Безпекоорієнтовані управлінські рішення як основа національного судноплавства за критеріями інноваційного розвитку

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Анотація. Актуальність даного дослідження зумовлена постійно зростаючою увагою до забезпечення системної економічної та навігаційної безпеки у сфері морських перевезень, ефективним управлінням роботою флоту та впровадженні інновацій, в умовах глобалізації економіки та неспинного розвитку індустрії саме інновації є одним із дієвих рушіїв прогресу і набуття конкурентоспроможності.

У цій статті розглядаються управлінські рішення, орієнтовані на безпеку, як одна із фундаментальних основ інноваційного розвитку держави та національного судноплавства.

Метою статті є пошук нових можливостей для автоматизації прийняття управлінських рішень з метою підвищення економічної та системної безпеки судноплавства та морського комплексу. Методологічну основу дослідження становлять порівняльний аналіз, структурно-логічне узагальнення, системний підхід, аналізується роль державної інноваційної політики, цифрових інновацій, типових інновацій, які вже впровадженні в морській індустрії, механізмів стратегічного та операційного регулювання, а також міжнародного досвіду з використання розумних екосистем, портів, хабів, зокрема Європейського Союзу та Азії. Проведено порівняльний аналіз правових нормативів ЄС та України, зазначено спільні та відмінні риси векторів розвитку. Розглянута класична інноваційна політика світових лідерів і сучасних національних стратегій. Особлива увага приділяється впровадженню автоматизованих систем підтримки рішень у морському транспорті як інструменту мінімізації людських помилок та підвищення безпеки навігації, взаємозв'язки управлінських ланок для забезпечення системної безпеки судноплавства. Зазначено особливості розрахунку ризиків у морській індустрії, що впливають на економічну безпеку експлуатації флоту через зменшення можливої аварійності при маневруванні.

Як наслідок, були розглянуті теоретичні можливості використання допоміжних навігаційних систем у національних акваторіях і запропонована модель автоматизованого прийняття управлінських рішень під час прибуття та відправлення з порту, яка демонструє потенціал для підвищення безпеки, економічної ефективності та

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інвестиційної привабливості національного, а на його прикладі і світового, судноплавного сектору.

Ключові слова: інноваційний розвиток; національне судноплавство; управлінські рішення; менеджмент; безпекоорієнтованість.

Safety-oriented management decisions as the basis of national shipping according to the criteria of innovative development

Abstract. The relevance of this study is driven by the growing attention to ensuring systemic economic and navigational security in maritime transportation, effective fleet management, and the implementation of innovations. In the context of economic globalization and the rapid development of the industry, innovation serves as one of the key drivers of progress and competitiveness.

The present study undertakes a comprehensive examination of safety-oriented managerial decisions as one of the fundamental foundations for the development of national shipping within the framework of the state's innovative development.

The purpose of this research is to identify new opportunities for automating managerial decision-making processes in order to enhance the economic and systemic security of shipping and the maritime sector as a whole. The methodological framework of the research is based on comparative analysis, structural and logical generalization, and a systems approach. The study analyzes the role of state innovation policy, digital innovations, and typical innovative solutions already implemented in the maritime industry, as well as mechanisms of strategic and operational regulation and international experience in the use of smart ecosystems, ports, and hubs, particularly in the European Union and Asia. A comparative analysis of the legal and regulatory frameworks of the EU and Ukraine was conducted, identifying common and distinctive vectors of development. Classical approaches to innovation policy adopted by global leaders and contemporary national strategies are also examined. Special attention is given to the implementation of automated decision support systems in maritime transport as a tool for minimizing human error and enhancing navigational safety, as well as to the interconnections among managerial levels in ensuring systemic shipping security. Particular emphasis is placed on the specific features of risk assessment in the maritime industry, which affect the economic security of fleet operations by reducing the likelihood of accidents during maneuvering.

Consequently, theoretical possibilities for the use of auxiliary navigational systems in national waters are identified, and a model for automated managerial decision-making during vessel arrival at and departure from port is proposed. The conceptual model proposed in this research demonstrates potential for improving safety, economic efficiency, and investment attractiveness of both the national and, by extension, the global shipping sector.

