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THE FORMATION OF A RATIONAL MODEL OF MANAGEMENT OF THE CONSTRUCTION COMPANIES CAPITAL STRUCTURE

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ABSTRACT

The paper deals with the improvement of the methodical approach to the management model of the construction companies' capital structure. The purpose of the research is to substantiate the characteristics of capital structure management, taking into account the criterion functions and limitations according to the criteria of effective capital structure management. The result of the work is an improved methodical approach to the optimization model of capital structure management, which, unlike the existing ones, has a complex nature and takes into account the criterion functions of maximizing financial autonomy and minimizing the cost of capital, as well as limitations according to the criteria of capital adequacy (based on the predicted factors of the external environment and macroeconomic situation according to simulation scenarios), financial risk, profitability of the capital. The two-criterion optimization model of capital structure management proposed in the paper makes it possible to find an optimal solution that satisfies the criterion functions by the method of concessions regarding the coefficient of financial autonomy, taking into account its average industry value and the size of the construction company based on sales revenue, and to automate the process of managing sources of capital formation in view of strategic goals of the construction company, and also, in the absence of a globally optimal solution, to apply concessions according to certain criteria, substantiating the risk scenarios for enterprises and the effectiveness of the taken management decisions. The mechanism for implementing the capital structure management model based on the example of three construction companies in Ukraine demonstrated its effectiveness and ability to find optimal solutions for capital formation in compliance with a number of criteria of capital adequacy, its cost, financial risk and capital profitability.

Keywords: model, capital, structure, construction company, criterion, optimization, criterion function, limitation

JEL Classification: G17

INTRODUCTION

The ratio of borrowed funds to equity capital, which is used to analyze the financing of the company's activities and development, is the main indicator of the capital structure of the company. The solvency of the population, the population's investment in housing construction, and the volume of mortgage lending quite clearly explain the change in the volume of production and capital of construction enterprises in Ukraine. Large and medium-sized companies in the construction business actively attract liabilities to finance their activities, while small construction companies on average have the highest level of equity capital and almost do not use credit resources. Regarding the factors influencing the capital of construction companies, the dependence of its volume on external factors, as well as the influence of the size of enterprises and internal factors on the formation of the capital structure, is obvious. However, more attention should be paid to the application of capital structure management modelling methods. Modelling the management of the capital structure is an urgent problem of modern economic science. At the same time, scientists use both sets of indicators that differ in their content and apply various modelling methods, so there is a need to form a rational model

of capital structure management that takes into account the specifics of the activity of construction companies.

LITERATURE REVIEW

Traditional approaches to the empirical analysis of the optimization of the formation of the capital structure of enterprises are largely based on theories and their corresponding criteria for the formation of the amount of capital and its sources. Thus, domestic scientists [1-4] classify the method of optimization according to the criterion of the effect of financial leverage, as well as according to the criteria of minimizing the cost of capital and maximizing the value of the enterprise, to static ones.

When Miller and Modigliani's theory of capital structure and the basis of optimizing its value was published [5, 6], it gained considerable interest. There appeared studies that developed guidelines for finding the optimal ratio or balance between debt and equity that minimizes the cost of capital and therefore maximizes the value of companies. However, the trade-off theory is the most well-known. It explains the relationship between debt and equity financing of a company and suggests that there is an optimal level of debt financing that a company should maintain, and that too much or too little debt can harm a company's profitability and sustainability [7]. Accordingly, the level of the tax burden, financial stability and the cost of sources of capital attraction are the elements of the empirical analysis in this case. Maximization of the advantages of the tax shield and minimization of the cost of capital and the risk of bankruptcy, measured by indicators of financial stability, are the criteria for making decisions for the enterprise.

A limitation of this approach consists of the variability, uncertainty, and imperfection of information regarding the assessment of the costs and benefits of debt financing, the cost of equity capital, the ease of access to debt capital markets, and methods of equity capital acquisition. A dynamic approach to the formation of the capital structure is defined in the papers of domestic scientists [1-4] through the theory of signalling, information asymmetry, agency costs, corporate control and a number of behavioural theories (the theory of the financing hierarchy, adaptation to the market, dynamic compromise). This approach involves changing the capital structure, its correction and adjustment depending on certain conditions, that is, it deviates from a static vision of the target capital structure as a predetermined ratio.

The theory of the hierarchy of capital financing is the most common in this approach. It assumes that companies keep to a certain order in their financing decisions, when the internal funds (retained earnings) are the main source, and borrowed funds and raised equity capital follow. The theory states that companies prefer debt financing when they have positive cash flows and equity financing when they have negative cash flows. Accordingly, in this case, the balance of cash flows is subject to analysis, both as a whole and by its components – for operational, investment and financial activities. Instead of targeting a specific debt-to-equity ratio, managers follow a sequence of steps aimed at minimizing the negative effects of information asymmetry [8-9].

However, the aspects of this theory are considered not entirely convincing since criteria such as the cost of debt capital and financial stability are not taken into account, and under certain circumstances (for example, lower cost of loans) companies can choose to increase capital through debt obligations even with a negative balance of cash flows, not through corporatization.

If we turn to single-criterion methods of optimizing the capital structure, then four can be distinguished from the above theories:

- using the maximization of the indicator of the effect of financial leverage, which affects the change in financial profitability. In this case, the assessment of the effect of financial leverage does not take into account the division of loan capital into long-term and short-term ones; cost of equity; inflation;
- minimizing the cost of capital. At the same time, the WACC formula reflects the industry and other types of risks included in the price of equity capital through the SARM model. The difficulty in calculating the WACC lies in the calculation of the cost of a unit of capital obtained from a specific source of financing;
- optimizing the asset financing policy. In this case, indicators of solvency and financial stability are used, both in comparison with the norm and with the average industry value, and one of the target indicators is chosen as a criterion;
- maximizing earnings per share (stock yield) or taking into account such profitability of peer companies. At the same time, the rating of companies may include non-public joint-stock companies, and in the conditions of an underdeveloped stock market, such an assessment of the efficiency of the capital structure may be complicated.

The method of optimizing the target capital structure based on the criterion of maximizing the level of projected profitability allows for determining only the optimal value of the effect of financial leverage. If only this method is used, the aspect of the sufficiency of the own funds for the normal functioning of the company – its solvency – may be unacceptably underestimated.

