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## THE IMPACT OF INFORMATION TECHNOLOGY ON E-COMMERCE SUPPLY CHAIN MANAGEMENT

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**ABSTRACT:** This article examines the role of advanced information technologies in improving the efficiency, competitiveness and sustainability of supply chain management (SCM) in the e-commerce sector. The study applies a structured literature review combined with a quantitative survey conducted among Polish e-commerce enterprises. The findings indicate that information technologies – particularly e-commerce platforms, ERP, WMS, AI and Big Data analytics – significantly enhance order processing, inventory management and shipment monitoring, while simultaneously supporting environmental and social sustainability objectives. The study is limited by its national scope, which may affect the generalizability of the results; future research should extend the analysis to international contexts. From a practical perspective, the results support managers in prioritising IT investments that deliver both operational and strategic benefits. By integrating technological, operational and sustainability dimensions, the study contributes original empirical evidence to the literature on digital and sustainable SCM in e-commerce.

**KEYWORDS:** e-commerce, information technology, supply chain management, sustainability, logistics

## Introduction

Over the past few decades, the e-commerce sector has undergone fundamental changes that have not only revolutionised the way business is conducted but have also profoundly influenced supply chain management (SCM). As one of the most dynamically developing segments of the global economy, e-commerce is characterised by rapidly growing order volumes, increasing return rates, high expectations regarding delivery speed, and rising pressure to ensure transparency and sustainability across logistics operations. These challenges force companies to continuously improve operational processes in order to meet growing consumer demands and intensified market competition.

In this context, information technology (IT) has become a key enabler of efficiency, flexibility and sustainability in e-commerce supply chain management. Technologies such as artificial intelligence (AI), machine learning (ML), cloud-based systems, the Internet of Things (IoT), blockchain and advanced data analytics have transformed traditional logistics models by automating information flows, optimising inventory management, improving demand forecasting and supporting real-time decision-making (Brynjolfsson & McAfee, 2014; Porter & Heppelmann, 2014; Tokarski & Fajczak-Kowalska, 2024). In highly competitive e-commerce environments, where delivery speed, reliability and cost efficiency are critical success factors, the strategic role of IT is becoming increasingly evident.

At the same time, supply chain management in e-commerce is no longer focused solely on operational performance. Increasing regulatory pressure, EU climate policies and growing consumer awareness regarding ethical and environmental issues have placed sustainability at the core of logistics strategies. Sustainable supply chain management now encompasses not only environmental objectives, such as reducing CO<sub>2</sub> emissions or minimising waste, but also social aspects, including responsible employment practices, transparency and consumer trust. Companies that effectively integrate IT solutions with sustainability goals are more likely to strengthen their competitive position and enhance long-term value creation (Seuring & Müller, 2008; Lee et al., 2013; Jeurissen, 2000).

## Theoretical contribution of the study

Despite the extensive body of literature on information technology in supply chain management, several important research gaps remain. Previous studies have predominantly examined the role of IT either from the perspective of operational efficiency or from the viewpoint of sustainability and corporate social responsibility. Moreover, recent research in e-commerce increasingly focuses on strategic decision-making related to recommender systems, pricing mechanisms, platform competition or delivery strategies (Zhou et al., 2022; Yu et al., 2023; Zhou et al., 2025), often without explicitly addressing the operational and sustainability implications of IT adoption within supply chains.

This study contributes to the existing literature by integrating these fragmented research streams. First, it provides empirical evidence on the impact of advanced IT technologies on operational efficiency and competitiveness in e-commerce supply chain management. Second, it extends the analysis by explicitly incorporating the sustainability dimension, adopting a triple bottom line perspective that considers economic, environmental and social effects simultaneously. Third, the study identifies key technological and organisational barriers that limit effective IT implementation in e-commerce SCM. By focusing on e-commerce enterprises operating in a dynamic and regulation-intensive environment, the article offers a comprehensive and practice-oriented contribution to the literature on digital and sustainable supply chain management.

