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EVALUATION OF CARGO SHIPS CONSTRUCTION PRICES AND THEIR IMPACT ON INSURANCE COSTS

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Summary

Introduction. *The relevance of the research is determined by high capital expenditures for ships construction, complexity of ships as objects of assessment, the need to take into account factors affecting the prices of ships construction, use of adequate assessment methods, and the relationship between ship prices and the costs of insurance.* ***Purpose.*** *The article is devoted to development of methodological and methodical bases for evaluating the construction prices of cargo ships, in particular: systematization of factors affecting construction prices, classification of methodical approaches to determining ship prices, improvement of assessment methods from the point of view of shipowners, and taking into account the influence of ship price on the costs of insurance.* ***Results.*** *The factors affecting shipbuilding prices are systematized. The classification of approaches to determining ships construction prices has been developed. The method for calculating the discounted value of free cash flows to equity is proposed. The method of correlation-regression analysis for estimating the construction prices of ships of a certain type depending on deadweight is proposed. The stages of estimating the ship's construction price on the example of the market method have been determined. It is shown that the price of a ship directly affects the insurance premium and other terms of the insurance contract.* ***Conclusions.*** *The shipbuilding costs are affected by the prices of steel, equipment and materials, the cost of labor, demand from shipowners and supply of shipbuilding capacity, currency fluctuations, regulatory requirements, government regulation, etc. The classification of approaches to the estimation of ships construction prices includes cost approach, intrinsic value and market approaches. The proposed method of discounted free cash flow to equity is universal, and can be used for various chartering schemes. The market approach includes the methods of correlationregression analysis, the method of parametric series, the method of specific indicators, and the engineering method. There is a close positive correlation between deadweight and construction prices of cargo ships. Nonlinear regression models sufficiently describe the dependence of the construction price of a certain type of ship on deadweight. The ship price directly affects the insurance premium and other terms of ship's insurance.*

Key words: *cargo vessels, assets valuation, pricing, shipbuilding, price of ship construction, insurance, maritime transport.*

ОЦІНКА ЦІН БУДІВНИЦТВА ВАНТАЖНИХ СУДЕН ТА ЇХ ВПЛИВ НА ВИТРАТИ НА СТРАХУВАННЯ

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Анотація

Вступ. *Актуальність теми дослідження зумовлена високими капітальними витратами судновласників на будівництво флоту, складністю морських суден як об'єктів оцінки, необхідністю врахування факторів, що впливають на формування будівельної ціни, використання адекватних методів оцінки, а також зв'язком між цінами суден та витратами на їх страхування.* ***Мета.*** *Стаття присвячена розвитку методологічних та методичних засад оцінки будівельних цін морських суден, зокрема: систематизації факторів, що впливають на будівельні ціни, класифікації методичних підходів до визначення цін вантажних суден, удосконаленню методів оцінки з погляду судновласника, урахуванню впливу будівельної ціни судна на витрати на страхування.* ***Результати.*** *Систематизовано фактори, що впивають на ціни будівництва суден. Розроблено класифікацію підходів до визначення ціни будівництва судна. Запропоновано методику розрахунку приведеної вартості вільних грошових потоків на власний капітал, пов'язаних із судном. Запропоновано методику кореляційнорегресійного аналізу для оцінки цін суден певного типу залежно від дедвейту.*

Визначено етапи оцінки будівельної ціни судна на прикладі ринкового підходу. Показано, що ціна впливає на страхову премію та інші умови страхового контракту. ***Висновки.*** *На ціни будівництва суден впливають ціни сталі, обладнання та матеріалів, вартість трудових ресурсів, попит з боку судновласників і пропозиція суднобудівельних потужностей, коливання курсів валют, регулятивні вимоги, заходи державного регулювання тощо. Класифікація підходів до оцінки цін на будівництво морських суден включає витратний, дохідний та ринковий підходи. Запропонований метод дисконтованих вільних грошових потоків на власний капітал є універсальним і може використовуватися для різних схем фрахтування. Ринковий підхід включає кореляційно-регресійний аналіз, метод параметричних рядів, метод питомих показників та інженерний метод. Між дедвейтом і будівельними цінами вантажних суден існує тісна позитивна кореляція, а моделі нелінійної регресії якісно описують залежність будівельної ціни судна певного типу від дедвейту. Ціна судна напряму впливає на страхову премію та інші умови страхування судна.*