The minimization of the weighted average cost of capital also leads to an increase in financial risks. As in the previous method, one can expect an increase in the share of loan funds, the value of which is mostly lower than the value of equity capital. In contrast to these two methods, minimizing the level of financial risks aims at increasing the financial stability of the company and independence from external sources of financing, but does not create prerequisites for further development. Therefore, it is considered appropriate to apply a multi-criteria complex approach that combines the mentioned methods in view of the following features of each features industry and the organizational form of a separate enterprise in the construction industry. For example, in modern domestic literature, N. Korzh singles out the following approaches to capital structure management:

- focused on risk minimization at the minimum cost to the company;
- focused on maximizing the value of the company by increasing the level of return on equity and increasing risk;
- the optimal ratio of risk and market value of the company [4].

Despite numerous theories of capital structure and subsequent discussions regarding their application in justifying the most optimal capital structure based on them, these questions remain a challenge for most companies and financial managers in determining the rational combination of debt and equity capital to finance their operations.

However, in practice, companies often deviate from these theories due to various factors such as market conditions, regulatory constraints and management's perception of risk. The individual motivation of the managers' behaviour under the conditions of the modern information economy, available big data and methods and tools for their processing create prerequisites for the development of empirical methods of capital structure research based on factor analysis and modelling of capital structure hypotheses.

It is worth noting that a certain role is played by groups of factors that can influence the process of the empirical analysis of the formation of the enterprise capital structure. Domestic scientific developments in the substantiation of influencing factors on the capital structure are contained in the papers by S.O. Dombrovska [10], O.M. Kovaleva [11], N.O. Kovalchuk, Yu.I. Fedoruk [12]. Of course, first of all, the authors pay attention to macro- and meso-factors. They should include the discount rate of the central bank, the weighted average rate on bank loans, the level of average profitability of assets and equity in the industry for comparison with the first two factors, the components of the cost of equity according to the SARM model for a separate industry and country, and a number of other factors. Micro-factors influencing the capital structure include profitability, level of taxation and tax benefits, initial value of financial autonomy, and return on equity. Foreign researchers also use coefficient analysis, but unlike the domestic assessment of coefficients using qualitative methods, based on SPACE, PEST, and SWOT analysis, they use mainly correlational dependences, where profitability is chosen as the variable (measured by ROA - return on assets or ROE - return on equity or equity) and capital structure, primarily measured through the total debt ratio (total liabilities to total assets). Also, ambiguous conclusions as to the influence of the capital structure on the company profitability are stated during the review of foreign literature (Table 1).

Table 1. The results of the correlation analysis on the formation of the company capital structure in the papers of foreign scientists.
(Source: compiled from data [13-23])

Author	Results of empirical analysis
Relationship between capital structure and company profitability	
C.D. García-Gómez, M.H. Bilgin, E.Demir, J.M. Díez-Esteban [13]	Excessive leverage negatively affects business efficiency
A. Nasimi, R. Nasimi [14], A. Shah, J. Ilyas [15]	Higher risk associated with a higher level of debt brings lower value to the company and its shareholders (Pakistani companies as an example)
N. Iqbal, H. Ullah, A. Abbas [16], D.M. Roden, W.G. Lewellen [17]	Positive relationship between capital structure (debt load ratio) and profitability (ROA, ROE). The more a company is financed by debt, the more profitable it is for its shareholders.
A. Fernandes, C.B. Vaz, A.P. Monte [18]	Efficiency increases with an increase in the share of current assets in current liabilities (current liquidity ratio). More efficient firms prefer higher leverage because higher efficiency reduces the cost of potential bankruptcy. Financial leverage has a positive effect on business efficiency
W. Khémiri, H. Noubbigh [19]	There is a significant inverse relationship between debt levels and performance

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Table 1. Continued.

Author	Results of empirical analysis
S. Vatavu [20]	Efficiency is higher when using equity capital in contrast to debt financing
The impact on the capital structure of such factors as duration of existence, size and form of ownership	
Z.M. Silva Serrasqueiro, M.C. Rêgo Rogão [21]	A debt-laden capital structure has a statistically significant negative impact on a company's operations. This influence is stronger on state-owned enterprises than on non-state-owned enterprises. There is a statistically significant negative relationship between the share of debt and the age of the company. In other words, a company with a long existence does not seek to use external sources. On the other hand, there is a statistically significant relationship between the share of debt and the size of the company, which indicates diversification of activities in order to minimize the probability of bankruptcy of the company
Mursalim, M.Mallisa, H. Kusuma [22]	Company size and macroeconomic volatility play a dominant role in explaining fluctuations in capital structure. In addition, the capital structure is statistically significantly related to the company's performance
E.A. Nenu, G. Vintila, S.C. Gherghina [23]	Debt share is positively correlated with company size and stock price volatility. On the other hand, the debt structure has different effects on the performance and development of market share prices

It should be noted separately that researchers specify the impact on the capital structure of such factors as duration of existence, size and form of ownership.

J. Mazanec in his correlation analysis expands the list of indicators with indicators of liquidity and asset structure:

- the share of debt and the share of non-current assets have a negative impact on profitability, as they indicate a higher degree of financial risk, which can reduce the creditworthiness of the company and increase the cost of borrowing;
- the current ratio of liquidity, the proportion of cash and cash equivalents in assets has a positive effect on profitability, although in general high liquidity or assets with the highest level of liquidity usually do not have a positive effect on productivity, since these funds are not invested in business development;
- return on capital in medium-sized businesses is higher than in small businesses [24].

The author's research results in the following: company managers should give priority to equity capital over external liabilities, maintaining high liquidity, which in aggregate contributes to increasing business efficiency and return on invested capital. The given results of the empirical analysis of foreign scientists create the basis for determining the factors of further correlation-regression analysis of the capital structure of enterprises in the construction industry of Ukraine.

Domestic scientists also emphasize the role of investments in capital formation and investigate the factors of their activation [12], while others [24] talk about the direction of venture capital financing and apply correlation-regression modelling. Domestic scientists [25] apply simulation modelling of factors influencing the capital structure, using appropriate methods and models along with examples of regression factor analysis.

Paying due attention to the role and content of empirical analysis, its methods and the determination of the most important factors affecting the actual capital structure of companies and the effectiveness of its use, it is necessary to form the determinants of a complex methodical approach to the analysis of the capital structure of construction enterprises of Ukraine.

AIMS AND OBJECTIVES

The purpose of the research is to substantiate the characteristics of capital structure management, taking into account the criterion functions and limitations according to the criteria of effective capital structure management.

The following tasks were set and solved to achieve the purpose:

- the substantiation of the composition of indicators of the optimization model for managing the capital structure of construction companies;
- the formation of the criterion function and linear constraints of the optimization model of capital structure management;
- the approbation of modelling results by the example of construction companies of Ukraine.

