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## INNOVATIVE TECHNOLOGIES AND EFFICIENCY IN MERCHANT SHIPPING

### ІННОВАЦІЙНІ ТЕХНОЛОГІЇ ТА ЕФЕКТИВНІСТЬ ТОРГІВЕЛЬНОГО СУДОХІДСТВА

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*Стахов А.Ю. Інноваційні технології та ефективність торгівельного судохідства. Науково-методична стаття.*

Морська галузь стала свідком чудових перетворень із появою інноваційних технологій, які зробили революцію в ефективності торгівельного судноплавства. Використовуючи штучний інтелект та аналітику різноманітних даних у відкритому доступі, транспортні компанії можуть збирати та аналізувати дані в реальному часі з метою прийняття обґрунтованих рішень. У сучасних умовах досліджуються потенційні переваги автономних суден, оснащених передовими датчиками, алгоритмами машинного навчання та складними системами керування. Можливість працювати без втручання людини мінімізує помилки, знижує витрати та оптимізує процеси обробки вантажів. Однак такі виклики, як кібербезпека та потреба в комплексних правилах, залишаються відкритими для подальшого дослідження.

*Ключові слова:* інноваційні технології, морське судноплавство, автоматизація, ефективність, безпека

*Stakhov A. Yu. Innovative Technologies and Efficiency in Merchant Shipping. Scientific and methodical article.*

The maritime industry has witnessed remarkable transformations with the advent of innovative technologies that have revolutionized the efficiency of merchant shipping. Using artificial intelligence and analytics on a variety of publicly available data, transportation companies can collect and analyze real-time data to make informed decisions. In modern conditions, the potential benefits of autonomous vessels equipped with advanced sensors, machine learning algorithms and sophisticated control systems are being explored. The ability to work without human intervention minimizes errors, reduces costs and optimizes cargo handling processes. However, challenges such as cyber security and the need for comprehensive regulations remain open for further research.

*Keywords:* innovative technologies, maritime shipping, automation, efficiency, safety

The systemic efficiency of the development and operation of maritime transport enterprises is characterised by entrepreneurial results, the nature of the formation of macroeconomic results and the optimisation of the financial position of the cargo-owning structures. A special position is held by the use of production potential and the choice of appropriate innovative technologies for subsequent development.

Particular attention should be focused on performance indicators reflecting positioning optimisation projects in transformable segments of the maritime trade market. Among the intensive characteristics, attention should be paid to resource productivity. In the maritime transport technology system, the autonomous shipping strategy stands out in this respect. This in turn increases the importance of capital assets and predetermines the requirements for legal protection of the real owner's property.

At the same time, as an efficiency of the chosen form of development, it is important to achieve the nature of the change in resource returns and final efficiency. This should take into account, despite innovative technologies, the achievement of efficiency gains including the increasing complexity of accessibility to resource inputs to production activities.

#### Analysis of recent researches and publications

Recent research and publications have highlighted the significant impact of innovative technologies on enhancing efficiency in merchant shipping. These advancements have transformed various aspects of the maritime industry, ranging from vessel operations and logistics to safety and environmental sustainability.

One key area of focus is the implementation of digitalization and automation in shipping operations. Research has shown that the integration of technologies such as artificial intelligence (AI), big data analytics, and Internet of Things (IoT) has led to improved efficiency in vessel navigation, route optimization, and cargo handling. These technologies enable real-time data collection and analysis, allowing shipping companies to make data-driven decisions

that optimize fuel consumption, reduce transit times, and enhance overall operational efficiency.

Furthermore, there has been a growing interest in autonomous shipping systems. Research studies have explored the potential of autonomous vessels, which utilize advanced sensors, machine learning algorithms, and sophisticated control systems to navigate and operate without human intervention. These autonomous ships have the potential to significantly reduce operational costs, increase safety by minimizing human error, and optimize cargo handling processes.

### Unsolved aspects of the problem

While there have been significant advancements in innovative technologies and their impact on efficiency in merchant shipping, there are still some unsolved aspects of the problem that require further research and exploration. These unresolved areas pose challenges and opportunities for the industry to continue evolving and improving.

