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TABLE OF CONTENTS (BY BRANCH GROUPS)

A SOCIAL SCIENCES

THE POTENTIAL AND PROSPECTS OF ARTIFICIAL INTELLIGENCE USE IN STRATEGIC PLANNING: ISSUES OF SECURITY AND DEFENSE OLHA RUDENKO, IHOR RAFALSKYI, OLEKSANDR YERMAK, VLADYSLAV VARYNSKYI, YAROSLAV KONOPLIA	6
STYLES AND DIRECTIONS OF CONTEMPORARY UKRAINIAN FINE ARTS IN THE CONTEXT OF WORLD TRENDS TETIANA PROKOPOVYCH, OLEKSANDRA PANFILOVA, HALYNA VAKHRAMIEIEVA, IVAN TARASIUK, OLGA KALENIUK	13
METHODOLOGICAL PRINCIPLES OF PSYCHOLOGICAL AND PEDAGOGICAL SUPPORT OF FUTURE SPECIALISTS PROFESSIONAL TRAINING IN HIGHER EDUCATION INSTITUTIONS OLEKSANDRA KHALLO, NADIIA KICHUK, VALENTYNA VERTUHINA, VOLODYMYR FEDORAK, LILIANA KHMICHUK, OLEKSANDR VOROBETS	19
SOME INDICATORS OF STUDENTS' MENTAL HEALTH IN THE CONDITIONS OF WAR (ON THE EXAMPLE OF THE KHARKIV STUDENTS DURING THE FULL-SCALE MILITARY INVASION OF RUSSIA INTO UKRAINE) IRYNA NECHITAILO, OKSANA BORIUSHKINA, YANA PONOMARENKO, IULIIA TVERDOKHVALOVA, TETIANA YELCHANINOVA, DALIA KOBELIEVA	25
PARTICIPATION OF THE STATE IN INTERNATIONAL COMMERCIAL TRANSACTIONS (INTERNATIONAL COMMERCIAL ACTIVITY): IMMUNITY ISSUES YEVGEN POPKO, VADYM POPKO, VIKTOR KALAKURA	36
THE ESSENCE AND SCOPE OF UKRAINE'S VICTORY IN THE CONTEXT OF RUSSIA'S TOTAL WAR AGAINST THE UKRAINIAN STATE ANATOLII RACHYNSKYI, OLEKSANDR ZIUZIA	41
HOLISTIC EDUCATION IN THE EUROPEAN SOCIO-CULTURAL SPACE IN THE EARLY MODERN PERIOD MARYNA GRYNKOVA, RUSLAN BASENKO, VASYL FAZAN, DMYTRO LOBODA, MARYNA ZUYENKO	45
NEW FUNCTIONAL APPEARANCES OF STABLE EXPRESSIONS IN THE MEDIA TEXTS OF THE RUSSIAN-UKRAINIAN WAR PERIOD MARYNA NAVALNA, NATALIIA KOSTUSIAK, OLEKSANDR MEZHOV, VOLODYMYR OLESENKO, TETIANA LEVCHENKO, MARIIA LYCHUK, OLESIA SKLIARENKO, IRYNA POLIAK, YURII DRUZ, GALYNA DRUZ	49
GRAPHO-BARBARISMS IN THE HEADLINES OF UKRAINIAN MEDIA TEXTS MARYNA NAVALNA, NATALIIA KOSTUSIAK, OLEKSANDR MEZHOV, LIUDMYLA MARCHUK, OKSANA BUHAIOVA, SVITLANA NOVOSELETSKA, NATALIIA SHAPRAN, TETIANA KHOMYCH, TETIANA MUSICHUK, VADYM BOBKOV	59
MUSICAL AND INSTRUMENTAL FORM CREATION AS A STRUCTURAL AND PROGRESSIVE PHENOMENON: GUIDING PRINCIPLES YULIIA IVANOVA, LI JUAN, WEN WEN, XU NIANJIA, LIU LU	67
THE VOCAL HERITAGE OF JOHANNES BRAHMS WITHIN THE CONTEXT OF THE RELIGIOUS AND ETHICAL PRINCIPLES OF 19TH-CENTURY GERMAN CULTURE OLHA MURAVSKA, LARISA GORELIK, LARYSA LOBODA, HALYNA SHPAK, YAOLISHA FANG	71
TRANSLATION TRAINING OF FUTURE PHILOLOGISTS USING MODERN INFORMATION TECHNOLOGIES VIKTORIA IHNATENKO, IRYNA VAKULYK, IRYNA VORONIUK, MYKOLA PROKHOROV, HALYNA MELEKH	75
INCLUSIVE PEDAGOGY IN SOCIETY 5.0: SOCIAL ASPECT LARYSA SUSHCHENKO, ROMAN SUSHCHENKO, TETIANA MARTYNIUK, IRYNA PUSHCHYNA, ALONA SADYKINA, GNAT STRYZHAK	80
PHYSICAL CULTURE AND A HEALTHY LIFESTYLE IN THE LANDSCAPE OF SUSTAINABLE DEVELOPMENT YURIY YAKIMETS, IVAN ILNYTSKYI, NATALIIA KORZH, OLGA SOKOLOVA, INNA PAVLENKO	85
CYBERSECURITY AS A COMPONENT OF INTERNATIONAL SECURITY OLEKSANDR HOMANIUK	90
SOME GENRES AND FORMS OF EARLY MUSIC IN MODERN DOMESTIC PRACTICE OLHA SHADRINA-LYCHAK, NATALIYA FOMENKO, IRYNA DRUZHHA, HANNA IVANIUSHENKO, OLENA ZHUKOVA	94
THE IMPACT OF LIABILITIES ON A COMPANY'S FINANCIAL STABILITY NORA ŠTANGOVA, AGNEŠA VIGHOVA	99
SECURITY OF SUSTAINABLE DEVELOPMENT OF THE AGRICULTURAL SECTOR OF THE REGION BASED ON DIGITALIZATION AND CIRCULAR ECONOMY: A CASE STUDY OF UKRAINE MARYNA DIELINI, OLGA KORNELIUK, TETIANA SHMATKOVSKA, NATALIIA NAUMENKO, LILIIA VIRUN, NATALIIA KHOMIUK, ROSTYSLAV MARTYNIUK	104
ANALYSIS AND MANAGEMENT OF LOGISTICS CHAINS IN THE CONTEXT OF THE CONVERGENCE OF DIGITAL TECHNOLOGIES IN THE ECONOMIC ARCHITECTURE OF UKRAINE OLHA SHULHA, YULIIA POPOVA, MYKOLA SHVETS, DMYTRO RUDENKO, BOHDAN SAMOILENKO, NATALIIA KHOMIUK, NADIIA BUKALO, RUSLANA SODOMA	109
THE APPLICATION OF THE "ROMAN FORMULA" METHOD IN CRIMINAL OFFENCE INVESTIGATIONS: PAST AND PRESENT ANATOLII STARUSHKEVYCH, ANDRII ZHUKOV, ANNA HREBENYUK, IVAN BANDURA, OLEKSANDR HOLOVKO, PETRO HLAMAZDA	114

