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ASSESSMENT OF CONSISTENCY IN THE FUNCTIONING OF SEAPORTS OF UKRAINE

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Introduction. Seaports in a state's economies are the main levers of economic development, investment generators, and innovation demand. Modern trade ports are open systems that are influenced by many factors. During the last decades of globalization and innovative technologies, an essential factor in the competitiveness of seaports, such as the stability of the functioning of Ukraine, is gaining relevance. The improvement of port management is driven by the urgent need to apply innovative strategies and methods to ensure the development and efficiency of the port industry due to the impact of many factors affecting the stability and growth of the port system.

Aim and tasks. The aim of the study is to assess the influence of various factors on the consistency of the management system of the port industry.

Result. An algorithm for forming generalized stability indicators for the functioning system of the port industry is proposed. Using an entropy approach to the management indicators of the development of the port industry functioning system showed an increase in the indicators of the ship operations group by 1.07% and cargo operations by 1.01%, a decrease in the financial group by 1.65%, and a port environment by 1.30%. The application of the established approach and the defined sequence of relevant calculations will allow ports to respond sensitively to violations of the stability of their system both at the industry and individual port levels and to find answers for each group of selected influential indicators for the finance group, the ship and cargo operations group, and the port environment. The main difference between the proposed approach and the existing ones is the calculation of the overall level of functioning of the port management system, which is based on the accumulation of the values of the relevant integral indicators for groups of indicators such as finance, ship-cargo operations, and port environment.

Conclusions. The operation system of the port economy can be considered from the perspective of researching its various states, which are a consequence of the dynamics of the external environment. This allows us to use such a quality of entropy by considering the final nature of the management processes of the industry. This will help determine the nature of trends that can be considered in the future when forecasting the port industry's development directions and when making relevant comparisons in the industry at the national and global levels.

Key words: stability, seaports, entropy, port industry, competitiveness.

1. Introduction.

Contemporary competitive circumstances, a dynamic external environment, and globalization have forced domestic maritime enterprises to actively use modern management approaches, which have become the key to their success (Luo et al., 2022). Therefore, modern approaches and methods for enterprise management are essential for the development and efficiency of enterprises. A modern port is not only a connecting link between land and sea in the chain of goods traffic but also an industrial and logistics centre, as well as a centre for cargo distribution and information support in the production and distribution system of goods. Currently, a modern port is not, as before, a passive link between sea and land transport. It is only a place of loading from one type of transport to another (Tsopa et al., 2022).

However, during the last decades of globalization and innovative technologies, an essential factor in the competitiveness of seaports, such as the stability of the functioning of Ukraine, is gaining relevance. Ports and shipping companies must implement multi-stakeholder sustainability strategies to avoid losing their market positions and remain competitive in a dynamic environment.

The geopolitical transformations now taking place in the world, economic instability and changes in the business environment, fierce competition in the market of port services, and uncertainty of the environment require the determination of the impact of environmental factors on the results of its activities. Since the seaports in each country's economy act as the main levers of economic development, generators of investment, and demand for innovation, the stability of port work is of practical interest to scientists.

Modern commercial ports are open systems influenced by many external and internal factors. Globalization and integration in transport have led to the improvement of cargo transportation technologies and the development of port equipment, which has made it possible to increase the speed of cargo passage through ports. Information technologies made it possible to reduce costs during the organization of data exchange processes supporting material flows, the logistics of transport processes formed “just-in-time” and “door-to-door” technologies.

This made it possible to reduce transport costs in trade. Consequently, determining the nature of trends in the industry will allow the prevention of negative processes and the timely finding of a decision concerning the correction of identified deviations and return the system to an equilibrium state.

This explains the search for methodological approaches to determine the stable state of the port system, considering the most significant factors influencing the port.

2. Literature review.

The theoretical and methodical principles of ensuring the stability of the company's functioning system and the peculiarities of strategic decision-making are considered in the works of such foreign and domestic scientists as Marlow and Paixão Casaca (2003), Notteboom et al. (2013) and Parola et al. (2017).

Some issues of the management practice of port industry enterprises are highlighted in the research of Primachev and Primacheva (2017), Nikolaieva et al. (2019), Golubkova et al. (2021).

Parola et al. (2017) and Talley et al. (2014) contributed significantly to developing the port operation system management, substantiation and improving theoretical foundations.

By scrutinizing the theoretical and practical contributions of these authors, it becomes apparent that there needs to be more investigation into guaranteeing the stability of port and industrial operational systems. The lack of a concrete definition of stable enterprise and port functioning and a straightforward procedure for determining stability in a modern seaport context necessitates further development and explanation (Alamoush et al., 2021). Scientific support is essential for making informed and appropriate management decisions.

