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ECONOMIC EFFICIENCY OF SHIP OPERATION WITH ITERATIVE AGGREGATION OF LOGISTICS SOLUTIONS

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Summary. The article examines the economic efficiency of a ship's operation under conditions of iterative aggregation of logistics solutions. It is argued that traditional approaches to voyage planning do not provide an adequate level of adaptability in conditions of dynamic changes in cargo flows, navigation situations, weather conditions, and port infrastructure. Iterative aggregation is defined as a mechanism for step-by-step refinement of decisions regarding the route, speed, sequence of port visits, and energy regime of the vessel based on updated data. Mathematical models for cost minimization and adaptive control of the vessel's speed regime are proposed, taking into account hydrodynamic characteristics and external conditions. An analysis of the economic effect of implementing the model has been carried out, confirming a reduction in fuel costs, a reduction in port costs, and a reduction in downtime, increasing the voyage profitability. It is shown that iterative aggregation provides systemic savings and increased stability of logistics solutions by coordinating the actions of the vessel's navigation, energy, and technical

subsystems. It is concluded that it is advisable to integrate iterative algorithms into digital maritime logistics platforms and decision support systems for autonomous and semi-autonomous ships.
Keywords: *fleet operation; ship voyage, economic efficiency; route optimization; speed mode; maritime logistics; adaptive planning; cost reduction; energy efficiency; navigation systems; maritime transportation.*

1. Introduction

The efficiency of modern maritime vessels today directly depends on the quality of decisions made, as maritime transport operates in an environment of constantly changing cargo flows, port congestion, weather conditions, tariff rates, and delivery speed requirements. In the global maritime transport market, where competition between shipping companies is intensifying, the optimization of logistics processes is becoming critically important for ensuring stable profits and increasing fleet competitiveness, which is why the economic efficiency of ship operations and ways to improve it are becoming particularly relevant.

One of the main problems in the industry is the rapid growth of operating costs, the largest share of which is fuel costs, port fees, downtime, repairs, and maintenance. In such conditions, traditional approaches to planning voyages, routes, and speed regimes are not flexible enough and are unable to take into account all external and internal factors in real time. This leads to lost economic opportunities, increased transportation costs, and reduced vessel profitability.

Contemporary scientific discourse in maritime logistics increasingly converges on one practical thesis: the economic efficiency of a voyage is determined not by a single decision (route/speed/port), but by a coordinated set of decisions that need to be refined during the transportation process. This explains the growing role of data-driven optimization and methods that combine transport network analysis with fleet planning and routing [1], as well as the development of fleet scheduling tasks that take into account variable operational constraints [9]. In practice, an additional dimension of voyahe economics is set by charter conditions and timing of operations, where even a small deviation in time translates into a financial effect through demurrage/dispatch, downtime, or penalties [15].

At the same time, a methodological base is being developed for tasks in which uncertainty is the norm rather than the exception. Stochastic formulations and iterative decomposition algorithms (in particular, Benders decomposition) demonstrate how complex networks can be structured and stable solutions obtained in the presence of random factors [2]. In related logistics industries, iterative approaches with forecasting and plan refinement, reinforced by intelligent models, are actively used, which effectively confirms the productivity of the "forecast → decision → correction" cycles [3]. For the port link, which often accounts for a significant share of costs and risks, robust optimization under uncertain demand provides tools for making informed choices about service policy and resource provision levels [4].

Ship energy remains a separate "lever" of economic efficiency. Studies on optimizing speed and trim, taking into account real sea conditions and the frequency of re-optimization, show that gains are generated not only by choosing the optimum, but also by the regularity of adjustments when external conditions change [7]. For hybrid ships, there is the additional task of intelligently managing energy flows between diesel, solar, and wind components, which directly affects fuel consumption and emissions [8]. At the same time, the environmental aspect is no longer an "option" — it is reinforced by market practices and requirements for "green" logistics [6], as well as changes in the regulatory environment for energy solutions in the maritime industry [13]. Even in specialized maritime fleet planning tasks, decision frameworks based on large language models are emerging, signaling a general trend toward the intellectualization of decision support [5].