Ключові слова: *вантажні судна, оцінка активів, ціноутворення, суднобудування, ціна будівництва судна, страхування, морський транспорт.*

Introduction. Sea vessels are unique and expensive engineering objects that consist of hundreds of different mechanisms and elements. The process of estimating the cost of building a ship is a complex task that requires taking into account various factors that influence its formation and applying reasonable estimation methods. The cost of building ships is constantly increasing, which increases capital expenditures of shipping companies. Insurance costs are a significant part of direct operating expenditures of shipowners. All this makes it relevant to study the process of formation of prices for the construction of cargo vessels and their impact on insurance costs.

Formulation of the problem. The further development of the methodological and methodical bases for estimating prices for the construction of cargo ships requires taking into account the factors that influence the formation of prices for the construction of sea ships, the systematization and improvement of methodical approaches to determining construction prices, which have a significant impact on the financial results of operations and the level of risk of shipping and insurance companies.

Analysis of recent research and publications. The issues of analysis and evaluation of the cost of building sea vessels were studied mainly by foreign scientists. In the study of José & Gordo (2017), the analysis of the cost structure in shipbuilding was performed [1]. The methodology that allows the shipyard to determine the costs of building the ship's hull and directions for increasing productivity was proposed. In the article by Azhar and Kristiyono (2022), a study of the cost structure for the construction of ferries of various sizes and their components was carried out [2]. The use of linear regression models was proposed for the analysis of statistical data on the cost of construction of ferries and their components.

The analogy approach, parametric approach and engineering approach to the determination of ship prices are widely used in world practice (CostFact, 2022) [3]. In the study of Shuker (2018), it is shown that shipbuilding prices are based on costs that depend on the prices of material and labor resources, as well as supply and demand in the shipping market [4]. In the article of Dai, Hu, Chen, and Zheng (2015) the relationship between construction price fluctuations and the volatility of freight rates on the dry cargo transportation market using methods of descriptive statistics is investigated [5]. It was shown that freight rates have a significant influence on the construction prices of bulk carriers. In the paper by Zhykharieva, Shyriaieva, and Vlasenko (2019), the measures of state regulation of the shipbuilding industry, which affect construction prices and financial results of shipyards and shipping companies, are studied [6]. They include subsidizing shipbuilding, preferential lending, and the creation of reserve funds.

In the study of Knapp and Heij (2017), an empirical assessment of risk in sea shipping, which is based on a monetary value, is given [7]. It includes data on the quality of ship safety and insurance premiums related to potential losses. The relationship between a high level of risk and insurance premiums is illustrated.

The market price of a vessel is closely related to the CASCO insurance value, which can affect the coverage, as well as the provision of the Protection and Indemnity Insurance (P&I) (Gard News, 2005, February 1) [8].

Shipbuilding enterprises determine contract prices for the construction of sea vessels on the basis of the cost approach. However, the methodical approaches for estimating the construction value of sea vessels based on the intrinsic value approach and market approach, which are the most acceptable from the point of view of shipping

and insurance companies, are poorly developed. In addition to a shipyard and a shipping company, a creditor bank may participate in the transaction, which will judge its collateral value within the framework of mortgage lending, based on the economic attractiveness of the ship's construction, as well as an insurance company. Adequate assessment will allow establishing a fair relationship between the value of a vessel being mortgaged, the loan size and the amount of the insurance premium.