The aim of this article is therefore to analyse the impact of information technology on the efficiency, competitiveness and sustainability of supply chain management in e-commerce. In particular, the study addresses the following research questions:

- How does the use of advanced information technologies affect the efficiency and flexibility of supply chain management in the e-commerce sector?
- To what extent does IT adoption enhance the competitiveness of e-commerce enterprises operating in a turbulent market environment?
- Which digital technologies are most frequently applied in e-commerce SCM, and what barriers limit their effective implementation?

The remainder of the article is structured as follows. The next section presents a thematic review of the literature. Subsequently, the research methodology is described, followed by the presentation and discussion of empirical results. The final section concludes the paper and outlines implications for theory and practice, as well as directions for future research.

## An overview of the literature

The literature on information technology in logistics and supply chain management is extensive; however, existing studies are dispersed across several thematic areas and rarely provide an integrated perspective tailored to the e-commerce context. To systematise prior research and clearly position the present study, the literature review is structured into four interrelated research streams.

### **IT as a driver of operational efficiency in e-commerce SCM**

A substantial body of research examines information technology primarily as a tool for improving operational efficiency in supply chain management. Early studies emphasise that IT integration enhances coordination, reduces information asymmetry and improves key performance indicators such as inventory turnover, delivery reliability and order fulfilment time (Gunasekaran et al., 2001; Croom, 2005). In e-commerce environments, characterised by high demand volatility and time pressure, technologies such as ERP systems, cloud-based platforms and Big Data analytics enable real-time process monitoring, scalability and process optimisation (Wamba et al., 2017). Recent contributions further highlight the role of predictive analytics and artificial intelligence in demand forecasting and inventory management, allowing firms to reduce resource waste and operational disruptions (Ivanov et al., 2019).

### **IT as a strategic capability and source of competitive advantage**

Another important stream of literature approaches IT from a strategic perspective, viewing digital technologies as a source of long-term competitive advantage. Building on the resource-based view, studies argue that IT can contribute to superior performance when it is effectively embedded in organisational routines and decision-making processes (Barney, 2000; Kramer & Porter, 2011). In the context of digital transformation, e-commerce platforms, integrated information systems and data-driven tools are increasingly considered core elements of business strategy rather than merely operational support mechanisms. At the same time, the growing complexity of digital infrastructures generates challenges related to system integration, cybersecurity and implementation costs, often leading firms to outsource IT services in order to mitigate technological risk and access specialised competencies (Teece, 2018).

### **Sustainability and the triple bottom line perspective in digital SCM**

An expanding stream of research focuses on the role of IT in supporting sustainable supply chain management, frequently adopting the triple bottom line framework that integrates economic, environmental and social objectives (Seuring & Müller, 2008; Alhaddi, 2015). In e-commerce logistics, digital solutions contribute not only to cost optimisation and shorter delivery times, but also to reducing CO<sub>2</sub> emissions through intelligent transport management systems, energy-efficient warehousing and sustainable packaging solutions (Kumar et al., 2021). Moreover, technologies such as blockchain and advanced data analytics enhance supply chain transparency and traceability, which are increasingly important in meeting regulatory requirements and responding to ethical and environmental expectations of consumers (Saberli et al., 2019).

### **Research gaps and implications for further studies**

Despite the growing interest in the impact of IT on supply chain management in e-commerce, several research gaps remain. Existing studies tend to analyse operational efficiency, strategic competitiveness and sustainability separately, with limited empirical evidence integrating these dimensions within a single analytical framework. In particular, there is a lack of firm-level empirical research

examining how specific IT solutions simultaneously affect efficiency, competitiveness and long-term supply chain resilience. Consequently, further research is needed to integrate technological, economic and social perspectives in order to develop comprehensive logistics management models capable of addressing the challenges of contemporary e-commerce supply chains.