THE ROLE OF DIGITIZATION OF THE EDUCATIONAL PROCESS IN THE CREATION AND FUNCTIONING OF ARTIFICIAL INTELLIGENCE
IRINA MOSIAKOVA, VALENTYN ROGOZA, YAROSLAV SMOLYN, VIKTORIIA BAIDALA, IHOR HAVRYLOV, OLGA KAZANSKA

120

F MEDICAL SCIENCES

DEVELOPMENT OF ADAPTIVE CHANGE MANAGEMENT PRINCIPLES IN THE PHARMACETICAL INDUSTRY UNDER THE INFLUENCE OF THE PANDEMIC
TETIANA DZIUBA

126

ANALYSIS AND MANAGEMENT OF LOGISTICS CHAINS IN THE CONTEXT OF THE CONVERGENCE OF DIGITAL TECHNOLOGIES IN THE ECONOMIC ARCHITECTURE OF UKRAINE

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Abstract: This article explores the peculiarities of analyzing and managing logistics chains within the context of the active implementation of digital technologies in Ukraine's economy. It examines how the convergence of digital solutions—particularly the Internet of Things, blockchain, and analytics automation—affects the efficiency of logistics processes. The need to integrate modern digital tools into logistics chains to maintain the competitiveness of Ukrainian enterprises in the global market is identified. An analysis of Ukraine's logistics infrastructure reveals critical challenges associated with digital transformation. The article proposes approaches to optimizing logistics processes through the adoption of innovative technologies, which are expected to reduce costs, increase delivery speed, and improve customer service quality. Additionally, the role of state policy and legislative initiatives in supporting the digitalization of logistics chains is discussed.