Marlow explored a range of port performance metrics designed to evaluate the efficiency of streamlined ports and foster the advancement of adaptable ports. Introducing novel port performance indicators targeting quality concerns enhances visibility within port operations and the entire transportation network, thereby promoting improved integration of all components within the logistics supply chain.

Meanwhile, Notteboom et al. (2013) delved into the phenomenon of institutional expansion, examining how it facilitates the emergence of new opportunities and activity types and the formalized mechanisms driving management reforms. Notteboom et al. (2013) investigated the influence of state ownership on the decisions of companies engaged in port development. This issue is relevant, given the economic consequences of port development and the critical role of ports in the transition to a more sustainable economy.

Parola et al. (2017) investigated the factors of competitiveness of ports and their measurements, the multidimensional nature of competitiveness and the main factors of competitiveness of ports.

Talley et al. (2014) examined a methodology to assess the efficiency of specific port services, employing the concept of the port service chain, which focuses on service quality.

However, the role and importance of seaports as the main drivers of the country's economic development require further research into their development. Despite this, the problem of determining and ensuring the stable functioning of the port industry, taking into account the external and internal environmental factors, still needs to be solved.

3. Aim and tasks.

The aim of the study is to assess the influence of various factors on the consistency of the management system of the port industry.

For this aim, the following research tasks were set: to investigate the various factors that influence the port management system stability, taking into account the uncertainty measurement, which is based on the calculations of the system entropy in quantitative terms; to develop a methodical approach for the stability level determination of the functioning system both at the industry level and at the level of an individual port; to group the factors and indicators of the assessment of the port economy functioning stability; to propose an algorithm for the general indicators formation of the port industry functioning system stability, which is based on the relevant integral indices for groups of indicators as finance, ship and cargo operations and the port environment.

4. Methods of research.

The methodological and theoretical basis of the study was the fundamental provisions of the economy of enterprises and the management of seaports. In the research process, the following general scientific and unique methods were used, in particular, point and expert assessment, to establish a qualitative assessment of indicators and their importance in the study of the influence of environmental factors on the port management system: terminological analysis to clarify scientific definitions of economic categories; generalization, grouping, and systematic approach for systematization of factors and comprehensive study of the object of management; system-structural method, structural-functional, logical generalization during the formation of the seaport management mechanism; economic and statistical analysis during the study of the level of stability of ports; and scientific generalization for formulating research conclusions.

The complexity of obtaining information under conditions of uncertainty, the turbulence of the external environment, and fierce competition make it advisable to develop and implement a procedure for determining the integral indicator of the stability of the port industry based on the degree of uncertainty (entropy) (Baştuğ et al.,2022).

The use of entropy is increasing in the study of various phenomena, as in physics, biochemistry, and the study of technical and economic processes. Consequently, this phenomenon has many definitions, but let us dwells on the following: it is a degree of incompleteness, uncertainty, and a function of state (Laha, & Rohatgi, 2020). Any state can be contrasted with the corresponding value of entropy. For example, Shannon (1948) represented entropy in his way and believed that it could help establish a systematization of a turbulent economic system based on the corresponding measure of economic information that characterizes it. In further calculations we will use the formula proposed by Shannon (1948):

$$H = -\sum p_i \log_2 p_i \quad (1)$$

where p_i is the degree of probability of the system under study ($p_i = \overline{(1, n)}$).

Shannon (1948) established a certain correspondence between such categories as information and entropy, so he considered it possible to use it to evaluate information processes.

Thus, the system of functioning of the port industry can be considered from the angle of study of its different states, which are a consequence of the dynamics of the environment. This approach will make it possible to additionally use another valuable quality of entropy, namely, considering the final nature of industry management processes. For this purpose, the establishment of stability in the system of port industry functioning is based on calculations of the entropy of the system in a quantitative dimension.

This will make it possible to determine the character of tendencies, which can be taken into account in the future when making forecasts of the directions of industry development and when making appropriate comparisons in the industry at the level of the country and the world.

A data set was used for the calculations, including the period from 2012 to 2021. Three groups of indicators were included in the statistical database:

- Finance. EBITDA/revenue (operating margin), court meetings/revenue, cargo meetings/revenue, labour/revenue.
- Ship and Cargo Operations. Average gross tonnage per ship, total average profit of cargo ship, average tonnage per event (all), ton per meter berth (all).
- Environment. Investments in environmental projects/total CAPEX, environmental costs/income, CO2 emissions, NOx emissions.