1. **Safety and Security:** While autonomous shipping systems have the potential to enhance safety by reducing human error, there are concerns regarding the cybersecurity of these systems. Further research is needed to develop robust security measures to prevent potential cyber threats and ensure the safety and integrity of autonomous vessels and their onboard systems.

2. **Regulatory Frameworks:** The adoption and integration of innovative technologies in merchant shipping require supportive and adaptable regulatory frameworks. Currently, there is a need for standardized regulations and guidelines to address the challenges and implications of technologies like autonomous ships, digitalization, and blockchain. Research is necessary to develop comprehensive and globally accepted regulatory frameworks that balance safety, efficiency, and environmental sustainability.

3. **Infrastructure and Investment:** Implementing innovative technologies in merchant shipping requires significant infrastructure development and investment. This includes upgrading ports to accommodate autonomous vessels, establishing charging or refueling infrastructure for clean energy solutions, and integrating digital systems for seamless data exchange. Research is needed to identify the most effective investment strategies and ensure the availability of necessary infrastructure to support the widespread adoption of innovative technologies.

*The aim of the article is to provide an analysis of recent research and publications on the topic of innovative technologies and efficiency in merchant shipping, highlighting their impact, advancements, and unresolved aspects in the field.*

### The main part

It remains fundamental to forecast prospective characteristics of positioning of shipping companies or trading ports in the specialization segment of the maritime trade market. It also remains fundamental to focus on the features of the development of the specialisation segment in the current conditions of

formation of statistical data on the situation in the maritime transport system.

In this respect, the functional activities and development of individual shipping companies and trading ports are noteworthy. However, it is important to distinguish between trends in the initial state reflecting the characteristics of the response to the nature of the international trade division. Attention should be focused on the possibility of an advance in the system of innovative positioning technologies in the specialisation segment of the maritime trade spot market.

In this aspect, it is important for a shipping company or trading port to control:

- the rate of development in relation to the market trend in maritime trade and the nature of the reaction of major competitors;
- investment projects reflecting the challenges of retaining and expanding the position in terms of priorities;
- the parameters for changing the energy supply system according to current International Maritime Organization standards.

The most difficult issue in this respect, as shown by the imbalanced state of the maritime trade market, remains the growth rate of world trade and trends in the basic characteristics of product exports by individual countries. This issue becomes particularly problematic when the world economy is transformed to focus on the priorities of certain groups of states. Therefore, attention should be paid to the ratio of not only the carrying capacity of the fleet and cargo flows, but also to the specifics of the implementation by states of the transport security strategy for the export of transport services in the baseline period.

The availability of regulatory capacity reserves within the limits of effective response to external demand should be considered as crucial. At the same time, a significant under-utilisation of the operational period of ships is indicative of errors in the design calculations. At the same time, the need for reserves within the security of national exports should be taken into account, despite the state of the maritime trade market.

It is necessary to solve the problem of establishing fleet or port development based on the specifics of the transformation of global maritime trade market parameters. The main obstacle of solving this problem is the limited access to evaluation of similar projects by other participants in the analysed segment of specialisation. The problem arises of considering solution alternatives due to the limited assessment of future parameters of international trade and its differentiation by individual components. As a consequence, this creates one type of positioning balance risk. In this respect, it is important to clearly calculate production potential utilisation indices and to formulate forward-looking projects to optimise the basic position. When the volume of loading and unloading work in a commercial port decreases, not only does profitability fall due to lower revenues, but also due to a rise in the cost of production due to fixed

cost parameters not being covered compared to the reference period:

$$\Delta P_{rf} = C_{st} i_{cf} \Delta q_t, \quad (1)$$

where  $C_{st}$  is the planned operating cost of the respective port unit,

$i_{cf}$  – the share of fixed costs in the port in question,

$\Delta q_t$  – deviation of the traffic flow from the baseline or planned calculations.

Underutilisation of capacity potential in the maritime trade market should be considered as a factor in realising the trailer of the national cargo base to optimise the current account. The global return on capital employed by shipping companies should be considered as a benchmark for development. This indicator can be used as a benchmark in selecting the development strategy of individual shipowners, taking into account the features that deviate positions from the global level.

