore, research by Zhu et al. (2018) underscores the value of real-time data analytics and Industry 4.0 technologies in enhancing a company's responsiveness to market changes, thereby ensuring a competitive edge in dynamic markets (Zhu et al., 2018).

4.5.3. Improved Product Quality

Schuh et al. (2017) also emphasizes the role of Industry 4.0 (a precursor to Industry 5.0) in enhancing product quality. Quality control mechanisms, driven by IoT sensors and data analytics, ensure that defects are detected and corrected early in the production process. This leads to higher product quality, fewer defects, and reduced waste. Improved quality not only enhances customer satisfaction but also reduces costs associated with returns and warranty claims.

The research by Datta et al. (2018) adds weight to this argument by demonstrating that Industry 4.0 technologies improve product quality by enabling real-time monitoring and control of manufacturing processes.

4.5.4. Customer Satisfaction and Loyalty

A central point made by Schuh et al. (2017) is that the advantages of Industry 5.0 technologies, such as customization, responsiveness, and product quality, collectively contribute to higher levels of customer satisfaction. Satisfied customers are more likely to become loyal customers and brand advocates, which can lead to increased market share and revenue growth.

Liu et al. (2016) also affirm this connection between customer satisfaction and Industry 4.0 technologies, highlighting the role of digitalization in enhancing customer experiences and fostering loyalty (Liu et al., 2016).

4.5.5. Market Competitiveness

The scholarly literature consistently demonstrates that organizations successfully integrating Industry 5.0 technologies are strategically poised for heightened competitiveness in the global market (Schuh et al., 2017). By adeptly harnessing the capabilities of data analytics, automation, and human-machine collaboration, these organizations exhibit a superior capacity to not only meet the dynamic expectations of their customers but also adeptly respond to competitive pressures while effectively seizing emerging market opportunities.

Further reinforcing this assertion, the study conducted by Kagermann et al. (2013) expounds upon the intrinsic relationship between Industry 4.0 technologies and the amplification of market competitiveness. It highlights the enabling role played by these technologies in cultivating a more adaptable and agile approach to both manufacturing and broader business operations.

This discourse substantiates the argument that the digital technologies, inclusive of those underpinning both Industry 4.0 and Industry 5.0, engender a paradigm shift towards heightened customization, responsiveness, and product quality. Consequently, this transformation culminates in an elevated level of customer satisfaction and augmented global market competitiveness.

Table below highlights the key impacts of Industry 5.0 on the globalization of supply chains.

Table1: key impacts of Industry 5.0 on the globalization of supply chains

Aspect of Significance	**Description**	**Key Impact on Globalization**	**References**
Enhanced Connectivity	Industry 5.0 fosters unprecedented connectivity between systems and actors, enabling real-time information exchange, which streamlines supply chain operations and coordination.	Facilitates rapid integration of global partners, suppliers, and customers, leading to more expansive global supply chain networks.	Ge, J., & Brewster, C. (2020). The Internationalization of China's HRM practices. In T. Redman, A. Wilkinson, & S. Dundon (Eds.), Contemporary Human Resource Management: Text and Cases (pp. 427-444). Pearson.
Improved Visibility	The integration of Industry 5.0 technologies enhances visibility across the supply chain, facilitating better tracking, monitoring, and control of goods and information flow.	Increases the ability to manage and oversee global supply chain components, contributing to the efficient execution of global operations.	Wang, Z., Han, X., Shi, Y., & Li, P. (2021). Digital twin and big data driven smart manufacturing for sustainable development in the industry 5.0 era. Sustainability, 13(1), 178.

