IMPACT OF EMERGING TECHNOLOGIES ON EFFICIENCY AND SUSTAINABILITY IN BUSINESS LOGISTICS

Sayon MONI YOHANNAN, Vytautas Magnus University, Agriculture Academy, Faculty of Bioeconomy Development, email: sayonmoniyohannan@vdu.lt

Abstract

Business logistics has become a critical component of modern supply chain management as organisations aim to improve efficiency, reduce costs, and adapt to dynamic market conditions. Innovation in logistics is in high demand due to the requirements of digitalization, sustainability, and the growing complexity of global trade. Digital supply chains, automation, artificial intelligence (digital technology), technology, blockchain transportation, and sustainable logistics innovation are some of the most important technological and strategic innovations that are improvement of business logistics. Research aims to identify the major innovations in business logistics and evaluate their impact on supply chain efficiency and sustainability. The study uses the qualitative research method and analyses case studies on logistics innovation and industry reports and recent scientific advancements. The findings show that the integration of Smart technologies provide the possibility of increasing the supply chain transparency and optimisation of transportation routes, and the better control of inventories and cooperation with the supply chain partners. In addition to this, sustainable logistic solutions are gaining more and more popularity in the form of green transportation, energy-efficient warehousing and circular logistics models to reduce the environmental footprint. This study does fill the gap in the knowledge on how important it is for business to adopt novel logistics solutions in order to improve operational efficiency and get an edge in the global markets. Business logistics will depend a lot on digital transformation, data-driven decision making and sustainable supply chain strategies moving forward.

Keywords: digital logistics, sustainability, supply chain, green logistics, artificial intelligence

Introduction

In the last few years, the logistics sector has seen its fair share of transformation that has come from rapid growth in all (world) trade, as well as expanded e-commerce and rising customer expectations. Business logistics is an essential component that enables goods, services and information to flow effectively through supply chains. The companies are faced with the need to deliver products in a short time, reduce operational costs, and ensure service quality while being in very competitive markets. Consequently, logistics management innovation is very critical for enhancing supply chain performance and sustaining organisations' competitive abilities (NG & Hung Anh, 2020). This creates opportunities to improve logistical process thanks to technological developments. Digital technologies such as AI, big data analytics, blockchain and the Internet of Things (IoT) will help organisations to monitor supply chains in real time, optimise transportation networks and improve decision-making processes (Agrawal et al., 2025). It offers companies a chance to improve operational efficiency, increase transparency and manage the supply chain disruption risks.

Along with technological innovations, sustainability is another big trend to take place that can bring a change in the operations of logistics. There is a growing pressure from governments, customers and stakeholders on businesses to reduce their impacts on the environment and engage in environmentally responsible practices. Ongoing trends in the sustainability of logistics which include reverse logistics, green transportation, energy efficient systems are the significant components of contemporary logistics strategies (Winkelhaus & Grosse, 2019). As much as logistics technologies have evolved, implementations for innovative solutions remain slow among organisations due to high investment costs, lack of technological expertise and integration issues with existing supply chain systems. Hence, assessing the latest innovations and future directions of sustainable solutions in business logistics is a significant step to demonstrate the possibilities that companies can occupy for better supply chain performance and sustainable growth.

Research Problem: many businesses still have trouble successfully integrating digital and sustainable solutions into their existing supply chain systems, despite rapid advancements in logistics technologies. There is a gap in our comprehension of these innovations' practical value due to the lack of clarity surrounding their actual impact on operational efficiency and sustainability. Therefore, the research problem addressed in this study is: How do emerging innovations in logistics contribute to increasing supply chain sustainability and efficiency in contemporary business environments?

Research aim: to identify the major innovations in business logistics and evaluate their impact on supply chain efficiency and sustainability.

The following **objectives** have been set to achieve the aim:

1. To analyse the impact of digital technologies on logistics efficiency
2. To evaluate the effectiveness of automation and blockchain in supply chains
3. To assess the role of sustainable logistics practices in reducing environmental impact
4. To propose practical recommendations for improving logistics performance through innovation.