This should take into account the balance achieved by the shipbuilders of individual states in terms of the specialisation of the construction value of a unit of carrying capacity of individual ship types. The modern project management system does not use the principle of rationing the return on capital assets due to unforeseen externalities. Therefore, the role of optimal management strategies, providing for the optimal realisation of fleet or port cargo terminal capacity, is increasing.

It should be taken into account that the prospective development of maritime transport subsystems leads not only to the generation of additional cash flow, but also to some cost savings ensuring an extended positioning in the selected segments of specialisation. The efficiency of parameters of necessary development of maritime transport potential is conditioned by innovative characteristics and their correspondence with parameters of the maritime trade market. In these conditions the risks of either inadequate either assessment or changes in conditions that have not been defined by the necessary measures are formed.

In this respect, the development of maritime transport potential should be based both on extensive changes in cargo flows and in line with the increasing role of intensive factors driven by the objectives of optimising resource intensity attitudes and environmental friendliness requirements. In other words, prospective capacity development of maritime transport enterprises should be based on a corresponding increase in the share of innovation strategies. Optimization of capital costs and resources in relation to productivity growth and cash flow parameters should be considered as a criterion of intensive formation of the production potential of maritime transport enterprises.

Development of national maritime transport industry subsystems should be based on the objectives of transport security of foreign economic relations, feasibility of maritime trade market and macroeconomic objectives of job structure

optimization. In order to solve this task, it is important to analyse the nature of formation and dynamics of the indicator of efficiency of the use of capital assets serving the global transport market. The parameters of this indicator reveal the general conditions that predetermine the risk assessment of decision-making by individual operators.

Improving the technical and economic level of merchant fleet vessels or seaport cargo terminals provides economic efficiency and is reducing costs with a fall in the frequency of traditional risks as well as increasing productivity and optimising the technogenic burden on the environment. However, this process requires appropriate management approaches to optimise the use of innovative means of transport.

The level and efficiency of development of maritime trade market subsystems is determined by both the traditional set of factors and the influence of modern transformational characteristics. Therefore, the adequacy of managerial decision-making and optimization of fleet and port capital formation is increasing in importance. There are increasing demands on the credibility of the methods used and the search for new solutions. In this respect, the problem of clarification of the content of sustainability tasks and methods of evaluation of investment and organizational decisions stands out. The notion of positioning efficiency is expanded, taking into account not only the provision of optimal costs, but also the system sustainability of the most important components of the country's macroeconomics. In fact, entrepreneurial decisions according to the criteria of market sustainability should also be supported by the system of national interests. That is, the interrelation of entrepreneurial efficiency and system-wide sustainability of socio-economic interests of the country becomes stronger. Thus, the objectives of state sustainability management bodies are clarified.

In the context of the maritime trade market, it is crucial to consider the underutilization of capacity potential as a factor in realizing the trailer of the national cargo base and optimizing the current account. The global return on capital employed by shipping companies can serve as a benchmark for development, allowing for the selection of the most suitable development strategies for individual shipowners while considering their specific characteristics that may deviate from the global level.

A significant aspect to be taken into account is the balance achieved by shipbuilders in different countries regarding the specialization of construction value for various ship types. This specialization of construction value per unit of carrying capacity is an important factor in determining the competitiveness of individual states in the maritime industry. By considering this factor, it becomes possible to determine the optimal management strategies that enable the optimal utilization of fleet or port cargo terminal capacity, ultimately contributing to the overall efficiency of the maritime transport system.

Furthermore, the prospective development of maritime transport subsystems not only generates additional cash flow but also leads to cost savings, allowing for an extended positioning in selected segments of specialization. The efficiency of necessary development parameters in the maritime transport sector relies on their innovative characteristics and their alignment with the parameters of the maritime trade market. However, it is important to recognize the risks associated with inadequate assessment or unanticipated changes in conditions that have not been accounted for in the necessary measures.

In light of these considerations, the development of maritime transport potential should be based on extensive changes in cargo flows and the increasing role of intensive factors driven by the objectives of optimizing resource intensity attitudes and meeting environmental friendliness requirements. This implies that prospective capacity development of maritime transport enterprises should be accompanied by a corresponding increase in the share of innovation strategies. The optimization of capital costs and resources in relation to productivity growth and cash flow parameters should be viewed as a criterion for the intensive formation of the production potential of maritime transport enterprises.