Keywords: Innovative development; shipping; management decisions; management; safety.

Problem Statement. Within the framework of accelerating globalization, technological transformation, and increasing international competition, the development of a national innovation policy has become a determining factor in long-term economic sustainability and competitiveness. For Ukraine, which is undergoing structural economic transformation and integration into the European and global economic space, the formation of an effective state innovation base is of strategic importance. This need is especially evident in sectors with high technological intensity and systemic importance, such as maritime transport and shipbuilding. Simultaneously, global trends indicate a shift from traditional models of competitiveness based on production volumes and cost advantages to models determined by the level of technological excellence, digitalization, and effective risk management. The growing role of knowledge, automation, and intelligent systems in ensuring shipping safety and economic efficiency

underscores the need for systemic modernization of maritime governance mechanisms. In developed economies, innovation policies in the maritime sector integrate support for research and development, environmental sustainability, workforce training, digital transformation, and the implementation of automated decision support systems.

Accordingly, the key problem addressed in this study is to identify effective mechanisms for integrating innovation policy instruments with automated decision-making technologies in order to strengthen systemic and economic security in the maritime sector of Ukraine. The lack of a comprehensive model that combines strategic state regulation, digital innovation, risk assessment mechanisms, and operational automation during critical navigation processes such as port arrival and departure constitutes a significant gap in both academic research and practical management.

Solving this problem requires the development of a structured approach that integrates state innovation priorities, international best practices, and modern technological solutions into a single system capable of ensuring sustainable development, enhanced safety standards, and increased investment attractiveness of the national shipping industry.

Analysis of recent research and publications. The issue of innovative factors influencing the development of the maritime industry, the transformation of maritime supply chains, strategic imperatives for the advancement of shipping and ports, and the risks associated with the introduction of digital innovations has become the subject of active scholarly investigation in recent years. In particular, Shaposhnikov D. [1], Lebedchenko V., Tabenko V., and Ponomarenko O. [2] outline key transformations in maritime supply chains and analyze the risks related to the implementation of digital innovations within the industry. Lysenko N. and Lokaiets M. [3], as well as Stovba T.A. [4,5], focus on innovative development factors and strategic priorities shaping the contemporary evolution of the national maritime sector. Melnyk O.M. [6] and Rødseth Ø., Wennersberg L.A.L., and Nordahl H. [7] examine the integration of automation and vessel autonomy within the established maritime transport environment, emphasizing their role in enhancing navigational safety. Gucma M. [9], Bojić F., Bošnjak R., Lušić Z., and Gudelj A. [10], along with Can E. [11], propose significant contributions to auxiliary navigational systems, as well as risk assessment models in navigation and logistics, which may serve as a methodological foundation for the models proposed in this study.

Furthermore, Rusanova S. and Perepichko M. [12], Sotnychenko L.L., Burmaka L.O., and Tabenskyy S.V. [13], Li K., Li M., Zhu Y., Yuen K.F., Tong H., and Zhou H. [14], as well as Melnyk O., Pasternak O., Kucherenko V., Kotenko O., Shcheniavskyi H., Zayats S., Checha O., Varlan T., and Voloshyn D. [15], emphasize the geopolitical factors affecting port stability and examine the effectiveness of implementing the “smart port” concept to reduce operational costs and cargo handling time. Their research addresses complex logistics hubs and models that are expected to become integral components of the industry’s future development, providing quantitative evidence of efficiency gains and environmental impact reduction achieved through artificial intelligence technologies. Nevertheless, despite the considerable body of research, a scientific gap remains in the integration and systematization of these diverse innovative approaches into a unified conceptual and operational framework that could be theoretically adapted and implemented within the national shipping sector.