Keywords: logistics, logistics infrastructure, logistics management, digital transformation, digital technologies, sustainable development.

1 Introduction

The specificity of the current functioning of the Ukrainian national economy includes addressing issues related to the destructive impact of war on logistics supply chain management. Additionally, there is a pressing need to ensure that traditional logistics processes comply with the demands of the modern market, which is undergoing significant transformation due to globalization and the digitalization of economic systems. Consequently, optimizing and enhancing business competitiveness requires the integration of digital technologies—such as blockchain, the Internet of Things, artificial intelligence, and analytics automation—into logistics chains. The convergence of these technologies fosters transparency, speed, accuracy, and adaptability in logistics processes. However, the implementation of digital technologies in logistics in Ukraine remains at an early stage and is hindered by several challenges.

Key obstacles to the digital transformation of logistics chains include the underdevelopment of digital infrastructure, limited financial resources for investing in modern technologies, and the absence of a comprehensive state-level strategy to support logistics digitalization. Furthermore, there is a shortage of qualified personnel with the expertise to apply digital solutions in logistics. This deficit has been exacerbated by wartime conditions, making it even more challenging to integrate innovative technologies and develop effective logistics chains.

It is also important to highlight the need for a unified legal framework to regulate the use of digital technologies in the logistics sector. Currently, various barriers arise from legal uncertainty, cybersecurity concerns, and data protection issues. Additionally, the lack of standardization and uniform protocols for operational procedures complicates interactions among different stakeholders in logistics processes, resulting in inefficiencies and increased costs.

Therefore, it can be concluded that there is an essential need to analyze and develop approaches for effective management of

logistics chains, considering the convergence of digital technologies [31]. This would enable the creation of an innovative and flexible logistics system that meets the modern demands of the digital economy.

2 Literature Review

Modern research in logistics and supply chain management highlights the increasing role of digital technologies in transforming the industry. Scientific literature addresses the digitization of logistics chains through the application of technologies such as the Internet of Things, blockchain, artificial intelligence, automation, and big data analytics. Specifically, studies by I. Arakelova [2], I. Britchenko [4-8], N. Khomiuk [18], M. Rudenko [21], and R. Sodoma [29] underscore the importance of implementing digital solutions to enhance the efficiency and transparency of logistics processes. Notably, the integration of the Internet of Things into logistics management systems facilitates real-time data acquisition and analysis, which contributes to optimizing inventory management, transportation, and customer service.

The issue of logistics digitization is also explored in the research by M. Dziamulych [9-15], V. Kostiuk [19], V. Sarioglo [22], and A. Verzun [32], who examine the challenges and opportunities associated with the digital transformation of logistics chains in Ukraine. These studies emphasize the need to adapt digital technologies to the specific conditions of the Ukrainian economy, which faces infrastructural and legal constraints exacerbated by the ongoing war. The importance of developing a national strategy for logistics digitization, addressing contemporary challenges, and integrating Ukrainian enterprises into global supply chains is also highlighted.

The implementation of digital technologies in logistics is closely tied to the concept of Industry 4.0, as discussed in the works of N. Antoniuk [1], S. Filatov [17], I. Mazniev [20], T. Shmatkovska [23-28], and other researchers. These studies highlight that Industry 4.0 involves the use of interconnected systems and automation to enhance the efficiency of production and logistics processes. This aspect underscores the necessity for an integrated approach to implementing digital solutions, which must encompass not only technological elements but also socio-economic, legal, and organizational factors.

Despite the considerable body of research dedicated to managing logistics chains within the context of digital technology convergence in specialized scientific literature, there remains a need to further develop and refine these studies. A comprehensive analysis of the challenges and opportunities associated with integrating digital technologies into logistics chains in Ukraine is essential, considering both the national characteristics of its economic framework and global best practices.

3 Materials and Methods

A comprehensive approach employing various general and specialized scientific methods was used to address the research objectives. The primary methods included comparison, analysis, synthesis, as well as abstract reasoning and logical generalization. This methodology enabled a thorough examination of the challenges associated with managing logistics chains amidst the convergence of digital technologies and facilitated the formulation of practical recommendations for optimizing logistics processes.