METHODS

Optimization in the formation of the capital structure makes it possible to determine the limit value of the ratio of loan and equity capital, which maximizes the profitability of the latter, taking into account both the effect of the tax shield (tax corrector), financial stability (the arm of financial leverage), and the cost of loan capital (in the differential) [28]. This method of optimization allows avoiding excessive indebtedness and excessive corporatization.

First of all, simulation modelling of capital is considered necessary to determine its sufficiency according to the demand for construction. In the paper by V.B. Kochkodan [25], simulation modelling is devoted to the variability of the dynamics and structure of capital. So, in view of the task, it is proposed to determine the simulation modelling of scenarios of the dynamics of external factors as the first stage of the model, which is the basis for compliance with the criterion of capital adequacy. It is this aspect that is considered initial in the optimization of the capital structure since excess capital involvement reduces the efficiency of its use. External factors (aggregate resources per month on average per household, population investment in housing construction and mortgage lending volumes) significantly determine changes in the volume of production and capital of construction enterprises. Taking into account that the influence of the specified factors on companies of different sizes is different, it seems appropriate to build a regression equation of the dependence of the amount of capital on the factors for each individual company.

The forecast amount of capital for each company under each of the scenarios is determined by the regression equation:

$$OK_i = b_0 + b_1X_{1i} + b_2X_{2i} + b_3X_{3i}, \quad (1)$$

where OK_i – the amount of capital of construction companies of Ukraine according to scenario i; X_{1i} – aggregate resources per month on average per household according to the scenario i; X_{2i} – population investment in residential construction according to scenario i; X_{3i} – volumes of mortgage lending according to scenario i.

The formation of a multi-criteria optimization model provides for the presence of criterion functions and constraints. The methods for its solution can be as follows.

Interactive methods include the use of the Hierarchy Analysis method and the Pareto method. The former is a system approach tool in which the criteria are located in a certain hierarchy. Analysis and decision-making are carried out in several stages. First, a hierarchical structure containing the goal, criteria and alternatives is built. Next, by carrying out the procedure of pairwise comparisons, the priorities that have relative importance are determined and the alternative solution with the maximum priority is calculated. The Pareto method assumes that each criterion of the criterion function cannot be improved without simultaneously worsening another criterion.

Lexicographic optimization involves the use of the concession method when the search and decision-making are carried out in the following stages. All criteria are ranked by importance in advance and the most important criterion is determined, and the most optimal solution is sought for it. Then, the next criterion is selected (in order of importance) and its optimal solution is determined, but the loss of the importance of the previous criterion by some amount (concession) is allowed. The optimization process for each criterion continues until the last most important criterion is considered.

In addition, reduction to single-criterion optimization models is possible. The following can be used for this purpose:

- the method of the main criterion, similar to the method of concessions. That is, first the main criterion is determined, and all other criteria are formed into the constraints of the selected criterion function. Indicators or the lower limit of criteria are set by the system of control indicators, and as a result, the task is reduced to solving a problem with one criterion;
- the convolution method, which consists of the fact that when individual criteria are combined, one scalar criterion is obtained (multiplicative and additive), and everything comes down to solving a single-criteria problem;
- the target programming method involves solving a number of tasks in each of the initial criteria, ordered by level. At the same time, solving the problem with the criterion function, which is less important, does not deteriorate the optimal value of the criterion function with a higher priority.

We introduce the notations for the simulated indicators of the capital structure:

- K_1 – amount of equity capital;
- K_2 – long-term bank credits;
- K_3 – short-term bank credits;

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- K_4 – long-term liabilities, including long-term investments in construction;
- K_5 – current liabilities (accounts payable).

It is proposed to form the criterion functions of the model based on the main problems of capital formation of construction enterprises of Ukraine, namely the function of maximizing the financial autonomy of companies and minimizing the cost of capital:

$$f_1=\frac{K_1}{OK} \rightarrow max; \quad (2)$$

$$f_2=r_e * \frac{K_1}{OK} + r_{d1} * (1-t) * \frac{K_2}{OK} + r_{d2} * (1-t) * \frac{K_3}{OK} \rightarrow min, \quad (3)$$

where OK is the amount of capital of the construction company; r_e, r_{d1}, r_{d2} – the price of equity, long-term and short-term loans, respectively; t – income tax rate.

It is proposed to use for further modelling the method of concessions, defining the maximization of the indicator of financial autonomy (f_1) as the criterion function at the first stage, and the minimization of the cost of capital (f_2) at the second stage, setting the concession for (f_1) as the difference between the maximized indicator and the average value of the coefficient of financial autonomy for companies of the appropriate size.

The formation of restrictions of the multi-criteria model of capital structure optimization includes the requirement of capital adequacy:

$$К_1+К_2+К_3+К_4+К_5=ОК. \quad (4)$$

To account for the risk of bankruptcy, the second limitation of the model includes an indicator of current solvency:

$$\frac{ОА}{К_3+К_5} \geq КПЛср,$$

where OA – current assets, which in the forecast period are calculated as the difference between the forecast amount of capital (OK) and non-current assets of the company; КПЛср – the average value of the ratio of current liquidity of the company of the corresponding size.

By transformation:

$$КПЛср*К_3+ КПЛср*К_5 \leq ОА. \quad (5)$$

Restrictions on the efficiency of the use of the total amount of capital (return on assets) stem from the belief that the purpose of the functioning of companies (especially under the conditions of a post-war state or crisis economy) is not only to measure but also to stabilize or improve profitability, which is important from the point of view of the adoption of tactical and strategic decisions in financial management. The above determines the focus on monitoring and comparing profitability indicators with the previous period.

Since net income must be taken into account to enter the model of the projected profitability of assets and equity, its expression is possible due to the assumption of an unchanged structure of production and corresponding costs (the level of the effect of operating leverage in the last reporting period), the invariance of other costs and revenues and an increase in interest costs on loans funds. Hence, the projected net profit is equal to:

$$ЧПп=ОП_з + ОП_з * (\frac{ВРп}{ВРз}-1) * ЕОВ + СДВін - r_{d1}/100\% * (1-t) * К_2 - -r_{d2}/100\% * (1-t) * К_3, \quad (6)$$

where ЧПп – projected net income; ОПз – operating profit of the reporting period; ВРп and ВРз – projected net income and net income of the reporting period; ЕОВ – the effect of operating leverage; СДВін – the balance of other income and expenses.