For each of the indicators in the group, it was necessary to calculate its average value for the period considered and the normal standard deviation of the dynamic series [9]:

$$\sigma = S = \sqrt{\frac{\sum(x_i - \overline{x})^2}{n}} \quad (2)$$

where x_i is the value of the indicator under study for the corresponding period of time.

To make further calculations, we must assume that a normal distribution characterizes all the indicators we study in each group. The next step is to determine the density value for the probability of normal distribution [9]:

$$f(x) = \frac{1}{s\sqrt{2\pi}} e^{-(\frac{x_i - \overline{x}}{\sigma})^2/2} \quad (3)$$

where $p_i = f(x_i)$ probability as a measure of the possibility of an event occurring.

Uncertainty refers to the need for more information about the phenomenon being studied, its consequences, or its probabilities.

5. Results.

Since entropy is a measure of the uncertainty of knowledge or the incompleteness of information, its state function will be considered. Each state of the system under study was matched to the corresponding entropy values.

Thus, when studying the influence of different factors on the functioning of the port industry, it is necessary to consider the presence and size of uncertainty.

Ensuring the stability of seaport operation is challenging to predict because the emergence of uncertainty factors, the trajectory of which changes rapidly, cannot be controlled. This study groups uncertainty factors using the following indicators: finance, shipping and cargo operations, and environment.

Today, bottlenecks in logistics, rapidly increasing costs, and asymmetric recovery of the world economy are the main factors of uncertainty. The uncertainty of Ukraine's regulatory and legal framework restrains the direction of investment in port industry development.

Variations in entropy values are possible. This range includes [0, 1]. When approaching "0" entropy decreases, and the degree of state certainty increases. When approaching the value of "1", the uncertainty of the phenomenon under study increases and the state of the system is unstable.

Based on the above provisions, an approach to assessing the stability of the port industry was developed (Fig. 1).

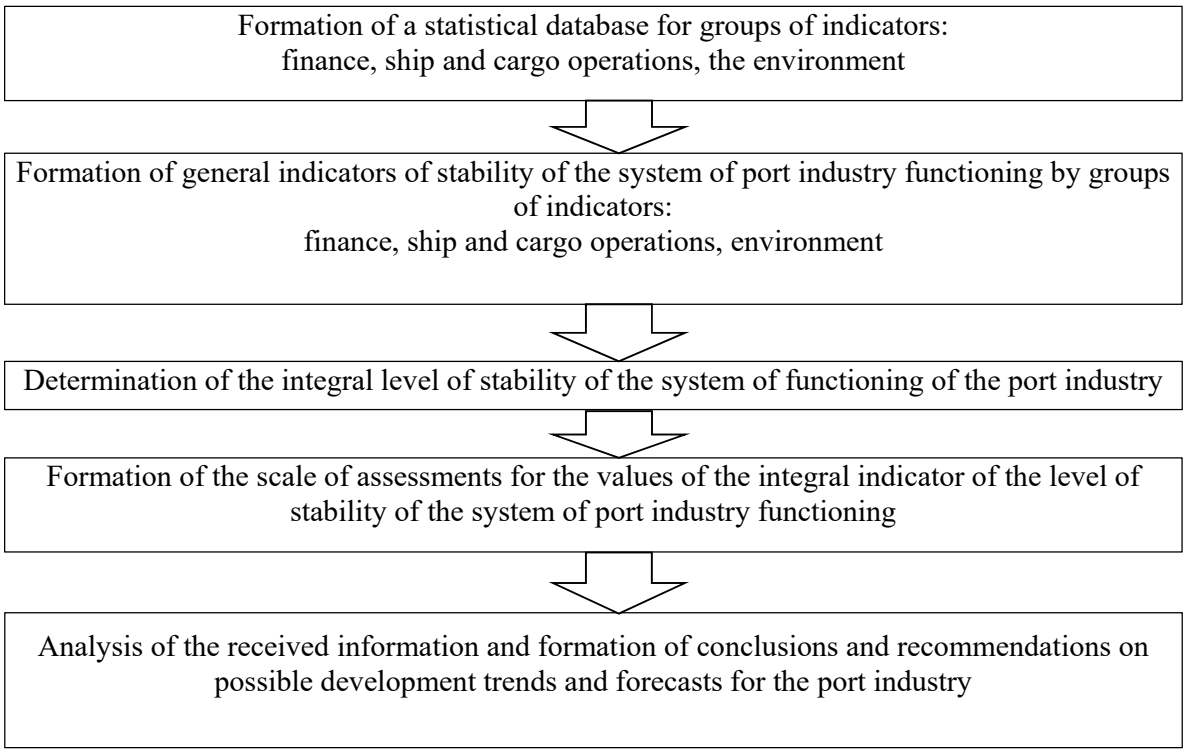

Fig. 1. Methodological approach to determining the level of stability of the port industry functioning system.