Specifically, the comparison method was employed to evaluate the level of digitization of logistics chains in Ukraine relative to other countries. This method revealed significant differences in the approaches to implementing digital technologies and

identified which strategies could be effectively adapted to the Ukrainian context.

Methods of analysis and synthesis were employed to examine the key aspects of implementing digital technologies in logistics chains. The analysis facilitated a review of the components of logistics processes in the context of their digital transformation. This included an examination of existing challenges in the digitalization of logistics in Ukraine, such as infrastructural, financial, and regulatory barriers. The synthesis method was then used to integrate the findings and develop a comprehensive strategy for managing logistics chains through digital technologies. This approach enabled the formulation of a holistic perspective on how the integration of digital solutions can enhance the efficiency and flexibility of logistics processes.

The abstract method was applied to develop a theoretical model for the digitization of logistics chains. This method highlighted the critical elements of digital transformation and created conceptual diagrams to illustrate the relationships between various components of logistics and digital technologies. The use of the abstract method helped avoid excessive detail and focus on the fundamental principles and laws underpinning the digital transformation of logistics. These principles formed the basis for developing recommendations for managing logistics chains in the context of digitalization.

At the final stage of the research, the method of logical generalization was employed to summarize the results and draw conclusions. This method enabled the integration of findings from the analysis and synthesis stages, highlighting key trends and patterns in the digitalization of logistics chains. Consequently, recommendations were developed for advancing Ukraine's logistics infrastructure and implementing digital technologies in logistics processes, with consideration of national characteristics.

Thus, the application of a defined set of research methods facilitated a comprehensive and in-depth analysis of logistics chain management within the context of Ukraine's economic digital transformation.

4 Results and Discussion

The analysis and management of logistics chains within the context of the active integration of digital technologies in Ukraine's economy present unique challenges. These challenges include the need to adapt logistics systems to the dynamic changes in the digital environment. Integrating modern technologies at every stage of the logistics chain is essential to enhance transparency, accuracy, and speed in business processes. Concurrently, the analysis of logistics data becomes increasingly complex, requiring big data and analytics for demand forecasting, route optimization, and inventory management. Ukrainian companies face additional hurdles, such as limitations in digital infrastructure, insufficient investment, and a shortage of qualified personnel, largely due to the destructive impact of the war on the national economy. Addressing these issues necessitates a new approach to managing logistics chains, focused on flexibility and innovation. Thus, effective management requires a comprehensive strategy that accounts for the features of the digital economy and enhances overall enterprise competitiveness [3].

The convergence of digital solutions significantly transforms the management of logistics processes, making them more efficient, transparent, and adaptable. This transformation impacts various aspects of logistics, from monitoring and control to strategic planning and resource optimization. Crucially, these technologies do not merely complement existing business processes but fundamentally alter them, offering new opportunities to boost productivity, reduce costs, and improve service quality. A key mechanism of this transformation is the increased transparency of logistics chains. Technologies such as the Internet of Things and blockchain enable real-time tracking of goods, providing a complete view of the condition and location of each cargo unit throughout its journey. This shift

from disparate data sources and accounting systems to a unified information platform ensures that logistics operators, manufacturers, suppliers, and customers have access to current and reliable information. Such transparency helps prevent discrepancies and facilitates the quick resolution of supply chain issues. The effectiveness of digital solutions is further evidenced by the dynamics of investments in Ukraine's logistics infrastructure (Figure 1).

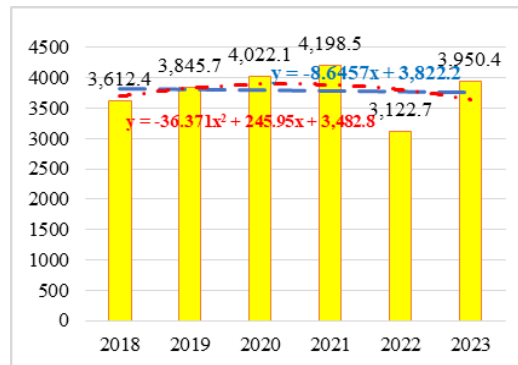


Figure 1. Correlative assessment of the dynamics of investments in logistics infrastructure in Ukraine for 2018-2021, UAH million.

