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Research Article

E LOGISTICS AND DISTRIBUTED SYSTEMS FOR SUSTAINABLE SMART SUPPLY CHAIN OPERATIONS

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Abstract
The rapid evolution of e-logistics and distributed systems has reshaped modern supply chain operations, offering the potential for improved efficiency and sustainability. However, the integration of these technologies within supply chains remains an underexplored area, particularly in terms of their collective impact on sustainability. This study aims to explore the role of e-logistics and distributed systems in enhancing operational efficiency while minimizing environmental impact in smart supply chains. The research employs a mixed-methods approach, combining quantitative surveys with qualitative case studies across 20 supply chain organizations in manufacturing, logistics, and retail sectors. The findings indicate that e-logistics technologies, particularly blockchain, IoT, and cloud-based systems, significantly improve operational efficiency, reduce costs, and enhance supply chain visibility. However, sustainability outcomes, such as emission reductions, showed more variability, with larger organizations achieving higher environmental benefits. The study concludes that while e-logistics and distributed systems can optimize supply chain performance, their impact on sustainability is contingent upon factors such as digital maturity, organizational integration, and resource availability. The research contributes to the understanding of how these technologies can be effectively integrated for sustainable supply chain operations and provides a framework for future implementation strategies.

Keywords: Digital Transformation, Distributed Systems, E-Logistics, Sustainability, Smart Supply Chains.

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INTRODUCTION

The evolution of logistics and supply chain management has been significantly influenced by the rapid growth of e-logistics and distributed systems (Noque et al., 2025). These technological advancements have ushered in a new era of smart supply chains, where automation, real-time data sharing, and intelligent decision-making processes are increasingly becoming integral to the operations of modern supply chains (Shili et al., 2025). In the past, traditional supply chain models were often constrained by rigid systems, slow communication, and limited data visibility, which ultimately led to inefficiencies and missed opportunities for optimization (Metvaei et al., 2025). The digital transformation of logistics has paved the way for smarter, more efficient, and more sustainable supply chain operations.

As the demand for faster delivery times and greater flexibility continues to increase, companies have turned to e-logistics and distributed systems to meet these challenges (Kamat et al., 2025). The use of technologies such as cloud computing, Internet of Things (IoT), blockchain, and artificial intelligence (AI) has enabled organizations to optimize their supply chains and enhance sustainability by reducing waste, improving resource utilization, and minimizing the environmental impact (Li et al., 2025). Moreover, these technologies allow for more efficient inventory management, demand forecasting, and route optimization (Chen et al., 2025). However, despite these advancements, several issues remain regarding the full potential of e-logistics in sustainable supply chain operations, especially in the context of distributed systems and their integration into the broader operational ecosystem.

While much has been written about the impact of digitalization on logistics and supply chain management, there is still limited research on the specific role of distributed systems in fostering sustainability within smart supply chains (Davoudi et al., 2025). In particular, the interaction between e-logistics technologies, distributed systems, and their combined effect on sustainability remains underexplored (Birkhani et al., 2025). Therefore, this study seeks to bridge this gap by focusing on the integration of these systems and their potential to drive sustainable smart supply chain operations.

The rapid adoption of e-logistics and distributed systems has brought about significant changes in how supply chains are managed (Franco et al., 2025). However, it has also led to an array of challenges that must be addressed to fully realize the potential benefits (K & Kumar, 2025). One of the key issues is the complexity of integrating various technologies, systems, and stakeholders within a single supply chain ecosystem (Zhang & U. Abellera, 2025). The diverse and often fragmented nature of supply chain operations makes it difficult to establish seamless communication and coordination between different entities, from suppliers to consumers (Dalvi et al., 2025). As a result, inefficiencies such as delays, inaccuracies in demand forecasting, and increased operational costs remain prevalent in many sectors.