Highlighting previously unresolved parts of the overall problem. Despite the formal recognition of innovation-oriented development at the highest government level and the adoption of strategic documents, in particular the Law of Ukraine “On Innovation Activity” and the National Transport Strategy of Ukraine until 2030, the practical implementation of innovation policy in the maritime sector remains fragmented and insufficiently systematized. The existing mechanisms of state regulation, financial support and institutional coordination do not fully comply with modern global standards, in particular those demonstrated by the European Union. Consequently, the maritime sector of Ukraine continues to face structural

imbalances, outdated fleet capacities, insufficient technological modernization and limited integration of advanced digital and automated systems.

For Ukraine, the problem has two aspects. On the one hand, there is a need to harmonize the national regulatory and institutional framework with European standards, while preserving national economic interests and strategic priorities. On the other hand, it is necessary to implement practical tools capable of increasing shipping safety, minimizing human errors, reducing operational risks and increasing the cost-effectiveness of fleet operation. Insufficient integration of automated management systems, limited investment in maritime innovation infrastructure and weak coordination between public authorities, private stakeholders and research institutions limit the development potential of the sector.

Formulation of the article's purpose (task statement). The purpose of this paper is to conduct a comprehensive and systematic assessment of innovative marine and navigational technologies, with particular emphasis on their influence on the systemic safety and economic sustainability of the maritime industry. The research aims to determine the financial and economic effects associated with the implementation of proposed technological solutions within the national shipping sector, including their impact on operational efficiency, risk reduction, and investment attractiveness. Furthermore, the study seeks to develop and substantiate a model for the automation of managerial decision-making processes in maritime operations, grounded in the criterion of economic security. The conceptual model proposed in this research is intended to integrate risk assessment mechanisms, navigational safety parameters, and economic performance indicators in order to enhance the reliability, efficiency, and strategic resilience of national shipping in the context of innovation-driven development.

Presentation of the main research material. As global experience demonstrates, the determination of national priority areas for the development of science and technology consists of three interrelated processes: the formation of the main strategic goal of the state, consideration of generally recognized global priorities, and reflection of national characteristics and country-specific features. Taking into account the experience of developed countries is of exceptional importance at a time when Ukraine is searching for approaches and tools capable of ensuring sustainable economic development.

In accordance with current requirements, the foundation of Ukraine’s strategic development course and its key priorities should be the development and implementation of state policy aimed at structural modernization of the national economy, its rapid transition to an innovation-driven development path, and the establishment of Ukraine as a high-tech state. The priority of innovative development of the national economy and the active role of the state in structural transformations have been determined at the highest governmental level.

Innovative development is currently becoming not only a “national economic idea” but also a tactical instrument of state economic and humanitarian policy.

The formation of a new economic system introduces fundamental changes in our understanding of the direct relationship between “production volume” and the real potential of the economy, primarily due to the increasing role of knowledge. Knowledge has the ability to multiply the results of economic activity far more effectively than any other factor of production. The traditional concept of national competitiveness focused on production volumes, GDP share, and growth rates is being replaced by the concept of prospective competitiveness, which is determined by the level of utilization of new technologies.

The objectives of state regulation at each historical stage of economic development depend on many factors, primarily on the overall level of economic development.

For Ukraine, it is necessary to identify a priority economic goal that would correspond to the newly established market-based economic mechanism and reflect national interests. This goal can be detailed according to the directions of state economic policy implementation.

Hence, structural and investment regulation instruments should be used to develop production, while financial stabilization of the economy requires fiscal and monetary regulation tools.

The classical set of state economic regulation objectives in economically developed countries is presented in Figure 1.

The development of a state regulation system also includes the identification of key social, economic, and other long-term goals and objectives, including social benchmarks, core proportions, and structural shifts, as well as the most effective socio-economic policy facilitating their achievement. Economic objectives should be determined for the country as a whole, its regions, economic sectors, and territorial-production complexes, based on the urgent need to meet societal demands, available resources, and defined development priorities [16].