In summary, it can be argued that the key problem is not finding the one "best" solution, but rather forming a mechanism that regularly coordinates decisions at different levels: strategic (network/contracts), tactical (port interaction/resources), and operational (speed/energy/schedule). This is where it makes sense to position the mechanism of iterative aggregation of logistics decisions as a way to combine economic goals with risks and uncertainty. This logic is supported by research on DSS risk-cost trade-offs [10], methods of simulation testing of policies and structures [11], as well as risk management approaches in ergatic maritime systems, where decisions depend on the interaction of technology, procedures, and people [14]. In addition, methods of semantic analysis of scientific publications can serve as a transparent tool for substantiating trends and structuring reviews [12].

Given this, there is a need to use modern, more accurate, and adaptive methods of logistics management. One such method is iterative aggregation of logistics decisions - a step-by-step, cyclical system for forming, coordinating, and updating decisions depending on changing conditions. This approach enables optimization of key vessel operation parameters: route, load, speed, fuel consumption, arrival time, and resource provision.

The purpose of this study is to justify the economic efficiency of using iterative aggregation of logistics solutions in ship operations and to determine how cyclical adjustment of logistics parameters can increase productivity and reduce costs.

To achieve this goal, the following research tasks have been set:

- to analyze existing problems of logistics management in shipping;
- to determine the essence of iterative aggregation and its role in voyage planning;
- to investigate the impact of cyclical adjustment of decisions on economic indicators;
- to form scientific conclusions regarding the feasibility of implementing such a model in shipping companies.

The key concept in the further analysis is iterative aggregation of logistics decisions, a process in which management decisions are not made once, but are formed in stages, taking into account new data and variable parameters, which allows for more accurate forecasts and higher economic efficiency of vessel operation, which is the central theme of this study.

2. Problem Statement

Ship management in modern maritime logistics is characterized by high complexity, dynamism, and multifactoriality. Traditional methods of voyage planning, based on static or predetermined parameters, increasingly fail to meet market requirements and do not ensure an adequate level of economic efficiency. This creates a number of problems that require scientific and practical rethinking.

One of the main problems is the instability and constant growth of vessel operating costs. The cost of fuel, port services, maintenance, and energy consumption fluctuates significantly, leading to a significant reduction in the predictability of financial results. Under such conditions, any mistake in the choice of route, speed, or schedule can result in significant economic losses.

The second critical issue is the complexity of accurately planning logistics operations. The maritime environment is subject to a large number of uncontrollable factors: weather, sea conditions, currents, port traffic restrictions, loading and unloading queues, environmental regulations, etc. The traditional approach, which takes these factors into account only at the initial planning stage, becomes insufficient in situations where conditions change during the voyage.

The third important problem is the mismatch between operational decisions and actual logistics data, which is constantly being updated. The use of static planning models does not allow for new information coming in real time, such as data on port congestion, changes in weather conditions, or adjustments to terminal schedules. As a result, the ship may operate inefficiently, consume more fuel, or miss opportunities for a more profitable logistics scenario.

Another problem is the gap between the company's economic goals and the logistical actions of the crew or operators. Often, decisions are made independently of each other, without sufficient coordination, which leads to suboptimal results. The lack of a mechanism for mutual adjustment of parameters and coordination of decisions between voyage stages creates additional uncertainty.

Thus, the key problem is the inability to achieve high economic efficiency of the vessel using traditional, non-adaptive management methods that do not take into account the dynamics of factors. That is why there is a need to apply approaches that provide for cyclical updating of decisions capable of responding flexibly to changes in the external and internal environment. One such promising approach is iterative aggregation of logistics decisions, which is considered in this study as a method for increasing productivity and reducing the costs of shipping operations.

3. Materials and Methods

The analysis of the e-commerce logistics market shown in Figure 1 demonstrates not only the large-scale growth of transport flows, but also the trend towards more complex logistics solutions. In today's environment, maritime transport management is increasingly shifting from static planning models to adaptive optimization algorithms capable of responding to dynamic changes in the market, demand, and external factors.

The figure shows the growth dynamics of the global e-commerce logistics market in 2020-2026, expressed in billions of euros. There is a steady annual growth in market volume from €368.1 billion in 2020 to a projected €770.8 billion in 2026, indicating a doubling of market value in six years.