Research object and methods

The object of this study is innovations and technology development in business logistics systems, namely, digital logistics technologies, automation solutions, and sustainable logistics.

The study has adopted qualitative research methodology of secondary data analysis. The data from supply chain management and logistics innovation reports, academic literature, scientific journal and industry publications were analyzed in determining the most current trends and solutions in logistics management. The key technological advancements that have an effect on logistics performance is based on this review strategy, makes it possible to incorporate the findings of research. Comparative, descriptive, and conceptual analytical methods were applied in this study. First, Artificial intelligence (AI)-based logistics platforms, Blockchain supply chain solutions and automated warehouse systems were shown and discussed through the technology comparison in logistics system applications. Second, a descriptive analysis has been performed for interpreting the role of these innovations on logistics efficiency, cost optimisation and supply chain transparency. Also, case-based examples were examined using the literature from logistics companies worldwide to portray actual adapted innovative logistics solutions. These are examples of how organisations implement digital technologies and sustainability practices in the real-world supply chains.

The literature included in this study was selected based on relevance, recency (2020-2026), and contribution to logistics innovation research. Consideration was given to conference papers, peer-reviewed journal articles, and industry reports. Various technologies, including artificial intelligence, blockchain, and automation systems, were compared to see how they impacted sustainability, efficiency, and cost. Trends were interpreted using descriptive analysis, and relationships between innovation adoption and supply chain performance were established using conceptual analysis.

Research results and discussion

Digital transformation in logistics

One of the biggest value generators for contemporary business logistics systems is digital transformation. Organisations are being compelled to implement digital technologies that will improve logistics visibility and operational efficiency due to the growing complexity of global supply chains and a rapid expansion of e-commerce. By using digital platforms, a large amount of logistics data can be collected, processed and analysed by organisations which facilitate optimal decision-making and coordination between certainly partners in the supply chain (Zhang et al., 2024).

IoT Integration is a first step in the digital transformation of logistics. With the help of IoT technologies, businesses can leverage the sensors that are embedded in the logistics infrastructure and use them to track the shipments, monitor the transportation conditions, and gather real-time data regarding the operations. By allowing logistics managers to monitor the supply of goods at different stages in the supply chain network, these technologies play an important role in the development of visibility across the supply chain (Winkelmann et al., 2024). The other factor for digital logistics is using latest analytics tools. For logistics companies, lots of data are generated from the transportation systems, warehouse operations, and customer transaction. Through the interpretation of these large-scale dataset and identifying behaviours to strengthen enhanced demand forecasting, route optimisation and inventory management organisations utilise big data analytics (Malekzadeh et al., 2025). Predictive analytics can help businesses do better planning for logistics and eliminate operational inefficiencies.

AI technologies are increasingly being integrated into the logistics systems. AI based algorithms has the ability to process the historical data of logistics information and create the predictive models to help managers in recognition of the supply chain disruptions before they happen. By enabling decision-making, these technologies make logistics systems more proactive in their response and faster in solving problems (Zhang et al., 2024). However, despite the advantages, digital transformation requires high investment and organisational readiness, which may limit its adoption in small and medium enterprises. Digital logistics increases efficiency but introduces dependence on technological infrastructure in comparison to conventional systems.

Automation and robotics in the logistics operations

While automation in logistics operations is not a new idea, its use in warehouse management and distribution systems has been a game-changer in the fulfilment process over the last few years. Automated storage and retrieval systems, robotic picking technologies, autonomous mobile robots are becoming more widely used for increasing operational productivity as well as decreasing requirements of manual labour (Gunasekaran et al., 2021). Warehouse automation enables logistics facilities to process orders with speed and precision. Automation of repetitive tasks such as product sorting, packaging and inventory movement are best suited for robotic systems which can outperform manual labour with high precision. Consequently, businesses are able to enhance warehouse efficiency & minimize operation errors and labour expenses (Chen, 2024).