Projected net income can be determined based on capital turnover in the last reporting period. Forming restrictions on the profitability of assets, we substitute expression 6:

РАп≥РАз;

$$\frac{(\text{ОП}_з+\text{ОП}_з*(\frac{\text{ВРп}}{\text{ВРз}}-1)*\text{ЕОВ}+\text{СДВін})*100\%-r_{d1}*(1-t)*\text{К}_2-r_{d2}*(1-t)*\text{К}_3}{\text{ОК}} \geq \text{РАз};$$

$$r_{d1}*(1-t)*\text{К}_2+r_{d2}*(1-t)*\text{К}_3 \leq (\text{ОП}_з+\text{ОП}_з*(\frac{\text{ВРп}}{\text{ВРз}}-1)*\text{ЕОВ}+\text{СДВін})*100\% \quad -\text{РАз}*\text{ОК}, \tag{7}$$

where РАз – return on assets of the reporting period.

We form a similar restriction for the profitability of equity:

РВКп≥РВКз;

$$\frac{(\text{ОП}_з+\text{ОП}_з*(\frac{\text{ВРп}}{\text{ВРз}}-1)*\text{ЕОВ}+\text{СДВін})*100\% \quad *r_{d1}(1-t)*\text{К}_2-r_{d2}*(1-t)*\text{К}_3}{\text{К}_1} \geq \text{РВКз};$$

$$\text{РВКз}*\text{К}_1+r_{d1}*(1-t)*\text{К}_2+r_{d2}*(1-t)*\text{К}_3 \leq (\text{ОП}_з+\text{ОП}_з*(\frac{\text{ВРп}}{\text{ВРз}}-1)*\text{ЕОВ}+\text{СДВін})*100\% \quad , \tag{8}$$

where РВКз – return on equity of the reporting period.

In addition to the above restrictions on the amount of equity capital, long-term and short-term loans, long-term liabilities and payables also require restrictions. Each construction enterprise with an established practice of forming such liabilities (long-term investment funds and other liabilities) has its maximum level, which depends on certain features of economic activity. Therefore, we form the last restrictions as follows:

$К_4 \leq μДЗ_{max}*ОК$, (9)

$К_5 \leq μКЗ_{max}*ОК$, (10)

where $μДЗ_{max}$ – the maximum weight of long-term liabilities (except long-term loans) in the capital of the company in recent years; $μКЗ_{max}$ – the maximum weight of payables in the capital of the company in recent years.

RESULTS

Using the Forecast function of MS Excel, we determine the parameters of the basic, optimistic and pessimistic development of these factors (Figures 1-3).

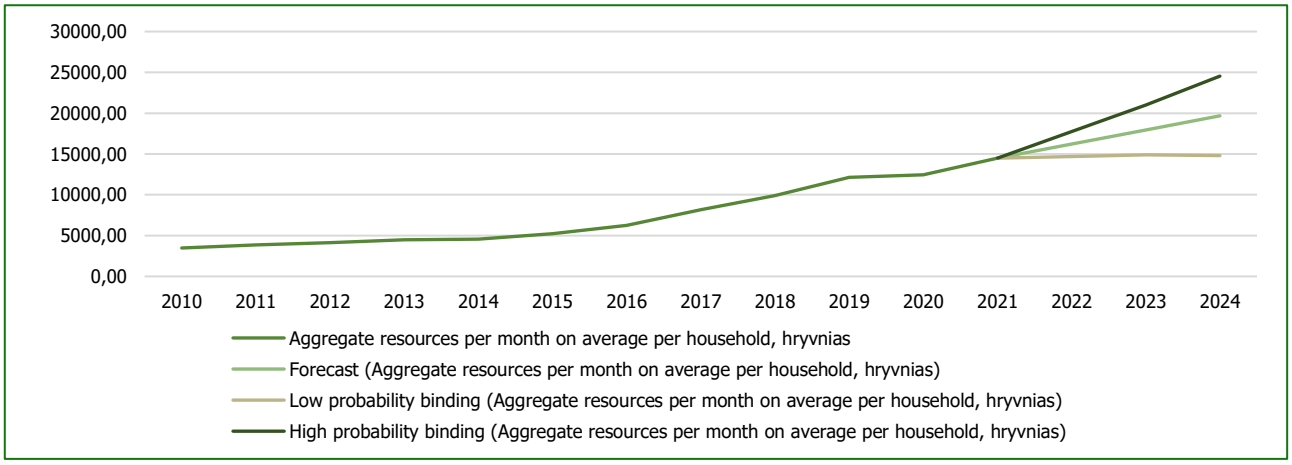

Figure 1. Predictive scenarios of dynamics of aggregate resources of households, UAH. (*Source: built on the basis of data from the State Statistics Service of Ukraine [27]*)

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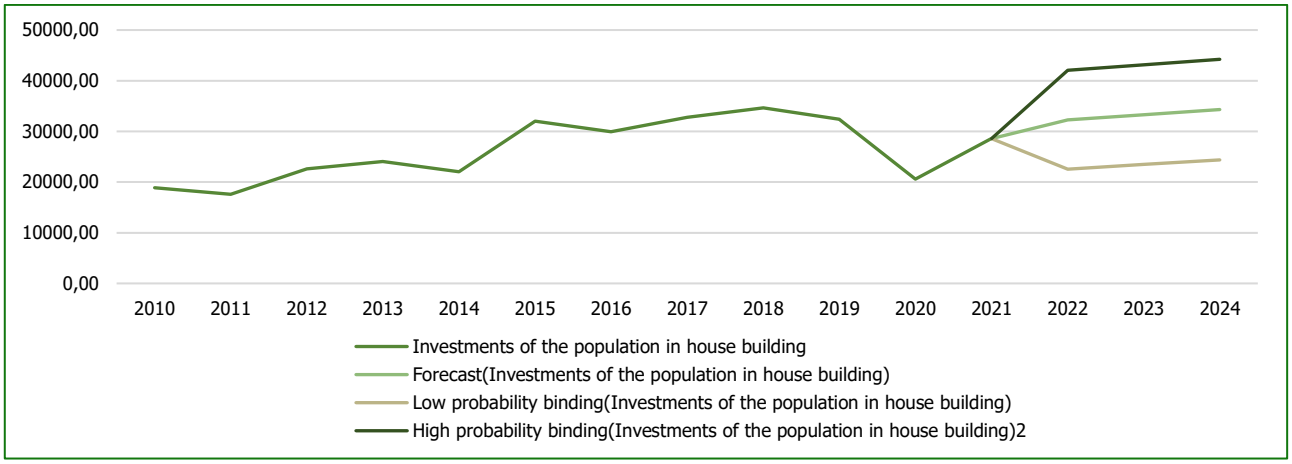

Figure 2. Predictive scenarios for the dynamics of investment of the population in housing, UAH. (*Source: built on the basis of data from the State Statistics Service of Ukraine [27]*)