The main difference between the proposed approach and the existing ones is the calculation of the general level of the port industry functioning system, which is based on the accumulation of values of the corresponding integral indices for groups of indicators such as finances, ship and cargo operations, and port environment. According to the proposed methodology, the study should proceed in appropriate stages. First, based on the information collected on the above indicators, a database was created (Table 1).

Table 1. Group of factors and their indicators for assessing the stability of the operation of the port economy.

Group of factors	Notation Keys	Indicators
Finances	F^1	EBITDA / income (operating margin)
	F^2	Shipping charges / income
	F^3	Freight charges / income
	F^4	Labour / income
Ship and cargo operations	SCO^1	Average gross tonnage per ship
	SCO^2	Total average profit of a cargo ship
	SCO^3	Average tonnage per entry (all)
	SCO^4	Tons per meter berth (all)
Environment	E^1	Investment in environmental projects / general CAPEX
	E^2	Environmental costs / income
	E^3	Emissions CO_2
	E^4	Emissions NO_x

The next step is the calculation of general indicators of the stability of the system of port industry functioning by groups of indicators: finances, ship and cargo operations, environment: $Z_i^F, Z_i^{\text{SCO}}, Z_i^E$.

These indices are calculated considering the additivity of entropy and its quantification.

Consequently, the customary distribution law of a continuous random variable represents the basis for calculating the entropy value (Gauss's law) (Kruskal & Shepard, 1974).

An algorithm for forming generalized indicators of stability of the system of functioning of the port industry, presented in Fig. 2 is proposed.