One more major trend of automation in logistics is the introduction of autonomous transportation technologies. They are also researching self-driving cars and drones to mean the delivery will be more efficient. These technologies are intended to decrease the time needed for delivery and optimize logistics activity in metropolitan areas with heavy road congestion and poor infrastructure systems that tend to slow down normal forms of transportation (Kumar et al., 2025). The expansion of the logistics operation through automation goes to the higher end that efficient automated. Automated logistics systems such as this let organisations scale up or down the operational capacity on a pay-as-you-go basis into global markets where fluctuating levels of labour composition are needed, but which do not require a fundamental redesign of the operational capability. As a result of this type of adaptation, organizations can be better able to respond

to changing markets and customer needs (Wang et al., 2024). Automation technologies involve an initial capital cost to implement, but increase operational productivity and reliability of logistics systems and decrease operational expenditures over time.

Blockchain technology in supply chains

One such innovation they explore is blockchain technology, which has the potential to enable greater transparency and trust in logistics and supply chain operations. Blockchain has a distributed, digital ledger that securely and permanently logs transactions. Information can be shared by all supply chain participants without relying on a central authority. One of the main benefits of blockchain in logistics is improved traceability. There is no control over usage of supply chain and in traditional supply chain as you have different suppliers & distributors. Using blockchain systems, companies register every single transaction of the supply chain which allows products to be traced throughout logistics (Herbke et al., 2024). Counterfeit goods are less likely to re-enter the supply chain and consumer and product trust is restored.

The blockchain technology allows for smart contracts to be set in motion as well during logistics exchanges. Smart contracts are digital protocols that automatically perform defined actions when set criteria are satisfied. Automation reduces the workload of manual verification and makes the operations more effective by freeing up human resources that can focus on different tasks. With the nature of supply chains increasingly being globalised and complex, blockchain technology is rapidly evolving to enable better transparency and coordination in the supply chain.

Sustainable logistics solutions

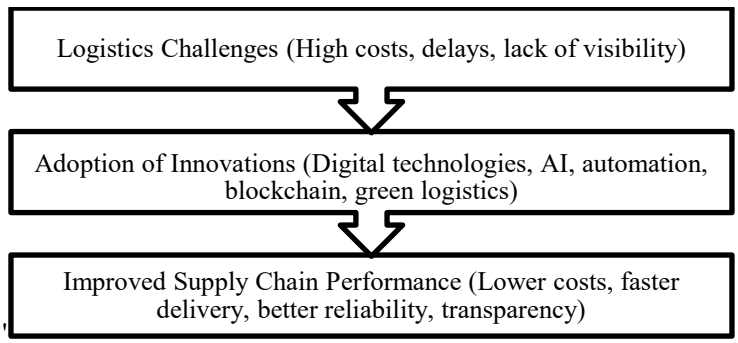
Environmental sustainability is now a major concern for logistics organisations as transportation and distribution operations have great negative impact on the environment. Logistics operation plays a critical role in carbon emission and energy consumption; hence organisations are embracing the concept of green logistics (Issa et al., 2024). It is about being eco-friendly in providing logistics solutions without compromising on productivity. However, one of the most widely deployed strategies are green transport technologies. To reduce the carbon footprint related to freight transport, many logistics companies are investing in electric vehicles, hybrid trucks and other alternative fuel technologies (Zulfikri, 2024).

Sustainability in the supply chain is also improved through the practices of reverse logistics. Product returns, recycling and reuse are all elements of reverse logistics, which it the process of moving goods back up to the supply chain. The process is in line with the principles of circular economy, reducing waste and maximizing the use of resources (Aladaileh et al., 2024). Apart from the environmental benefits, green practices can also be used to enhance the image of the organisation and build relationships with eco-friendly customers and business partners. With sustainability becoming the new strategic imperative for businesses across the world, the green logistics solutions market is expected to increasingly make its mark on supply chain operations across industries.