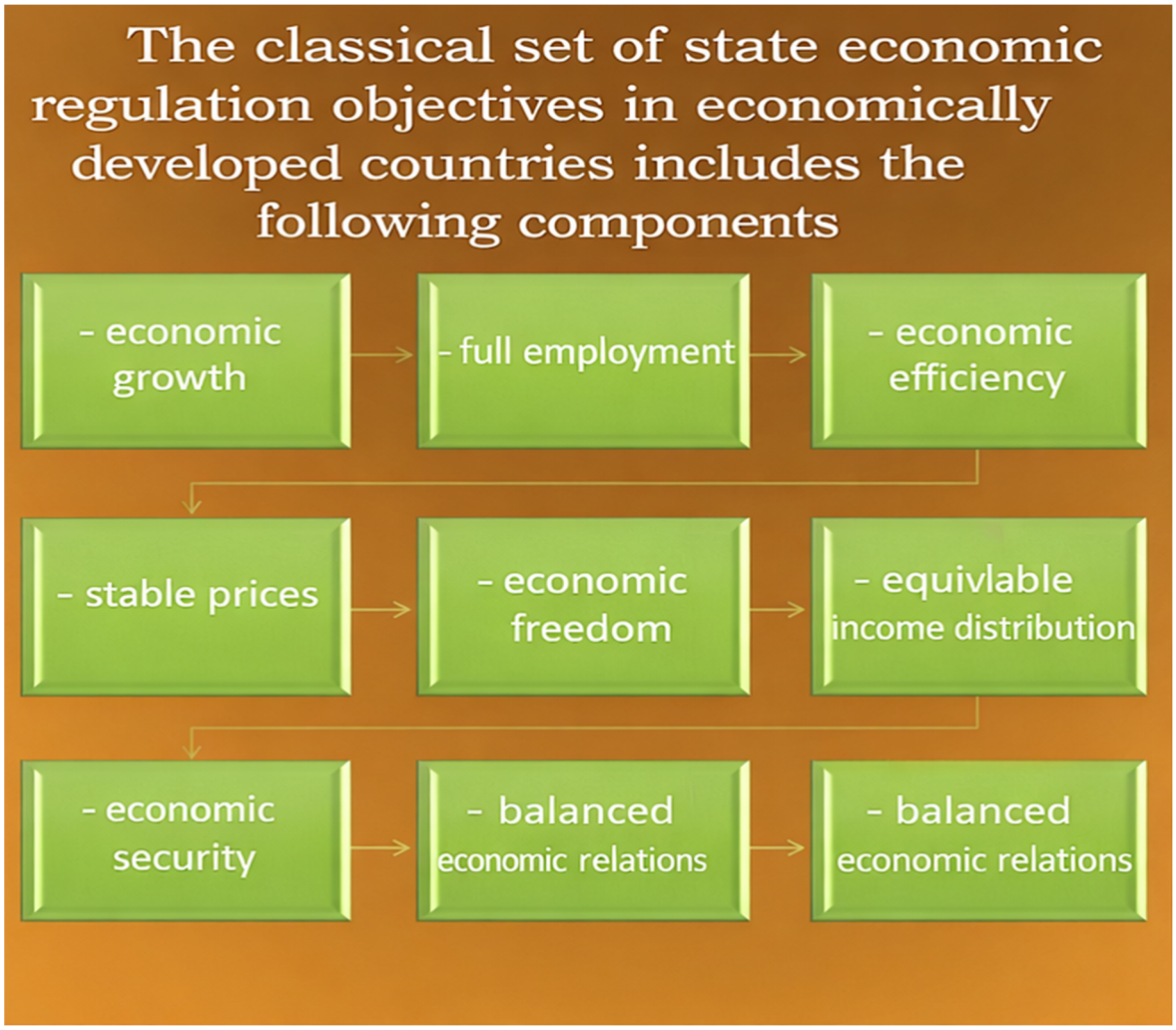

Figure 1. Components of the classical set of state economic regulation objectives in economically developed countries.

Source: developed by the author

According to the Law of Ukraine "On Innovative Activity," the main objective of state innovation policy is to create socio-economic, organizational, and legal conditions for effective reproduction, development, and utilization of the country's scientific and technological potential, ensuring the introduction of modern environmentally friendly, safe, energy-efficient, and resource-saving technologies, as well as the production and commercialization of new competitive products.