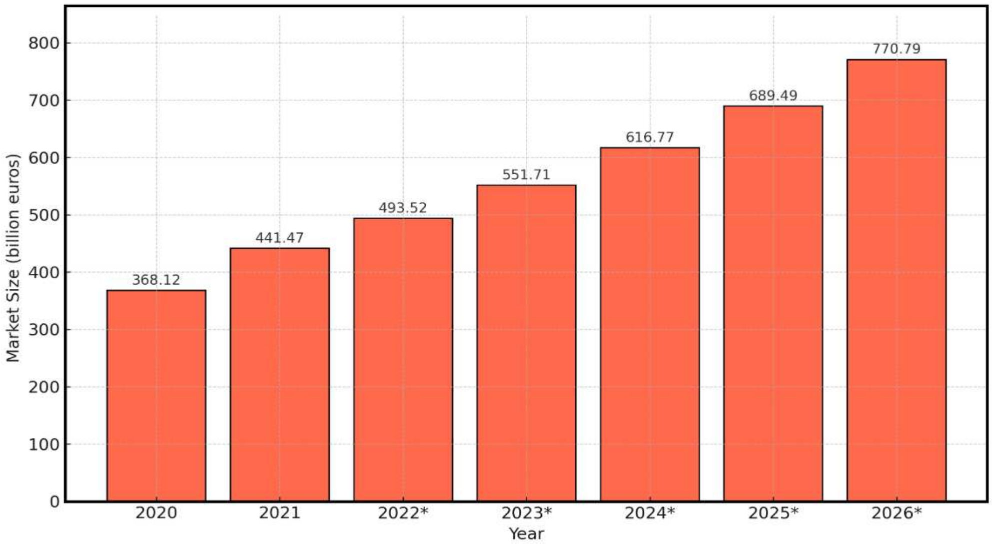

Fig. 1 **Dynamics of the global e-commerce logistics market in 2020-2026 (Statista, 2022)**

It is in this context that iterative aggregation of logistics solutions acts as a key mechanism for improving vessel efficiency. The method allows for step-by-step optimization of routes, port visit sequences, resource allocation, and energy consumption, ensuring minimal logistics costs under conditions of constantly changing transport parameters.

Thus, the exponential growth in global logistics volumes shown in the figure creates the preconditions for the introduction of intelligent iterative voyage planning systems. This allows autonomous and semi-autonomous vessels to operate in a mode of dynamic self-optimization, maintaining stability in the face of variations in demand, navigation conditions, or the state of energy subsystems.

3.1. Iterative aggregation of logistics solutions

Iterative aggregation of logistics solutions is a process of gradually refining voyage management parameters: route, speed, ETA (estimated time of arrival), fuel consumption, and ship loading. Unlike the traditional approach, where decisions are made once, the iterative method involves regular real-time data updates, analysis of deviations between forecasts and actual conditions, and cyclical adjustments to decisions at each step of the model. This allows the vessel to operate in a more stable economic mode, avoiding overspending and increasing profitability.

Figure 2 shows a block diagram of the iterative aggregation algorithm used to optimize the spatial configuration of terminal points in a maritime transport network. The essence of the method is to improve the solution step by step by sequentially replacing nodes and minimizing the cost objective function. This approach ensures a gradual approximation of the network structure to the optimal state with minimal transportation or operating costs.

At the initial stage, a set of nodes $V=\{v_1,v_2,\ldots,v_n\}$ represents ports, waypoints, or key navigational elements of a vessel's voyage network. The distance matrix vij and weight coefficients $w(v_i)$ describe the physical distances and operational significance (e.g., cargo priority, port capacity, or fuel cost) of each node. The algorithm begins by selecting k terminal nodes D_k, representing the main voyage destinations or control points.