## Research methods

Information technology (IT) plays a fundamental role in shaping modern supply chain management (SCM) models, particularly in the e-commerce sector, which is characterised by high dynamics, increasing complexity and the need for agile responses to evolving customer expectations and the market environment. Tools such as ERP (Enterprise Resource Planning) systems, WMS (Warehouse Management Systems), e-commerce platforms, CRM (Customer Relationship Management), as well as Business Intelligence and Big Data analytical technologies, enable automation of logistics operations, optimisation of inventory levels, integration of sales channels and real-time analysis of consumer behaviour (Croom, 2005; Choi et al., 2018).

The inspiration for the research derives from the accelerated digital transformation of e-commerce enterprises, accompanied by rising consumer expectations, globalisation pressures and the growing significance of sustainability. The study aligns with empirical research on the impact of digitalisation on operational efficiency and competitiveness, aiming to assess the actual importance of modern IT tools in practical business environments.

The aim of the study is to identify and evaluate the impact of advanced IT technologies on the efficiency, flexibility and sustainable development of supply chain management in e-commerce enterprises. The subject of the analysis includes both the scope of application of IT tools in logistics and operational processes, and their influence on competitiveness and the ability of companies to adapt to turbulent market conditions.

The main research problem was formulated as follows:

- How does the use of advanced information technologies affect the efficiency and flexibility of supply chain management in the e-commerce sector, as well as the ability of enterprises to maintain competitiveness in a turbulent market environment?

On this basis, three specific research questions were formulated:

- What specific IT technologies are most frequently used in supply chain management within the e-commerce sector?
- To what extent do IT technologies contribute to increasing operational efficiency in supply chain management?
- Does the implementation of advanced IT technologies improve the competitiveness of e-commerce enterprises?
- To what extent are advanced digital technologies (AI, ML, AR, Big Data, IoT) used in supply chain management in e-commerce companies, and which SCM areas are most frequently supported by these technologies?
- What barriers limit the implementation of information technologies in supply chain management in the e-commerce sector, and which of them are dominant?

The following research hypotheses were adopted:

- The most commonly used technologies include warehouse management systems (WMS) and enterprise resource planning systems (ERP).
- Information technologies significantly increase operational efficiency, particularly in the areas of inventory management and order processing.
- The implementation of advanced information technologies positively influences the competitiveness of e-commerce enterprises, enabling faster order fulfilment and improved supply chain control.

- Advanced digital technologies in the SCM of e-commerce companies are primarily applied in demand forecasting, inventory management, and the automation of warehouse processes, while their use in strategic and decision-making areas remains limited.
- The main barriers to the implementation of IT in the SCM of e-commerce companies are high implementation costs, integration difficulties with existing infrastructure, and a shortage of qualified human resources, whereas regulatory and organisational barriers are of secondary importance.

A quantitative research method was employed to identify statistical relationships between variables and generalise results to the population of enterprises operating in the e-commerce sector. This approach facilitates an assessment of the impact of selected information technologies on key aspects of supply chain performance, including efficiency, flexibility and innovativeness.

The survey was conducted in the third quarter of 2024 using an online questionnaire addressed to representatives of e-commerce companies, including logistics managers, IT specialists, warehouse managers and members of digital transformation teams. The objective was to obtain cross-sectional insight into the current use of IT technologies in SCM and subjective assessments of their effectiveness.

The questionnaire was prepared electronically using online tools (e.g. Google Forms). It included closed questions (Likert scales, single- and multiple-choice questions) as well as semi-open questions enabling respondents to expand on their answers and share additional insights.

The survey instrument consisted of four thematic blocks:

- Demographic and firmographic characteristics (e.g. company size, order volume, respondent's role).
- Types of IT technologies used (e.g. ERP, WMS, CRM, AI, Big Data, IoT).
- Evaluation of the impact of technologies on various dimensions of operational efficiency and logistics management.
- Perceived influence of IT on competitiveness and adaptability under market volatility.