The main principles of state innovation policy include:

- orientation toward an innovation-driven economic development path for Ukraine;
- identification of state priorities for innovative development;

• formation of a regulatory and legal framework in the field of innovation;

• creation of conditions for preservation, development, and utilization of domestic scientific, technological, and innovation potential;

• ensuring interaction between science, education, production, and the financial-credit sector in innovation development;

• effective use of market mechanisms to stimulate innovation activity and support entrepreneurship in the scientific and production sphere;

• implementation of measures to support international scientific and technological cooperation, technology transfer, protection of domestic products in the internal market, and their promotion in external markets;

• financial support and implementation of favorable credit, tax, and customs policies in the field of innovation;

• promotion of innovation infrastructure development;

• information support for innovation activity entities;

• personnel training in the field of innovation activity [16].

An important principle is ensuring the unity of strategic and current state regulation, with operational flexibility of the latter. Strategic state regulation has nationwide significance and aims to preserve the state's economic and social strategic course embedded in reform programs, national target-oriented and comprehensive programs. To maintain this strategic course, the state compiles and monitors a list of strategically important resources.

Current state regulation aims to implement the strategic course under specific economic and political conditions, necessitating flexibility in state influence mechanisms. Operational regulation relies on tax, emission, credit, budgetary, social, and other economic policies. Within this framework, the Government of Ukraine forms the state budget, determines key directions of tax policy, and shapes foreign economic policy (through customs tariffs, export quotas, etc.). All components of state economic governance must be interconnected and systematically implemented to ensure realization of the strategic course. A key principle of state regulation is adherence to material and financial balance requirements to ensure the resource potential of society and regulation of financial flows (money, credit obligations, shares, securities, etc.).

A characteristic trend of global economic development in the early 21st century is the intensification of competition among various industrial policy models and the diversity of macroeconomic approaches.

Competition in goods and services is becoming secondary. Prosperity is determined not by market access but by the level of scientific and informational support for production, organizational efficiency, quality of workforce training, and employee motivation toward final performance results.

Innovation policy is an integral part of economic policy and is aimed at ensuring the effectiveness of innovation activity. The strategy and mechanisms for implementing state innovation policy are generally defined by legislative and governmental bodies. Reliance solely on market mechanisms to overcome economic crises has proven ineffective, as demonstrated by historical experience (the United States during the Great Depression, Germany and Japan in the post-war period).

In Western countries, state intervention in the innovation sphere has become standard practice, with continuous improvement of methods. The primary objective of such intervention is to ensure sustainable economic growth, maintain low inflation, promote high innovation activity, and sustain employment levels.

According to the Law of Ukraine "On Innovative Activity," state regulation of innovation activity is carried out through:

• identification and support of priority areas of innovation at national, sectoral, regional, and local levels;

• development and implementation of state, sectoral, regional, and local programs;

• creation of regulatory and economic mechanisms to support and stimulate innovation activity;

• financial support for innovative projects;

• provision of preferential taxation for innovation entities;

• support for the functioning and development of modern innovation infrastructure [17].

The law defines the powers of the Verkhovna Rada of Ukraine, the Cabinet of Ministers, local self-government bodies, as well as the specially authorized central executive body in the field of innovation activity.

A significant document for Ukrainian shipbuilding and shipping is the Resolution of the Cabinet of Ministers of Ukraine dated May 30, 2018, No. 430-r "On Approval of the National Transport Strategy of Ukraine until 2030." This strategy defines the transport sector as one of the basic sectors of the economy and outlines the maritime and river transport system, including 13 seaports with a total cargo handling capacity exceeding 230 million tons per year and 2,714.5 kilometers of navigable inland waterways. A developed network of ferry connections and maritime container lines connecting Ukraine with partner countries in the Black Sea region is also highlighted.

Despite the significant structural potential of the sector, the main objectives have not yet been achieved. In addition to military-related factors affecting shipping, insufficient fleet capacity and the wear of existing vessels remain unresolved issues. Although attention has been paid to shipbuilding development over the past decade, reliance has primarily been placed on private companies rather than state orders, which cannot be considered a positive factor.