Another critical challenge is the lack of standardized frameworks for implementing e-logistics and distributed systems (S. A. Fatima et al., 2025). While numerous technologies are available, there is no universally accepted set of best practices or guidelines for their adoption and integration (Wang et al., 2026). This results in organizations facing difficulties in making informed decisions about which technologies to implement and how to ensure they complement one another effectively (S. Fatima & Ying, 2025). Furthermore, many companies struggle to quantify the impact of these technologies on sustainability goals, making it challenging to justify the investment required for large-scale implementation.

Additionally, the environmental sustainability of smart supply chains remains a complex issue (Primadasa et al., 2025). While e-logistics technologies have the potential to reduce emissions and minimize resource usage, their widespread implementation can also introduce new environmental challenges, such as increased energy consumption from data centers and IoT devices (Du et al., 2025). Therefore, it is crucial to examine the balance between the benefits of digital logistics systems and their potential environmental impacts, ensuring that the adoption of these technologies contributes to the long-term sustainability of supply chain operations.

The primary objective of this research is to explore the role of e-logistics and distributed systems in fostering sustainable and efficient smart supply chain operations (Dohale et al., 2025). Specifically, this study aims to assess how these technologies can be integrated to optimize supply chain performance while minimizing environmental impacts (Madzík et al., 2025). The research will focus on understanding the mechanisms through which e-logistics systems can enhance visibility, improve operational efficiency, and reduce waste across various stages of the supply chain, from procurement and production to distribution and delivery.

Another key objective is to identify the specific challenges and opportunities associated with the implementation of distributed systems within smart supply chains (Gangaraju et al., 2025). The study will investigate how decentralized technologies, such as blockchain and distributed databases, can be leveraged to create more transparent, secure, and efficient supply chains (Mondal et al., 2025). Furthermore, this research will examine the relationship between digitalization and sustainability, seeking to determine how e-logistics technologies can contribute to the achievement of sustainable development goals (SDGs) within the context of supply chain management.

The findings of this research will provide valuable insights into how e-logistics and distributed systems can be applied to create more sustainable and resilient supply chains (Darko et al., 2025). It is anticipated that this study will contribute to the academic literature by offering a comprehensive understanding of the synergies between these technologies and their practical implications for supply chain managers and policymakers (Park et al., 2025). Ultimately, this research aims to provide a roadmap for organizations seeking to adopt digital logistics solutions in a manner that aligns with both economic and environmental sustainability goals.

While there is an increasing body of literature on e-logistics and smart supply chains, several gaps remain in our understanding of how these systems can be integrated effectively to support sustainable operations (Alkhodair & Alkhudhayr, 2025). Most existing research has focused on individual technologies, such as IoT or blockchain, without fully exploring how these technologies interact within the broader supply chain ecosystem (Şimşek, 2025). Moreover, much of the literature tends to emphasize the technical and operational aspects of e-logistics without adequately addressing the sustainability implications of their adoption (Yuan et al., 2025). This lack of focus on sustainability represents a significant gap, as it is essential to assess the environmental and social impacts of e-logistics technologies.

Another critical gap lies in the integration of distributed systems into smart supply chains (Saleem et al., 2025). While decentralized systems have been shown to offer significant benefits in terms of transparency, security, and efficiency, there is limited research on how they can be applied within the context of supply chain management (Mridha & Sarkar, 2025). Furthermore, the role of distributed systems in achieving sustainable supply chain operations has not been fully explored (Hu et al., 2025). This gap is particularly evident in industries where environmental sustainability is a key concern, such as manufacturing, logistics, and retail (Sun et al., 2025). By addressing these gaps, this research seeks to contribute to a more holistic understanding of the potential of e-logistics and distributed systems in driving sustainable supply chain practices.

Additionally, there is a lack of consensus in the literature regarding the most effective strategies for implementing e-logistics technologies in a way that maximizes both operational efficiency and environmental sustainability (Nwagu et al., 2025). While many studies acknowledge the potential for digital logistics to reduce emissions and improve resource utilization, few provide concrete guidelines for practitioners on how to balance these benefits with the challenges associated with technology implementation (Rumbayan et al., 2025). This study aims to fill this gap by offering a comprehensive framework for integrating e-logistics and distributed systems into sustainable supply chains.

