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CRITERION FOR ENSURING THE EFFECTIVENESS OF THE MANAGEMENT OF THE GLOBAL MARITIME INDUSTRY

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Introduction. The significant dynamic nature of modern geopolitical and military threats sets new requirements for evaluating the criteria effectiveness of solving maritime industry management problems, requires new methodological approaches and mathematical models for evaluating criteria, and determines a new architecture of information systems in the structure of which these approaches and models are implemented. This makes the issue of the analysis of the application of criteria and the development, research, and implementation of such models and systems extremely relevant.

Aim and tasks. The purpose of the study is to create a methodological approach to evaluating the criteria that characterize the effectiveness of the management of the maritime industry, with the dynamic change of criteria due to the influence of threats and challenges.

Results. A methodological approach has been developed to evaluate the criteria that characterize the effectiveness of the management of the maritime industry based on the model for assessing the convergence of the absolute values of the first derivatives of the criteria over time, which, at short time intervals, can be considered as criteria change trends. It has been established that instead of reducing transportation costs, management switches to the principle of ensuring optimal costs, which leads to an increase in the cost of freight and shock reactions in the sea transportation market. It was established that it is advisable to use the LSCI criterion as an indicator of the negative effect of “local optimization”. After determining the development trends of the criteria, their evaluation as well as the assessment of their convergence were carried out, which became the basis for proposing directions for improving the efficiency of maritime industry management.

Conclusions. The developed methodological approach and the mathematical model of its implementation make it possible to conduct both quantitative and qualitative analyses of the effectiveness of management of the maritime industry. To increase the efficiency of management, it is proposed: to integrate port community systems; to increase the stability of the port infrastructure so that it can function in crisis conditions; to achieve coordination of management actions at all levels; to avoid “local optimization” and introduce integral optimization; to respond not only to direct threats but also to detect the cascading effects of threats.

Keywords: criteria, management, efficiency, maritime industry, mathematical model.

1. Introduction.

The global maritime industry is a complex system is influenced by many factors. And since it is designed to ensure the operation of the world trade market, all factors that influence the functioning of this market also have an impact on the maritime industry. This leads to a significant increase in variability in the activity of the merchant fleet and its infrastructure, and, accordingly, complicates the task of effective industry management.

Based on the analysis, in 2022, in addition to those threats and challenges to which the maritime industry has more or less adapted (tsunamis, earthquakes, pandemics), a new type of global level appeared: the deterioration of the geopolitical situation (blockade of Ukrainian ports, threat of blockade of Taiwanese ports). New challenges create new conditions for the functioning of both the global market and the transport industry.

The dynamic nature of changes, which has significantly increased over the last period, also makes it difficult for the management involved in the maritime industry to implement operational management measures. The specified variability creates an increase in the level of uncertainty for planning and implementation of management tasks, which requires the use of information technologies for the relevant analysis of changes and ensuring management activities.

This necessitates the application of mathematical models that use different methodological approaches and the creation of intelligent systems based on them to increase management efficiency (Katerna, 2018; Zeynali & Rahimli, 2022).

One of these approaches, tested by scientists and practitioners, is criterion-referenced management (Bazaluk et al., 2022; Golubkova et al., 2021). But the above-mentioned effect of strengthening the dynamic nature of changes sets new requirements for mathematical models of maritime industry management and requires new approaches in the use of information systems in the structure of which these models are implemented, which makes relevant the issue of analysis of the application of criteria, development, research and implementation of such models and systems.

2. Literature review.

Given the importance of the maritime industry for world trade (Noble, 2019), the task of properly ensuring the effectiveness of its management and evaluating the factors that influence this process has arisen (Bottalico et al., 2022). Such factors can be presented, for example, as quantitative specifications of port characteristics for their classification (Russo and Musolino, 2020), or factors of the strategic basis of environmental performance management for navigation (Makarenko et al., 2019; Svyrydenko & Revin, 2022; Yarmol et al. 2021). In the literature, these factors are often presented in a criterial form: criteria for managing the constant positioning of the fleet in conditions of globalization (Golubkova et al., 2019); criterion limitations of sustainable development in the management of maritime transport complexes (Rony et al., 2019; Yavorska, 2018); competitive selection criteria among marine terminals as indicators of their management efficiency (Balci et al., 2018); criteria for managing the development of maritime transport logistics centers (Çavuşoğlu et al., 2022); criteria for evaluating the organizational and economic prerequisites for the development of land-based structures of the maritime industry (Remzina, 2020); criteria for evaluating the level of effectiveness of the organizational culture of the seaport (Balanovska, 2019; Makarenko et al., 2019; Praise & Rapina, 2022).