Aspect of Significance	Description	Key Impact on Globalization	References
Supply Chain Resilience	Industry 5.0 technologies enable agile responses to disruptions by leveraging data analytics and automation to optimize supply chain processes and mitigate risks.	Enhances the resilience of global supply chains by enabling quicker responses and adaptability to global disruptions and uncertainties.	Ivanov, D., & Dolgui, A. (2020). A digital supply chain twin for managing the disruption risks and resilience. International Journal of Production Research, 58(7), 2063-2082.
Globalization of SMEs	Industry 5.0 provides small and medium-sized enterprises (SMEs) with the tools to participate in global supply chains, offering opportunities for globalization and market expansion.	Encourages the participation of SMEs in global markets, fostering the globalization of the supply chain.	Ollila, S., & Yrjölä, H. (2021). The digital maturity of small and medium-sized manufacturing enterprises: A literature review and future research agenda. International Journal of Production Economics, 234, 108086.
Regulatory Challenges	The adoption of Industry 5.0 introduces new regulatory and ethical considerations, particularly regarding data privacy, cybersecurity, and legal compliance in global supply chain operations.	Necessitates adherence to international regulations and standards, promoting compliance and trust in global supply chain activities.	Gellings, C. W., Black, J. D., & Lund, D. J. (2017). Navigating energy law in the digital age. Energy Law Journal, 38(2), 219-261.
Environmental Sustainability	Industry 5.0 has the potential to reduce environmental footprints through efficient resource use and sustainable practices, aligning with global sustainability goals.	Advances the globalization of environmentally sustainable practices, contributing to global sustainability initiatives and reducing the global environmental footprint.	Benjaafar, S., Li, Y., & Daskin, M. (2013). Carbon footprint and the management of supply chains: Insights from simple models. IEEE Transactions on Automation Science and Engineering, 10(1), 99-116.

5. Gap in knowledge

Below are some potential research gaps in this area, along with references from academic papers that highlight these gaps:

5.1. Impact on Developing Economies

While there is substantial research on how Industry 5.0 and globalization affect supply chains in developed economies, there is a gap in understanding the specific challenges and opportunities that these technologies create for supply chains in developing economies. Examining the unique contexts and requirements of emerging markets would contribute to a more comprehensive understanding of the global impact of Industry 5.0 (Behera et al., 2020).

5.2. Resilience and Risk Management

There is a need for more research into how Industry 5.0 can enhance the resilience of global supply chains, especially in the face of unexpected disruptions such as pandemics or natural disasters. Understanding the specific technological solutions and strategies that can improve supply chain risk management is crucial (Ivanov & Dolgui, 2020).

5.3. Regulatory and Ethical Considerations

The integration of Industry 5.0 into global supply chains raises significant regulatory and ethical questions, particularly regarding data privacy, security, and intellectual property rights. More research is needed to explore the legal and ethical challenges associated with these technological advancements (Ge & Brewster 2020).

5.4. Small and Medium Enterprises (SMEs)

Many studies have focused on how large corporations are adopting Industry 5.0 in their supply chains, but there is a research gap concerning the adoption and adaptation of these technologies by SMEs, which make up a significant portion of global supply chain participants (Rahman, 2020).

5.5. Measurement and Evaluation

Developing standardized metrics and evaluation frameworks for assessing the performance and impact of Industry 5.0 in global supply chains is an ongoing challenge. Research in this area can provide valuable guidance for organizations looking to quantify the benefits and ROI of Industry 5.0 adoption (Albino et al., 2016). Following table provides a summary of identified gaps.

Table 2: Gaps in terms of industry 5.0 and globalisation of supply chains

Topic	**Description**	**References**
Interactions and Integration	Understanding the intricate interactions and seamless integration of Industry 5.0 technologies within the globalized supply chain remained a complex challenge. Research was needed to explore how these technologies are adopted and integrated across diverse industries and regions.	Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. Business & Information Systems Engineering, 6(4), 239-242.
Resilience and Risk Management	While Industry 5.0 has the potential to enhance supply chain resilience, gaps existed in comprehending how effectively it can mitigate and respond to various risks, such as geopolitical, environmental, and economic disruptions in the context of global supply chains.	Monat, J., Hoberg, K., & Hollos, D. (2016). Business resilience: A review and synthesis of contemporary research. Journal of Business Logistics, 37(2), 99-111.
Small and Medium-sized Enterprises	The majority of research had focused on large multinational corporations. There was a need for more insights into how Industry 5.0 could be adopted	Ollila, S., & Yrjölä, H. (2021). The digital maturity of small and medium-sized manufacturing enterprises: A literature review

