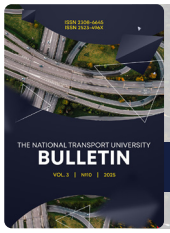

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Concept and structure of an improved risk management system in international transportation

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Abstract. In the conditions of international transportation development, characterised by a high level of uncertainty, increased requirements for customs control, and active digitalisation of logistics processes, the issue of effective risk management is of particular importance. Risks arise at the intersection of transport, logistics, and customs operations, have a complex nature, and are capable of spreading along the entire supply chain, which complicates their timely identification and mitigation. The aim of the study was to develop a concept and structure of an improved risk management system in international transportation, focused on process integration and real-time decision support. The study employed system analysis, methods of structural and functional modelling, risk assessment methods in accordance with ISO 31000 provisions, as well as fuzzy logic methods to formalise decision-making processes under conditions of uncertainty and incomplete information. A hierarchical transport and technological risk management system was proposed, covering all stages of international cargo transportation – from planning to execution control. The composition of key subsystems was defined, including identification, assessment, decision support, implementation of mitigation measures, and monitoring. A methodology for forming an integrated risk map had been developed, enabling the determination of risk criticality levels and the establishment of management priorities. An architecture of an intelligent decision support system was proposed, ensuring the integration of data, expert evaluations, and analytical tools. The results of the study can be used to improve the efficiency of customs control, reduce delays in international transportation, optimise logistics processes, and enhance the reliability of transport system operations

Keywords: customs procedures; logistics processes; digitalisation; integrated risk map; fuzzy logic; decision support system

Introduction

The modern development of international transportation is characterised by a high level of uncertainty, increasing complexity of transport and logistics processes, and stricter requirements for customs control. The conditions of globalisation, digitalisation of the economy, and geopolitical instability lead to the emergence of new types of risks that affect all stages of cargo delivery – from route planning to the completion of customs clearance. Under these conditions, the formation of an effective risk management system becomes particularly important, as it should ensure the adaptability of transport and logistics systems, enhance their resilience, and minimise losses caused by adverse factors. At the same time, traditional approaches to risk management no longer meet current requirements,

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which necessitates the development of new conceptual solutions based on the integration of digital technologies, analytical tools, and modern decision-support methods.

A significant contribution to the study of risk management in transport and logistics systems has been made by both Ukrainian and international researchers. In particular, K. Yereshko *et al.* (2024) demonstrated that the resilience of supply chains directly depends on the ability of the system to adapt to external changes, while effective risk management is a key factor in ensuring such resilience. In turn, Yu. Zhyshchynskyi & O. Sharko (2025) substantiated the need for a risk-oriented approach to logistics management, emphasising the importance of comprehensive consideration of uncertainty factors. The issues of digitalisation of logistics processes and their impact on risk management are addressed in the works of S. Sakhno & Yu. Khrutba (2025), who found that the implementation of digital technologies enhances transparency and efficiency in supply chain management. A similar position is held by D. Bugayko & V. Reznik (2025), who proved that the use of intelligent transport systems significantly reduces risk levels through real-time monitoring and data analysis. An important aspect of the research is related to the application of modern analytical tools and artificial intelligence in risk management. Thus, V. Prokhorova *et al.* (2025), in their systematic review, established that the use of Big Data & AI significantly improves the accuracy of risk assessment and contributes to more informed managerial decision-making. In turn, V. Tyshchenko *et al.* (2022) identified key directions for the application of artificial intelligence in supply chain risk management, emphasising its role in forecasting and mitigating negative impacts.