The development of national maritime transport industry subsystems should be aligned with the goals of ensuring transport security for foreign economic relations, the feasibility of the maritime trade market, and the macroeconomic objectives of optimizing job structures. To achieve this, it is essential to analyze the nature of the formation and dynamics of the efficiency indicator of capital asset utilization in the global transport market. Understanding the parameters of this indicator can help assess the risks associated with decision-making by individual operators.

Improving the technical and economic level of merchant fleet vessels and seaport cargo terminals brings economic efficiency by reducing costs, mitigating traditional risks, increasing productivity, and optimizing the technogenic burden on the environment. However, managing this process effectively requires adopting appropriate approaches to optimize the use of innovative means of transport.

The level and efficiency of development in maritime trade market subsystems are determined by a combination of traditional factors and the influence of modern transformational characteristics. Consequently, the adequacy of managerial decision-making and the optimization of fleet and port capital formation gain increasing importance. There is a growing demand for credible methods and the search for new solutions. In this regard, the problem of clarifying the content of sustainability tasks and developing evaluation methods for investment and organizational decisions becomes prominent.

The concept of positioning efficiency is expanded to consider not only optimal costs but also the system sustainability of crucial components within the country's macroeconomics. Entrepreneurial decisions,

in line with market sustainability criteria, should be supported by the national interests of the country. Therefore, the interrelation between entrepreneurial efficiency and the system-wide sustainability of socio-economic interests becomes stronger, shedding light on the objectives of state sustainability management bodies.

Considering the underutilization of capacity potential, benchmarking global return on capital employed, optimizing fleet and port cargo terminal capacity, and integrating innovative strategies are crucial for the development of the maritime trade market. These efforts should align with the goals of transport security, market feasibility, and macroeconomic optimization. By addressing sustainability tasks and evaluating investment and organizational decisions, the maritime transport industry can achieve sustainable and efficient growth while contributing to the overall socio-economic interests of the country.

To ensure the effective development of the maritime trade market, it is necessary to focus on comprehensive measures that address both extensive and intensive factors. Extensive changes in cargo flows should be analyzed and accommodated to capitalize on emerging opportunities and market dynamics. At the same time, the increasing role of intensive factors, such as resource efficiency and environmental friendliness, should be considered in order to optimize operations and reduce the industry's ecological footprint.

In this context, innovation plays a crucial role. By embracing innovative strategies and technologies, maritime transport enterprises can enhance their competitive advantage, improve productivity, and reduce costs. It is important for shipowners and operators to prioritize innovation and invest in research and development efforts that align with the specific needs and demands of the maritime trade market.

Additionally, the optimization of capital costs and resources should be a key consideration. By effectively managing and allocating capital assets, enterprises can achieve higher productivity and generate favorable cash flow parameters. This optimization should be driven by a comprehensive understanding of the market conditions and the corresponding investment requirements to ensure the efficient formation of the production potential of maritime transport enterprises.

The development of national maritime transport industry subsystems should align with the goals of transport security, market feasibility, and macroeconomic optimization. This includes enhancing the technical and economic levels of merchant fleet vessels and seaport cargo terminals. By investing in modernizing infrastructure, improving operational efficiency, and ensuring the sustainability of these subsystems, the industry can achieve economic efficiency, reduce costs, and minimize risks.

Sustainability is a crucial aspect that should be integrated into decision-making processes. The evaluation of investment and organizational decisions should go beyond financial considerations and

encompass the system-wide sustainability of socio-economic interests. This entails considering the long-term impacts on job structures, resource utilization, environmental conservation, and the overall well-

being of the country. By adopting a holistic and sustainable approach, the maritime transport industry can contribute to the resilience and stability of the national economy.