Formulation of the goals of the article. The goals of the paper are the systematization of factors that influence the formation of prices for the construction of cargo vessels, the classification of methodical approaches to determining the construction price of vessels, the improvement of methodical bases of price assessment from the point of view of a shipowner based on intrinsic value approach and market (analogy) approach, and taking into account the influence of the construction price on insurance costs.

Presentation of the main research material. Figure 1 shows the dynamics of the Producer Price Index by Industry: Shipbuilding and Repairing (U.S. Bureau of Labor Statistics, 2023) [9], which indicates increase in shipbuilding prices in the USA for the period from 1985 to 2023 by almost 2.5 times.

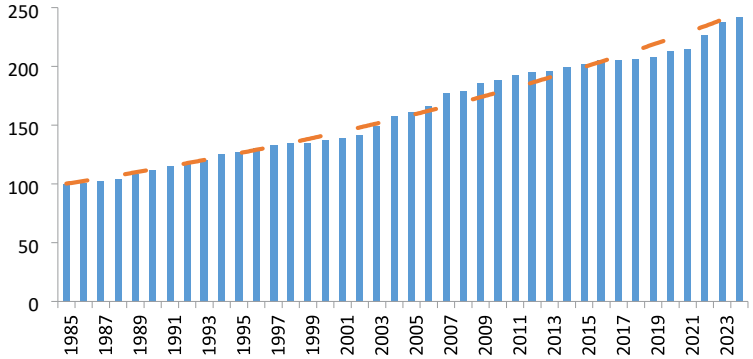

Fig. 1. Dynamics of Producer Price Index by Industry: Ship Building and Repairing (Index Dec 1985=100)

Table 1, based on data by Shuker (2018) [4], defines the typical structure of costs for the construction of Ultramax bulk carriers in China. As can be seen from this data, most of the costs for the construction of bulk carriers fall on the purchase of equipment and materials – 42%, steel for the ship's hull – 32%, and the labor cost – 16%. Other costs include project work, the cost of a guarantee for advance payments, and insurance for the construction period.

Table 1

Shipyard cost structure for building Ultramax bulk carriers in China

Expenditures	%
Equipment and materials	42
Steel	32
Labor cost	16
Other expenditures	10
Total	100

Consequently, shipbuilding costs depend on price fluctuations for various types of steel, materials and equipment, the country of construction, and labor standards. In addition, shipbuilding prices are affected by fluctuations in currency rates, regulatory requirements and measures related to state credit and financial regulation, which include subsidizing shipowners and shipbuilding enterprises, preferential lending, creation of reserve funds, etc. The price of a ship is affected by the relationship between supply and demand in shipbuilding. Fluctuations in demand are largely related to the length of the production cycle. Since the delivery of the ship is usually not carried out earlier than a year after the conclusion of the contract, shipowners order ships based not on the current situation, but on the forecast of its development. The increase in orders for the construction of ships, as a rule, exceeds the actual needs, as a result of which the volume of tonnage on the market increases and leads to the creation of a surplus fleet.

In figure 2 shows the main factors affecting fluctuations and changes in shipbuilding prices.