The study covered a representative sample of e-commerce companies operating on the Polish market, differentiated by size, business model (B2C/B2B), scale of operations (domestic/international) and digital maturity.

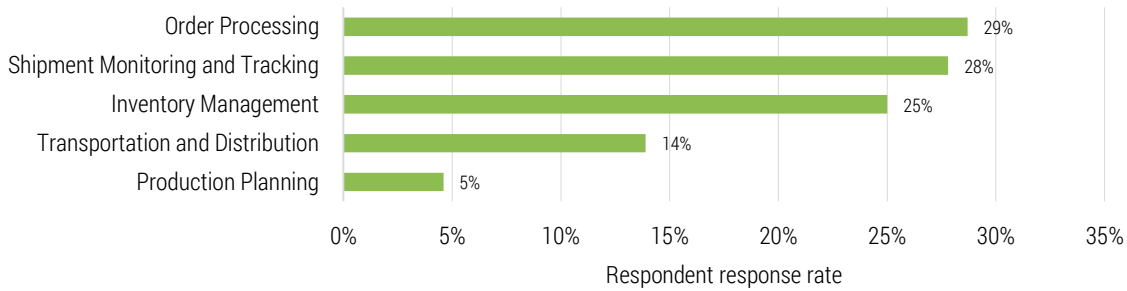
The collected data were statistically analysed using SPSS and Excel software, allowing for the identification of correlations between the use of IT technologies, supply chain management efficiency, and the competitiveness of e-commerce enterprises. This comprehensive approach allowed for a multidimensional understanding of the problem and the verification of research hypotheses. The conclusions drawn form the basis for strategic and operational recommendations for companies planning the further development of their supply chains using advanced digital technologies.

## Results of the research and discussion

The impact of information technology (IT) on the efficiency and sustainability of supply chain management (SCM) in the e-commerce sector is multidimensional and dynamically evolving in response to changing market realities and consumer expectations. The empirical results obtained in this study confirm that modern IT solutions play a fundamental role not only in operational optimisation but also in supporting long-term strategic and sustainability-oriented objectives. This section discusses the findings in relation to the identified literature streams and theoretical perspectives outlined earlier.

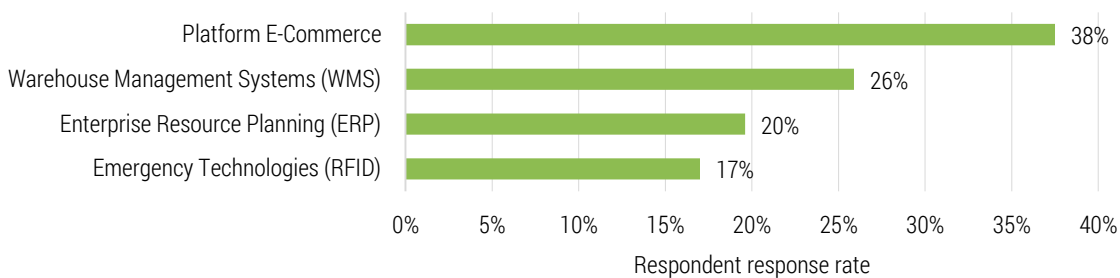
The results clearly demonstrate that IT significantly improves key dimensions of operational efficiency in e-commerce SCM, including order processing speed, shipment monitoring, and inventory management accuracy. This finding is consistent with earlier studies by Croom (2005) and Sanders (2016), who emphasised the role of IT integration in enhancing supply chain KPIs such as delivery reliability, inventory turnover, and order fulfilment time. Moreover, the respondents' assessments align with Mohsen (2022), who highlighted the importance of data-driven systems and predictive analytics in improving demand forecasting and reducing excessive inventory levels. The continued

relevance of technologies such as RFID in warehouse operations further supports the arguments of Attaran (2007) regarding their contribution to inventory accuracy and process transparency.