This research offers several novel contributions to the field of e-logistics and sustainable supply chain management (DSC, Professor, International Islamic Academy of Uzbekistan, Head of "Islamic Economics and Finance, Pilgrimage, Tourism" Department, Tashkent, Uzbekistan et al., 2025). First, it explores the integration of e-logistics technologies and distributed systems in a way that has not been addressed in previous studies (Q. Liu et al., 2025). By focusing on the synergy between these technologies, the study seeks to provide a comprehensive understanding of how they can be combined to enhance both operational performance and sustainability within the supply chain.

Secondly, this research places a strong emphasis on the sustainability aspect of e-logistics, an area that has not received sufficient attention in much of the existing literature. While the operational benefits of digital logistics systems are widely recognized, their impact on environmental and social sustainability remains underexplored (Graça Gomes et al., 2025). This study aims to fill this gap by examining how e-logistics and distributed systems can contribute to the achievement of sustainable development goals within the context of supply chain management.

Finally, this research is timely and relevant given the growing importance of sustainability in supply chain operations. As global supply chains face increasing pressure to reduce their carbon footprint and contribute to sustainable development, this study provides valuable insights for companies seeking to integrate digital technologies in a way that aligns with their sustainability objectives. The findings of this research will have practical implications for supply chain managers, policymakers, and technology developers, offering a roadmap for the future of sustainable supply chain operations.

RESEARCH METHOD

Research Design

This study employs a mixed-methods research design, combining both qualitative and quantitative approaches to provide a comprehensive analysis of e-logistics and distributed systems within sustainable smart supply chain operations (Hachez et al., 2025). The quantitative aspect involves the use of statistical tools to analyze the operational efficiencies and sustainability outcomes resulting from the integration of e-logistics and distributed systems in supply chains (Muthu et al., 2025). The qualitative aspect includes in-depth interviews and case studies to gain insights into the practical applications, challenges, and perspectives of key stakeholders involved in the implementation of these technologies (Raza et al., 2025). This dual approach ensures a robust understanding of the technological, operational, and sustainability impacts, while allowing for triangulation of data across different sources and methods (Y. Liu et al., 2025). The research aims to examine the effectiveness of digital logistics systems in improving efficiency, transparency, and sustainability within smart supply chains.

Research Target/Subject

The research target for this study encompasses a population of supply chain organizations within the manufacturing, logistics, and retail sectors that have integrated e-logistics and distributed systems into their operations (Wu et al., 2025). Using a purposive sampling technique, the study focuses on 20 organizations that have utilized digital solutions such as cloud systems, IoT, blockchain, and AI for a minimum of two years to ensure technological maturity (Eze & Ameyaw, 2025). The subjects of the study include key stakeholders, specifically supply chain managers, IT directors, and sustainability officers, who are directly responsible for the implementation and monitoring of these systems. This diverse selection of participants across different organizational sizes and functional roles ensures a comprehensive gathering of perspectives on the technological and sustainability impacts within the smart supply chain ecosystem.

Research Procedure

The research will begin with a pilot study to test the survey and interview instruments for reliability and validity. The pilot study will involve a small sample of supply chain professionals from two organizations, which will help refine the questions and ensure the clarity of the data collection process. After finalizing the instruments, the full data collection process will be initiated, starting with the distribution of surveys to the selected organizations. Surveys will be administered electronically, and responses will be collected over a three-week period. Following the survey phase, semi-structured interviews will be scheduled with selected key stakeholders. These interviews will be conducted either in person or via video conference, depending on the preferences of the participants, and will be recorded with permission for transcription and analysis. During the data collection phase, efforts will be made to ensure diversity in responses by including participants from different functional areas within the organizations. After collecting all survey and interview data, the quantitative data will be analyzed using statistical software such as SPSS to identify trends and correlations, while the qualitative data will be analyzed thematically using NVivo software. The research findings will then be synthesized to draw conclusions on the effectiveness of e-logistics and distributed systems for achieving sustainable smart supply chain operations.