For comparative analysis, it is necessary to consider the experience of other countries, particularly the European Union, which serves as a benchmark development vector:

• public recognition of the strategic importance of the maritime industry for the EU and its role in providing high-quality employment and ensuring security and defense;

• profitability of the innovation sector, enhancing product attractiveness, competitiveness, efficiency, and productivity;

• development of long-term employment opportunities for highly qualified professionals, including young specialists;

• implementation of "green" environmental policy based on safe, innovative technologies and responsible use of water resources;

• emphasis on energy efficiency, alternative energy sources, and emission reduction;

• fair competition supported by a strong state industrial base.

The conditions for successful industry operation are divided into four categories: employment and skills; market access and fair market conditions; investment and finance; research, development, and innovation.

Employment and Skills

Restructuring has been integrated into long-term strategies aimed at ensuring sustainable development and competitiveness. It has been established that employment in the maritime industry demonstrates high regional concentration, which maximizes the likelihood of successful restructuring.

Personnel recruitment has been implemented through the formation of a positive and accurate perception of the industry among talented young people, including women, whose representation in the sector has traditionally been limited. A clear and convincing message has been conveyed that the sector represents a high-technology industry with long-term positive

prospects. Simultaneously, experienced and highly competent personnel within the maritime sector have been retained.

The development of new skills and continuous lifelong learning has improved the transfer of competencies between older and younger generations. A systematic approach to continuous professional development has been established at the European Union level.

Harmonization of training and mobility of qualified personnel is encouraged within the maritime sector, with particular emphasis on fostering a flexible and dynamic workforce. Increased attention is given to the acquisition of professional skills. Workforce mobility and flexibility facilitate the adaptation of educational programs to industrial diversification and emerging competency requirements, ensuring alignment with current market needs and improving employability.

Improving Market Access and Ensuring Fair Market Conditions

The World Trade Organization has supported the European Union regarding illegal export subsidies provided by the Republic of Korea to a number of its shipbuilding yards. However, political forces have hesitated to initiate dispute settlement procedures due to concerns about potential risks to international relations [18].

The International Labour Organization is responsible for the formulation and monitoring of international labour standards. Representatives of employers and employees jointly develop policies and programs that comply with all relevant international standards.

Public procurement practices are guided by public interest considerations in each specific case, particularly when public funds are allocated to environmental protection, energy efficiency improvement, and labour conditions. According to EU public procurement regulations [19], contracting authorities may exclude any participants from procurement procedures if violations of obligations established by social, labour, environmental, or international labour legislation are identified.

Intellectual property rights are protected to prevent affiliated sector companies from copying innovations and attracting investments by exploiting technologies developed by others. Each product is required to have detailed specifications supported by appropriate documentation to minimize fraud risks and to maintain fair and transparent competitive market standards.

Investment and Finance

Appropriate guarantees are provided over a significant period from the commencement of construction until the launch of a specific vessel or series of vessels.

Financing of environmental technological improvements in the European maritime industry has been identified as a transformative force capable of changing the “rules of the game” in the short term. Mandatory international regulations predominantly support “green” projects, as they align with global environmental preservation policies. Nevertheless, certain environmentally oriented projects still face a lack of investment, while technologies that could generate positive commercial effects for shipowners are often overlooked.

Research, Development, and Innovation

Support is provided for emerging markets specializing in offshore wind installations, marine energy, Arctic navigation, and other sectors that require opportunities for growth and access to European support to unlock their economic potential and enhance development capacity.

Innovation stimulation is continuous and consistent. Based on the most recent reporting periods preceding the adoption of strategic frameworks, state support has been identified as a key factor in the successful development of the industry.

European regions independently develop regional innovation strategies based on smart specialization, creating a foundation for targeted measures aimed at establishing regional

innovation ecosystems. This approach facilitates cross-sectoral linkages with other regional industries and synergy among various EU funding instruments. Structural funds support and promote the development of a common knowledge base that underpins the competitive positioning of regional maritime technology sectors.