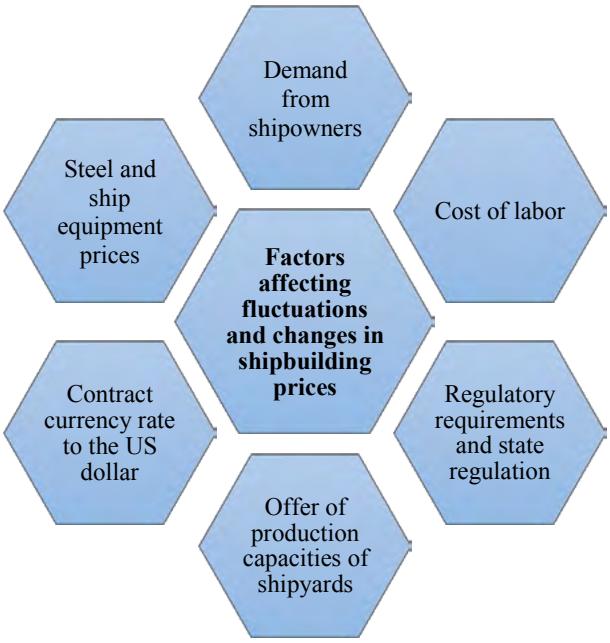

Fig. 2. The main factors affecting the prices for cargo vessels construction

The demand from shipowners is influenced by such factors as global demand for sea transportation, freight rates and forecasts of the freight market condition, market sentiment and expectations, fleet renewal, measures of credit and financial regulation of shipping companies, ship scrapping prices, the ratio of prices of new ships and second-hand ships (fig. 3).

To estimate the value of ships, as well as other assets, the cost approach, the intrinsic value approach and the market (analogy) approach are used. The cost approach involves taking into account the total costs of the shipyard for ship construction and the profit that the shipbuilding company expects to receive (José & Gordo, 2017) [1]. This method requires the calculation of the cost of all materials and components necessary for the construction of a ship, the availability of data on the labor intensity of all works,

wages, overheads and other costs, but it has a number of disadvantages and is rarely used to estimate ship prices by shipping companies.

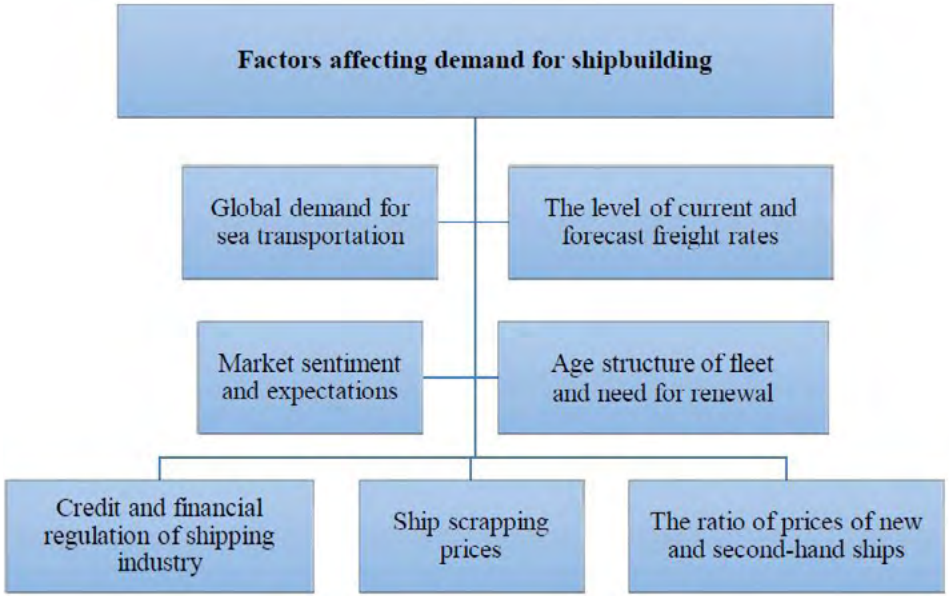

Fig. 3. Factors affecting the demand of shipowners for building ships

The intrinsic value approach (the discounted cash flow approach) is a set of methods for estimating the value of a vessel, based on the determination of the expected total discounted cash flows associated with the operation of the built vessel and its liquidation. The following method is proposed for calculating the discounted value of cash flows related to the vessel, based on the free cash flows to equity:

$$SV = \sum_{t=1}^{T} \frac{FCFE_t}{(1+r)^t} + \frac{S_T}{(1+r)^T}, \quad (1)$$

where

SV – intrinsic value of ship, defined as present value of free cash flows to equity:

$FCFE_t$ – free cash flows to equity in year t; r – discount rate; t – number of year;

S_T – the projected cash flow from sale of vessel on the secondary market or scrapping in year T;

T – period of implementation of the investment project, years.