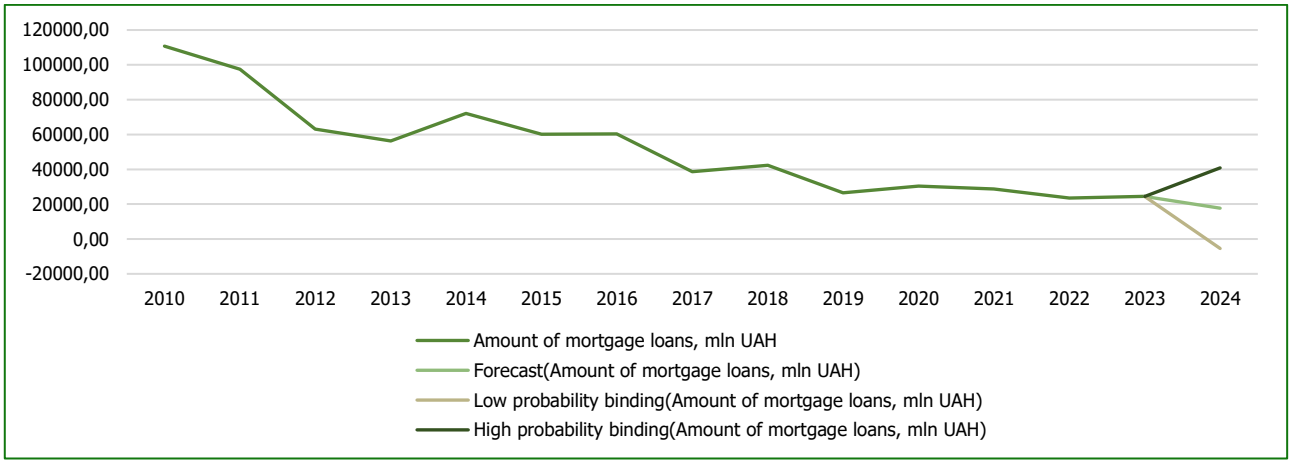

Figure 3. Predictive scenarios for the dynamics of mortgage loans, million UAH. *(Source: built on the basis of data from the State Statistics Service of Ukraine [27])*

The forecast results of the factors are summarized in Table 2, and the amount of mortgage loans was determined as of the 2023 data, as reported by the NBU [28].

Table 2. Parameters of simulation forecasting of the amount of capital of construction enterprises in Ukraine. *(Source: created by the authors based on data from the State Statistics Service of Ukraine [27])*

Forecast period	Aggregate resources per month on average per household	Investments of the population in house building	Amount of mortgage loans
Basic scenario			
2023	17947.85	33303.64	24423.00
2024	19677.78	34312.55	17709.15
Pessimistic scenario			
2023	14895.47	23470.51	24423.00
2024	14815.45	24400.46	0.00
Optimistic scenario			
2023	21000.24	43136.77	24423.00
2024	24540.10	44224.63	40845.90

Three companies were chosen for further applied research.

In the group of large companies in the construction industry, attention was paid to PJSC "Holding Company "Kyivmiskbud". The company is one of the largest developers in Ukraine and the largest in Kyiv, but in 2023, the company is in a difficult

situation due to a lack of financial resources for the implementation of economic activities and compliance with obligations to investors, which led to an audit by a specialized international auditing company [29].

Among the companies with average revenue from sales, PJSC "Production Design and Construction Firm Atlant" was chosen for the study, that has a fairly positive business image and 100% completion of its facilities, which in the pre-war conditions allowed it to "overcome global economic crises with honour and successfully implement its mission to date" [30]. Even in 2022, the company had a net profit, and the return on equity was quite high compared to the corresponding data in the industry. However, the low share of equity capital and the current liquidity at the lower limit of the critical state determine the presence of the company's financial risk. The optimization model of capital structure management should be aimed at solving these problems.

JSC "Construction Company "UkrBud" was chosen from the companies with a low amount of revenue from sales. At the same time, statistical data show that up to and including 2017, the company increased the volume of sales, reaching significant values. Subsequently, from 2018, sales revenue began to decline, which in 2022 became the minimum for the entire observation period since 2010. The company's explanation is logical: "The military aggression of the russian federation, which began on February 24, 2022, significantly reduced the demand of buyers for the services provided by the Company and its subsidiaries for design work, training and retraining of personnel, leasing of business premises and construction work" [31], as a result of which the enterprise did not carry out construction work in 2022.

The implementation of the model for managing the capital structure of construction enterprises after determining its goals should begin with forecasting the adequacy of capital in accordance with the economic situation that determines the demand for products.

Regression equations (1) were constructed on the basis of statistical data for 2010-2021, which establish the relationship between the amount of capital of an individual company and the factors of the external environment (Table 3).

Table 3. Regression equations that determine the relationship between the amount of capital of an individual company and factors of the external environment.

Construction company	Regression equations	R^2
PJSC "Holding Company "Kyivmiskbud"	$OK= -3092634.50+ 1149.95X_1+16.44X_2+ 27.83X_3$	0.9341
PJSC "Production Design and Construction Firm Atlant"	$OK= -694971.10+ 158.70X_1+ 3.59X_2+ 1.67X_3$	0.9678
JSC "Construction Company "UkrBud"	$OK= -339665.42 -18.61X_1+ 31.38X_2+ 1.17X_3$	0.4937

The obtained parameters of the regression equations indicate a close relationship between the amount of capital of PJSC "Holding Company "Kyivmiskbud" and PJSC "Production design and construction firm "Atlant" with factors of demand formation, that is, the management of the capital structure in them is flexible. At the same time, only 49.37% of the capital of JSC "Construction Company "UkrBud" is due to changes in demand factors. This is precisely the observance of the principle of maintaining a steady level of capital, which is mentioned in the company's reporting [31]. The parameters of simulated forecasting of capital volumes of construction enterprises of Ukraine given in Table 3 made it possible to determine the forecast amount of the researched capital corresponding to each of the scenarios (Table 4).

Table 4. Forecast values of capital volumes of construction enterprises of Ukraine, thousand UAH.

Forecast period	PJSC "Holding Company "Kyivmiskbud"	PJSC "Production Design and Construction Firm Atlant"	JSC "Construction Company "UkrBud"
Basic scenario			
2023	18773594.23	2313900.23	399805.40
2024	20592657.40	2580862.22	391412.17
Pessimistic scenario			
2023	15101858.92	1794131.21	148080.43
2024	14345470.88	1743999.44	150193.89
Optimistic scenario			
2023	22445329.53	2833669.26	651530.37
2024	26990888.01	3426786.75	638976.47

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Taking into account the forecast volume of capital, as well as the known price of equity capital of construction companies as of June 2023 (determined on the basis of Damodaran data [34]), long-term and short-term loans in construction (according to NBU data [28]), as well as average industry indicators of current liquidity, we formalize a multi-criteria capital structure management model for each company in 2023.