Naturally, development strategies related to inland water transport and shipbuilding in the European Union are significantly broader and more advanced than those implemented in Ukraine. Many mechanisms and innovative investment attraction schemes applied in Europe for shipbuilding development and workforce training could also be effectively implemented in Ukraine.

As previously noted, innovation serves as a key driver of development capable of transforming the current state of shipbuilding. Another critically important factor is ensuring navigational safety and minimizing human error.

One of the key innovative solutions aimed at enhancing navigational safety is the implementation of onboard automation systems. Ship personnel perform operational, technical, and support functions but cannot influence vessel design or configuration, which are determined at the shipbuilding stage through contracts between shipowners and shipyards. According to International Maritime Organization standards, modern vessels must be equipped with technical systems that provide the level of automation prescribed by international conventions. Currently, specialized software solutions are being developed to further enhance automation levels and promote the concept of vessel autonomy.

At the testing and implementation stages, these systems are capable of collecting data, performing calculations, and making informed decisions to minimize human error. Such systems are intended for use both on navigation bridges and in engine rooms.

The introduction of innovations in the modern development of maritime and inland shipping is not merely a trend but an essential component that enables compliance of newly built vessels with International Maritime Organization standards and conventions. A critical factor influencing these innovations is the safety of human life. The development of advanced technological solutions can provide a substantial impetus for the shipbuilding sector, enabling it to technologically catch up with global leaders.

A model of the sequential operation of an automated management decision-making system during port arrival and departure is proposed (Figure 2). The first part of the model is completed by vessel-level management representatives; the middle section is continuously updated and monitored by shipowner company management and port infrastructure authorities. Calculations based on selected mathematical models enable the transition to the final stage, which provides recommended actions and decisions. These outputs are subsequently reviewed by on-site specialists to enhance systemic navigational safety, economic efficiency, risk reduction, and coordinated operational performance.

The conceptual model proposed in this research may also incorporate a “Risk Assessment” calculation, conducted in accordance with the International Safety Management (ISM) Code by shipboard management personnel and shipping companies. This assessment aims to evaluate all identified risks affecting vessels, personnel, and the environment in order to establish appropriate preventive measures and continuously improve safety management skills both ashore and onboard, including preparedness for emergency situations related to safety and environmental protection [20]. Automated mathematical modeling combined with input data from the initial stage enables a broader evaluation of potential risks, mitigation pathways, and significantly reduces time and resource expenditures.