Free cash flow to equity in year t (FCFEt) is used to determine the amount of free cash flow that will remain in the company after paying off all of its liabilities. FCFE are determined on the base of 3 financial statements model, taking into account type of vessel chartering which affecting on revenue calculation. For our case, it is suggested to use the indirect method of calculating cash flows from operating activities, and debt financing for ships construction:

$$\begin{aligned} FCFE_t &= NI_t + D_t + CWC_t - \text{Cash CAPEX}_t - F_t = \\ &= CFO_t - \text{Cash CAPEX}_t - F_t, \end{aligned} \quad (2)$$

where

NI_t – net income in year t;

D_t – depreciation of ship value taking into account the expenditures for dock repairs in year t;

CWC_t – changes in working capital in year t, defined on the base of changes in inventories, receivables and payables;

Cash $CAPEX_t$– cash capital expenditures related to acquisition of a vessel and dock repairs in year t;

CFO_t – cash flow from operating activity in year t;

F_t– principal debt repayment in year t.

The procedure for calculating the revenue for defining the net income depends on a type of chartering and can be determined on the basis of voyage, time or bareboat charter schemes. The intrinsic value approach takes into account the forecast of changes in external operating conditions, macroeconomic indicators and characteristics of the vessel. The problems associated with forecasting future cash flows limit the applicability of this approach. The level of income fluctuates significantly due to the cyclical nature of the freight market, and the level of operating costs strongly depends on specific operating conditions, changes in prices for bunker fuel and other resources. The need to take into account the time value of money introduces additional uncertainty into calculations.

The market approach (the analogy approach or the relative value approach) is a set of methods for estimating ship value based on comparing its parameters with the parameters and prices of prototype ships for which there is sufficiently complete statistical information (CostFact, 2022) [3]. Comparison according to the commercial conditions of the agreements involves the introduction of technical, economic and commercial corrections in the prices of selected analogues, i.e. bringing them to the conditions of a specific order. The most important and common commercial corrections include corrections for bidding, delivery time, serialization and payment terms. To simplify the calculation of prices, the subgroups of structural elements listed above can be combined into more consolidated positions, for example: hull, engine room, room equipment, industrial equipment, etc.

If the price of a vessel or its structural element is calculated taking into account the change in the parameters of the object under study, such method is called parametric. The parametric methods include correlation-regression analysis, the method of specific indicators, and the aggregate (engineering) method.

The method of correlation-regression analysis establishes an empirical formula for the dependence of the price on the technical parameters or operational characteristics of a vessel, its structural elements or components of construction costs (Shuker, 2018) [4]. A variant of this method is the method of parametric series of vessels of the same type or their structural elements. The method of specific indicators assumes that the price is calculated based on consolidated indicators, depending on the cost of a unit of useful effect (for example, the weight of a structural element of a ship). The engineering method consists in determining the price of a vessel or its structural element based on the unit market prices of its constituent parts, followed by the summation of all the received prices (CostFact, 2022) [3].

Figure 4 presents the classification of methods of valuation the prices for construction of cargo vessels.