A separate group of studies focuses on the analysis of risks in the transport system of Ukraine. In particular, A. Dolgui & D. Ivanov (2021) noted that the digitalisation of customs procedures is a key factor in improving the efficiency of risk management in international trade. Yu. Zhyshchynskyi & O. Sharko (2025) proposed approaches to modelling risks in multimodal transportation and substantiated the need for using mathematical models to assess uncertainty. S. Sakhno & Yu. Khrutba (2025) investigated the risks of dangerous goods transportation and found that their management requires consideration of specific safety factors. In turn, A. Dolgui & D. Ivanov (2021) analysed the functioning of the transport market under martial law conditions and identified key threats to international transportation, while S. Hosseini & D. Ivanov (2020) characterised systemic risks affecting the unified transport system of Ukraine. Recent studies also highlight the importance of collaboration and adaptability in supply chains, particularly under crisis conditions, which significantly affects risk mitigation efficiency (Jarašūnienė & Gelžinis, 2025).

Despite the significant number of scientific studies, it should be noted that most existing approaches to risk management are fragmented and do not ensure a comprehensive consideration of the interaction between transport, logistics, and customs processes. In addition, issues related to the integration of digital platforms, monitoring systems, and analytical tools into a unified decision-support system remain insufficiently explored. The lack of a coherent concept that combines traditional risk management methods with modern digital tools limits the possibilities for improving the efficiency of international transportation. The aim of the study was to develop a scientifically grounded concept and structure of an improved risk management system in international transportation, which ensures the integration of transport, logistics, and customs processes, as well as the use of digital technologies and intelligent data analysis methods to enhance the effectiveness of managerial decision-making under conditions of uncertainty.

Literature Review

The issue of risk management in international transportation has become increasingly relevant at the current stage of development of transport and logistics systems. This is due to the rapid digitalisation of economic processes, the growing complexity of customs procedures, and the increasing influence of external uncertainty factors. Globalisation processes, the transformation of international supply chains, and geopolitical instability significantly affect the functioning of transport systems and create new challenges for ensuring their efficiency and reliability. Under such conditions, risks arise at all stages of cargo delivery, including planning, transportation, customs clearance, and final distribution. Therefore, the development of effective approaches to risk management is a key prerequisite for improving the sustainability and competitiveness of international transportation systems.

A significant contribution to the study of risk management in transport and logistics systems has been made by both Ukrainian and foreign researchers. In particular, V. Tyshchenko *et al.* (2022) demonstrated that the resilience of supply chains depends on the ability of logistics systems to adapt to changes in the external environment. The authors emphasised that effective risk management serves as a fundamental mechanism for ensuring stability and continuity of transport processes. In a related study, V. Prokhorova *et al.* (2025) substantiated the importance of applying a risk-oriented approach to logistics management, highlighting the need to consider uncertainty factors in a comprehensive and systematic manner. The impact of digital transformation on logistics processes and risk management has also been widely studied in recent years. A. Dolgui & D. Ivanov (2021) found that the implementation of digital technologies significantly enhances transparency in supply chain operations and contributes to more efficient risk monitoring and control. According to the authors, digital platforms enable real-time data exchange and improve coordination between stakeholders, which is crucial for reducing operational risks. A. Jarašūnienė & M. Gelžinis (2025) demonstrated that intelligent transport systems play an important role in minimising risks by enabling real-time monitoring of transport operations and predictive analysis of potential disruptions.

An important direction of modern research is the application of advanced analytical tools and artificial intelligence in risk management. For instance, T. Wang *et al.* (2022) conducted a comprehensive review and concluded that the use of Big Data analytics and artificial intelligence significantly improves the accuracy of risk assessment and supports more effective decision-making. Their findings indicate that data-driven approaches allow for early identification of potential threats and provide opportunities for proactive risk mitigation. In turn, V. Lebid *et al.* (2021) analysed the role of artificial intelligence in supply chain risk management and identified key areas of its application, including risk prediction, scenario modelling, and optimisation of decision-making processes under uncertainty.