Source: calculated by the author based on [30]

The figure illustrates that the calculated parameters of the linear trend indicate a decrease in the volumes of Ukraine's logistics infrastructure during the analyzed period. This decline is attributed to the adverse impact of Russian aggression on the national economy. Specifically, the absolute decrease in this indicator amounted to UAH 8.6457 million. Conversely, the analysis of the polynomial trend reveals that the actual annual change in financing volume is UAH 245.95 million, with an initial reduction of UAH 36.371 million.

Additionally, the consistency of information provided by blockchain technology is crucial for enhancing the overall efficiency of logistics systems. Traditional systems often encounter issues with data disparity and the complexity of data exchange between different supply chain participants. Each party typically operates its own accounting system, which can result in discrepancies and errors due to the varied functionalities of the software. In contrast, blockchain offers a single, immutable, and secure record of all transactions and events within the supply chain. This ensures that all participants have access to the same information, fostering trust and collaboration. Such data integration helps to reduce reconciliation times, expedite order processing, and improve overall efficiency.

Automation of analytics processes plays a crucial role in enhancing the efficiency of logistics operations. By automating data collection and analysis, logistics companies can swiftly respond to shifts in demand, market conditions, or risk realization. Specifically, automated systems can process vast amounts of data from diverse sources—such as IoT sensors, warehouse management systems, and transportation systems—providing actionable insights for making optimal decisions under varying conditions. This capability increases the speed and accuracy of decision-making, thereby reducing enterprise costs and boosting operational productivity.

Another key aspect of this process is resource and process optimization. The convergence of digital solutions enables more effective planning and utilization of resources, including transportation, warehouse space, and labor. For instance, data gathered via IoT sensors can be used to optimize delivery routes, minimize downtime, and ensure efficient vehicle loading. Additionally, automated analytics can forecast demand, determine optimal inventory levels, and guide timely stock replenishment decisions. This approach helps prevent overstocking, which ties up capital, and avoids market shortages.

Furthermore, the integration of digital solutions enhances the flexibility and adaptability of logistics chains. The modern market is characterized by high dynamism and unpredictability, necessitating rapid adaptation by companies. IoT technologies and automated analytics enable logistics operators to adjust plans and routes promptly in response to real-time conditions, such as traffic congestion, customs delays, or fluctuations in demand. This results in minimized operational delays, optimized costs, and timely delivery of goods.

An essential aspect of the impact of the convergence of digital solutions is the improvement of interaction between participants in the logistics chain. It is known that traditional logistics chains are often characterized by a complex structure with many parties involved, including manufacturers, suppliers, transport companies, warehouses, distributors, etc. Each has its processes, systems, and requirements, which can complicate the exchange of information and the coordination of actions in moving goods and services. However, digital technologies provide a single platform for data exchange and commercial interaction between parties, which facilitates better coordination. As a result, all supply chain participants get the opportunity to achieve more effective management of logistics processes.

It is important to note that the convergence of digital solutions also contributes to reducing enterprises' operating costs. Automation and digitization of business processes can minimize manual labor and errors while accelerating order processing. For instance, automated warehouse management systems can optimize inventory placement, decreasing the time required to locate and prepare goods for shipment. This efficiency reduces logistics operation costs and enhances personnel productivity. Additionally, digital solutions facilitate the reduction of paper document handling and associated expenses, leading to more efficient and environmentally responsible logistics management.

Another benefit of digital convergence is the enhancement of customer service. In the current market, customers expect timely and reliable delivery from logistics providers, along with real-time order tracking. IoT technology enables customers to receive up-to-date information about delivery status, boosting their trust and satisfaction. Furthermore, automated analytics systems can forecast delivery times with greater accuracy by considering various factors. This capability allows for more realistic delivery time estimates and improves overall service quality. However, it is noteworthy that following the onset of Russian aggression in 2022, the volume of investments by Ukrainian companies in logistics digitalization decreased (Figure 2).

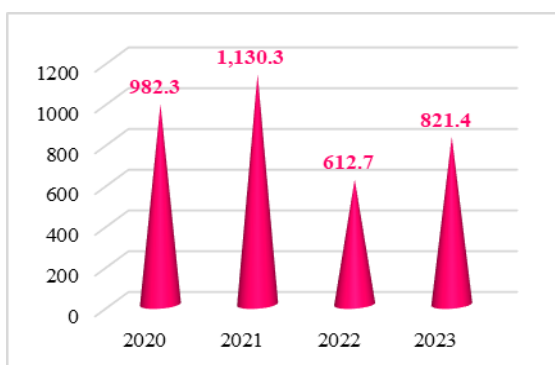


Figure 2. Volumes of investments in digital software solutions by logistics companies of Ukraine for 2020-2023, in million UAH.