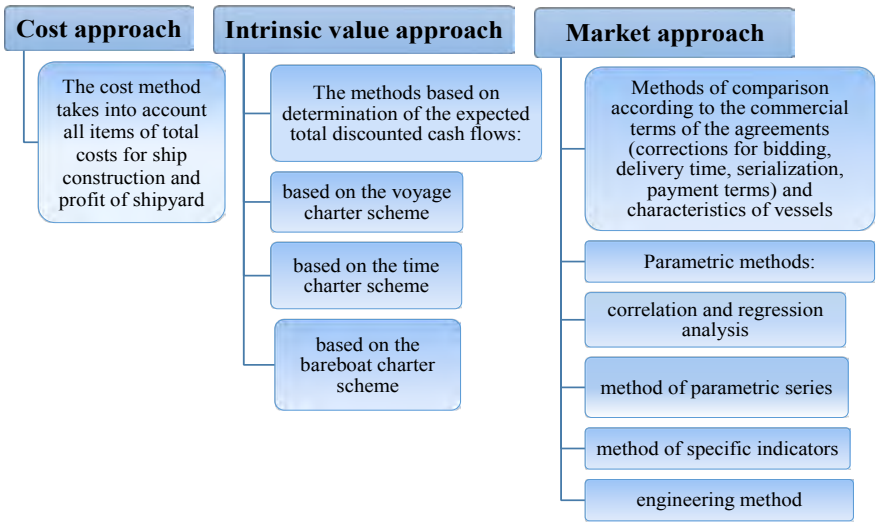

Fig. 4. Classification of methods of vessels construction prices valuation

Table 2 shows data on orders for bulk vessels in 2021–2023 (International Shipping News, 2022 [10], International Shipping News, 2023 [11], Simpson Spence Young, 2023, July 20 [12], Made-in-China, 2023, July 21) [13]). Table 3 shows descriptive statistics characterizing the sample.

Table 2

Data on orders for bulk carriers in 2021–2023

Order date	Quantity and class	Deadweight	Customer	Shipbuilder	Years of delivery	Ship price, USD mln
21.09.2021	6 dry cargo vessels	5400	Atobatc	Chowgule	2023–2024	13,6
14.10.2021	8 Ultramax bulkers	63600	COSCO Shipping	Bank of Communications Financial Leasing	2023	32
16.04.2021	10 Panamax bulkers	82000	Nisshin Shipping	Jiangsu Hantong Ship Heavy Industry	2022–2023	28
14.06.2021	12 Capesize bulkers	209800	Himalaya Shipping	New Times Shipbuilding	2023–2024	67
21.09.2022	Capesize Newcastlemax Bulkers	210000	Bocimar	Quingdao Beihai Shipbuilding	2024	66
18.03.2022	4 Handy Bulkers	40000	Vogemann	Jiangsu Daijin Heavy Ind	2024	29
02.11.2022	2 Post Panamax Bulkers	95000	NYK Line	Oshima	2025	65
17.11.2022	10 Capesize Newcastlemax Bulkers	210000	Bocimar	Qingdao Beihai Shipbuilding	2025–2026	64
21.07.2023	Bulk Carrier	3000	Open offer	Taizhou Quihai Shippinf Science and Technology	2023	6,818

Table 2 (continuance)

01.02.2023	Handymax	48000	n.d.	Japan	n.d.	38
01.02.2023	Panamax	65000	n.d.	Japan	n.d.	24
01.02.2023	Handysize	33000	n.d.	Japan	n.d.	32
01.02.2023	Capesize	98000	n.d.	Japan	n.d.	65
01.03.2023	Handymax	49000	n.d.	Japan	n.d.	38
01.03.2023	Panamax	79000	n.d.	Japan	n.d.	36
01.03.2023	Handysize	34000	n.d.	Japan	n.d.	32
01.03.2023	Capesize	99000	n.d.	Japan	n.d.	66
01.04.2023	Handymax	50000	n.d.	Japan	n.d.	40
01.04.2023	Panamax	80000	n.d.	Japan	n.d.	36,5
01.04.2023	Handysize	35000	n.d.	Japan	n.d.	33
01.04.2023	Capesize	199000	n.d.	Japan	n.d.	68

Table 3

Descriptive statistics

Indicators	Deadweight	Building price of ship, USD mln
Average	81580,95238	41,90085714
Standard error	14915,54577	4,143663179
Median	63600	36,5
Mode	210000	32
Standard deviation	68351,61753	18,98865017
Sampling variance	4671943619	360,5688354
Kurtosis	-0,041106811	-1,064345863
Asymmetry	1,056200724	0,133194644
Amplitude	207000	61,182
Minimum	3000	6,818
Maximum	210000	68

Based on these data, correlation-regression analysis of the dependence of construction prices of bulk vessels of different classes on deadweight is performed. Figure 5 shows linear and non-linear regression models that demonstrate the dependence of the construction price on the deadweight of bulk vessels.