A separate group of studies focuses on risk management in the transport system of Ukraine, particularly in the context of digitalisation and external challenges. K. Yereshko *et al.* (2024) emphasised that the digitalisation of customs procedures is a critical factor in improving the efficiency of risk management in international trade. The authors highlighted the importance of integrating information systems and analytical tools into customs processes to enhance their effectiveness. Yu. Zhyshchynskyi & O. Sharko (2025) proposed approaches to modelling risks in multimodal transportation and demonstrated the necessity of applying mathematical models to assess uncertainty and support decision-making. Furthermore, S. Sakhno & Yu. Khrutba (2025) investigated the risks associated with the transportation of dangerous goods and concluded that their management requires consideration of specific safety-related factors and regulatory requirements. In addition, D. Bugayko & V. Reznik (2025) analysed the functioning of the transport services market under martial law conditions and identified key threats that significantly affect international transportation. The authors pointed out that increased uncertainty and disruption of logistics chains require the development of adaptive risk management strategies. V. Prokhorova *et al.* (2025) examined systemic risks in the unified transport system of Ukraine and concluded that these risks are complex and interconnected, which necessitates a comprehensive and integrated approach to their management. The application of mathematical modelling and fuzzy logic approaches in customs processes has been substantiated in recent studies by G. Prokudin *et al.* (2025).

Despite the considerable number of scientific studies in this field, it should be noted that most existing approaches to risk management are fragmented and focus on individual aspects of the problem. In many cases, researchers concentrate on specific elements such as risk assessment methods, digitalisation of logistics processes, or supply chain resilience, without considering the interaction between transport, logistics, and customs processes within a unified system. This limitation reduces the effectiveness of risk management practices in real-world conditions, where these processes are closely interconnected and mutually dependent. Moreover, issues related to the integration of digital platforms, monitoring systems, and analytical tools into a unified decision-support system remain insufficiently explored. Although modern technologies provide significant opportunities for improving risk management, their practical implementation often faces challenges related to data integration, system compatibility, and organisational readiness. In this context, there is a growing need to develop integrated approaches that combine traditional risk management methods with advanced digital solutions. Thus, the analysis of recent scientific publications confirms the existence of a solid theoretical foundation in the field of risk management in international transportation, while also highlighting the need for further research aimed at developing integrated and adaptive systems. Such systems should be capable of effectively managing risks under conditions of uncertainty and ensuring the resilience of transport and logistics processes.

Materials and Methods

The methodological framework of this study was based on a systems approach to the analysis of risk management processes in international transportation, which enables the consideration of transport, logistics, and customs operations as a unified integrated system. This approach ensured a comprehensive understanding of risk formation mechanisms and supports the development of effective management solutions under conditions of uncertainty. The research was conducted in several sequential stages. At the first stage, an analysis of the current state of risk management in international transportation was performed based on scientific publications, international standards, and regulatory documents, including ISO 31000:2018 (2018), World Customs Organization (n.d.), European Commission (n.d.). This stage made it possible to identify the main categories of risks and determine the limitations of existing approaches.

At the second stage, methods of systems analysis and structural-functional modelling were applied (Prokudin *et al.*, 2025). Within the framework of this approach, the risk management system was considered as a multi-level structure covering all stages of cargo delivery – from transportation planning to execution control. The proposed system includes interconnected functional blocks: data collection, risk identification, risk assessment decision-making, implementation of measures and monitoring (Vijayakumar, 2025). A key methodological element of the study was the formalisation of risk assessment using a quantitative approach based on two main parameters: probability of occurrence and severity of consequences. The integrated risk indicator was calculated using the following expression (1):

$$R = P \times S, \tag{1}$$

where R – integrated risk indicator; P – probability level of the event; S – level of impact or severity of consequences.

To ensure consistency in evaluation, a five-level scale is used for both probability and severity parameters, ranging from 1 (very low) to 5 (very high). The combination of

these values formed a 5×5 risk matrix, which enabled classification of risks according to their criticality level. Based on this matrix, risks were categorised as low, medium, high, or critical, which provided a foundation for prioritising management actions. The methodology also included the construction of an integrated risk map, which served as a visualisation tool for representing the distribution of risks within the system. The development of the risk map was carried out through a sequence of steps: identification of key risk groups (customs, transport, logistics, documentary, and security risks); assessment of probability and severity for each risk; calculation of the integrated risk indicator; placement of risks within the matrix; determination of appropriate management measures.