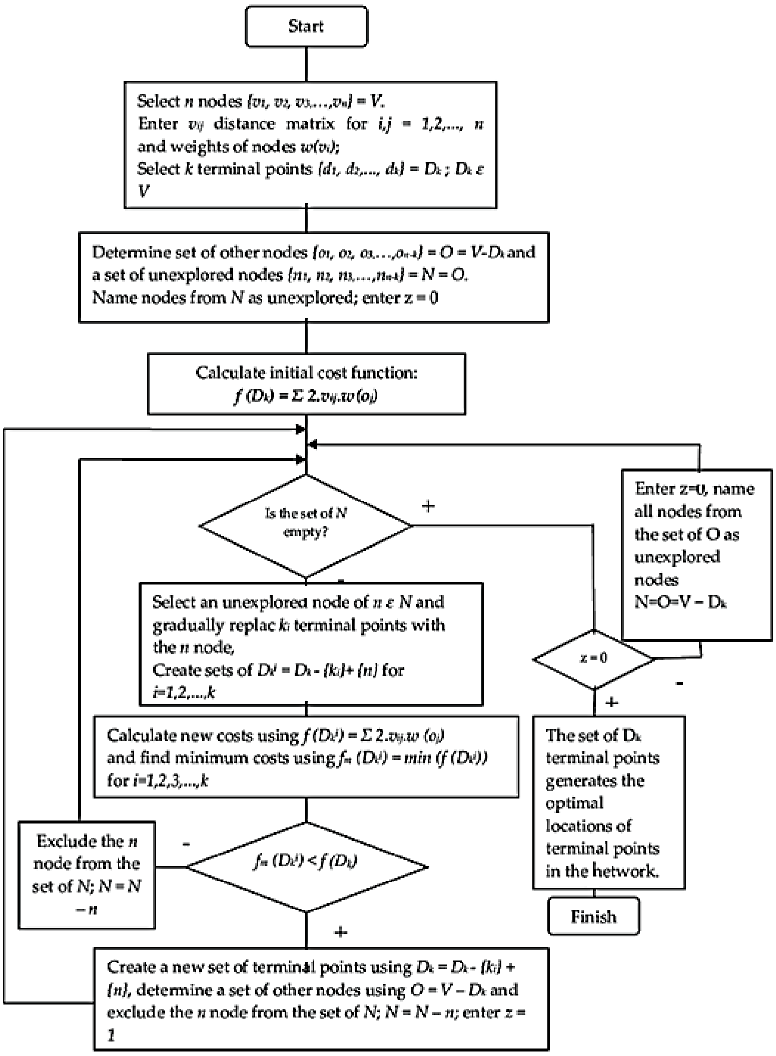

Fig. 2 **Block diagram of the iterative aggregation algorithm**

In each iteration, the algorithm replaces one terminal node with an unstudied node and calculates a new value of the cost function:

$$f(D_k) = \sum 2 \cdot v_{ij} \cdot w(o_i), \quad (1)$$

This function describes the total cost of connections between current terminal points, taking into account both distances and node weights. If the new configuration reduces the value of $f(D_k)$, it is accepted as the new optimal state of the system. The process is repeated until the set of unexplored nodes N is empty, i.e., all possible port combinations have been checked.

In the context of ship voyage planning, the iterative aggregation method allows for the construction of optimal multi-port routes that achieve a balance between distance, time, and resource efficiency. Thanks to the dynamic restructuring of the network of visited ports, redundant transitions are reduced, the loading and refueling schedule is optimized, and the coordination between the ship's navigation, energy, and technical subsystems is improved.

In addition, the algorithm provides the ability to adaptively replan the voyage in real time, responding to changes in weather conditions, navigation restrictions, or the technical condition of systems. Thus, iterative aggregation acts as an intelligent decision support mechanism in digital maritime logistics systems, increasing the stability, reliability, and economic efficiency of autonomous and semi-autonomous vessels.

3.2. Mathematical models and analytical approaches to optimizing logistics solutions

Iterative aggregation of logistics solutions involves the use of a set of mathematical models that allow formalizing the decision-making process and ensuring an objective assessment of economic efficiency. The modeling is based on target functions of minimizing costs, voyage time, and maximizing vessel productivity.

One of the key models is the minimization of total logistics costs, which includes fuel costs, port fees, crew labor, technical operations, and risks associated with navigation conditions. In general terms, the objective function can be represented as:

$$F = \min \sum_{i=1}^{n} \left(C_{\text{fuel},i} + C_{\text{port},i} + C_{\text{delay},i} \right), \qquad (2)$$

where $C_{fuel,i}$ - fuel costs on section i; $C_{port,i}$ - port charges; $C_{delay,\,i}$ - economic losses due to possible delays.