As it can be seen from the list above, the different purpose of assessment, different tasks cause different criterion representation of management efficiency. This is a confirmation of the thesis that the effectiveness of management of the maritime industry is a sufficiently broad concept. This thesis is used and developed in the presented study.

Given the significant rate of growth of information in this area, the analysis of criterial representations of management goals of various levels, tasks and results requires more and more computing resources and new information technologies and systems. The effectiveness of management, in particular, is determined by the possibility of adapting the specified criteria to modern digital tools (Gavalas et al., 2022) and factors of digital transformation of the maritime industry (Jović et al., 2022).

Nowadays, all aspects of the management of the global maritime industry are undergoing digital transformation, from the specific practical needs of evaluating the technical efficiency of terminals for various types of cargo using data envelopment analysis (Suliman et al., 2019) to the tasks of comparative analysis of business models of liner shipping companies (Lam and Wong, 2018). The digital transformation of management, as defined by some scientists, at present has the character of a digital revolution (Verhoef et al., 2019). The consequence of this is not only technological changes, economic shifts, reduction of the technological load on the environment, but also the prediction of significant social changes (Tijan et al., 2021).

The use of digital technologies, the ability to analyze large and ultra-large volumes of data is promising for management to rely on planning in conditions of dynamic changes in performance criteria (Warner and Wäger, 2019). Unfortunately, the models proposed by scientists, in particular the model based on nine microfoundations (Warner and Wäger, 2019), do not always provide the appropriate level of relevance. According to the analysis (Del Giudice et al., 2022), IT, first of all, allows to increase the efficiency of criterion management for the maritime industry in the operational dimension. For example, digitization and new technologies have accelerated the implementation of sustainable criteria business models at the ship-port interface (Del Giudice et al., 2022). First of all, IT allows to increase the efficiency of management in the maritime industry by significantly increasing the coordination of various technological processes, including that on sufficiently multivariate and multi-stage logistics routes (Balci, 2021), improving the quality of service of sea ports through the introduction of digital technologies (Agatić et al., 2020). This is also evidenced by the increase in the speed of implementation and spread of innovations in the maritime industry (Acciaro et al., 2020). This is used in the presented article.

Significant shifts in the implementation of digital technologies for criterion-based ensuring the effectiveness of maritime industry management are also characteristic of Ukraine. An example of this is the development of a protected consolidated information resource for

analyzing and increasing the efficiency of the management of Ukrainian seaports (Azarova et al., 2020).

In general, a review of the scientific literature on the presented issues indicates that the dynamic nature of changes determines the need to analyze and assess the state of the maritime industry and propose ways and tools to increase the efficiency of the industry's management, in particular, in terms of its criterion support.

3. Methodology.

Since the dynamic updating of technologies, a wide range of tasks facing the management of the global maritime industry, and the amount of information necessary to solve these tasks, the amount of information that grows exponentially, there is a need for a broad statement of the task for an intelligent decision-making preparation system, with the next possibility of fragmentation of this task, depending on the set goal.

To create a methodological approach for evaluating the criteria that characterize the effectiveness of the management of the maritime industry, for dynamic changes in criteria due to the influence of significant threats and challenges, the method of mathematical abstraction is used, which consists of the following. In the data space θ , using those criteria from their databases that meet the set goal, the area in the coordinates φ , $\eta_1, \eta_2, \eta_3, \dots, \eta_n$, where φ is the target function; $\eta_1, \eta_2, \eta_3, \dots, \eta_n$ – criteria, $i = 1, 2, 3, \dots, n$ – current criterion index, n is the total number of criteria. Next a search on the response surface of the function $\varphi(\eta_1, \eta_2, \eta_3, \dots, \eta_n)$ under the given restrictions.