**Figure 1.** Impact of IT on operational efficiency

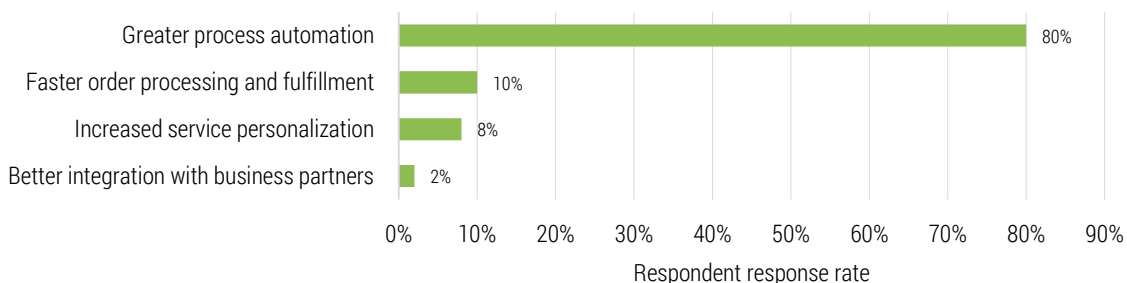
Source: authors' work based on research results.



**Figure 2.** Use of IT systems in e-commerce SCM

Source: authors' work based on research results.

An important contribution of this study is the empirical verification of the structure of IT usage in e-commerce SCM. The first research hypothesis, which assumed that ERP and WMS systems are the most commonly used technologies, was not confirmed. Instead, e-commerce platforms emerged as the dominant IT solution. This result indicates a structural shift in technological priorities toward systems that are directly integrated with sales channels and customer interfaces. Similar trends have been observed by Mollenkopf et al. (2010) and Kumar and Ayedee (2021), who noted the increasing adoption of flexible, cloud-based solutions, particularly among small and medium-sized e-commerce enterprises. From a strategic perspective, this finding suggests a gradual redefinition of IT architectures in e-commerce, where front-end integration and scalability are becoming more critical than traditional back-office dominance.

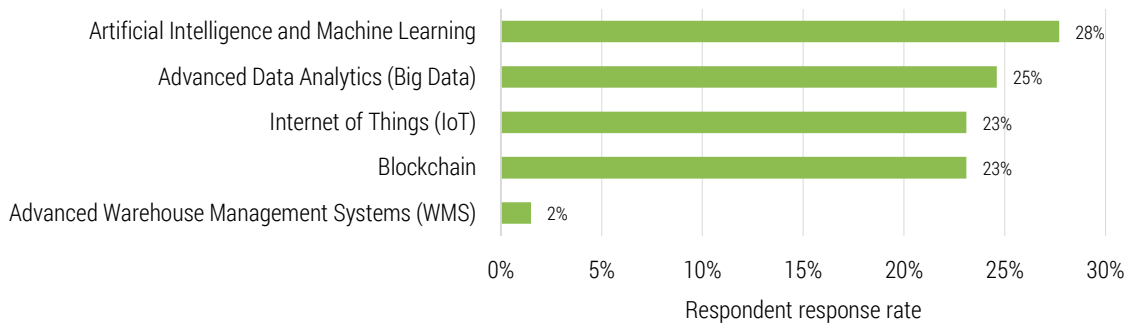


**Figure 3.** IT impact on company competitiveness

Source: authors' work based on research results.

The majority of respondents confirmed a positive impact of IT on company competitiveness, primarily through higher levels of automation and faster order processing. These results are well aligned with the resource-based view (RBV), which assumes that IT resources can generate sustainable com-

petitive advantage if they are valuable, rare, difficult to imitate, and effectively embedded in organisational processes (Barney, 2000; Melville et al., 2004). In this context, IT systems should be interpreted not merely as operational support tools, but as strategic assets that enable firms to respond more effectively to market volatility and increasing customer expectations in e-commerce.