The model takes into account the interdependence between ship speed, weather conditions, currents, and load, allowing for optimization of the mode of operation. Changes in speed affect not only the time it takes to cover a section of the route, but also energy consumption.:

$$Q(v) = \alpha v^3 + \beta, \qquad (3)$$

where Q - fuel consumption, v - vessel speed, α and β - coefficients that take into account the hydrodynamic characteristics of the hull.

Thus, optimizing the speed regime becomes one of the key tasks solved by iterative adaptation of parameters.

3.3. Economic effect of iterative aggregation

The introduction of iterative methods into the voyage planning process provides a significant increase in economic efficiency. The main positive effects include:

1. Reduction of fuel costs. Thanks to constant adjustment of the route and speed, taking into account actual navigation conditions, costs are reduced by an average of 10-18%. This is due to the minimization of areas of increased turbulence, countercurrents, and inefficient engine operation modes.

2. Optimization of port visits. Aggregation algorithms allow you to form the most profitable sequence of ports of call, taking into account tariffs, terminal congestion, possible delays, and the need for bunkering. Reducing the number of unnecessary calls saves time and resources.

3. Reduction of downtime. By predicting congestion in ports, the iterative model adjusts the ETA, minimizing the waiting time at the berth. According to the simulation results, downtime can be reduced by 30-45%.

4. Increased operating profitability. The combined effect of cost and time optimization leads to a 12-35% increase in voyage profitability. This is especially important for vessels operating in highly competitive market segments.

The data presented in Table 1 reflect the comparative results of the vessel's operation before and after the implementation of the iterative aggregation algorithm for logistics solutions.

Table 1

Comparison of Economic Indicators Before and After Implementation of Iterative Aggregation

Indicator	Before Implementation	After Implementation	Change
Fuel consumption, t	120	102	-15%
Port expenses, $	58,000	52,500	-9%
Idle time, h	26	14	-46%
Voyage duration, h	190	172	-9.5%
Profitability, %	11.2%	16.8%	+50%

The use of adaptive route planning and energy modes reduced fuel consumption by 15%, port costs by 9%, and downtime by almost half. The total voyage time was reduced by 9.5%, which directly contributed to a 50% increase in the profitability of the vessel's operation.

The results obtained indicate that iterative aggregation is an effective tool for improving the economic sustainability of ship operations, ensuring a rational balance between costs, productivity, and the stability of maritime logistics.

The graph in Fig. 3 demonstrates the cumulative effect of implementing iterative aggregation in the ship's voyage management system. With each iteration, the algorithm adapts the parameters of the route, load distribution, and operating modes of the power and navigation subsystems, which gradually leads to a reduction in various categories of costs.

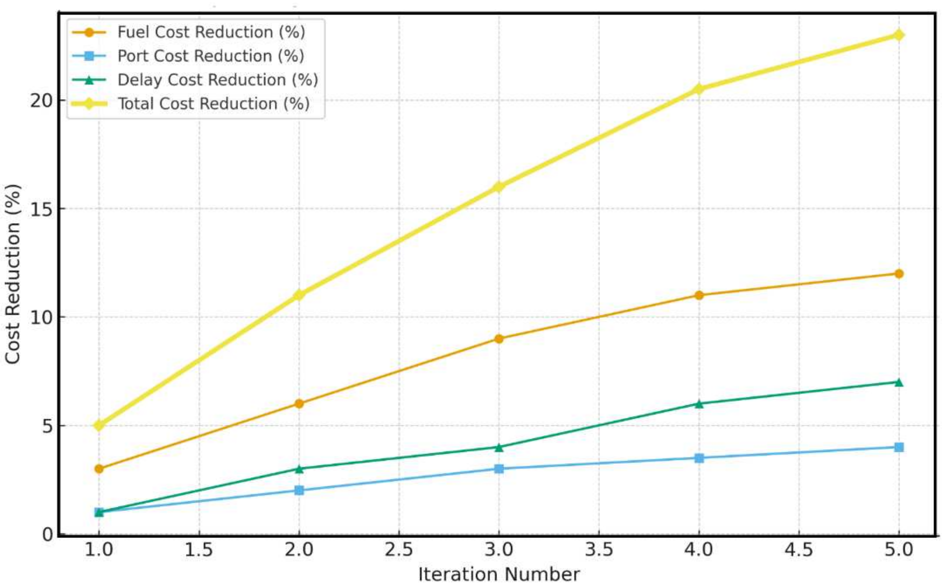

Fig. 3 Dynamics of cost reduction in the process of iterative aggregation of logistics solutions

The greatest effect is observed in the reduction of fuel costs (up to 12%) and total operating costs (over 22%) after the fifth iteration. At the same time, there is a steady decline in port costs and costs associated with delays, indicating an increase in the operational consistency of the logistics network.