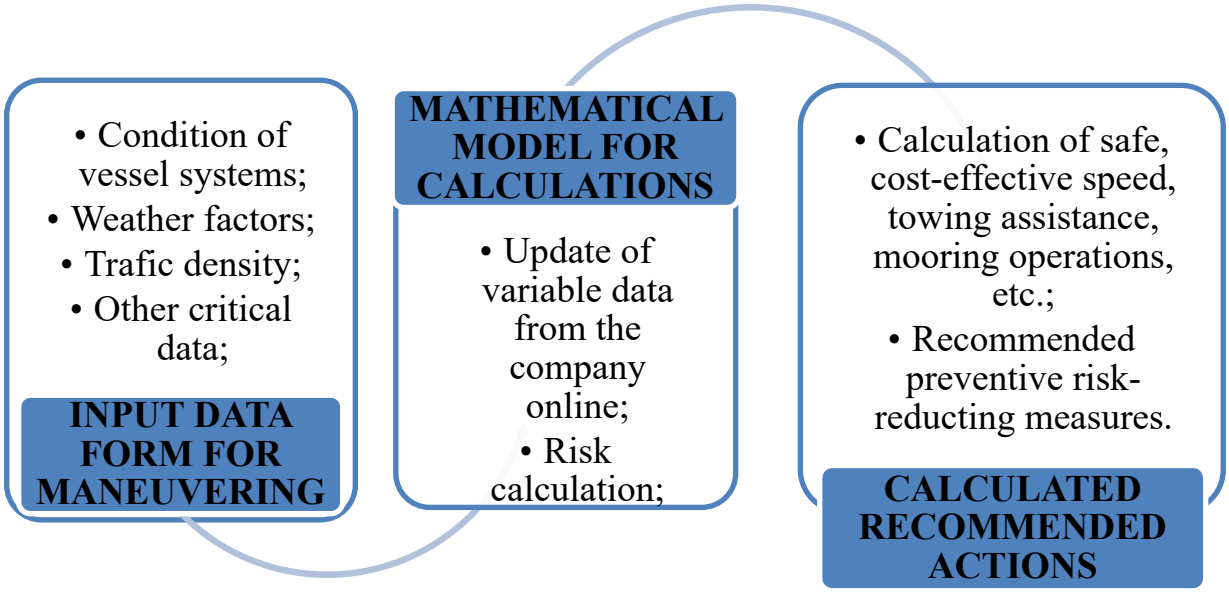

Figure 2. Schematic model of the sequential operation of an automated management decision-making system during port arrival and departure.

Source: developed by the author

The practical and analytical effectiveness of the proposed model could be significantly enhanced through the integration of external data sources, such as information from an information-analytical logistics center - an infrastructure complex responsible for coordinating and optimizing cargo flows and forming a comprehensive package of logistics services for transit cargo management. This integration would provide broader visibility into traffic density, cargo and passenger transport routes, improved scheduling of arrivals and departures, safe speed calculations, and other operational parameters. The conceptual model proposed in this research for automating maneuvering calculations within port waters and associated waterways can reduce the impact of the two primary factors leading to maritime accidents - namely, the human factor and system or equipment failures. It reduces decision-making time, lowers risk levels, and calculates preventive measures that are economically and operationally optimal for each specific situation. This innovative solution could be implemented experimentally on modern inland waterways in Ukraine as one of the approaches to enhancing navigational safety and attracting foreign interest and investment.

Conclusions. The results obtained in the course of the conducted research substantiate that the transformation of the maritime industry under conditions of globalization, digitalization, and increasing geopolitical and economic uncertainty necessitates a systemic integration of innovation policy instruments with advanced technological solutions. The analysis of international experience and contemporary scholarly contributions demonstrates that sustainable development of the maritime sector is increasingly determined not by traditional production indicators, but by the level of technological sophistication, digital infrastructure maturity, and the effectiveness of risk-oriented management systems.

The comprehensive assessment of innovative marine and navigational technologies has shown that their implementation exerts a multidimensional impact on systemic safety, operational reliability, and the economic sustainability of shipping enterprises. Automation, digital decision-support tools, and intelligent navigational systems reduce the probability of accidents by minimizing human-factor influence and mitigating technical system failures. Simultaneously, they contribute to improved operational efficiency through optimized

maneuvering, reduced turnaround time, and enhanced coordination between vessels, ports, and logistics operators.

The conceptual model proposed in this research for automated managerial decision-making during port arrival and departure represents a conceptual framework that integrates navigational parameters, economic security criteria, and risk assessment mechanisms into a unified analytical structure. Its effectiveness can be substantially strengthened through the incorporation of external data streams, including those generated by information-analytical logistics centers. Such integration enables real-time monitoring of traffic density, cargo and passenger flows, scheduling synchronization, safe speed calculations, and other operational variables. Consequently, the model ensures a higher degree of transparency, predictive capacity, and adaptability in maritime operations.

From an economic perspective, the implementation of the proposed automated system has the potential to generate measurable financial effects, including cost reduction associated with accident prevention, optimization of fuel consumption and port time, improved asset utilization, and increased investment attractiveness of the national maritime sector. By aligning operational decisions with the criterion of economic security, the model supports balanced resource allocation and strengthens the resilience of shipping enterprises under volatile market conditions.

The study also substantiates the feasibility of experimental implementation of the proposed solutions on selected inland waterways of Ukraine. Relatively moderate traffic density creates favorable conditions for pilot testing of innovative navigational and managerial technologies, thereby reducing systemic risk during the initial stages of adoption. Successful pilot projects may serve as a platform for scaling digital solutions to the broader maritime domain and for attracting foreign investment through demonstration of technological readiness and regulatory modernization.

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