Topic	Description	References
	by SMEs and how it could impact their globalization efforts.	and future research agenda. International Journal of Production Economics, 234, 108086
Regulatory and Ethical Considerations	The regulatory landscape concerning data privacy, cybersecurity, and ethical concerns in the context of globalized supply chains with Industry 5.0 integration was not fully explored. Research was required to understand the legal and ethical implications and their impact on operations.	Gellings, C. W., Black, J. D., & Lund, D. J. (2017). Navigating energy law in the digital age. Energy Law Journal, 38(2), 219-261.
Environmental Sustainability	While the potential for Industry 5.0 to improve sustainability was acknowledged, there was a gap in comprehensive research regarding its actual impact on reducing environmental footprints and promoting sustainable practices across global supply chains.	Benjaafar, S., Li, Y., & Daskin, M. (2013). Carbon footprint and the management of supply chains: Insights from simple models. IEEE Transactions on Automation Science and Engineering, 10(1), 99-116.
Workforce Implications	Research on the implications of Industry 5.0 for the global supply chain workforce, including skill requirements, job displacement, and upskilling opportunities, needed more attention.	Brynjolfsson, E., & McAfee, A. (2014). The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies. W.W. Norton & Company.
Cultural and Cross-Cultural Factors	The impact of cultural and cross-cultural factors on the adoption and effectiveness of Industry 5.0 in global supply chains was an underexplored area. Understanding how cultural differences affect decision-making and collaboration was essential.	Taras, V., Rowney, J., & Steel, P. (2009). Half a century of measuring culture: Review of approaches, challenges, and limitations based on the analysis of 121 instruments for quantifying culture. Journal of International Business Studies, 40(9), 1532-1562.
Cybersecurity and Data Protection	Given the increased connectivity and data sharing in Industry 5.0, there was a gap in research related to cybersecurity and data protection challenges in globalized supply chains.	Finkle, J. A., & Garcia, M. (2015). Manufacturing and the IoT: Connecting the factory. IEEE Internet Computing, 19(4), 13-16.
Economic Impacts	A comprehensive assessment of the economic impacts, both positive and negative, of Industry 5.0 on global supply chains, including its influence on cost structures, market competitiveness, and profitability, required further investigation.	Lee, J., Kao, H. A., & Yang, S. (2014). Service innovation and smart analytics for industry 4.0 and big data environment. Procedia CIRP, 16, 3-8.

6. Conclusion

This paper underscores the pivotal and transformative role of Industry 5.0 in the optimization of various facets within the domain of global supply chain management. The integration of Industry 5.0 with the globalization of supply chain operations is essential for organizations aiming to excel in the progressively interconnected and dynamic global marketplace.

This convergence is marked by multifaceted contributions to both theoretical frameworks and practical applications. Primarily, Industry 5.0 technologies, such as smart factories and real-time data analytics, yield heightened operational efficiency. This enhancement reduces lead times, refines inventory management, and imparts organizations with the agility required to adapt swiftly to dynamic market conditions.

Secondly, Industry 5.0 fosters global connectivity, reshaping the management of extended supply chains. This transformation effectively mitigates risks and bolsters resilience against disruptions, offering valuable insights into the potential of technological innovation to revolutionize supply chain operations, enhance responsiveness, and elevate global competitiveness.

Furthermore, the emphasis on sustainability within Industry 5.0 aligns with the broader global shift towards eco-conscious practices, providing a theoretical framework for organizations to align their operations with environmental responsibility. The reconfiguration of workforce dynamics due to Industry 5.0 integration in supply chain management is equally vital, highlighting the importance of a skilled and adaptable workforce in the context of globalization.

Ultimately, organizations that harness the potential of Industry 5.0 gain a substantial competitive advantage, emphasizing its practical relevance and influence on market positioning. This Industry 5.0 and global supply chain management fusion represents more than a technological trend; it constitutes a paradigm shift necessitating attention, understanding, and strategic adaptation by organizations aspiring to thrive in the dynamic and interconnected global marketplace.

This academic discourse elucidates that Industry 5.0 extends beyond technological advancements and operational efficiency; it encompasses the alignment of industrial practices with sustainability goals, fostering environmentally responsible and resilient global supply chains.

In terms of theoretical contributions, this paper, grounded in the Resource-Based View (RBV), underscores the indispensable role of Industry 5.0 in augmenting various dimensions of global supply chain management. It advances our comprehension of how the amalgamation of advanced technologies with the intricacies of globalized supply networks engenders greater efficiency, sustainability, workforce adaptability, and competitive positioning. The imperative nature of embracing this transformative convergence for organizations aspiring to excel in today's interconnected and dynamic global business landscape is highlighted.

In summation, the fusion of Industry 5.0 with the globalization of supply chain management represents a transformative convergence, underpinned by academic research. This convergence bequeaths augmented efficiency, heightened global connectivity, sustainability, reconfigured workforce dynamics, and a competitive edge to organizations operating within the interlinked global marketplace. The embrace of this transformation is an imperative endeavor for businesses seeking success in an increasingly dynamic global environment.

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