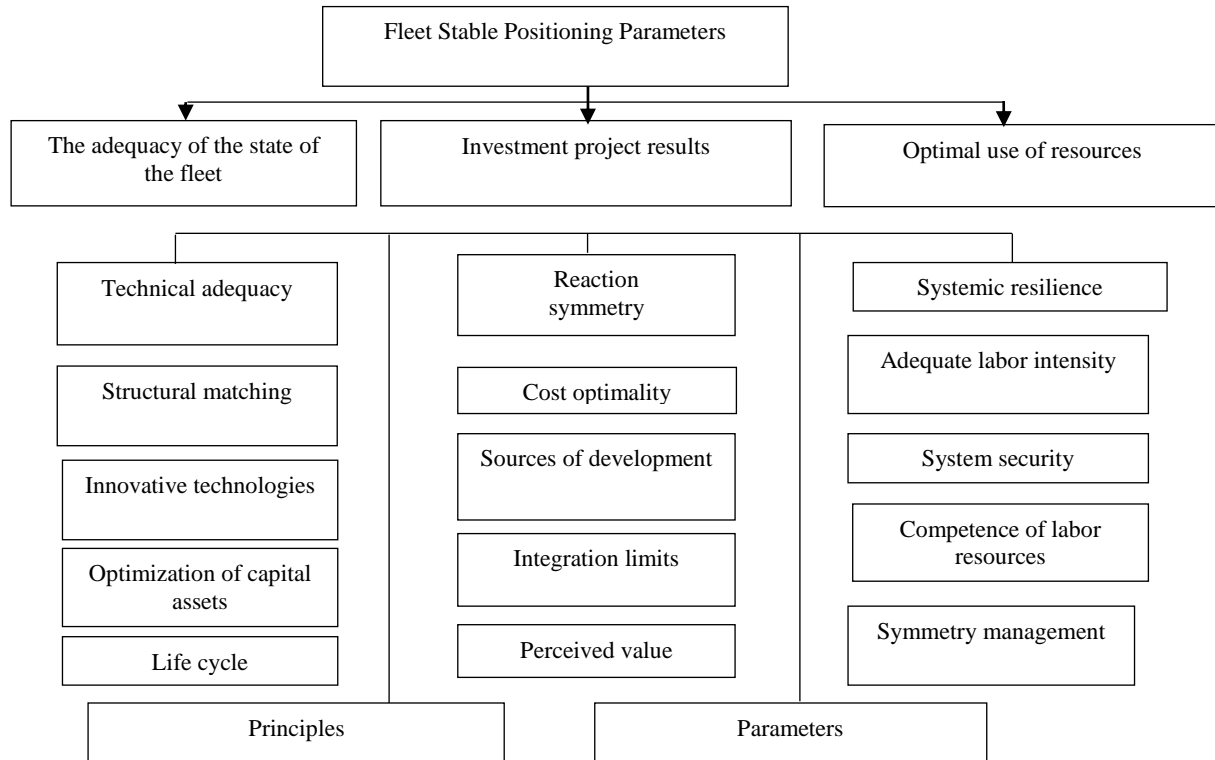


Figure 1. Conditions for optimising the parametric performance of a shipping company

*Source: author's own elaboration*

Methodology of consistency of cumulative choice of the most important characteristics of competitive positioning of fleet in the changing conditions of maritime trade market on the basis of optimization of the most important parameters. The necessity and possibility of formation of financial reserves for the period of unbalanced state of cargo traffic and aggregate carrying capacity of the fleet remains fundamental. The character of formation of principles of safety of navigation with emergence of new threats and strengthening of a role of strategy of achievement of cyber security predetermines growth of expenses. Depending on the concentration of deadweight of the shipping company, the growth can be significant.

It is necessary to distinguish between the real aspects of investment strategy development on the characteristics of the maritime trade market and the administrative and bureaucratic intentions of state management structures. The direct example could be the administrative management of investment flow based on the strategy of the Ministry of Infrastructure and real entrepreneurial technologies of enhanced investment activity.

### Conclusions

It is worth paying attention to the recurrence of unfounded assertions by specialists of the agency about the forthcoming activation of the investment process. This was particularly evident with regard to

the Ukrainian town Kherson and Olvia port concession projects, whose total investment amount was below UAH 70 million. Further investment flows from world brands on the basis of departmental approaches did not follow. Moreover, it was on the basis of entrepreneurial structures that more than \$500 million arrived in the development of Mykolaiv port.

This indirectly confirms the problem with the level of competence of public administration employees. Even the involvement of the EBRD has not led to increased investment activity in the commercial port development system under the agency's programme. It is ridiculous to look for those willing to participate in a ferry concession, which does not represent a guarantee of large-scale cash flow. Such facilities are prioritised in the ownership of ship-owning entities.