The tasks of ensuring the effectiveness of the management of the maritime industry, even at the regional level, require large amounts of information and, accordingly, significant computer resources. The dynamic nature of these tasks significantly increases the need for IT resources. To reduce the time and volume of calculations, it is proposed to apply a model for assessing the convergence of the absolute values of the first derivative criteria in time:

$$\bigcup_{i=1}^n \left(\left| \frac{\partial \eta_1}{\partial t} \right|, \left| \frac{\partial \eta_2}{\partial t} \right|, \left| \frac{\partial \eta_3}{\partial t} \right|, \dots, \left| \frac{\partial \eta_n}{\partial t} \right| \right) \rightarrow opt \quad (1)$$

For short time intervals, the first-time derivatives of the criteria can be defined as “trends”. The step-by-step implementation of management tasks approximates and gives the “trends” a broken character and allows implementing the method of steep ascent to the desired result. The desired result will belong to the area of convergence (Q) of the set of $m \in n$ criteria chosen to solve a specific problem:

$$Q \left(\frac{\partial \eta_1}{\partial t} \cap \frac{\partial \eta_2}{\partial t} \cap \frac{\partial \eta_3}{\partial t} \cap \dots \frac{\partial \eta_m}{\partial t} \right) \quad (2)$$

The use of absolute values is due to the fact that the signs of the first derivative criteria (trend directions) may be different but implement the same development trend. That is, an increase in the value of some criteria and a decrease in others can indicate an improvement in the result. In some cases, which will be analyzed below, the convergence of the absolute values of the first derivative criteria over time is ensured by the compensation of the decrease of some criteria by the increase of others.

Using the method of induction and deduction, it is indicated that since the effectiveness of the management of the maritime industry can be determined by different goals, then, in general, it is recommended to establish a group of criteria that correspond to the relevant assessment of the target function from the existing challenges and threats.

The method of critical analysis made it possible to establish that the model for evaluating the convergence of the absolute values of the first derivative criteria in time is suitable for both qualitative and quantitative analysis with proper provision of IT resources.

The method of analysis and synthesis was used to analyze and evaluate the available information. An analytical method was used for the development of proposals for increasing the efficiency of maritime industry management.

4. Aim and tasks.

The purpose of the article is to create a methodological approach to evaluating the criteria that characterize the effectiveness of the management of the maritime industry, with dynamic changes in the criteria due to the influence of significant threats and challenges.

The objectives of this article are:

- development of a mathematical model for evaluating criteria that characterize the effectiveness of maritime industry management;
- analysis of the criteria for the effectiveness of the maritime industry and its management, the impact of threats and challenges on them;
- analysis of criteria trends and establishment of their compensatory interactions;
- proposing directions for increasing the efficiency of maritime industry management.

5. Results.

Management efficiency and its ability to solve management tasks optimally will be regarded, given the need to ensure reliability in the organization of the transport process and the management's ability to neutralize adverse effects or minimize their consequences. Economic efficiency can be defined, in particular, as economic security, resource efficiency, reduction of the cost of transporting a unit of cargo, etc. The implementation of each efficiency function should be considered in the system of the process approach because it consists of a set of management actions of performers at different levels and sectors of the maritime industry. Efficiency should also be ensured by the appropriate level of coordination and consistency of management at organizational levels.

As the analysis shows, under the conditions of new geopolitical and military risks, instead of the traditional orientation of management to reduce the costs of cargo transportation, transport companies are switching to the practice of implementing the principle of ensuring optimal costs. Optimal costs also include costs for reducing the impact of threats or minimizing their probable consequences. The management of transport companies is also beginning to form not only the main routes to ensure the proper functioning of logistics chains but also backup options. This led to a certain change in the selection of criteria for evaluating the effectiveness of the maritime industry and its management. For example, it may increase the cost of transporting goods, but it will reduce costs due to the reduction of threats.