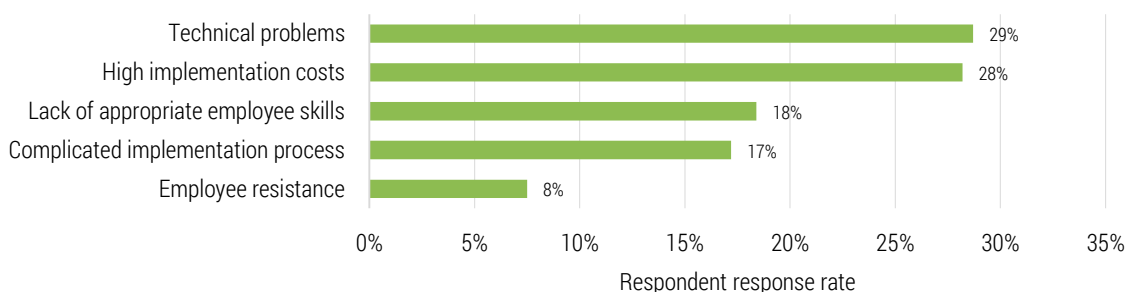
**Figure 4.** Application of advanced technologies in SCM

Source: authors' work based on research results.

The growing importance of advanced technologies such as artificial intelligence, machine learning, and augmented reality is also reflected in the empirical findings. This observation is consistent with the literature (Choi et al., 2018; Wamba et al., 2017), which emphasises the role of these technologies in enabling dynamic demand–supply matching, automating operational decisions, and enhancing customer experience personalisation. In addition, the application of AR in warehouse operations, employee training, and order picking supports productivity improvements and error reduction, reinforcing the operational and strategic benefits of digital transformation in SCM.

Beyond efficiency and competitiveness, the results confirm that IT plays a crucial role in supporting sustainable SCM practices in e-commerce. As demonstrated by Tachizawa and Wong (2014), IT solutions facilitate the monitoring of energy consumption and carbon emissions, thereby supporting environmental objectives. Furthermore, Dey et al. (2018) highlighted the importance of blockchain, IoT, and Big Data in enhancing supply chain transparency and accountability. The respondents' perceptions in this study confirm that companies increasingly recognise the potential of IT to support environmental and social dimensions of sustainability, in line with ESG principles.

This orientation toward sustainability is further reinforced by regulatory pressures, particularly within the European Union, as well as by growing consumer awareness of environmental and ethical issues. As noted by Rita and Ramos (2022), sustainability considerations increasingly influence purchasing decisions. Consequently, e-commerce companies that effectively integrate advanced IT solutions with sustainable SCM practices may achieve not only efficiency gains but also reputational benefits and stronger customer loyalty.



**Figure 5.** Barriers to IT implementation

Source: authors' work based on research results.

Despite the generally positive assessment of IT impacts, the results also highlight significant barriers to implementation, including high investment costs, technical complexity, system integration challenges, and cybersecurity risks. These findings are consistent with previous studies that empha-

size the organisational and technological constraints of digital transformation in SCM. The growing tendency to outsource IT services observed among respondents may be interpreted as a strategic response aimed at reducing technological risk and accessing specialised expertise.

In summary, the results and their discussion provide strong empirical support for the conclusion that information technologies play a strategic role in shaping efficient, competitive, and sustainable supply chain management in e-commerce. The rejection of the first hypothesis underscores the increasing strategic importance of integrated e-commerce platforms relative to traditional ERP and WMS systems. This shift has important implications for IT investment decisions and digital strategy development. Future research could further explore the comparative effectiveness of individual technologies and examine their combined impact on the resilience and sustainability of e-commerce supply chains in an evolving regulatory and technological environment.

## Conclusions

The results of this study confirm that information technologies play a decisive and increasingly strategic role in shaping efficient, competitive and sustainable supply chain management in the e-commerce sector. The empirical findings demonstrate that IT solutions are no longer limited to supporting operational processes, but have become key enablers of long-term value creation, organisational resilience and sustainability-oriented logistics strategies.