The linear correlation coefficient is 0.85, which indicates a close positive correlation between deadweight and construction prices in the bulk sector of the freight market within the experiment. The coefficients of determination for the polynomial and stepwise regression models exceed 0.8, which indicates that these models explain more than 80% of the dependence of the construction price on the deadweight of bulk vessels. A comparison of the coefficients of determination shows that the maximum coefficient is in the stepwise regression model (table 4). This means that of all the considered models, it most qualitatively explains the dependence of the price on the deadweight. Further, the calculation results should be adjusted taking into account commercial corrections for the delivery period, serial construction, payment terms, etc.

The implementation of the procedure for determining the level of the price of ship construction based on the market approach is presented in figure 6.

The customer often announces a closed tender for the construction of a vessel with certain technical and economic characteristics. But the shipyard that won the tender can take the position of a monopolist, and it will be very difficult to reach a compromise

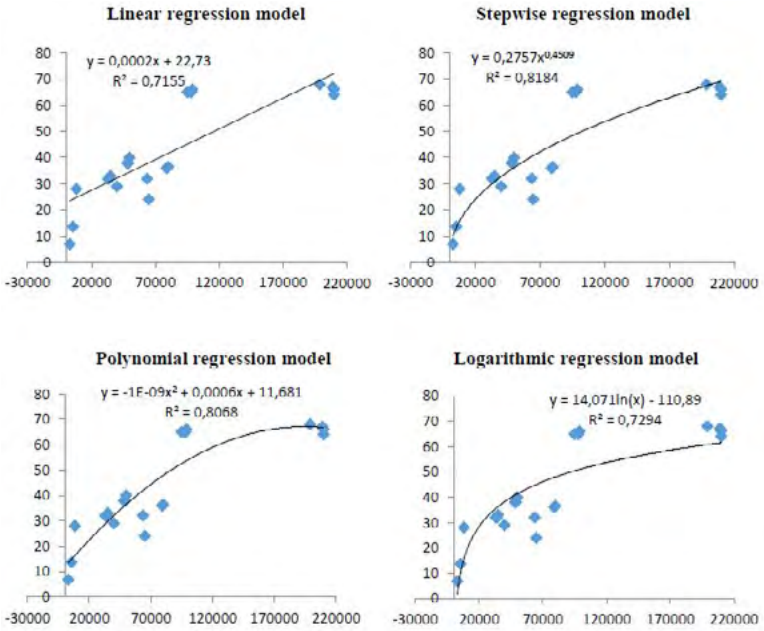

Fig. 5. Correlation-regression analysis of the dependence of ship construction prices from deadweight using different models

Table 4

Dependence of the ship construction price on deadweight

Regression model	Equation	Coefficient of determination (R^2)
Stepwise	$y = 0,2757x^{0,4509}$	0,8184
Polynomial	$y = -1E-09x^2 + 0,0006x + 11,681$	0,8068
Logarithmic	$y = 14,071\ln(x) - 110,89$	0,7294
Linear	$y = 0,0002x + 22,73$	0,7155