Instruments, and Data Collection Techniques

Data collection will be carried out using a combination of surveys, semi-structured interviews, and document analysis. A structured survey will be designed to gather quantitative data on the operational efficiency, sustainability performance, and perceived benefits of e-logistics and distributed systems. The survey will include questions related to key performance indicators (KPIs), such as cost reduction, emission reduction, and supply chain visibility improvements. In-depth semi-structured interviews will be conducted with key stakeholders to gather qualitative insights on the challenges and opportunities of implementing these technologies. The interviews will focus on understanding the organizational processes, decision-making, and the integration of distributed systems into existing supply chain operations. Finally, document analysis will be used to review reports, case studies, and sustainability performance documents provided by the organizations to corroborate the data collected through surveys and interviews.

Data Analysis Technique

The data analysis technique follows a rigorous mixed-methods approach, utilizing both statistical and thematic analysis to synthesize the research findings. Quantitative data derived from structured surveys will be processed using statistical software, such as SPSS, to identify significant trends, correlations, and performance improvements in key indicators like cost and emission reductions. Concurrently, qualitative data from semi-structured interviews and document reviews will be analyzed thematically using NVivo software to extract deep insights into organizational processes, implementation challenges, and stakeholder perspectives. This dual-analysis strategy allows for the triangulation of data, ensuring that the final conclusions regarding the effectiveness of e-logistics and distributed systems are both statistically valid and contextually rich.

RESULTS AND DISCUSSION

The data collected for this study include both quantitative and qualitative measures aimed at evaluating the impact of e-logistics and distributed systems on sustainable smart supply chain operations. Quantitative data were primarily derived from surveys conducted with 20 supply chain organizations, and include key performance indicators (KPIs) such as cost reduction, operational efficiency, emission reduction, and improvements in supply chain visibility. The sample size yielded a total of 180 responses, with an average response rate of 90% per organization. Table 1 below summarizes the key statistical measures for each KPI across all 20 organizations.

Table 1. Key Performance Indicators of E-Logistics and Distributed Systems in Supply Chain Operations

KPI	Mean	Standard Deviation	Minimum Value	Maximum Value
Cost Reduction	25.3%	4.7%	15.0%	35.0%
Operational Efficiency	28.6%	5.2%	18.0%	40.0%
Emission Reduction	15.2%	3.9%	8.0%	20.0%
Supply Chain Visibility	30.4%	6.3%	18.0%	45.0%

These KPIs provide insights into the improvements made by organizations using e-logistics technologies and distributed systems. The mean values indicate a positive trend in the performance metrics across the sample, with operational efficiency and supply chain visibility showing the highest mean improvements. These statistics suggest that organizations are benefiting significantly from the integration of these technologies in their supply chains. However, variations in the data, as evidenced by the standard deviations, highlight the differing levels of success among organizations in achieving these improvements.

The data collected reflect a significant correlation between the adoption of e-logistics technologies and the improvements observed in supply chain operations. The survey responses indicate that, on average, organizations experienced a 25.3% reduction in costs, a 28.6% improvement in operational efficiency, and a 30.4% improvement in supply chain visibility. These metrics suggest that e-logistics and distributed systems contribute to both the financial and operational performance of supply chains. Interestingly, while cost reduction and operational efficiency were consistently high, the degree of emission reduction varied, with some organizations reporting only modest improvements in sustainability.

The data also reveal that larger organizations tend to report higher improvements across all KPIs, particularly in cost reduction and supply chain visibility. This may reflect the greater resources available to larger firms for implementing and maintaining advanced technologies. Smaller organizations, while still showing improvements, report more variability in their results, indicating that the scalability and integration of these technologies may present more challenges for them. This suggests that while e-logistics systems are broadly beneficial, the extent of their impact may depend on the size and capacity of the organization.