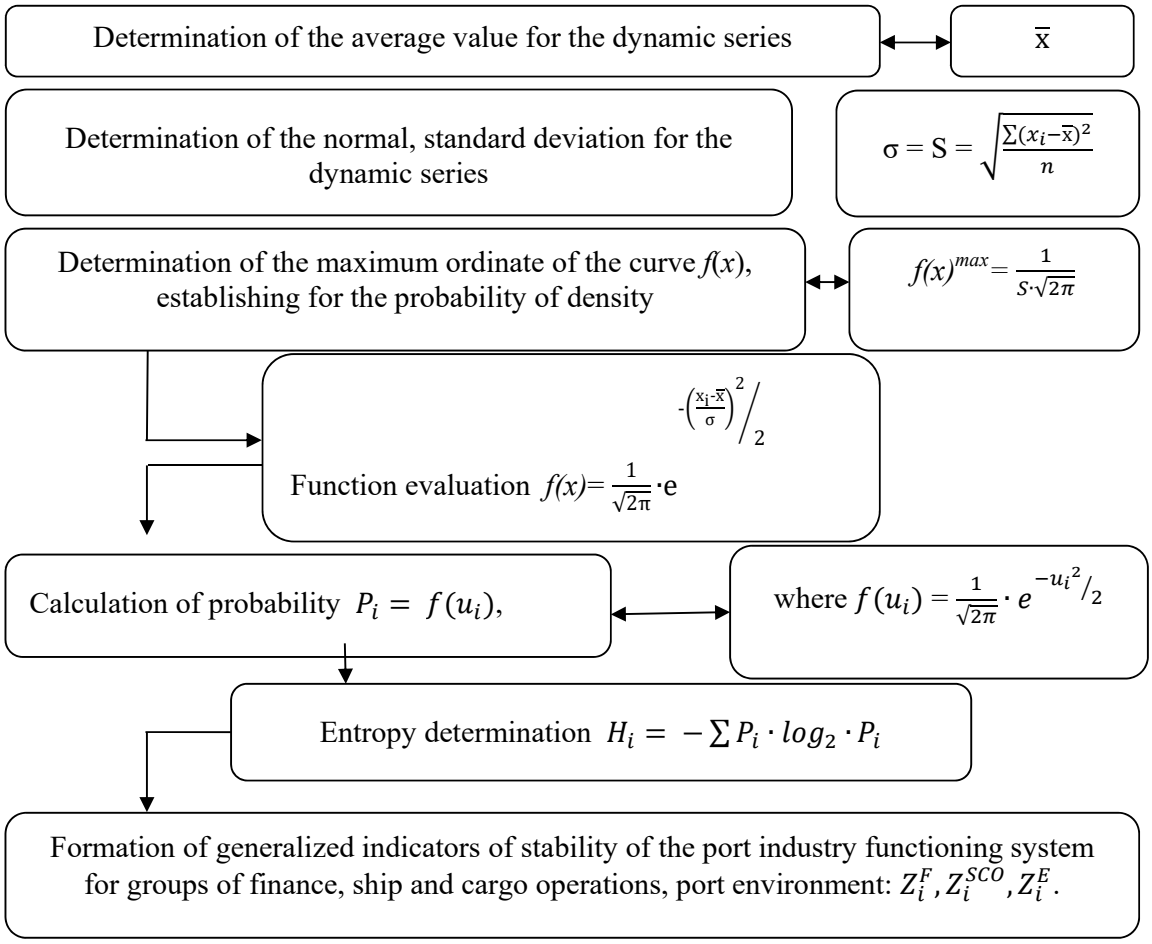

Fig. 2. Formation of general indicators of stability of port industry functioning system for the financial group, group of judicial and cargo operations, port environment.

The output data were indicators for the studied groups, which were considered in the dynamics for 2012-2021. The next step was to calculate the standard quadratic deviation for each indicator in the group for the considered period.

The general indicators of the stability of the port industry functioning system offered for consideration are generalized indicators of the state of stability of the system for its characteristics for each group under study: finances, ship and cargo operations, and port environment.

The quantitative calculations of these indicators of the generalized state of stability of the system of the functioning port industry are based on the definition of entropy.

Consequently, based on the results of the calculations of the statistical data set conducted in the Excel package, a table with entropy values of the indicators of the groups under study was formed (Table 2).

Table 2. Entropic values of indicators in the groups finance, ship and cargo operations, port environment.

Indicator	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
F^1	0,34	0,44	0,52	0,531	0,531	0,529	0,53	0,5	0,47	0,39
F^2	0,42	0,47	0,49	0,524	0,529	0,529	0,48	0,37	0,46	0,53
F^3	0,33	0,38	0,53	0,53	0,529	0,529	0,53	0,51	0,46	0,4
F^4	0,41	0,46	0,5	0,531	0,525	0,529	0,5	0,46	0,48	0,46
SCO^1	0,35	0,46	0,52	0,53	0,53	0,53	0,53	0,5	0,45	0,38
SCO^2	0,53	0,53	0,49	0,36	0,27	0,52	0,53	0,53	0,53	0,47
SCO^3	0,37	0,49	0,52	0,53	0,53	0,53	0,53	0,53	0,51	0,23
SCO^4	0,53	0,53	0,53	0,53	0,52	0,51	0,51	0,53	0,53	0,05
E^1	0,53	0,53	0,52	0,52	0,52	0,53	0,53	0,53	0,53	0,07
E^2	0,27	0,42	0,53	0,53	0,53	0,53	0,48	0,47	0,48	0,53
E^3	0,42	0,53	0,53	0,51	0,21	0,49	0,53	0,53	0,53	0,48
E^4	0,34	0,45	0,51	0,52	0,53	0,53	0,52	0,53	0,52	0,35

Based on the data presented in Table 2, it is possible to trace some trends in entropy indicator changes. Thus, all the factors included in the finance group during 2014-2017 had a high value of entropy, but since 2017, it has decreased. Analysing the “Finance” group, it can be noted that EBITDA / income (operating margin) during the 2012–2014 years had a small entropy value, which can be explained by the action of other group factors that positively influenced this trend. However, during the 2014–2019, this indicator increased its uncertainty, which indicated the relevant events in the world, which influenced the dynamics of movement of the studied indicator.

The next indicator is “Shipping charges/income” which increased its uncertainty value from 2012 to 2018. In 2019, it had the lowest entropy and began rising again. Again, the explanation can be found in the events that gradually covered the countries of the world.

Besides the geopolitical situation, various force majeure events in the countries that carry out maritime transportation can also be attributed to them (Asian countries).

The indicator, which repels the trends associated with cargo meetings, almost repeats the trend “EBITDA/Income” (operating margin). This emphasizes their importance to the phenomenon we study and indicates the extent to which commercial ports feel the impact of events occurring in the industry.

As for another indicator, namely “Labor/Income”, it can be state that since 2017, the entropy indicator has decreased by almost 3.52 to a value of 0.44, which positively characterizes the ports' position in their domestic markets.

The calculations and detailed analysis of the selected indicators from the studied groups allow us to establish their impact on the overall stability of the port industry's functioning.

Graphically, it is immediately possible to find “bottlenecks” in the indicators adopted for consideration since the indicators with a high entropy value require managers' close attention.