This approach allowed for the systematisation of risks, identification of critical vulnerabilities, and development of targeted mitigation strategies. An important component of the methodology was the application of fuzzy logic methods to model decision-making processes under conditions of uncertainty. A significant proportion of risk parameters were of a vague, qualitative nature and cannot be adequately described using classical mathematical methods. The applicability of fuzzy logic methods for decision-making in transport systems had been widely discussed in recent research (Pálková & Mašek, 2024). Hybrid approaches combining fuzzy logic and neural networks have also been proposed for risk assessment in international trade (Luo *et al.*, 2023). The integration of digital traceability technologies further enhances risk control capabilities (Kamble *et al.*, 2020). Quantitative methods for supply chain resilience analysis provide a strong foundation for risk assessment models (Dong & Tian, 2025).

The fuzzy logic model was implemented using a standard structure that includes the following stages: fuzzification – transformation of quantitative input parameters into fuzzy linguistic variables using membership functions; rule Base – formation of a system of expert "if-then" rules reflecting knowledge in logistics and customs processes; inference Engine – logical processing of rules using algorithms such as Mamdani or Sugeno; defuzzification – conversion of fuzzy results into a numerical value using the centroid method. The integrated risk level within the fuzzy model is represented as a generalised function (2):

$$R = f(R_m, R_l, R_i, R_t), \quad (2)$$

where R_m – the customs risk; R_l – the logistics risk; R_i – the infrastructure risk; R_t – the time-related risk.

This representation enabled the incorporation of multiple heterogeneous factors into a unified risk assessment model and allows the consideration of expert judgments and incomplete data. To support the practical implementation of the proposed approach, an architecture of an intelligent decision support system (DSS) was developed. The system integrates data from multiple sources, including Global Positioning System (GPS), customs information systems (such as new computerised transit system (NCTS) and automated risk analysis systems), and analytical platforms. The effectiveness of data-driven customs risk management systems has also been confirmed in recent studies (Vijayakumar, 2025). The DSS architecture includes the following components: data acquisition and preprocessing module; fuzzification module; rule base and inference engine; defuzzification module; risk evaluation module (Risk Score); decision-making module; feedback loop. The presence of a feedback mechanism ensures continuous improvement of the system through accumulation of experience and adjustment of model parameters.

Furthermore, the methodology required the integration of digital technologies into the risk management process. The use of GPS monitoring, customs information systems and analytical platforms makes it possible to automate the risk assessment process, ensure a prompt response to anomalies and improve the effectiveness of management decisions. Thus, the proposed methodology combines classical quantitative approaches, fuzzy logic methods, and digital technologies into a unified framework for risk management in international transportation. This ensures a high level of adaptability, scalability, and practical applicability of the developed system.

Results and Discussion

The results of the study demonstrate the practical implementation of the proposed integrated risk management system for international transportation and confirm its effectiveness under conditions of uncertainty. The developed system is based on a multi-level structure that integrates transport, logistics, and customs processes into a unified information and analytical environment. The application of a systems approach made it possible to form a structured model consisting of interconnected functional blocks, each of which performs a specific role within the overall risk management framework. As a result of the study, a conceptual structure of the risk management system was developed, which includes ten key stages: data collection, risk identification, risk assessment, fuzzification, rule formation, logical inference, defuzzification, decision-making, implementation of measures, and monitoring with feedback. This structure ensures the continuity of the risk management process and enables the integration of analytical and operational components into a single system. The developed digital model of risk management in international transportation consists of 10 blocks (Table 1).

The presented structure reflects a comprehensive approach to risk management, where each stage is logically interconnected and contributes to the formation of a unified analytical system. The integration of digital tools ensures the automation of processes and enhances decision-making efficiency. The practical application of the model made it possible to identify key risk groups characteristic of international transportation. The study of risks in international road transportation made it possible to develop a risk assessment matrix for international road transport (Table 2).