Impediments to implementing logistics innovations

Even though, some of the logistics innovations have really good advantages, however organizations face many challenges to work on new technologies. For example, some of the biggest barriers to adoption are often cited as being the capital-intensive characteristics of logistic technologies for instance automation systems, blockchain solutions and digital supply chain infrastructure (Bibri et al., 2026). A further challenge has to do with how technology fit in their current logistics systems. Numerous legacy systems are still being used by organisations that were not built to accommodate digital technologies. This means there can often be significant changes to both the organisation and systems required to integrate new technologies with existing infrastructure (Sundarakani et al., 2024). Human resource issues also affect the successful implementation of logistics innovations. There was a high demand of theories which help in controlling the flow of goods from as early as stage to anyone or further association. This requires organisations to invest in employee training and knowledge development for managing innovative logistics systems. Based on a review of the relevant literature, the conceptual framework identified key connections between performance outcomes, innovation adoption, and logistics challenges.

The conceptual framework as shown in Figure 1 is an adaptation in the way that logistics professionals respond to various challenges through adopting innovative measures and consequent enhancement in supply chain performance.



Source: created by the author

Fig 1. Supply Chain Challenges the Conceptual Framework

As seen in the figure, organisations experiencing logistic inefficiencies are increasingly adopting new technologies and sustainable measures to improve operational efficiency. Such innovations streamline the work of logistics by enabling better monitoring, processing and maximum utilisation of resources. In the long run, diverse logistics innovations adoption in turn improves supply chain performance, which is manifested by lower costs, quicker delivery times and better dependability.

Conclusions

1. This study basically emphasizes on the role of innovation in efficiency and effectiveness business logistic systems today. As global supply chains can be more complex and the growing rapidity of e-commerce activities is on the rise, organisations face a greater pressure to deliver goods in a timely manner, while at the same time, minimize operational costs - all while maintaining high levels of service quality. Therefore, it is the innovation in expressed logistics solutions that has become necessary for the provision of supply chain performance improvement as well as organisational competitiveness.
2. This article highlights one of the main findings of the research which indicates that digital transformation is increasing in importance in logistics management. Digital technologies such as Artificial Intelligence, data analytics and Internet of Things systems are helping organisations to improve visibility and coordination of logistics operations. They help logistics managers to take faster decisions by providing real-time information about transportation activities, availability in chain and distribution processes. Consequently, the digital logistics systems enable more transparency of operations and efficiency of supply chain.
3. Another important aspect that is focused on the study is sustainability in the modern logistics system. Logistics activities include environmentally-friendly logistics activities such as energy-efficient warehouse management, alternative and eco-friendly transport technologies and reverse logics processes in order to minimize the impact on the environment. Logistics strategies that are sustainable allows for the resource saving method as well as supply chain stewardship for long-term responsibility to the environment.
4. While there is a possibility that some challenges may be encountered by organisations in the implementation of new logistics solutions. The expenses which are associated with high investment, the challenges in integration of technology and requirement of domain knowledge may affect the adoption of advanced logistics technologies. Despite these challenges, organizations that invest in innovation and technology development will be better positioned to improve the performance of their supply chains and drive long-term competitive advantage. Overall, these results lead to the conclusion that innovation will continue to play a dominant role in the future development of business logistics systems.