Thus, the formalized models of capital structure management for PJSC "Holding Company "Kyivmiskbud", PJSC "Production design and construction firm "Atlant", and JSC "Construction company "UkrBud" are shown in Tables 5, 6 and 7, respectively.

Table 5. Formalized models for optimization of capital structure management of PJSC "Holding Company "Kyivmiskbud".

Basic scenario

$$\frac{1}{18773594.23}К_1 \to max;$$

$$\frac{26.07}{18773594.23}K_1 + \frac{16.564}{18773594.23}K_2 + \frac{16.154}{18773594.23}К_3 \to min$$

$$\begin{cases} К_1 + К_2 + К_3 + К_4 + К_5 = 18773594.23; \\ 2.37К_3 + 2.37К_5 \le 18444439.23; \\ 16.564К_2 + 16.154К_3 \le 1109553.98; \\ -2.46К_1 + 16.564К_2 + 16.154К_3 \le -2957157.00; \\ К_4 \le 14051500.38; \\ К_5 \le 11364943.79. \end{cases}$$

Pessimistic scenario

$$\frac{1}{15101858.92}К_1 \to max;$$

$$\frac{26.07}{15101858.92}K_1 + \frac{16.564}{15101858.92}K_2 + \frac{16.154}{15101858.92}К_3 \to min$$

$$\begin{cases} К_1 + К_2 + К_3 + К_4 + К_5 = 15101858.92; \\ 2.37К_3 + 2.37К_5 \le 14772703.92; \\ 16.564К_2 + 16.154К_3 \le -780637.30; \\ -2.46К_1 + 16.564К_2 + 16.154К_3 \le -4051981.87; \\ К_4 \le 11303311.12; \\ К_5 \le 9142190.65. \end{cases}$$

Optimistic scenario

$$\frac{1}{22445329.53}К_1 \to max;$$

$$\frac{26.07}{22445329.53}K_1 + \frac{16.564}{22445329.53}K_2 + \frac{16.154}{22445329.53}К_3 \to min$$

$$\begin{cases} К_1 + К_2 + К_3 + К_4 + К_5 = 22445329.53; \\ 2.37К_3 + 2.37К_5 \le 22116174.53; \\ 16.564К_2 + 16.154К_3 \le 2999745.26; \\ -2.46К_1 + 16.564К_2 + 16.154К_3 \le -1862332.14; \\ К_4 \le 16799689.64; \\ К_5 \le 13587696.92. \end{cases}$$

Table 6. Formalized models of capital structure management of PJSC "Production design and construction firm "Atlant".

Basic scenario

$$\frac{1}{2313900.23}К_1 \to max;$$
$$\frac{26.07}{2313900.23}K_1 + \frac{16.564}{2313900.23}K_2 + \frac{16.154}{2313900.23}К_3 \to min$$

$$\begin{cases} К_1 + К_2 + К_3 + К_4 + К_5 = 2313900.23; \\ 1.77К_3 + 1.77К_5 \le 2256431.23; \\ 16.564К_2 + 16.154К_3 \le 3644184.902; \\ 11.81К_1 + 16.564К_2 + 16.154К_3 \le 6274013.69; \\ К_4 \le 7446.23; \\ К_5 \le 2281372.04. \end{cases}$$

Pessimistic scenario

$$\frac{1}{1794131.21}К_1 \to max;$$
$$\frac{26.07}{1794131.21}K_1 + \frac{16.564}{1794131.21}K_2 + \frac{16.154}{1794131.21}К_3 \to min$$

$$\begin{cases} К_1 + К_2 + К_3 + К_4 + К_5 = 1794131.21; \\ 1.77К_3 + 1.77К_5 \le 1736662.21; \\ 16.564К_2 + 16.154К_3 \le 502392.77; \\ 11.81К_1 + 16.564К_2 + 16.154К_3 \le 2541485.83; \\ К_4 \le 7366.63; \\ К_5 \le 1768909.80. \end{cases}$$

Optimistic scenario

$$\frac{1}{2833669.26}К_1 \to max;$$
$$\frac{26.07}{2833669.26}K_1 + \frac{16.564}{2833669.26}K_2 + \frac{16.154}{2833669.26}К_3 \to min$$

$$\begin{cases} К_1 + К_2 + К_3 + К_4 + К_5 = 2833669.26; \\ 1.77К_3 + 1.77К_5 \le 2776200.26; \\ 16.564К_2 + 16.154К_3 \le 6785977.03; \\ 11.81К_1 + 16.564К_2 + 16.154К_3 \le 10006541.55; \\ К_4 \le 9959.99; \\ К_5 \le 2793834.29. \end{cases}$$

Table 7. Formalized models of optimization of capital structure management of JSC "Construction company "UkrBud".

Basic scenario

$$\frac{1}{399805.40}К_1 \to max;$$
$$\frac{26.07}{399805.40}K_1 + \frac{16.564}{399805.40}K_2 + \frac{16.154}{399805.40}К_3 \to min$$

$$\begin{cases} К_1 + К_2 + К_3 + К_4 + К_5 = 399805.40; \\ 3.6К_3 + 3.6 \le 162524.40; \\ 16.564К_2 + 16.154К_3 \le 185477.22; \\ -1.28К_1 + 16.564К_2 + 16.154К_3 \le -291375.05; \\ К_4 \le 129017.52; \\ К_5 \le 218476.64. \end{cases}$$

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Pessimistic scenario

$$\frac{1}{148080.43}К_1 \to max;$$

$$\frac{26.07}{148080.43}K_1 + \frac{16.564}{148080.43}K_2 + \frac{16.154}{148080.43}К_3 \to min$$

$$\begin{cases} К_1 + К_2 + К_3 + К_4 + К_5 = 148080.43; \\ 3.6К_3 + 3.6К_5 \le -89200.57; \\ 16.564К_2 + 16.154К_3 \le -174587.39; \\ -1.28К_1 + 16.564К_2 + 16.154К_3 \le -351204.54; \\ К_4 \le 47785.67; \\ К_5 \le 80919.66. \end{cases}$$

Optimistic scenario

$$\frac{1}{651530.37}К_1 \to max;$$

$$\frac{26.07}{651530.37}K_1 + \frac{16.564}{651530.37}K_2 + \frac{16.154}{651530.37}К_3 \to min$$

$$\begin{cases} К_1 + К_2 + К_3 + К_4 + К_5 = 651530.37; \\ 3.6К_3 + 3.6К_5 \le 414249.37; \\ 16.564К_2 + 16.154К_3 \le 545541.82; \\ -1.28К_1 + 16.564К_2 + 16.154К_3 \le -231545.56; \\ К_4 \le 210249.37; \\ К_5 \le 356033.63. \end{cases}$$

The systems of linear equations are solved using MS Excel's "Search for a solution" function first by the simplex method, and then, in the absence of a global optimal solution, by the generalized reduced gradient method.