Thus, after the beginning of the blockade of Ukrainian ports, transport companies of the maritime industry are forming alternative options for logistics chains. For example, potash fertilizers from Canada began to be transported to Nigeria, and grain from Brazil goes to African countries. This, in general, also led to an increase in the criterion indicator of freight volumes (tons/mile). This criterion currently has an upward trend, which, under these conditions, does not indicate deterioration in the effectiveness of the management of the maritime industry.

In addition, the increase in the level of threats directly affects such a criterion factor of sea transportation as the cost of freight. An increase in the cost of freight, in turn, affects the increase in the price of goods transported by sea. An example is the impact of the increase in cargo transportation tariffs on world prices for grain and other food products due to the blocking of seaports of Ukraine. In particular, for high-income countries, food prices rose by 0.8%; for lower-middle-income countries increased by more than 1.4% (UNCTAD, 2022). The increase in the price of goods transported by sea affects, in turn, other criteria of the maritime industry, in particular the criterion “Estimated productivity level, cargo carried per fleet capacity (ton/dwt)”, the rate of which is one of the criteria for assessing the effectiveness of the management of the maritime industry.

Significant challenges of the past periods led to significant shock reactions in the sea transportation market according to this criterion. Thus, the oil crisis led to a decrease in productivity by more than a third and reached up to 5 ton/dwt (UNCTAD, 2022). The adaptation period to neutralize the impact of this crisis lasted until the end of the 90s. The global financial crisis led to the next sharp decrease of this criterion. As a result of proper management activities, the average annual growth rate of supply at the sea transportation market (~5%/a year) began to exceed the growth rate of demand (~2%/a year) by almost two and a half times. The analysis of the coincidence of these trends, according to the proposed model, indicated that it allowed reducing the rate of decrease of the specified criterion for different segments of the fleet: tankers, dry cargo vessels and, with a lower level of efficiency, container

carriers – due to market consolidation, which led to a decrease in the peak values of excess supply. In 2021, total cargo volumes increased from 678 million tons to 940 million tons, and supply decreased from 95.5 million dwt to 92.5 million dwt (UNCTAD, 2022). But military actions and the deterioration of the geopolitical situation in 2022 led to a decrease of this indicator to almost the same minimum level for the period of 1960–1922, which was observed only in 1980.

The non-convergence of trends in this case is evidence of the unwillingness of the management of the global maritime industry to act proactively, rather than to minimize the consequences and reduce the impact of global crises on the fleet's activities only after they occur. Therefore, it is necessary to increase the effectiveness of management in this direction in view of the rates of the criterion “Estimated productivity level, cargo carried per fleet capacity (ton/dwt)”. Since, according to UNCTAD (2022), the cargo capacity of container carriers will grow to ~8%, it is possible to predict a further decrease in the “Estimated productivity level, cargo carried per fleet capacity” level criterion for objective reasons not related to a decrease in management efficiency for this type of transportation.

According to forecast values for dry cargo ships, fleet growth in the coming years will be insignificant (~0.4%), and the volume of dry cargo transportation will stabilize, which will stabilize this segment of the transportation market. For the market segment of oil tankers, the situation is much more complicated. With a slight increase in the fleet (~2%), there is a significant increase in demand. The significant increase in demand is due to the blocking of the EU market for Russian crude and an attempt to compensate for the loss of sales by making up the markets of Asian countries. The extension of routes and, accordingly, the time of transportation (~6.6 times) automatically causes the need for additional transport resources. An accurate forecast of this market is complicated by the considerable dynamics of the geopolitical situation.

The geopolitical crisis of the last two years also led to the disruption of logistics chains, congestion of major ports, and a significant increase in freight rates.

The cost of transportation was also increased by the risks of cargo delays, because the growth of these risks led to the risk of significant payments for the idleness of ships and cargo detention in ports. The reason for this is that the lack of coordination causes inefficiency of management in this area, which has the consequence of increasing the time of cargo handling. Therefore, attention is needed to this direction of management activity also.