References

1. Agrawal, R., Islam, N., Samadhiya, A., Shukla, V., Kumar, A., & Upadhyay, A. (2025). Paving the way to environmental sustainability: A systematic review to integrate big data analytics into high-stake decision forecasting. *Technological Forecasting and Social Change*, 214, 124060. https://doi.org/10.1016/j.techfore.2025.124060
2. Aladaileh, M. J., Lahuerta-Otero, E., & Aladayleh, K. J. (2024). Mapping sustainable supply chain innovation: A comprehensive bibliometric analysis. *Heliyon*, *10*(7). https://doi.org/10.2139/ssrn.4668833
3. Chen, R. (2024). Sustainable Supply Chain Management as a strategic enterprise innovation. *Advances in Economics, Management and Political Sciences*, 85(1), 24–29. https://doi.org/10.54254/2754-1169/85/20240831
4. Elias Bibri, S., & Huang, J. (2026). Empowering sustainable smart city digital twins with Deep Generative and foundation models. *The Generative AI-Driven Sustainable Smart City*, 74–139. https://doi.org/10.1201/9781003650126-2
5. Gunasekaran, A., Subramanian, N., & Papadopoulos, T. (2017a). Information Technology for competitive advantage within logistics and supply chains: A Review. *Transportation Research Part E: Logistics and Transportation Review*, 99, 14–33. https://doi.org/10.1016/j.tre.2016.12.008
6. Herbke, P., Lamichhane, S., Barman, K., Pandey, S. R., Kupper, A., Abraham, A., & Sabadello, M. (2024). Didchain: Advancing Supply Chain Data Management with decentralized identifiers and blockchain. 2024 IEEE *International Conference on Service-Oriented System Engineering (SOSE),* 54–63. https://doi.org/10.1109/sose62363.2024.00013
7. Issa, A., Khadem, A., Alzubi, A., & Berberoğlu, A. (2024). The path from Green Innovation to supply chain resilience: Do structural and Dynamic Supply Chain Complexity matter? *Sustainability*, 16(9), 3762. https://doi.org/10.3390/su16093762
8. Kumar, N., Kumar, K., Aeron, A., & Verre, F. (2025). Blockchain technology in Supply Chain Management: Innovations, applications, and challenges. *Telematics and Informatics Reports*, 18, 100204. https://doi.org/10.1016/j.teler.2025.100204
9. Malekzadeh, M., Torabi, S. A., & Sheikhalishahi, M. (2025). A supply chain digital twin for resilience analysis under immediate and long-term disruptions: A case study in plastic parts' manufacturing. *International Journal of Production Research*, 63(24), 10445–10467. https://doi.org/10.1080/00207543.2025.2551243
10. Sundarakani, B., Manikas, I., & Gunasekaran, A. (2024). The role of digital transformation in achieving sustainable supply chain management in Industry 4.0: An editorial review perspective. *International Journal of Logistics Research and Applications,* 27(6), 843–851. https://doi.org/10.1080/13675567.2024.2332123

11. Ng, T., & Anh, D. B. H. (2020). Global supply chain and logistics management. Academic Publications. https://www.researchgate.net/publication/338570722_Global_Supply_Chain_And_Logistics_Management
12. Winkelhaus, S., & Grosse, E. H. (2019). Logistics 4.0: A systematic review towards a new logistics system. *International Journal of Production Research*, 58(1), 18–43. https://doi.org/10.1080/00207543.2019.1612964
13. Winkelmann, S., Guennoun, R., Möller, F., Schoormann, T., & van der Valk, H. (2024). Back to a resilient future: Digital Technologies for a Sustainable Supply Chain. *Information Systems and E-Business Management*, 22(2), 315–350. https://doi.org/10.1007/s10257-024-00677-z
14. Zhang, T., Jia, F., & Chen, L. (2024). Blockchain adoption in supply chains: Implications for Sustainability. Production Planning & *Control*, 36(5), 699–722. https://doi.org/10.1080/09537287.2023.2296669
15. Zhang, S., Yu, Q., Wan, S., Cao, H., & Huang, Y. (2024). Digital Supply Chain: Literature Review of Seven Related Technologies. *Manufacturing Review*, 11, 8. https://doi.org/10.1051/mfreview/2024006
16. Wang, Y., Zhang, H., Yuan, C., Li, X., & Jiang, Z. (2025). An efficient scheduling method in supply chain logistics based on Network Flow. *Processes*, 13(4), 969. https://doi.org/10.3390/pr13040969
17. Zulfikri, A. (2024). Integrating Green Procurement and logistics: Overcoming barriers for sustainable supply chains. *Sinergi International Journal of Logistics*, 2(4), 264–276. https://doi.org/10.61194/sijl.v2i4.739