Source: [30]

As shown, in 2022, the volume of investments by Ukrainian logistics operators in digital technologies nearly halved, decreasing from UAH 1,130.3 million to UAH 612.7 million. However, with the stabilization of the market situation in 2023, expenditures on digitalization increased to UAH 821.4 million. Although this figure has not yet reached pre-war investment levels, it indicates that the need to enhance the efficiency of

supply chains through digital solutions remains highly relevant for Ukrainian operators.

Ultimately, the convergence of digital solutions enhances the resilience of logistics chains against external challenges and risks. Modern supply chains are subject to numerous threats, but companies can anticipate potential risks and implement preventive measures thanks to big data analytics and automated monitoring systems. As demonstrated in practice, these systems can suggest alternative delivery routes in the event of obstacles, ensuring supply continuity and mitigating the negative impact on business. Based on this convergence, methods for minimizing risks associated with the integration of digital technologies into supply chains can be determined (see Table 1).

Table 1: Methods of minimizing the risks of digital logistics

The main risks in logistics	Risk minimization measures in digital logistics
Spoilage of cargo, total or partial loss of consumer properties or product type	Marking of cargo with special sensors that determine temperature, humidity and other transportation parameters online
Loss of cargo, theft, shortage, mistaken shipment to third parties, late delivery	Digital coding, which makes it possible to enter all the necessary information into the marking of the cargo and track it anywhere in the traffic
Improper preparation of accompanying documents, inability to clear cargo	Electronic customs, preventing documents from entering the database and detecting errors even before the cargo has left
Disclosure of trade secrets or confidential information	Coding of information in digital transmission channels
Environmental risks due to violations of the rules of transportation and storage of goods	Equipping vehicles with "cloud" technology programs makes it possible to minimize or eliminate empty mileage. Ecology
The risk of civil liability for causing damage to third parties, traffic accidents	The use of RIO-type programs enables drivers to use the most convenient, safe vehicle control parameters, taking into account road conditions. Unmanned control. Delivery of goods by drones
Reputational risks, freedom from corruption, careful selection of partners	Transparency of contracts, verification of documentation

Source: [17]

Thus, the convergence of digital solutions directly enhances the efficiency of logistics processes through several key mechanisms. It increases the transparency and reliability of data, improves interactions among supply chain participants, optimizes resource utilization, and reduces operational costs for businesses. Consequently, these advancements contribute to the development of more flexible, adaptive, and sustainable logistics systems, capable of effectively addressing modern market challenges and maintaining high levels of business competitiveness.

5 Conclusion

Thus, we conclude that the convergence of digital technologies is a critical factor in enhancing the efficiency of logistics chains in Ukraine. Integrating solutions based on the Internet of Things, blockchain, and automation improves transparency, optimizes inventory management, and ensures flexibility in responding to market changes. This is essential for Ukrainian logistics companies aiming to boost their competitiveness amid the ongoing conflict and the broader digital transformation of the economy.

However, the successful implementation of digitalization in logistics requires robust support from the government. The role of state policy is pivotal in this context. The government should provide a supportive regulatory environment, promote the development of digital infrastructure, and encourage innovation within the logistics sector [33]. This includes developing regulations that govern the adoption of digital technologies and creating incentives for businesses to invest in these solutions. Additionally, government support for the education and development of digital skills is crucial for training qualified personnel capable of effectively utilizing new technologies.

A comprehensive approach is necessary to optimize logistics processes, which includes implementing advanced supply chain management systems that leverage big data and analytics for

demand forecasting and route optimization. The development of integrated platforms for data exchange among logistics chain participants will enhance coordination and reduce operational costs. The active use of blockchain technologies is also recommended to ensure transparency and security in supply chain operations. Therefore, the successful digitization of logistics chains in Ukraine can only be achieved through coordinated efforts between businesses and the government. Integrating modern digital technologies into logistics will enable optimized processes, reduced costs, and sustained national economic development amidst digital transformation.

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