On the other hand, this is also caused by a sharp increase in consumer demand, caused by both anxious public expectations and disruptions of supply chains. Indicators of chain disruptions are such criteria as, for example, the “Baltic Dry Index, LNG charter rates”,

“Container ship charter rates”, “Container spot freight rate index” and others (UNCTAD, 2022). The Shanghai Containerized Freight Index (SCFI) is also an internationally recognized evaluation criterion. SCFI indicates freight changes for the transportation of containers from China to the ports of its global trading partners. Table 1 shows changes in the value of this criterion for the ports of Shanghai and the base ports of Europe and America. It can be seen that the geopolitical crisis has significantly but unevenly affected these indicators. For example, the rate of change of SCFI Shanghai-Europe (base port) exceeds the rate of change of SCFI Shanghai-EC America (base port) by 29% (Table 1).

Table 1. Trends of changes in the criteria indicators of the global maritime industry.

Criterion	Ratio of 2022 to 2021, %
SCFI Shanghai-Europe (base port) Container Freight Rate	65
SCFI Shanghai-EC America (base port) Container Freight Rate	84
UNCTAD liner shipping connectivity index (LSCI)	98.2
Number of container ports served by regular liner shipping services	96.8
SCFI Comprehensive Container Freight Rate Index	39
Index Port calls for all ships	94.2
Average waiting time for dry bulk	113.3
Average waiting time for tanker	100.0
EBITDA/revenue (operating margin) of seaports	98.1
All cargo throughput	104.2
Changes in direct calls by region (World)	107.7

Source: based on UNCTAD (2022), Ghorbani et al (2022), World Trade Organization (2022).

The crisis also caused a significant decrease in the profits of liner transport companies. For example, the average profit of Clarksons decreased from \$89,000 per day in October 2021 to \$35,000 per day in October 2022 (UNCTAD, 2022). Over these two years, the SCFI Comprehensive Container Freight Rate Index has fallen significantly (see Table 1), but has even approached the average annual rate for the last 10 years (Ghorbani et al., 2022).

The analysis shows that the inefficiency of one of the sectors of the maritime industry - port activity, leads, in particular, to congestion in ports, which significantly worsens the criterion assessment of the maritime industry.

Based on the analysis, it was established that the effective management of port activities is facilitated by the ratification of the WTO Trade Facilitation Agreement by the country to which the port belongs and, what is important, ensuring the appropriate level of its

implementation. Let's consider this using the example of the level of implementation of multimodal transportation of goods as an effective method of transportation.

Nowadays, the average level of implementation of those articles of the Trade Facilitation Agreement (TFA), which are necessary for the effective implementation of multimodal transportation, is still insufficient. This is confirmed by the following data (the numerator is the percentage of countries that have ratified the relevant TFA articles; the denominator is the percentage of countries that request technical assistance in their implementation): expedited shipments – 74%/22%; the possibility of electronic payment – 72%/20%; implementation of risk management – 62%/38%; cooperation of border agencies – 71%/35%; availability of authorized operators – 70%/36% (World Trade Organization, 2022).

The rate of change of the indicated indicators, first of all, the denominator, is a criterion and a prerequisite for acquiring the appropriate level of efficiency in the management of the port infrastructure of a particular country. Therefore, this direction requires both governments' attention and the maritime industry's management.

The use of Port community systems (PCS) by their management is also an indicator of the effective operation of ports. An understanding of the importance of PCS for management efficiency is indicated by UNCTAD's attention to this problem and the introduction by that

organization of the TrainForTrade program for effective port management (UNCTAD, 2022).

The integration of PCS at the national, and at the next stage - at the global level can be a promising direction for improving the efficiency of port industry management, as this will stimulate management to speed up the implementation of the relevant articles of the TFA and will contribute to a drastic increase in the efficiency of ports due to a significant improvement in the coordination of the management of all sectors of the maritime industry. This is substantiated by the results of the data analysis shown in Table 2.

Table 2. Comparative efficiency of the port infrastructure of different countries when servicing container ships in 2021.