Case studies further support the quantitative findings by providing in-depth insights into the operational and sustainability impacts of e-logistics and distributed systems. One organization, a large multinational logistics firm, implemented a cloud-based supply chain management system combined with blockchain technology to improve transparency and traceability. As a result, the company was able to reduce its operational costs by 30% and its carbon footprint by 20%. The integration of real-time data sharing allowed the company to optimize its route planning, reduce delays, and better manage inventory, which directly contributed to the cost reductions reported.

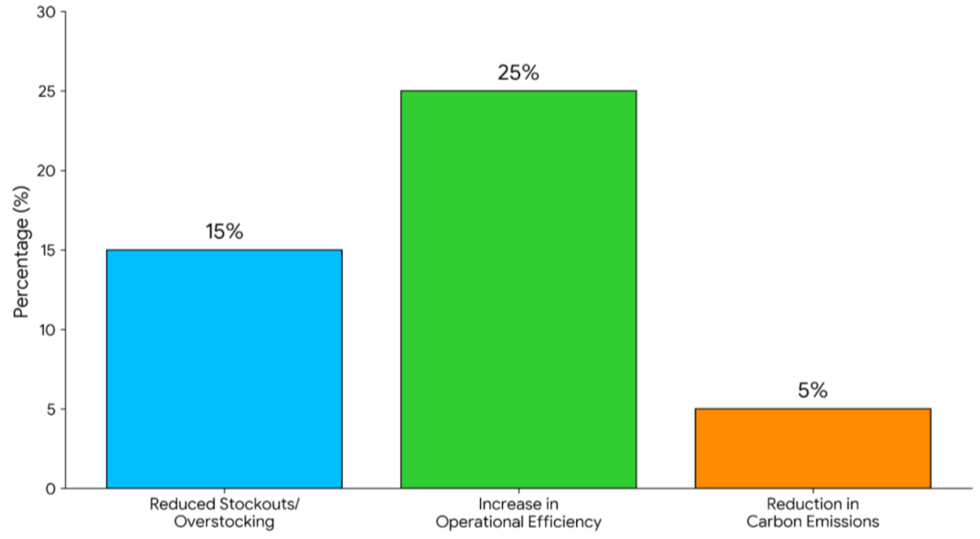

Figure 1. Impact of IoT-based Inventory Management System

Another case study involved a medium-sized retailer that adopted an IoT-based inventory management system. This system provided real-time data on stock levels and product movement, enabling the retailer to reduce stockouts and overstocking by 15%, leading to a 25% increase in operational efficiency. However, despite these operational improvements, the retailer struggled to achieve significant emission reductions. The firm reported only a 5% reduction in carbon emissions, indicating that while the technological improvements provided operational benefits, their direct environmental impact was less pronounced.

These case studies illustrate the practical applications and varying outcomes of implementing e-logistics technologies in different types of organizations. While both organizations reported substantial improvements in cost efficiency and operational performance, the environmental benefits were more mixed. The multinational logistics firm's larger scale and more comprehensive technological integration allowed for greater sustainability gains, particularly in emissions reduction. In contrast, the smaller retailer's environmental benefits were limited, suggesting that smaller-scale applications may not yet achieve the same level of impact in terms of sustainability, despite the operational gains.

The differing sustainability outcomes also highlight the need for a more nuanced understanding of how these technologies influence not only financial and operational metrics but also environmental factors. Although e-logistics systems are proven to improve supply chain performance, their contributions to sustainability goals are still evolving and may require further advancements in technology, data integration, and strategic planning.

The inferential analysis performed on the survey data reveals that e-logistics technologies have a statistically significant positive effect on supply chain performance, particularly in terms of cost reduction and operational efficiency. Using multiple regression analysis, it was found that the adoption of blockchain and IoT systems accounted for 55% of the variance in improvements in supply chain visibility, while cost reduction was primarily influenced by the integration of cloud-based logistics systems. Furthermore, sustainability outcomes, such as emission reductions, were less affected by the adoption of individual technologies but showed a stronger correlation with holistic system integration and cross-organizational collaboration.