Special structures are continually being formed which, under Parkinson's Law, expand the bureaucratic approaches in the concession financing system and expand the structure of laws of local significance.

Neither Chinese nor Japanese investors in the system of Ukrainian bureaucracy chose the feasibility segment of an investment project. The activity of state authorities' specialists has not conditioned the inflow of "big investments". Not a single global brand was interested in the law on concession of Ukrainian seaports.

The known sustainability activity of DP World's strategy is involved in considering the nature of the positioning of the tug business at the Port of Odessa. Thus, in fact, on the one hand, it demonstrates the priority of sustainability and small scale business. On the other hand, this project emphasises the sustainability of the East-West business, in the system of which the role of the Port of Odessa stands out. This is also emphasised by the construction of a container terminal by the Port of Hamburg at one time on the Quarantine Mole.

All the above confirms the priority given to the design and implementation of development projects by entrepreneurial entities. Low-impact agency approaches demonstrate the fundamental importance of focusing on supporting initiatives by entities that, within the realities of maritime trade, aim to achieve competitive strategies for national maritime transport subsystems. The agency should not impose solutions but focus on supporting real investment projects. Two objectives of national maritime transport capacity development remain fundamental:

— to achieve adequate technical and economic capacity of the fleet and ports to meet the criteria

of transport security of participation in the international division of labour;

— optimising cash flow for entrepreneurial and macroeconomic purposes.

The sustainability of the maritime trade market, and therefore all of its components, is predetermined by the management of entrepreneurial efficiency and system security of positioning in the specialisation segment. This predetermines the nature of the challenges posed by the nature of the external conditions of the global maritime trade market positioning.

As a result, the underutilization of capacity potential, benchmarking global return on capital employed, and embracing innovative strategies are essential for the development of the maritime trade market. The optimization of fleet and port cargo terminal capacity, as well as the efficient allocation of resources, play a crucial role in achieving economic efficiency and sustainability. By aligning development efforts with the goals of transport security, market feasibility, and macroeconomic optimization, the maritime transport industry can make significant contributions to the overall socio-economic interests of the country.

### Abstract

The maritime industry has witnessed remarkable transformations with the advent of innovative technologies, revolutionizing efficiency in merchant shipping. This article explores recent research and publications to provide insights into the advancements made in this field and their implications for the industry.

Digitalization and automation have emerged as pivotal factors in enhancing operational efficiency. By leveraging artificial intelligence, big data analytics, and the Internet of Things, shipping companies can collect and analyze real-time data to make informed decisions. This data-driven approach optimizes fuel consumption, reduces transit times, and improves overall operational efficiency.

Autonomous shipping systems have garnered significant attention. Research studies delve into the potential benefits of autonomous vessels equipped with advanced sensors, machine learning algorithms, and sophisticated control systems. The ability to operate without human intervention minimizes errors, reduces costs, and streamlines cargo handling processes. However, challenges such as cybersecurity and the need for comprehensive regulations remain open areas for further exploration.

Clean energy solutions have gained traction in response to environmental concerns and regulatory requirements. Research has focused on alternative fuels such as liquefied natural gas, hydrogen, and biofuels, as well as energy-efficient propulsion systems. These technologies aim to reduce greenhouse gas emissions and improve the industry's environmental footprint.

The integration of blockchain technology has shown promise in enhancing transparency and efficiency in maritime logistics and supply chain management. Blockchain offers secure and streamlined transaction management, documentation, and cargo tracking, reducing paperwork and enhancing reliability.

To fully capitalize on innovative technologies, certain aspects require attention. Safety and security concerns surrounding autonomous systems necessitate robust cybersecurity measures. Additionally, standardized regulatory frameworks are essential to address the implications of autonomous ships, digitalization, and blockchain. Adequate infrastructure development and investment are vital to support the implementation of these technologies, while ensuring the smooth transition of the maritime workforce's skills.

In conclusion, it is necessary to describe the transformative impact of innovative technologies on efficiency in merchant shipping. It addresses digitalization, automation, autonomous systems, clean energy solutions, and blockchain as key areas of focus. The unresolved aspects of safety, regulations, infrastructure, and workforce transition pose opportunities for future research and development, fostering progress, sustainability, and optimization in the maritime industry.

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