Country	Number of arrivals /annual change,%	Median time in port, days	Median time in port, annual change, %	Average age of vessels, years
China	70506/-5.3	0.73	17.2	13
USA	18806/-6.1	1.25	20.8	15
Taiwan	14909/-10.3	0.57	27.2	14
Spain	14705/2.7	0.65	-1.8	15
Türkiye	12171/5.0	0.63	2.8	17
Singapore	13408/-10.3	1.03	29.1	13
Netherlands	11516/-0.7	0.89	10.8	15
India	8983/14.2	0.93	1.1	16
Philippines	5816/12.3	0.94	6.2	16
All countries	446589/-2.8	0.80	13.7	14

Source: based on the World Trade Organization (2022).

As it can be seen from the average data of port activity (Table 2), the world's leading countries sometimes show worse results than developing countries. This is due, in particular, to the fact that in container transportation transport companies use not only large ships that call only at leading ports, but also small ships for domestic and regional delivery of goods to small ports. Ports of local and regional importance are characterized by lower efficiency indicators, which affect the average statistics.

The analysis of the data presented in Table 2 for USA ports (annual change in number of arrivals, Median time in port, etc.) also indicates an inadequate level of efficiency in the coordination of port activities and the unevenness of the efficiency of port management by country. The aforementioned integration of PCS at the national level is the direction to remedy the situation.

It should be noted that the current results of port activity in servicing container carriers in ports and their trends shown in Table 2 are also caused by the impact of consolidation of container transportation on the world market. The consolidation process, as is evidenced by the analysis of the data presented in Fig. 1, took place in 2018-2019.

Since this process (Fig. 1) looks more significant for the group of the first four and the group of the first ten main carriers and less significant for the group of the first twenty carriers, this indicates a significant level of concentration of container transportation services in a rather limited circle of companies. This process leads to an uneven influence on the criteria of management efficiency, in particular, the criteria of the efficiency of the port industry, which has to work in the conditions of an oligopoly on the transportation market.

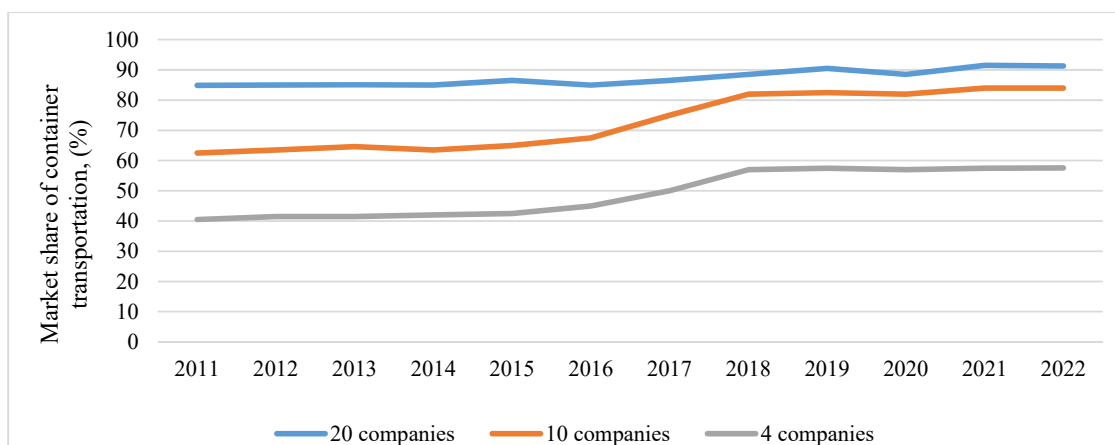


Fig. 1. Consolidation in the container transportation market.

Source: based on Alphaliner (2022).

The analysis also confirms the inconsistency of the supply and demand trends in the container transportation market and, accordingly, the rate of change of the “Estimated productivity level, cargo carried per fleet capacity”. For this purpose, tools were used to increase the effectiveness of companies' activities by increasing the share of fully loaded container carriers in the total volume of transportation. This is evidenced by the fact that by 2020, this share was 0.51-0.52, and in 2021-2022, it was increased to 0.6 by reducing the number of container ship calls to ports by 5.9%. The use of the tool of forming strategic alliances also provided carriers with a favorable position for negotiations with the management of the port industry and, accordingly, higher profits, but led, as mentioned above, to the deterioration of some criteria of the maritime industry. In particular: “Number of container ports served by regular liner shipping services”, “SCFI Comprehensive Container Freight Rate Index”, “Index Port calls for all ships”, etc.