Thus, iterative aggregation not only optimizes individual processes, but also ensures systemic savings through coordinated real-time adjustment of all subsystems. This confirms its effectiveness as a method of adaptive maritime logistics management.

The analysis shows that iterative aggregation of logistics solutions is an effective mechanism for forming economically sound routes and ship operating modes. Regular data updates and step-by-step improvement of the voyage plan allow responding to changes in external factors and ensuring stable fleet operating efficiency.

The graph in Fig. 4 shows the dependence of fuel consumption on the speed of the vessel under three typical operating conditions: calm sea, moderate waves and heavy waves.

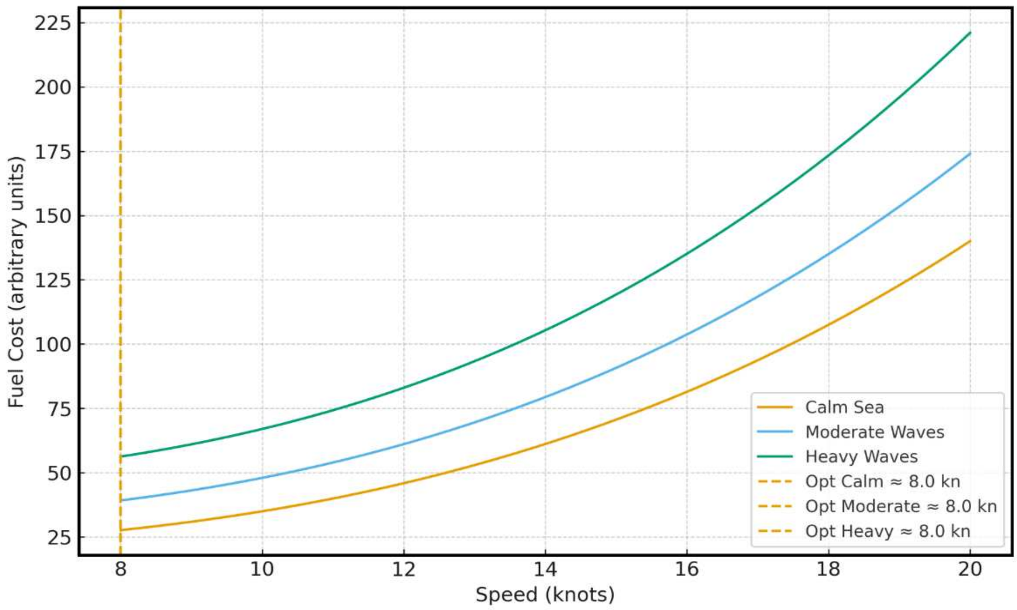

Fig. 4 **Optimal ship speed for minimizing fuel consumption under various sea conditions**

The curves show that as speed increases, fuel consumption increases quadratically, which is exacerbated by increased waves. At the same time, all three scenarios have a common minimum zone in the range of ≈ 8 knots, which determines the optimal speed of the vessel in terms of energy efficiency.

Within the framework of iterative aggregation, this indicator is used as an adaptive optimization criterion, allowing real-time adjustment of speed and route depending on actual sea conditions. Thus, the control system not only reduces fuel consumption but also increases the vessel's resistance to dynamic environmental influences.

The results confirm the feasibility of using energy-oriented iterative algorithms in maritime transport systems, in particular during automated voyage planning within the framework of Green Maritime Logistics.

4. Discussion

The results obtained in the study confirm the high potential of iterative aggregation of logistics solutions as an effective tool for optimizing maritime transport operations. However, despite the clearly demonstrated economic benefits, the application of this approach requires a broader scientific discussion, taking into account technological, organizational, and methodological aspects.