Table 1. Structure of the risk management system for international transportation

Stage / system block	Input data	Process (functions)	Output / result	Tools / technologies
Data	Cargo characteristics, route, customs procedures	Data collection and aggregation	Analytical database	GPS, ERP, customs systems
Risk identification	Transport data	Identification of risks	List of risks	Data analysis, expert evaluation
Risk assessment	Identified risks	Risk evaluation	Risk level	Risk matrix (5 × 5), ISO 31000
Fuzzification	Quantitative parameters	Transformation into fuzzy variables	Linguistic variables	Membership functions
Rule base	Fuzzy variables	Formation of rules	Rule set	Expert knowledge
Inference engine	Rule base	Logical inference	Fuzzy result	Mamdani / Sugeno
Defuzzification	Fuzzy result	Conversion to numerical value	Risk score	Centroid method
Decision making	Risk score	Formation of decisions	Recommendations	DSS
Implementation	Decisions	Execution of measures	Risk mitigation	NCTS, ASARM
Monitoring	Execution data	Monitoring and adjustment	System update	BI systems

Note: GPS – Global Positioning System; ERP – Enterprise Resource Planning; DSS – Decision Support System; NCTS – New Computerised Transit System; ASARM – Automated System for Analysis and Risk Management

Source: developed by the authors

Table 2. Risk assessment matrix for international transportation

Risk type	Probability (P)	Impact (S)	Risk value	Level
Customs risks	3	4	12	High
Transport risks	3	3	9	Medium
Documentary risks	4	3	12	High
Logistics delays	4	2	8	Medium
Security risks	2	5	10	High

Source: developed by the authors

The analysis of risks presented in Table 2 shows that customs and documentary risks have the highest level of criticality, which confirms their significant influence on the efficiency of international transportation. These risks are primarily associated with delays in customs clearance, inconsistencies in documentation, and the activation of automated control systems. Transport risks are related to operational factors such as vehicle condition, infrastructure, and weather conditions. Although their impact is moderate, their frequency makes them an important factor affecting transportation reliability. Logistical risks arise from disruptions in coordination between supply chain participants, including delays at border crossings and terminal congestion. Security risks, despite their lower probability, have severe consequences and therefore require special attention in risk management strategies. Their presence highlights the importance of implementing preventive measures and ensuring cargo protection. The visualisation of risks within the matrix enabled the construction of an integrated risk map, which reflects their relative importance and supports the prioritisation of management actions. This approach ensures the transition from fragmented risk analysis to a systematic and structured risk management process.

The results also demonstrate the effectiveness of integrating digital technologies into the risk management system. The use of GPS monitoring, customs information systems, and analytical platforms ensures real-time tracking of transportation processes and improves the responsiveness of management decisions. The implementation of intelligent decision support systems allows for the processing of large volumes of data and the generation of recommendations based on integrated risk indicators. This significantly reduces decision-making time and enhances the accuracy of risk assessment. Comparison of performance indicators before and after implementation of the risk management system (Table 3).

Table 3. Comparison of performance indicators before and after implementation of the risk management system

Indicator	Before implementation	After implementation	Change (%)	Explanation of improvement
Average customs clearance time (hours)	18-24	10-14	↓ 35-45	Automation of procedures, reduced manual checks
Probability of delays (%)	30-40	15-20	↓ 40-50	Risk prediction and route optimisation
Number of documentary errors (%)	12-15	5-7	↓ 50-60	Digital document verification and standardisation

Table 3, Continued

Indicator	Before implementation	After implementation	Change (%)	Explanation of improvement
Frequency of additional inspections (%)	25-30	12-18	↓ 35-45	Risk-based customs control (ASARM/NCTS)
Logistics costs per shipment (%)	100 (baseline)	85-90	↓ 10-15	Improved coordination and reduced idle time
Risk detection accuracy (%)	60-65	80-85	↑ 25-30	Use of analytics and fuzzy logic
Level of supply chain transparency (%)	50-60	80-90	↑ 40-50	Integration of GPS and digital platforms
Decision-making time (hours)	6-8	2-3	↓ 60-70	DSS implementation and automation