This analysis also indicates the systemic nature of the relationship between individual segments of the maritime industry and the industry as a whole. Thus, the efficiency of the management of seaports and the efficiency of the organization of their infrastructure significantly affect the criterion evaluation of the functioning of the entire maritime industry.

For example, let's take the crisis of the industry due to the pandemic as a base situation for analysis. The pandemic caused a significant number of port workers to be absent from their workplaces, which led to delays in

cargo handling, port congestion, a decrease in the value of the criterion “Index Port calls for all ships” and an increase in the value of the criterion “Average waiting time for all ships” (Sazonets et al. 2020; Kubalskyi, 2022).

Also, as the analysis showed, there is a multiplier effect of the crisis due to management actions, for example, the implementation of “local optimization”. Wanting to optimize vessel utilization, liner company managers reduced the number of calls to ports and prioritized calls only to major ports, resulting in congestion at major ports and, accordingly, increased cargo handling times. At the same time, according to the analysis of criteria indicators, the effectiveness of the management of the global maritime industry has generally decreased (Table 1). In particular, this has had the effect of reducing the UNCTAD Liner Shipping Connectivity (LSCI) criterion due to lower frequency of ship departures and narrowing of choices for shippers. That is, in this case, it is advisable to use the LSCI criterion and evaluate improvements in this direction to fix the negative effect of “local optimization”.

For example, the effectiveness of management in this direction was shown by India, which quickly invested funds in increasing the capacity of its main ports and improved the infrastructure of related types of transport. At the same time, the management of the container terminals at the main ports of the US west coast could not quickly resolve the issue of additional financing, which led to losses.

As mentioned above, crises lead to an increase in freight rates and encourage the management of shipping companies to operate all vessels at their disposal. This, in particular, leads to an inappropriate increase in the

criterion “average age of fleet vessels”, which is usually presented in a balanced form by the number and purpose of vessels (Fig. 2), which is a certain indicator of efficiency in the specified direction.

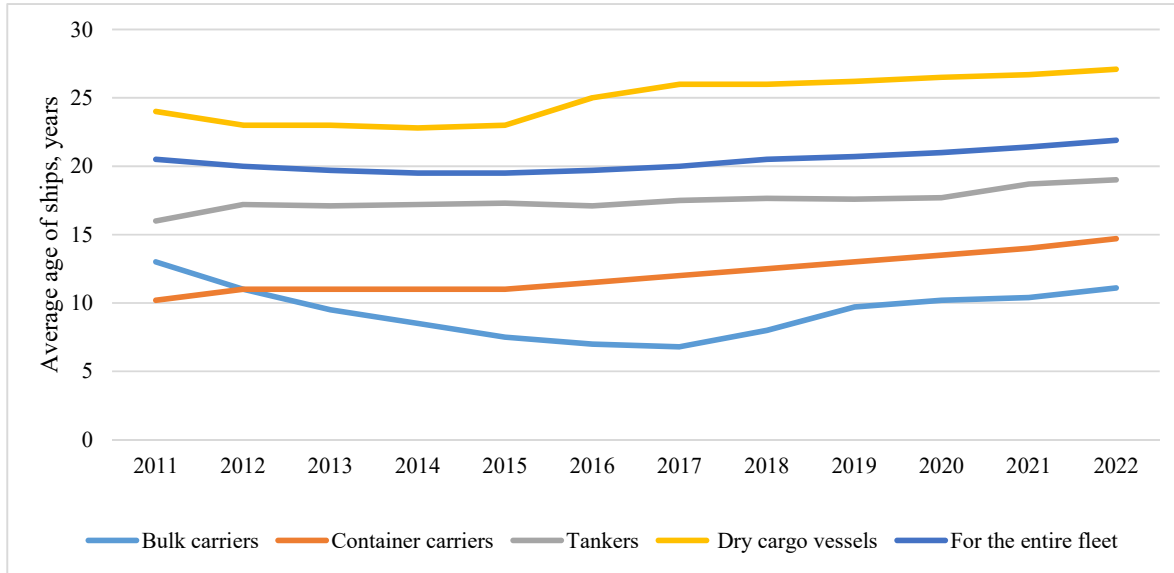


Fig. 2. Consolidation in the container transportation market.