Consequently, using the entropy approach to the indicators included in the groups selected for research will become a valuable tool for managing the development of the system of functioning of the port industry. It will allow forecasts of developments and assess the current state of affairs with clarification for each indicator that affects the system's overall stability.

The next stage of the proposed approach to determining the level of stability of the system of port industry operation involves the establishment of an overall index of the level of stability. Its calculations are based on synergistic principles combining the constituent components of the selected influential groups: the financial group, the group of judicial and cargo operations, and the port environment.

A normalization procedure behind the "variation spread" method is also proposed for this methodology. Such a procedure is used to establish the scope of the general index of the level of stability of the system of port industry functioning. It should also be emphasized that the method of spreading variation is used for those indicators, the size of which is desirable to reduce. Below are the formulas used to normalize the indicators (Kruskal & Shepard, 1974):

1. Group Finance:

$$N_i^F = \frac{Z_{max}^F - Z_i^F}{Z_{max}^F - Z_{min}^F}$$

2. Ship and Cargo Operations Group:

$$N_i^{SCO} = \frac{Z_{max}^{SCO} - Z_i^{SCO}}{Z_{max}^{SCO} - Z_{min}^{SCO}}$$

3. Environment Group:

$$N_i^E = \frac{Z_{max}^E - Z_i^E}{Z_{max}^E - Z_{min}^E}$$

where N_i^F, N_i^{SCO}, N_i^F – normalized values of the indicators of the studied groups of the i-th year; Z_i^F, Z_i^{SCO}, Z_i^F – values of generalized indicators of stability of the port industry functioning system for groups; $Z_{max}^F, Z_{max}^{SCO}, Z_{max}^E$ – minimal values of generalized indicators of stability of the port industry functioning system by groups.

The general index of the port industry's functioning system stability level is an aggregate index of system stability level according to the established general indicators in the groups of factors finance, group of ship and cargo operations, and port environment.

The level of consistency of the port industry functioning system is proposed to be assessed (Kruskal & Shepard, 1974):

$$I_i = N_i^F + N_i^{SCO} + N_i^E \quad (4)$$

Representation of the dynamics of changes calculated based on entropy values aggregated value of the general index of stability of the system of port industry functioning (Fig.3).

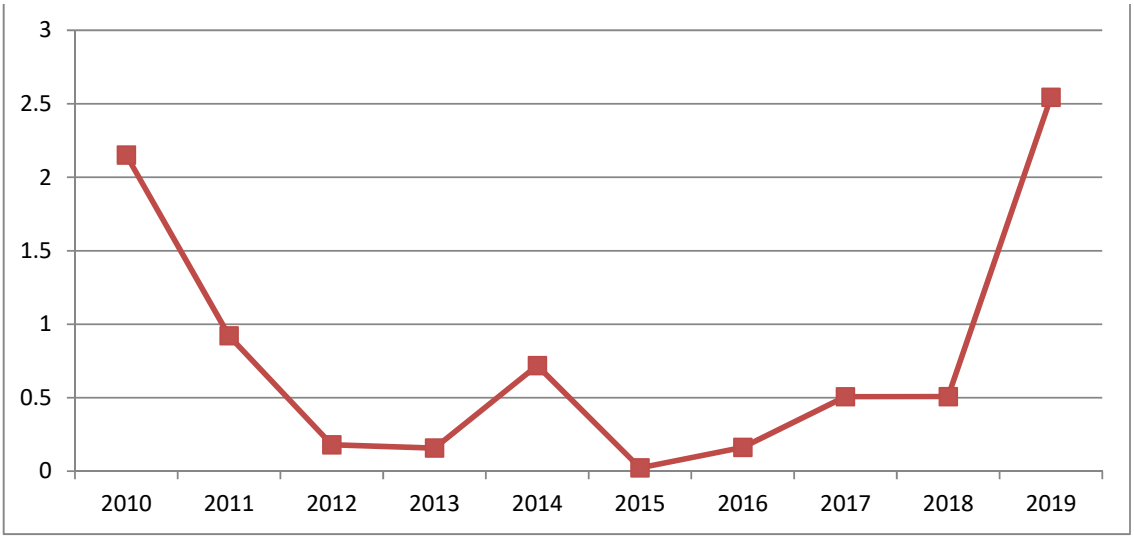

Fig. 3. Fluctuations in the overall stability index of the port industry operational system.

Since 2021, the value of the general index has rapidly increased. Therefore, it is characterized by a negative trend.

Thus, for practical application of the obtained data, it is necessary to translate quantitative values into qualitative values using an appropriate scale of assessment. Table 3 shows a possible gradation of assessments of the researched index and singles out three levels of stability of the port industry functioning system: high [0; 0.5], medium [0.5; 1.5], and low [1.5; 3].