The results of the solution of optimization models for PJSC "Holding Company "Kyivmiskbud" provided the following solution options. A local optimal solution was found for the basic scenario, at the first stage of maximizing the coefficient of financial autonomy using the generalized reduced gradient method, for which the maximum value of the equity share was set at the level of 9%. This value corresponds to the company's indicator of the reporting period but is lower than the average of large enterprises in the industry in terms of sales revenue (0.15). Therefore, at the second stage of optimization, according to the criterion of minimizing the price of capital, a limit was set for the coefficient of financial autonomy at the level of 0.09, i.e., no concession was applied. The cost of capital did not change significantly after the second stage, but the optimization had a positive effect on the profitability of assets and equity (losses decreased) due to the absence of long-term loans. Therefore, such a decision can be considered the optimal capital structure of PJSC "Holding Company "Kyivmiskbud" under the condition of the implementation of the basic scenario.

In the pessimistic scenario, the company capital and sales revenue are reduced causing even greater losses due to the presence of fixed costs and payments. In this regard, the system does not have a global and local solution, and the first stage of optimization by means of MS Excel is proposed to maximize the coefficient of financial autonomy to the level of 0.11, but with an increase in the unprofitability of the company's assets (a concession to restrictions) and an unchanged level of the equity capital. Therefore, in a pessimistic scenario, there are risks of unprofitability, subject to compliance with the conditions of financial risk and capital adequacy.

In the optimistic scenario, at the first stage, a globally optimal solution (simplex method) of maximizing the coefficient of financial autonomy to the level of 0.09 is determined. At the same time, the cost of capital will be 2.43%. At the second stage of minimizing the cost of capital its value of 2.35% is reached and the unprofitability of capital will decrease at the same time (local optimal solution).

In a similar way, optimization models were solved for PJSC "Production design and construction firm "Atlant". The effect of operating leverage in this company is the highest among the studied ones (5.45) and scales the growth of profit, however, any involvement of borrowed funds reduces the return on equity, since the return on assets is low compared to the cost of loans.

No optimal solutions were found for the basic scenario at the first stage of maximizing the coefficient of financial autonomy, and the system suggests setting the maximum value of the equity share at the level of 23%. At the same time, the capital adequacy condition is not met; its volume is lower than determined in the regression modelling. Therefore, the second stage of optimization was not carried out for PJSC "Production design and construction firm "Atlant".

Under the pessimistic scenario, the company's capital and sales revenue almost do not change (the increase is only 5%). However, even in this case, the system does not have a global and local solution, and the first stage of optimization by means of MS Excel suggested maximizing the coefficient of financial autonomy to the level of 0.12, but again with a concession to the limitation of capital adequacy.

In the optimistic scenario, the same situation is observed – the maximization of the coefficient of financial autonomy to the level of 0.30 with a concession on capital adequacy.

It should be noted that there is a risk of forming a sufficient amount of capital for PJSC "Production design and construction firm "Atlant" under all scenarios. At the same time, the price of the company's capital is higher than that of PJSC "Holding Company "Kyivmiskbud".

The results of solving the optimization models for UkrBud Construction Company JSC provided options for global optimal solutions under two scenarios – basic and optimistic.

For the basic scenario at the first stage of maximizing the coefficient of financial autonomy, its global optimal solution is set at the level of 1. At the second stage of optimization, according to the criterion of minimizing the price of capital, a limit was set for the coefficient of financial autonomy at the level of 0.28 (the average for small companies by sales revenue), i.e., a concession was applied. As a result, the coefficient of financial autonomy was reduced to the level of 0.57, and the price of capital after the second stage decreased from 26.07% to 14.80%, i.e., with the observance of other optimization criteria, this decision can be considered the optimal capital structure of JSC "Building Company "UkrBud" provided the basic scenario is implemented.

In the optimistic scenario, at the first stage, a globally optimal solution (simplex method) of maximizing the coefficient of financial autonomy to level 1 is determined. At the same time, the cost of capital will be 26.07%. In the second stage of minimizing the cost of capital, its value is 12.90%, and the share of equity will decrease to 48%. The above solutions are the most favourable for the company in view of the reduction of unprofitable capital and equity capital.

According to the pessimistic scenario, the forecast level of capital should be less than the formed non-current assets, which means the need not only to change the capital structure but also options for the sale of unused equipment or expansion of the company's spheres of activity and increased revenues. Therefore, optimization for the pessimistic scenario was not carried out.

By systematizing the results of the implementation of the optimization model of capital management at the three considered construction enterprises, it is possible to ascertain the found optimal solutions and the need for the application of optimization modelling tools in pessimistic scenarios of the development of events in the financing of the construction, as well as in the case of PJSC "Production design and construction firm "Atlant" from concessions other restrictions than capital adequacy.

Alternative options for simulation modelling of the capital structure for cases where there are no optimal solutions have been developed.

Simulation modelling made it possible to determine a rational structure for the pessimistic scenario of PJSC "Holding Company "Kyivmiskbud": acceleration of capital turnover by 20% due to reimbursement of receivables and their inclusion in circulation will reduce the need for capital and turn it around faster while reducing financial risk and the cost of capital.

For any scenario of PJSC "Production design and construction firm "Atlant" simulation models of the concession to the limitation of current liquidity and the concession to the profitability of equity capital are proposed. However, in the first case, when the financial risk increases to the average industry level of companies with an average volume of revenue, the return on equity significantly increases and the cost of the company's capital decreases. Therefore, this version of capital structure management is considered more rational for implementation.

For the pessimistic scenario of UkrBud Construction Company JSC, only one simulation model has been developed, which gives the optimal solution: the sale of fixed assets in proportion to the decrease in sales revenue (maintenance of return on capital) and the concession of profitability. Other options, even a real expansion of work (increase to 100%) do not provide optimal value.

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So, the mechanism of implementing the capital structure management model by the example of three construction companies in Ukraine demonstrated its effectiveness and ability to find optimal solutions for capital formation in compliance with a number of criteria of capital adequacy, its cost, financial risk and capital profitability.