Source: based on Alphaliner (2022).

The data presented in Figure 2 show that under the influence of the challenges of the pandemic in 2020, as a result of a decrease in the number of vessels put into operation, the indicator “Average age of fleet vessels” worsened. The increase in 2021 by ~5.2% of the total number of ships put into operation for all types of sea transportation did not change the trend of the mentioned indicator due to the increase in demand on the transportation market and, accordingly, the slowdown in the trend of decommissioning ships. To date, the reaction of the management of shipbuilding companies does not significantly influence the overall trend of the “Average age of fleet ships” indicator. The number of vessels put into operation remains below the figure of 2014-2017.

This shows that the effectiveness of the management of the industry lies not only in the need to quickly respond to challenges and threats, but also in achieving coordination of management actions of all levels and regions of the maritime industry, avoiding “local optimization” approaches and implementing integrated optimization measures.

Also, as the above analysis showed, management, in order to ensure the proper level of efficiency, must consider not only direct challenges and threats, but also take into account the possibility of cascading effects. To increase efficiency in this direction, it is necessary to apply global integration of regional and local support and decision-making systems. It is also necessary to increase the resilience of the port infrastructure to functioning in crisis conditions.

6. Conclusions.

It has been established that under the conditions of new geopolitical and military risks, instead of the traditional focus on reducing costs, transport companies are moving to the implementation of the principle of ensuring optimal costs, which also include costs for reducing the impact of threats or probable minimizing their consequences. The management of transport companies is also starting to form not only the main routes to ensure the proper functioning of logistics chains, but also their backup options.

This led to a certain change in the selection of criteria for evaluating the effectiveness of the maritime industry and its management. Since the dynamic nature of the influencing factors on the efficiency criteria of the maritime industry in conditions of significant challenges and threats increases the need for the amount of IT resources considerably, it is proposed to apply a model for assessing the convergence of the absolute values of the first derivative criteria over time. At short time intervals, the first derivatives can be considered trends of criteria change. This model is suitable for use in both qualitative and quantitative analysis, depending on the level of provision of IT resources, and can be used for information analysis subsystems and the preparation of options for Port Community Systems (PCS) management solutions.

In order to improve the efficiency of the management of the maritime industry, the integration of PCS at the national level, and at the next stage – at the global level, is proposed. This will contribute to the increase in the efficiency of ports due to a significant improvement in the management coordination of all sectors of the maritime industry. It is also necessary to increase the resilience of the port infrastructure to functioning in crisis conditions. Crises, as it was indicated, lead to an increase in freight rates, encourage the management of shipping companies to operate more intensively all the vessels at their disposal, which leads to an inappropriate increase in the “Average age of fleet vessels” criterion.

Using the developed model, criteria trends were analyzed, which made it possible to draw conclusions about the effectiveness of maritime industry management. Thus, according to the results of the study of the change in the “Estimated productivity level, cargo carried per fleet capacity” criterion, it was established that the management of the maritime industry mainly does not act proactively, but only minimizes the consequences of global crises on the fleet's activities after their occurrence.

The analysis of the effectiveness of the management of seaports and the effectiveness of the organization of their infrastructure indicated their significant influence on the criteria-based evaluation of the functioning of the entire maritime industry. It has also been established that the effectiveness of industry management consists not only in the need to quickly respond to challenges and threats but also in achieving coordination of management actions at all levels and regions of the maritime industry, avoiding “local optimization” approaches and implementing integrated optimization measures. It was established that it is advisable to use the LSCI criterion as an indicator of the negative effect of “local optimization”.

It has been established that in order to ensure the proper level of efficiency, management must consider not only direct challenges and threats, but also respond to the emergence of cascading effects. Integrated support systems and management decision-making will be able to predict the appearance of cascading effects from threats.

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