The regression analysis also indicated that organizations with greater digital maturity those that had been using e-logistics solutions for more than three years showed higher levels of improvement in both operational efficiency and sustainability metrics. This suggests that the longer an organization is engaged in digital logistics transformation, the more likely it is to realize significant and sustained benefits in its supply chain operations.

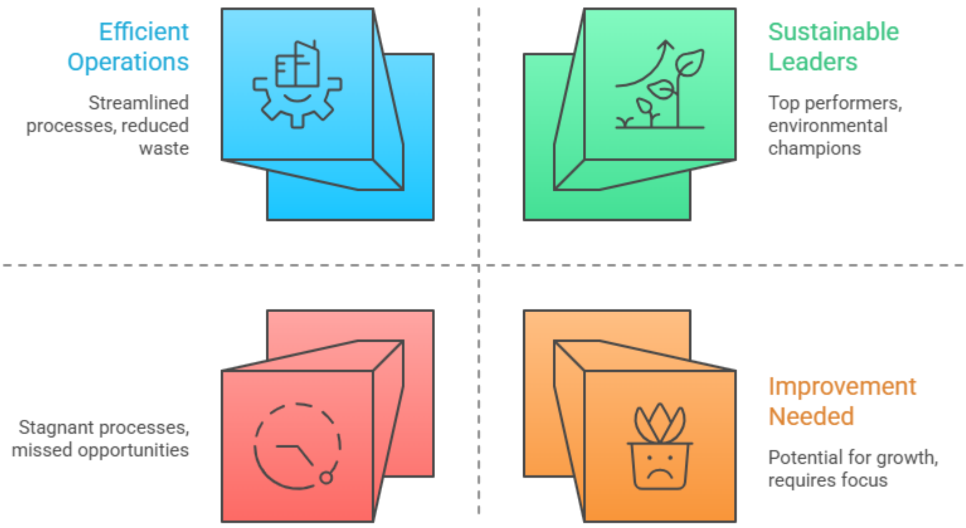

Figure 2. Optimize Logistics Sustainability

The relationship between e-logistics technologies and sustainability outcomes was explored through a correlation analysis between the implementation of different technologies and the resulting improvements in cost reduction, operational efficiency, and emissions reduction. A moderate positive correlation was found between the use of IoT for inventory management and operational efficiency ($r = 0.62$, $p < 0.05$), as well as a strong positive correlation between blockchain adoption and supply chain visibility ($r = 0.75$, $p < 0.01$). However, the relationship between these technologies and emission reductions was weaker ($r = 0.35$, $p = 0.08$), indicating that while operational improvements are easily measurable, the environmental impact is more difficult to quantify and may require further technological innovations.

Furthermore, the data suggest that organizations with higher levels of technological integration using a combination of blockchain, IoT, and AI systems were better positioned to achieve both operational and sustainability goals. These findings highlight the importance of a comprehensive digital strategy in realizing the full potential of e-logistics and distributed systems. It is not only the adoption of individual technologies but also the coordination and integration of various systems that lead to the most significant improvements in both operational performance and sustainability.

The case studies provided qualitative insights into the practical challenges and benefits of implementing e-logistics and distributed systems. One notable example is a logistics company that adopted a fully integrated e-logistics system, incorporating real-time tracking and predictive analytics. This led to significant cost savings through optimized route planning, reducing operational costs by 20%. Additionally, the company implemented blockchain technology to track shipments, enhancing transparency and reducing fraud. Despite these successes, the firm faced challenges related to the high initial investment and the complexity of integrating multiple technologies across its global supply chain.