Table 3. Scale of conversion of quantitative values into qualitative values for the general stability index of the port functioning system.

The magnitude of the comprehensive stability index of the port operational system	The level of stability of the port's functioning system
[0;0.5]	High
[0.5;1.5]	Average
[1.5;3]	Low

The developed approach for determining the level of stability of the operation of the port industry is based on the use of entropy to form generalized indicators of system stability and allows forecasts of development and evaluation of the current state of affairs with clarification on each indicator that affects the overall state of stability of the system, namely the financial group, shipping and cargo operations group, and environment.

Applying the developed approach and the defined sequence of relevant calculations will allow ports to respond to violations of the stability of their systems both at the industry level and at the level of an individual port.

6. Discussion.

Despite growth, however, the role and importance of the main driving forces of a country's economic development require further research into their development. In this regard, the study substantiates the feasibility of developing and carrying out a procedure for determining the integral indicator of the stability of the operation of the port industry based on the use of the degree of uncertainty (entropy).

Formula (1), proposed by Shannon (1948), was used in the calculations and was able to establish correspondence between such categories as information and entropy. The functioning of the port industry can be considered from the perspective of studying its various states, which are the result of the dynamics of the environment.

This approach makes it possible to use another valuable quality of entropy, namely taking into account the final nature of the industry's management processes. This will make it possible to determine the nature of the trend, which can be considered in the future when forecasting the direction of the industry's development.

An information array of data was used for the calculations, which included the period 2012–2021. Three groups of indicators were included in the statistical database: finance, ship and cargo operations, and environment.

Calculations were made for each indicator in the group of its average value for the considered period and the standard root mean square deviation of the dynamics series (Shannon, 1948), according to formula (2).

For further calculations, it was assumed that a normal distribution characterizes all studied indicators in each group. The next step was to determine the probability of a normal distribution of the density value using formula (3).

In this case, uncertainty is defined as the lack of information about the phenomenon under study, consequences, or probability. Because entropy is a measure of the uncertainty of knowledge or the incompleteness of information, it was taken as a state function. Each state of the studied system can be assigned an entropy value.

It has been proven that, when studying the influence of various factors on the functioning system of the port industry, it is necessary to consider the presence and size of uncertainty based on a possible change in entropy values within the range [0; 1]. In the case of approaching “0”, the entropy decreases, and the degree of certainty of the state increases. The state of the system is unstable when the value approaches “1” and the uncertainty of the investigated phenomenon also increases.

It is emphasized that the main difference between the proposed approach and the existing ones is the calculation of the overall level of the port industry functioning system, which is based on the accumulation of the values of the relevant integral indices for groups of indicators such as finance, ship and cargo operations, and port environment.

With the proposed methodology, it is necessary to go through appropriate stages during research.

General indicators of the stability of the port industry's functioning system were calculated using three groups of indicators: finance, ship and cargo operations, and environment. The indices were calculated by considering the additivity of entropy and its quantitative definition. Therefore, the customary distribution law of a continuous random variable forms the basis for calculating the entropy value (Gauss's law) (Kruskal & Shepard, 1974). An algorithm for the formation of generalized indicators of the stability of the port industry's functioning system is proposed. Based on the results of the calculations of the statistical array of data, data with entropy values for the indicators of the studied groups were formed.

Based on the data, some trends in the change of the entropy indicator were traced, and the calculations and detailed analysis of selected indicators from the studied groups made it possible to establish their influence on the general state of stability of the port industry.

The next stage of the proposed approach is to determine the level of stability of the port industry's functioning system to establish a general index of the level of stability. Its calculations are based on synergistic principles that combine the constituent components of selected influential groups: the financial group, the group of ship and cargo operations, and the port environment.

For this technique, it is also proposed to perform a normalization procedure using the "range of variation" method. This procedure is used to establish the scope of the general index of the level of stability of the functioning system of the port industry. It should also be emphasized that the technique of the range of variation is used for these indicators, the size of which is desirable to reduce. Formulas are given according to which the normalization procedure takes place (Kruskal & Shepard, 1974).

7. Conclusions.

The port management system's instability may necessitate using additional means and methods to stabilize the situation. As we have seen in recent years, ports need such resources. The harsh conditions of competition in the industry require ports to constantly seek new management approaches to anticipate positive trends in the industry. The developed approach to assessing the level of consistency of the port economy functioning system is based on the theory of the existence of an equilibrium state of an open system and entropy indicators by the group of finances, the group of ship-cargo operations, and the port environment according to the developed and substantiated gradation scale, which allows to analyse the obtained assessment results and qualitatively determine the stability of the system of operation of the port industry according to the general indicator.