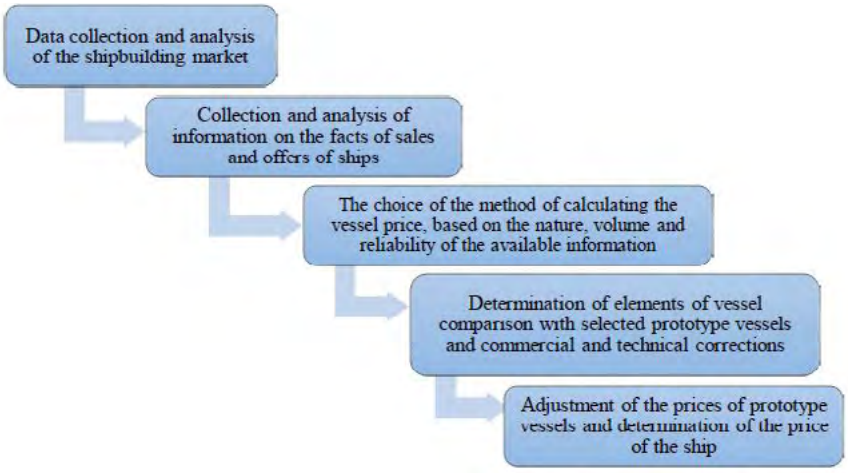

Fig. 6. Stages of the procedure for determining the ship construction price based on the market approach

with it when detailing the conditions of construction and delivery of the vessel. In order to avoid such situation, it is better to conduct the tender in two stages. At the first stage, two shipyards are determined, based on the price, delivery terms, financial and technological capabilities, as well as reputation. At the second stage, further coordination of the ship's construction conditions is simultaneously carried out with them.

Hull and machinery insurance (H&M) is a mandatory item of current expenses of shipping companies. Depending on the degree of protection, various types of damages are subject to compensation (Aligned Insurance, 2023) [14]. For example, CASCO insurance provides coverage for ships that are being operated and built, and the amount of coverage includes the ship's hull, engines and equipment. The market value of ships is closely related to the cost of H&M insurance, and also can affect the cost of P&I insurance (Gard News, 2005) [8]. The vessel value directly affects the premium, which is calculated on the basis of the insured value, other insurance conditions, and the right to claim compensation for total constructive loss and recovery of the share in the general average. If the vessel value changes significantly due to market fluctuations, it is advisable for both the insured and the insurer to request a change in the appraised value. If the estimated insurance value is too high, the shipowner pays too high premium for the risk of damage to the vessel, which increases operating expenditures and worsens the financial performance of the shipping company.

Conclusions. An analysis of the dynamics of shipbuilding prices on the example of the USA indicates their increase from 1985 to 2023 by almost 2.5 times. Construction costs of ships depend on fluctuations in the prices of steel, materials and equipment, the country of construction and labor cost standards. Shipbuilding prices are affected by the relationship between supply and demand in shipbuilding, exchange rate fluctuations, regulatory requirements and state credit and financial regulation of the shipbuilding industry. Demand from shipowners is influenced by global demand for sea transportation, current and forecast freight rates, market sentiment and expectations, pace of fleet renewal, credit and financial regulation of shipping industry, scrapping prices and the ratio of prices of new and second-hand ships.

The proposed classification of approaches to the estimation of prices for the construction of marine vessels involves the allocation of cost approach, intrinsic approach and market approaches. The cost approach takes into account the total costs of the shipyard for the ship construction and the projected profit. The intrinsic approach includes methods based on the determination of intrinsic value. The method of discounted free cash flows on equity, proposed within this approach, can be used for various chartering schemes. The market approach includes the methods of correlation-regression analysis, the method of parametric series, the method of specific indicators, and the engineering method.

The performed correlation-regression analysis of the dependence of the prices for the construction of bulk vessels of different classes on the deadweight indicates a close positive correlation between the deadweight and the construction prices of ships. Non-linear regression models sufficiently describe the dependence of the construction price of a certain type of ship on deadweight and can be used by shipowners to estimate the value of ships with further adjustment for commercial corrections.

In the case of tender pricing, it is advisable to conduct the competition in two stages.

The market value of the vessel directly affects the insurance premium and the terms of H&M insurance. In case of significant changes in the market price of the vessel after the conclusion of the insurance contract, it is necessary to change the appraised value of the vessel.

The practical value of the study is that the results can be useful for shipping and insurance companies in estimating the cost of building marine vessels in order to increase profitability and reduce financial risks. Methodical principles for calculating commercial corrections to the price of ship construction need further research.

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