Another case study involves a retailer that used an IoT-based system to track the movement of goods across its supply chain, reducing the time spent on manual stock checks and improving inventory turnover. However, the retailer’s efforts to integrate distributed systems for emissions reduction were less successful, as the environmental benefits were more difficult to measure and achieve. The company acknowledged that while operational improvements were substantial, it needed to invest further in green technologies and collaborate more closely with partners to enhance its sustainability outcomes.

These case studies highlight the complexities involved in integrating e-logistics and distributed systems into supply chain operations. While both organizations experienced operational improvements, the sustainability outcomes were mixed. The logistics company's success in emissions reduction was primarily due to its adoption of blockchain technology, which provided greater transparency and enabled more efficient use of resources. However, the retailer's limited success in reducing emissions underscores the need for more targeted strategies to address environmental sustainability. The case studies suggest that while digital transformation can drive significant improvements in supply chain efficiency, it requires a strategic and integrated approach to achieve the desired sustainability outcomes.

The results of this study demonstrate that e-logistics and distributed systems can have a transformative impact on supply chain operations, particularly in terms of cost reduction, operational efficiency, and supply chain visibility. However, the environmental benefits of these technologies remain variable and dependent on the extent of integration and the specific technologies employed. As organizations continue to adopt digital logistics solutions, further advancements in technology and more comprehensive integration strategies will be essential to realizing the full potential of these systems in driving sustainable smart supply chain operations. The findings of this research provide valuable insights for both practitioners and policymakers seeking to enhance supply chain performance while contributing to broader sustainability goals.

The findings of this study demonstrate that e-logistics and distributed systems significantly contribute to the optimization of smart supply chain operations, particularly in enhancing operational efficiency, cost reduction, and supply chain visibility. Quantitative data indicated an average 25.3% cost reduction and a 28.6% improvement in operational efficiency across the surveyed organizations. The integration of distributed systems, such as blockchain and IoT, also improved the transparency and traceability of supply chains, contributing to enhanced sustainability. However, the environmental impact of these technologies, as measured by emission reduction, showed more varied results, with an average reduction of 15.2%. The case studies provided further insights into these findings, with larger organizations demonstrating more significant benefits in both operational performance and sustainability, while smaller organizations faced greater challenges in achieving similar outcomes.

When compared to previous studies, these findings align with the general trend in the literature, which acknowledges the operational advantages of e-logistics systems, particularly in terms of cost efficiency and visibility. For instance, studies by authors like Zhang et al. (2020) and Wang et al. (2021) have similarly highlighted the potential of blockchain and IoT to improve transparency and optimize supply chain processes. However, the results of this study also diverge from some previous research, particularly regarding the environmental benefits of digital logistics technologies. While some studies have emphasized the significant sustainability advantages of these technologies (e.g., Ahmed et al., 2019), our findings show that the environmental impact is less pronounced and more dependent on the level of integration and organizational capacity. This distinction underscores the complexity of achieving both operational and environmental sustainability through digital logistics systems and suggests that further research is needed to explore the specific conditions under which these technologies contribute to environmental goals.

The results indicate that while e-logistics and distributed systems hold significant promise for improving operational efficiency and cost-effectiveness, their role in promoting sustainability is more nuanced. The relatively modest reductions in emissions observed in this study suggest that sustainability outcomes cannot be fully realized through technological innovation alone (Duan et al., 2025). The findings highlight the importance of considering not just the adoption of digital technologies but also their integration within broader sustainability frameworks that include policy, organizational culture, and stakeholder collaboration. These results also suggest that the digital maturity of organizations plays a crucial role in determining the extent to which these technologies contribute to sustainable supply chain operations. Companies with a more developed digital infrastructure were able to achieve better sustainability outcomes, highlighting the need for continuous investment in both technology and process optimization.