The general index of the level of stability of the system of the operation of the port industry is an aggregate indicator of the level of stability of the system according to the established general indicators in the groups of finance factors, the group of ship and cargo operations, and the port environment.

It is proposed to evaluate the level of stability of the port industry functioning system and the dynamics of changes in the aggregated value of the general stability index of the port industry functioning system calculated based on entropy values. It is emphasized that for the practical application of the obtained data, it is necessary to convert the quantitative values into qualitative values using the appropriate rating scale. Table 3 shows the possible gradation of estimates of the studied indicator, and three levels of stability of the port industry functioning system are highlighted: high [0; 0.5], medium [0.5; 1.5], and low [1.5; 3].

Based on the table obtained and the graphic material presented, it is possible to clarify the stability level of the system of operation in the port industry.

Thus, the application of the formed approach and a specific sequence of relevant calculations will allow ports to respond sensitively to the disturbance of their system stability both at the level of the industry and at the level of an individual port and to find answers behind each group of selected influential indicators behind the groups of finance, ship and cargo operations, and port environment. The developed approach will be a convenient, practical tool for managing the development of the port industry and individual ports.

REFERENCES

Alamoush, A. S., Ballini, F., & Ölçer, A. I. (2021). Revisiting port sustainability as a foundation for the implementation of the United Nations Sustainable Development Goals (UN SDGs). Journal of Shipping and Trade, 6(1). https://doi.org/10.1186/s41072-021-00101-6

Baştuğ, S., Haralambides, H., Esmer, S., & Eminoğlu, E. (2022). Port competitiveness: Do container terminal operators and liner shipping companies see eye to eye? Marine Policy, 135(104866), 104866. https://doi.org/10.1016/j.marpol.2021.104866

Golubkova, I., Sienko, H., Lysenko, N., Frasyniuk, T., & Parkhomenko, I. (2021). Criteria for the management of a sustainable and safe positioning of the fleet in the conditions of globalization. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 2, 178-183. https://doi.org/10.33271/nvngu/2021-2/178

Kruskal, J. B., & Shepard, R. N. (1974). A nonmetric variety of linear factor analysis. Psychometrika, 39(2), 123–157. https://doi.org/10.1007/BF02291465

Laha, R. G., & Rohatgi, V. K. (2020). Probability theory. Courier Dover Publications.

Luo, M., Chen, F., & Zhang, J. (2022). Relationships among port competition, cooperation and competitiveness: A literature review. Transport Policy, 118, 1–9. https://doi.org/10.1016/j.tranpol.2022.01.014

Marlow, P. B., & Paixão Casaca, A. C. (2003). Measuring lean ports performance. International Journal of Transport Management, 1(4), 189–202. https://doi.org/10.1016/j.ijtm.2003.12.002

Nikolaieva, L., Haichenia, O., Omelchenko, T., & Kozlova, V. (2019). Tools for Rating Evaluation of Human Resources as the Main Factor for Providing the Innovation Development of the Sea Ports. Advances in Economics. Business and Management Research. Atlantis Press, 99, 266–271. https://doi.org/10.2991/mdsmes-19.2019.50

Notteboom, T., De Langen, P., & Jacobs, W. (2013). Institutional plasticity and path dependence in seaports: interactions between institutions, port governance reforms and port authority routines. Journal of Transport Geography, 27, 26–35. https://doi.org/10.1016/j.jtrangeo.2012.05.002

Parola, F., Risitano, M., Ferretti, M., & Panetti, E. (2017). The drivers of port competitiveness: a critical review. Transport Reviews, 37(1), 116–138. https://doi.org/10.1080/01441647.2016.1231232

Primachev, N., & Primacheva, N. (2017). Problems of sustainable development of maritime transport industry. International Journal of Business and Social Science, 8(8), 22-26.

Shannon, C. (1948). Mathematical Theory of Communication. The Bell System Technical Journal, 27, 379–423.

Talley, W. K., Ng, M., & Marsillac, E. (2014). Port service chains and port performance evaluation. Transportation Research Part E: Logistics and Transportation Review, 69, 236–247. https://doi.org/10.1016/j.tre.2014.05.008

Tsopa, V., Cheberiachko, S., Yavorska, O., Deryugin, O., & Bas, I. (2022). Increasing the safety of the transport process by minimizing the professional risk of a dump truck driver. Mining of Mineral Deposits, 16(3), 101–108. https://doi.org/10.33271/mining16.03.101