DISCUSSION

The mechanism for implementing the model of capital structure management by the example of three construction companies in Ukraine has demonstrated its effectiveness and ability to find optimal solutions for capital formation in compliance with a number of criteria of capital adequacy, its cost, financial risk and capital profitability.

The developed model systematically takes into account the target criteria for optimizing the capital structure according to the trade-off theory [7]: the cost of capital (the criterion is also taken into account by Miller and Modigliani [5, 6]), financial stability. In this case, the limitations of the trade-off theory, consisting of a deterministic model for each company, which can be formalized and modified when the operating conditions change, are overcome. This corresponds to the provisions of the development of the dynamic approach to the optimization of the capital structure, which is discussed in the papers of domestic scientists [1-4], but, unlike cash flows, the situational ratio of equity and loan capital is chosen as a dynamic criterion, which leads to the minimization of the cost of capital while simultaneously maintaining the maximum possible financial stability under certain macroeconomic conditions and financing needs.

In turn, financing needs (restrictions on capital adequacy) are modelled through the hypothesis of the impact of macro-environmental factors on the volume of production activity. However, in contrast to the factors of the macro- and meso-environment specified in the papers by S.O. Dombrovska [10], O.M. Kovaleva [11], N.O. Kovalchuk, Yu.I. Fedoruk [12], it is proposed to focus on the most important determinants affecting the activity of construction companies (housing construction), namely: total resources per month on average per household; public investment in housing construction; and volumes of mortgage lending. The difference in the proposed approach to modelling the need for capital consists in the use of a scenario approach, which makes it possible to vary measures to manage the capital structure under different conditions of the development of the economic situation.

The advantage of the proposed model is the two-criteria approach, which, unlike the single-criteria approach common in financial science [4], allows taking into account not only the target criteria of the cost of capital and financial stability, but also restrictions on the asset financing policy through the inclusion of solvency indicators, which is normalized by the average industry value of companies of the corresponding size in terms of sales revenue (proof of the influence of these factors is contained in the papers by Mursalim, M.Mallisa, H. Kusuma [22], .A. Nenu, G. Vintila, S.C. Gherghina [23]), and the level of projected profitability. The relationship between profitability, liquidity, financial stability and the cost of capital, is investigated in the scientific papers by C.D. García-Gómez, M.H. Bilgin, E. Demir, J.M. Díez-Esteban [13], A. Nasimi, R. Nasimi [14], A. Shah, J. Ilyas [15], N. Iqbal, H. Ullah, A. Abbas [16], D.M. Roden, W.G. Lewellen [17], A. Fernandes, C.B. Vaz, A.P. Monte [18], W. Khémiri, H. Noubbigh [19], S. Vatavu [20], the proposed approach is a compromise solution to the scientific debate, as it is based on the comprehensive consideration of all financial indicators and their limitations, as well as their optimal values.

In general, the proposed model of management of the capital structure of construction companies is a synthesis of static and dynamic approaches, has a complex nature and allows justifying financial management decisions from the point of view of compromise, optimality and variability of measures.

CONCLUSIONS

The purpose of the paper consists in substantiating the characteristics of capital structure management and taking into account the objective functions and restrictions according to the criteria of effective management of the capital structure has been solved through the constructed two-criterion optimization model, which, unlike the existing ones, has a complex nature and takes into account the objective functions of maximizing financial autonomy and minimizing the cost of capital), as well as restrictions based on the criteria of capital adequacy (on the basis of predicted factors of the external environment and the macroeconomic situation according to simulation scenarios), financial risk, capital profitability. The substantiation of the composition of the indicators of the optimization model of the management of the capital structure of construction companies is based on the provisions of the trade-off theory, but takes into account the provisions of the dynamic approach, which involves updating the formalized representation of the model depending on the scenarios of the development of the macroeconomic situation The proposed model makes it possible to find an optimal solution that satisfies the objective functions by the method of concessions regarding the coefficient of financial autonomy, taking into account

its average value and the size of the company, and to automate the process of managing the sources of capital formation in view of the strategic goals of the construction company, as well as, in the absence of a global optimal solution , to apply concessions also according to certain criteria, substantiating risk scenarios for enterprises and the effectiveness of the made management decisions. The approbation of modelling results on the example of three construction companies in Ukraine has demonstrated the effectiveness of the model and the ability to find optimal solutions for the formation of capital in compliance with a number of criteria of capital adequacy, its cost, financial risk and capital profitability.

The perspective of further developments is to improve the methodical approach to assessing the effectiveness and risks of the capital structure management model, which will make it possible to avoid significant financial shocks of the post-war state of Ukraine and to function effectively under difficult macroeconomic conditions.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

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Data curation: *Viktoriia Mazur*
Methodology: *Viktoriia Mazur*
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ФОРМУВАННЯ РАЦІОНАЛЬНОЇ МОДЕЛІ УПРАВЛІННЯ СТРУКТУРОЮ КАПІТАЛУ БУДІВЕЛЬНИХ КОМПАНІЙ

Статтю присвячено вдосконаленню методичного підходу до моделі управління структурою капіталу будівельних компаній. Мета дослідження полягає в обґрунтуванні характеристик управління структурою капіталу, що враховують цільові функції та обмеження за критеріями ефективного управління структурою капіталу. Результатом роботи є вдосконалений методичний підхід до оптимізаційної моделі управління структурою капіталу, яка, на відміну від існуючих, має комплексний характер і враховує цільові функції максимізації фінансової автономії та мінімізації вартості капіталу, а також обмеження за критеріями достатності капіталу (на основі прогнозованих факторів зовнішнього середовища та макроекономічної ситуації за імітаційними сценаріями), фінансового ризику, рентабельності капіталу. Пропонована в роботі двокритеріальна оптимізаційна модель управління структурою капіталу дозволяє знайти оптимальне рішення, що задовольняє цільовим функціям методом поступок стосовно коефіцієнта фінансової автономії з урахуванням його середньогалузевого значення й розміру будівельної компанії за виручкою від реалізації, та автоматизувати процес управління джерелами формування капіталу з огляду на стратегічні цілі будівельної компанії, а також, у разі відсутності глобального оптимального рішення, застосувати поступки за певними критеріями, обґрунтувавши ризикові сценарії для підприємств і ефективність ухвалених управлінських рішень. Механізм упровадження моделі управління структурою капіталу на прикладі трьох будівельних компаній України продемонстрував свою результативність і здатність знаходити оптимальні рішення щодо формування капіталу з додержанням низки критеріїв достатності капіталу, його вартості, фінансового ризику та рентабельності капіталу.

Ключові слова: модель, капітал, структура, будівельна компанія, критерій, оптимізація, цільова функція, обмеження

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