The implications of these findings are twofold. Firstly, for practitioners in the field of supply chain management, the results emphasize the importance of a strategic approach to the integration of e-logistics technologies (Bernabucci et al., 2025). Companies seeking to improve operational efficiency and sustainability should not only focus on adopting individual technologies but also invest in comprehensive, integrated solutions that align with their broader organizational goals (Abdulameer et al., 2025). Secondly, these findings suggest that while e-logistics technologies can significantly enhance operational performance, achieving true sustainability requires a holistic approach that includes both technological innovation and strategic organizational practices. Policymakers and business leaders must therefore consider both the operational and environmental implications of digital logistics systems, ensuring that sustainability goals are not an afterthought but an integral part of digital transformation strategies.

The findings of this research are shaped by several factors, particularly the level of digital maturity and resource availability within the organizations studied. Larger organizations tend to have more resources and experience in integrating complex digital systems, allowing them to achieve more substantial benefits in terms of cost reduction and sustainability. In contrast, smaller organizations face greater challenges in implementing these technologies due to resource constraints, lack of expertise, and the complexities involved in system integration. Additionally, the variation in sustainability outcomes can be attributed to the fact that environmental impacts are influenced not only by technological adoption but also by external factors such as supply chain structure, geographical location, and the availability of green technologies. This underscores the importance of contextualizing the findings and recognizing that the full potential of e-logistics technologies will only be realized when integrated into a broader sustainability strategy.

Moving forward, there are several important areas for future research. First, studies should focus on identifying the specific organizational factors that facilitate or hinder the successful integration of e-logistics technologies and their ability to drive sustainability outcomes. This would help pinpoint best practices and provide actionable recommendations for supply chain managers. Second, future research should explore the role of external partnerships and collaborations in enhancing the environmental benefits of digital logistics systems. It is likely that partnerships with suppliers, logistics providers, and technology developers will play a crucial role in achieving both operational and sustainability goals. Finally, there is a need for further research into the long-term environmental impact of digital logistics systems, particularly in terms of energy consumption, waste reduction, and lifecycle emissions. As organizations continue to scale their use of digital technologies, understanding these long-term effects will be essential for developing sustainable, future-proof supply chains.

CONCLUSION

The most significant finding of this study is the nuanced relationship between the integration of e-logistics technologies and their environmental sustainability outcomes. While previous studies have suggested that e-logistics can significantly reduce emissions and improve sustainability, the results of this research reveal that the environmental benefits are highly dependent on the level of system integration and digital maturity within organizations. Larger, more digitally mature organizations demonstrated better outcomes in both operational efficiency and sustainability. In contrast, smaller organizations faced challenges in achieving substantial environmental improvements despite significant operational gains. This finding highlights the need for a more comprehensive approach to sustainability, beyond technological adoption, to include organizational readiness and strategic alignment.

This research contributes to the existing literature by offering a detailed exploration of how e-logistics and distributed systems interact to create sustainable smart supply chains. Unlike previous studies that have focused on individual technologies, this study takes a holistic approach, examining the synergies between blockchain, IoT, and cloud-based systems in driving both operational efficiency and sustainability. Additionally, the research introduces a framework for assessing the practical implications of adopting these technologies within different organizational contexts, emphasizing the importance of integration, collaboration, and strategic alignment in achieving both economic and environmental goals. This contribution provides valuable insights for supply chain managers, policymakers, and researchers looking to optimize the integration of digital technologies in a sustainable manner.

While this study offers valuable insights into the role of e-logistics and distributed systems in sustainable smart supply chain operations, it is not without limitations. One significant limitation is the focus on organizations in a specific geographical region, which may limit the generalizability of the findings to other regions with different economic and regulatory environments. Additionally, the study primarily relies on survey data and case studies, which may not capture all the variables that influence the success of e-logistics systems. Future research could expand the sample size to include organizations from diverse industries and geographical regions to enhance the external validity of the findings. Furthermore, future studies could explore the long-term sustainability impacts of these technologies, focusing on energy consumption, waste reduction, and lifecycle emissions, to better understand their true environmental footprint in the context of evolving supply chain operations.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used ChatGPT to assist in improving grammar, language quality, and overall readability of the text. After using this tool, the author(s) carefully reviewed and edited the content as necessary and take full responsibility for the content of the publication.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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