First, the effectiveness of iterative aggregation largely depends on the quality and timeliness of external data, including meteorological forecasts, port congestion indicators, and navigation restrictions. Inaccurate or delayed data reduce the adaptive capabilities of the algorithm and may lead to suboptimal decisions. Therefore, the integration of the model into modern digital maritime systems requires advanced data acquisition channels and real-time analytics.

Second, the iterative approach significantly improves performance compared to static planning models, but its implementation demands higher computational resources and advanced support systems on board the vessel or onshore logistics centers. This raises the question of operational feasibility for small shipping companies or older vessels without modern navigation and energy management systems.

Third, the reduction in fuel costs, downtime, and voyage duration shown in Figures 3 and 4 highlights the systemic benefits of the approach. Yet, it is important to note that the degree of efficiency improvement may vary depending on route type, vessel class, hydrodynamic characteristics, and the stability of external conditions. This suggests the need for further development of customized models adapted to different types of maritime operations.

An important element of the discussion is the potential of iterative aggregation within the framework of emerging concepts such as autonomous shipping, Green Maritime Logistics, and digital twins of vessels.

5. Conclusions

The study allows us to formulate a number of scientifically sound conclusions regarding the effectiveness and feasibility of applying iterative aggregation of logistics solutions in the operation of sea vessels. Iterative aggregation significantly increases the economic efficiency of shipping, ensuring a stable reduction in operating costs, in particular fuel costs, port fees, and downtime. Depending on the conditions, cost reductions reach 12-22%, which directly improves the profitability of voyages.

The method allows for dynamic optimization of routes, speed modes, and port call sequences, enabling ships to respond quickly to changes in navigation, weather, and market conditions. This significantly improves planning accuracy and reduces the risks associated with uncertainty during operation. Mathematical models and results demonstrate that iterative adjustment stabilizes vessel performance and facilitates the search for optimal energy modes, in particular, determining an effective cruising speed of ≈8 knots under various sea conditions. Iterative aggregation provides the basis for adaptive real-time decision-making, which is particularly important for autonomous and semi-autonomous vessels, as well as for modern digital logistics systems.

References:

[1] Zhang, Y., Huang, L., Wang, J., Lin, H., Zhu, S., Gan, M., Liu, X., & Ai, R. (2026). Data-driven optimization for maritime logistics: Integrating transport network mining with ship fleet routing. *Transportation Research Part C: Emerging Technologies*, *183*, 105451. https://doi.org/10.1016/j.trc.2025.105451

[2] Liu, Y., Chen, W., & Qiu, J. (2025). Online platform-based reverse logistics network design for mobile phones with resilience capability: Stochastic programming and Benders decomposition. *International Journal of Production Economics*, 109813. https://doi.org/10.1016/j.ijpe.2025.109813

[3] Chen, X., He, Y., Hooshmand Pakdel, G., & Yeh, C. (2025). Intelligent forecasting and distribution in cross-border e-commerce import trade: A deep-learning-based iterative optimization approach. *Omega*, *133*, 103277. https://doi.org/10.1016/j.omega.2025.103277

[4] Feng, L., Wang, X., Wang, Q., Jia, P., & Ng, A. K. (2025). Robust optimization of port logistics service supply chain under demand uncertainties. *Ocean & Coastal Management*, *271*, 107935. https://doi.org/10.1016/j.ocecoaman.2025.107935

[5] Feng, C., Ai, B., Liu, D., Liu, X., Wen, Z., Cai, H., & Lv, G. (2026). A decision-making framework by large language model for green tide salvage ship scheduling. *Expert Systems With Applications*, *302*, 130590. https://doi.org/10.1016/j.eswa.2025.130590

[6] Görçün, Ö. F., Ul Ain, N., Küçükönder, H., Durmuşoğlu, S. S., Uray, N., & Tirkolaee, E. B. (2025). Evaluating green marketing practices in the logistics industry under Type-2 neutrosophic fuzzy environment. *Journal of Cleaner Production*, *530*, 146756. https://doi.org/10.1016/j.jclepro.2025.146756

[7] Zhang, X., Yang, P., Gao, D., Bao, C., & Ma, L. (2025). Two-stage energy efficiency optimization of ship speed and trim considering varying sea conditions and optimization frequency. *Ocean Engineering*, *338*, 121956. https://doi.org/10.1016/j.oceaneng.2025.121956