Note: GPS – Global Positioning System; DSS – Decision Support System; NCTS – New Computerised Transit System; ASARM – Automated System for Analysis and Risk Management

Source: developed by the authors based on modelling results

The comparative analysis of performance indicators before and after the implementation of the proposed risk management system demonstrates a significant improvement in the efficiency of international transportation processes. In particular, the average customs clearance time decreased by up to 45%, while the probability of delays was reduced by nearly half. This confirms the effectiveness of integrating digital technologies and analytical tools into logistics and customs operations. A notable reduction in documentary errors and the frequency of additional inspections indicates improved data quality and the successful application of risk-oriented customs control. At the same time, the use of intelligent decision support systems contributed to a substantial decrease in decision-making time and an increase in risk detection accuracy. Overall, the obtained results confirm that the implementation of the proposed system leads to enhanced transparency, reduced operational costs, and improved reliability of international transportation processes. The reduction in customs clearance time and delays indicates improved coordination between logistics and customs processes. The decrease in documentary errors demonstrates the effectiveness of digital document processing and standardisation.

At the same time, the reduction in logistics costs reflects improved route optimisation and reduced downtime. These results confirm that the proposed system enables the transition from reactive to proactive risk management. The developed DSS plays a central role in ensuring these improvements. By integrating analytical tools and digital platforms, the system supports real-time monitoring and adaptive management of transportation processes. Thus, the obtained results confirm the effectiveness of the proposed concept of an integrated risk management system. The developed model ensures improved transparency, reduced risks, increased efficiency, and high adaptability of international transportation systems under conditions of uncertainty.

The obtained research results confirm that effective risk management in international transportation requires a transition from fragmented approaches to integrated system solutions that encompass all stages of the transport and logistics process (Osipchuk, 2024). The proposed hierarchical risk management model, which combines transport, logistics, and customs aspects, is consistent with modern scientific approaches; however, it extends them through comprehensive process integration and the use of intelligent analytical methods by N. Luo *et al.* (2023). In particular, the results correlate with the findings of V. Tyshchenko *et al.* (2022), who substantiate the necessity of ensuring supply chain resilience under conditions of uncertainty. At the same time, this study further develops this idea by detailing risk management mechanisms at the level of international transportation, taking into account the specifics of customs procedures. V. Lebid *et al.* (2021) emphasise a risk-oriented approach to logistics system management; however, their research focuses mainly on organisational and economic aspects, whereas the present study proposes a specific structural and functional model of the system.

An important direction of modern research is the digitalisation of logistics processes. Thus, K. Yereshko *et al.* (2024) consider digital transformation as a key factor in improving the efficiency of logistics systems. In this study, these provisions are further developed through the integration of digital systems (GPS, NCTS, analytical platforms) into the risk management process, enabling real-time decision-making. Among Ukrainian scholars, the work of Yu. Zhyshchynskyi & O. Sharko (2025) should be highlighted, as it examines the digitalisation of customs procedures and the implementation of risk-oriented technologies. The results obtained in this article confirm the importance of this direction but extend it by integrating customs risks with transport and logistics risks. Studies by S. Sakhno & Yu. Khrutba (2025) focus on risk modelling in multimodal transportation and the transportation of dangerous goods, respectively. In contrast to these works, the present study proposes a universal model applicable to various types of transportation.

Particular attention in scientific research is given to the impact of external factors, especially martial law, on the functioning of transport systems. Thus, A. Dolgui & D. Ivanov (2021) analyse risks and transformations of the transport market under crisis conditions. In this study, these aspects are taken into account in the formation of the risk structure, particularly by identifying security risks as a separate category with a high level of impact. A. Jarašūnienė & M. Gelžinis (2025) are focused on enhancing

the resilience of logistics systems and the use of intelligent transport technologies. In the present study, these approaches are integrated into a broader concept that includes not only transport and logistics but also customs processes, which is particularly important for international transportation.