The analysis shows that the concept of sustainable development is gaining growing importance in logistics management, driven both by regulatory pressure and by increasing consumer awareness. E-commerce companies recognise the need to implement solutions that generate not only economic benefits, but also environmental and social value. Information technologies support this transition by enabling more efficient resource utilisation, reducing CO<sub>2</sub> emissions, improving transparency and minimising operational losses. As a result, the integration of logistics activities with sustainable development objectives is becoming an integral element of corporate strategy rather than merely an expression of social responsibility.

An important conclusion of the study is the observed shift in technological priorities within e-commerce supply chains. The dominance of integrated e-commerce platforms over traditional ERP and WMS systems indicates a reorientation toward flexible, scalable and customer-oriented digital solutions. This finding has significant implications for IT investment decisions and highlights the need to redesign digital architectures in line with the dynamic nature of e-commerce operations.

Based on the research results, several practical recommendations can be formulated. First, organisations should systematically invest in advanced technologies such as artificial intelligence and predictive analytics, which enable more effective data management, demand forecasting and process optimisation. Second, strategic cooperation with specialised technology providers may enhance the quality of implemented solutions while reducing technological and implementation-related risks. Third, companies should prioritise system integration and the development of internal competencies related to digital security, as cybersecurity challenges are becoming a critical constraint of digital transformation. Finally, IT implementation strategies should be closely aligned with sustainable development goals, as this integration can generate tangible long-term benefits in terms of efficiency, competitiveness and corporate reputation.

Despite its contributions, this study is not without limitations. The research was based on a specific group of e-commerce enterprises, which may limit the generalizability of the results. Future research could focus on comparative analyses across different countries or regions, as well as on the effectiveness of individual technologies and their combined impact on supply chain resilience and sustainability under changing technological and regulatory conditions.

## The contribution of the authors

Establishing the concept, D.T.; establishing research methods, D.T.; text creation, D.T., M.S.S.; analytical description of the phenomenon, D.T., M.S.S.; implementation of the research idea, D.T., M.S.S.; critical evaluation, D.T., M.S.S.; data collection, D.T.; data analysis and interpretation, D.T.; development of research results, D.T., M.S.S.; literature review, D.T., M.S.S.

The authors have read and agreed to the published version of the manuscript.

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## WPŁYW TECHNOLOGII INFORMACYJNYCH NA ZARZĄDZANIE ŁAŃCUCHEM DOSTAW W E-COMMERCE

**STRESZCZENIE:** Artykuł analizuje rolę zaawansowanych technologii informacyjnych w poprawie efektywności, konkurencyjności oraz zrównoważonego rozwoju zarządzania łańcuchem dostaw w sektorze e-commerce. W badaniu zastosowano ustrukturyzowany przegląd literatury oraz badanie ilościowe przeprowadzone wśród polskich przedsiębiorstw e-commerce. Wyniki wskazują, że technologie informacyjne – w szczególności platformy e-commerce, systemy ERP, WMS, a także rozwiązania oparte na sztucznej inteligencji i analizie Big Data – istotnie usprawniają procesy realizacji zamówień, zarządzania zapasami oraz monitorowania przesyłek, jednocześnie wspierając realizację celów środowiskowych i społecznych. Ograniczeniem badania jest jego krajowy charakter, który może wpływać na możliwość uogólniania wyników; przyszłe badania powinny objąć szerszy, międzynarodowy kontekst. Z perspektywy praktycznej uzyskane wyniki wspierają menedżerów w podejmowaniu decyzji dotyczących inwestycji w technologie informacyjne przynoszące zarówno korzyści operacyjne, jak i strategiczne. Artykuł wnosi oryginalny wkład empiryczny do literatury dotyczącej cyfrowego i zrównoważonego zarządzania łańcuchem dostaw w e-commerce.

**SŁOWA KLUCZOWE:** e-commerce, technologie informacyjne, zarządzanie łańcuchem dostaw, zrównoważony rozwój, logistyka