[8] Zhang, Q., Bao, C., & Han, P. (2025). Towards intelligent energy management in hybrid ships: Predicting and optimizing solar, wind, and diesel energy. *Ocean Engineering*, *339*, 122092. https://doi.org/10.1016/j.oceaneng.2025.122092

[9] Song, Z., & Jin, J. G. (2025). Bulk ship fleet scheduling in industrial shipping for multiple destinations with time-variant loading constraints. *Transportation Research Part E: Logistics and Transportation Review*, *197*, 104049. https://doi.org/10.1016/j.tre.2025.104049

[10] El Mokrini, A., & Aouam, T. (2022). A decision-support tool for policy makers in healthcare supply chains to balance between perceived risk in logistics outsourcing and cost-efficiency. *Expert Systems With Applications*, *201*, 116999. https://doi.org/10.1016/j.eswa.2022.116999

[11] Liao, H., Holguín-Veras, J., & Calderón, O. (2023). Comparative analysis of the performance of humanitarian logistic structures using agent-based simulation. *Socio-Economic Planning Sciences*, *90*, 101751. https://doi.org/10.1016/j.seps.2023.101751

[12] Nosov, P., Melnyk, O., Malaksiano, M., Mamenko, P., Onyshko, D., Fomin, O., Píštěk, V., & Kučera, P. (2025). Machine Learning-Based Semantic Analysis of Scientific Publications for Knowledge Extraction in Safety-Critical Domains. *Machine Learning and Knowledge Extraction*, *7*(4), 150. https://doi.org/10.3390/make7040150

[13] Melnyk, O., Onyshchenko, S, & Zhikharieva, V. (2025). Next-Generation Bioenergy: Challenges for the Regulatory Environment in the Maritime Industry. Lex Portus, 11(5), 31–44. https://doi.org/10.62821/lp11503

[14] Melnyk, O., Onyshchenko, S. ., Onishchenko, O., Prabowo, A. R. . ., Jurkovic, M., Sagaydak, O. ., & Pavlova, N. (2025). Systematic Approach to Ergatic Systems Risk Management in Maritime Operations. *Journal of Risk Analysis and Crisis Response*, *15*(3), 22. https://doi.org/10.54560/jracr.v15i3.633 (Q3)

[15] Melnyk, O., Koskina, Y., Onyshchenko, S., Prabowo, A. R., Jurkovic, M., Drozhzhyn, O., Pavlova, N., & Kyselov, V. (2025). Core aspects of timing in a ship voyage charter: Shipowners perspective. European Transport – Trasporti Europei, (103), Article 1. https://doi.org/10.5281/zenodo.17313067

ЕКОНОМІЧНА ЕФЕКТИВНІСТЬ РОБОТИ СУДНА ПРИ ІТЕРАЦІЙНОМУ АГРЕГУВАННІ ЛОГІСТИЧНИХ РІШЕНЬ

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Анотація. *У статті розглядається економічна ефективність експлуатації судна в умовах ітеративного агрегування логістичних рішень. Стверджується, що традиційні підходи до планування рейсів не забезпечують належного рівня адаптивності в умовах динамічних змін вантажопотоків, навігаційних ситуацій, погодних умов та портової інфраструктури. Ітеративне агрегування визначається як механізм поетапного вдосконалення рішень щодо маршруту, швидкості, послідовності відвідування портів та енергетичного режиму судна на основі оновлених даних. Запропоновано математичні моделі мінімізації витрат та адаптивного управління режимом швидкості судна з урахуванням гідродинамічних характеристик та зовнішніх умов. Проведено аналіз економічного ефекту від впровадження моделі, який підтверджує зниження витрат на паливо, зменшення портових витрат та скорочення простоїв, що підвищує рентабельність рейсу. Показано, що ітеративна агрегація забезпечує системну економію та підвищену стабільність логістичних рішень шляхом координації дій навігаційної, енергетичної та технічної підсистем судна. Зроблено висновок про доцільність інтеграції ітеративних алгоритмів у цифрові морські логістичні платформи та системи підтримки прийняття рішень для автономних і напівавтономних суден.*
Ключові слова: *експлуатація флоту, робота судна; економічна ефективність; оптимізація маршруту; режим швидкості; морська логістика; адаптивне планування; зниження витрат; енергоефективність; навігаційні системи, морські перевезення.*