A significant distinguishing feature of the obtained results is the application of fuzzy logic methods for modelling decision-making processes. Unlike traditional approaches based on precise data, the proposed model allows for the consideration of uncertainty and incomplete information, which is typical of real-world transport system operations. Similar approaches are discussed in the work of V. Borsa & Yu. Terebeichyk (2024). Thus, the research results confirm and further develop existing scientific approaches to risk management in international transportation by proposing their systemic integration, digitalisation, and the application of intelligent analytical methods. The obtained results provide a more comprehensive understanding of the risk management process and create a foundation for further research aimed at implementing intelligent systems in the practice of international transportation.

Conclusions

The conducted study has established that risk management in international transportation under current conditions is characterised by a high level of complexity, driven by the integration of transport, logistics, and customs processes, as well as the influence of uncertainty factors in the external environment. It has been demonstrated that existing risk management approaches are fragmented and do not ensure an adequate level of efficiency without their integration into a unified system. The article develops a concept of an improved risk management system for international transportation based on a systemic approach, covering all stages of the transport and logistics process – from shipment preparation to execution control. The proposed system structure includes functional subsystems for risk identification, assessment, decision support, implementation of risk mitigation measures, and monitoring with feedback.

The proposed risk management system enables the integration of different transportation stages into a unified decision-making framework. The use of a matrix-based approach and fuzzy logic methods ensures more flexible and well-grounded risk assessment. The methodological approach to risk assessment has been improved through the application of the matrix, which allows for quantitative determination of risk levels, their classification according to criticality, and the development of substantiated management decisions. An integrated risk map for international transportation has been constructed, providing systematisation of risks and determination of their priorities. The feasibility of applying fuzzy logic methods for modelling decision-making processes under uncertainty has been substantiated. An architecture of an intelligent decision support system has been developed, enabling the integration of statistical data, expert evaluations, and digital risk analysis tools. Prospects for future research include the development of mathematical models for risk assessment using machine learning methods, as well as the implementation of the proposed system within real digital platforms for managing international transportation.

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Conflict of Interest

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Концепція та структура вдосконаленої системи управління ризиками у міжнародних перевезеннях

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Анотація. В умовах розвитку міжнародних перевезень, що характеризуються високим рівнем невизначеності, посиленням вимог до митного контролю та активною цифровізацією логістичних процесів, питання ефективного управління ризиками набуває особливої ваги. Ризики формуються на стику транспортних, логістичних і митних операцій, мають комплексний характер і здатні поширюватися вздовж усього ланцюга постачання, що ускладнює їх своєчасне виявлення та мінімізацію. Метою дослідження стало розроблення концепції та структури удосконаленої системи управління ризиками у міжнародних перевезеннях, орієнтованої на інтеграцію процесів і підтримку прийняття рішень у режимі реального часу. У роботі було використано системний аналіз, методи структурно-функціонального моделювання, методи оцінювання ризиків відповідно до положень ISO 31000, а також методи нечіткої логіки для формалізації процесів прийняття рішень в умовах невизначеності та неповноти інформації. Запропоновано ієрархічну транспортно-технологічну систему управління ризиками, що охоплює всі етапи міжнародного перевезення вантажів – від планування до контролю виконання. Визначено склад ключових підсистем (ідентифікації, оцінювання, підтримки прийняття рішень, реалізації заходів мінімізації та моніторингу). Розроблено методику формування інтегрованої карти ризиків, що дозволило визначити рівень їх критичності та встановити пріоритети управління. Запропоновано архітектуру інтелектуальної системи підтримки прийняття рішень, яка забезпечує інтеграцію даних, експертних оцінок та аналітичних інструментів. Результати дослідження можуть бути використані для підвищення ефективності митного контролю, скорочення часу затримок у міжнародних перевезеннях, оптимізації логістичних процесів та підвищення надійності функціонування транспортних систем

Ключові слова: митні процедури; логістичні процеси; цифровізація; інтегрована карта ризиків; нечітка логіка; система підтримки прийняття рішень