This paper reports the design of a methodological toolkit for financial provision of enterprise sustainability, taking into account the target needs of the enterprise's capital management, available opportunities, and digital changes in the business environment.

This study considers the processes and mechanisms of financial provision sustainability of enterprises in the context of digital transformations of the economy.

The task addressed relates to the lack of effective methodological tools for flexible adaptation to changes under financial conditions and strategic needs for ensuring financial sustainability of enterprises, taking into account the requirements of balanced economic development. Such tools are based on the mechanism of capital structure optimization and make it possible to build the financial architecture of the enterprise and effectively respond to digital challenges.

Using the linear programming method, an economic and mathematical model for optimizing the capital structure of the enterprise has been constructed. It includes an objective function that is focused on maximizing profit and minimizing the weighted average cost of capital and makes it possible to determine the rational ratio of the enterprise's equity and debt capital. The system of constraints of the objective function takes into account the policy of financing the assets of the enterprise under the conditions of digital transformations, and covers the criteria of financial stability, solvency, and efficiency of capital use of the enterprise. This makes it possible to ensure the consistency of financial decisions with the strategic goals of the enterprise's development, to increase its resistance to the latest challenges of the digital economy.

The practical significance of the designed methodological toolkit is in the possibility of its application for substantiating management decisions, developing financial and economic policy

Keywords: digital transformations, enterprise, financial provision, stability, capital structure, management, optimization

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DESIGN OF A METHODOLOGICAL TOOLKIT FOR FINANCIAL PROVISION OF ENTERPRISE SUSTAINABILITY IN THE CONTEXT OF DIGITAL TRANSFORMATION

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1. Introduction

Against the background of the constant search for ways of socio-economic development of business entities, globalization processes based on the introduction of the latest digital technologies for the transformation of traditional economic systems are gaining leading importance. The modern technological landscape forms the basis for ensuring the financial

stability of enterprises, integrating digital solutions related to the implementation of intelligent analytical systems, platform business models, automation of financial transactions, and innovative FinTech. At the same time, the institutional conditions for ensuring the financial stability of enterprises are changing, the issues of rapid adaptability and resilience to turbulent changes in the economic environment, cyclical crises, and digital challenges are becoming more acute. Effective risk management, the ability to form the vision and mission of the enterprise and implement development strategies in order to achieve long-term competitiveness, reduce operational risks, and optimize key performance indicators, are gaining fundamental importance. It is the integration of leading digital management solutions and classical models of financial provision for enterprise sustainability that contributes to the construction of a management circuit using flexible business models under conditions of uncertainty.

Assessment of enterprise sustainability, based on a systemic approach, is a requirement of the time and requires the use of innovative support and comprehensive methodological tools that eliminate financial risks, including by optimizing the capital structure of the enterprise. The significant concentration of efforts of the scientific community around the issue of financial provision for enterprise sustainability is evidence of its significance in the implementation of the principles of sustainable development and digital transformation of the economy. At the same time, modern scientific research is focused on finding effective financial mechanisms that can ensure information transparency and adaptability of business to changes in the technological environment. Researchers are trying to find solutions to increase the innovative potential of enterprises, which will lead to the achievement of sustainable development goals in the long term.

Therefore, devising scientifically based approaches to measuring the financial stability of enterprises, which take into account the synergy of innovative financial solutions and adaptive strategies for enterprise management on the basis of a balanced economy, is becoming relevant. In the context of digital transformations of the economy, the implementation of analytical and applied mechanisms for financial provision of enterprises makes it possible to qualitatively improve the level of determining the prospects for socio-economic development and adaptability of enterprises.

2. Literature review and problem statement

The results of scientific research confirm the efforts to build a new management paradigm as a synergy of information, innovation, environmental friendliness, and digitalization, taking into account ESG principles. Thus, the basis of study [1] is the model of accounting for stakeholders to ensure financial sustainability, transparency, and responsibility of enterprises in the context of sustainable development. However, the study of the influence of other modern determinants, primarily the digital transformation of the economy, remains out of focus. The synergy between sustainability and financial results of enterprises is the object of paper [2], which confirms the positive impact of the implementation of sustainability principles on long-term competitiveness. At the same time, the study lacks the development of methodological approaches to assessing financial mechanisms for ensuring sustainability. The theoretical reflection of worldview changes took the form of a scientific approach [3], which considers diagnostics as a tool for managing economic activity in the process of digital transformation of business. At the same time, the design of analytical tools for optimizing the capital of enterprises as the basis of their financial stability remains an unresolved problem. In contrast, study [4] is focused on identifying the return on invested capital and the ability of firms to achieve better results after mergers and acquisitions. In it, the authors provide empirical evidence that the ability to effectively use capital is a key factor in financial stability and business performance, which attracts investors. At the same time, there is a significant gap between the formation of financial and non-financial data for making informed management decisions. The methodological approach to identifying economic potential reported in [5] is noteworthy from the perspective of investment attractiveness and ensuring business performance. Although this approach is fundamental, it does not contain indicators of economic development that form the potential relevant to the present. The utilitarian understanding in study [6] justifies that excessive financial expansion can worsen investment efficiency, while financial decentralization mitigates this negative impact. However, there is a lack of a more detailed assessment of the interaction with digitalization and integrated strategies to support the financial and environmental sustainability of enterprises.

An important scientific result is reported in work [7], which concerns the formation of resilience plans for the adaptation of enterprises to business turbulence and risk management mechanisms and operational flexibility. However, it lacks the integration of digital technologies and sustainable development principles in BRPs. According to [8], there is a significant importance of digital transformation for increasing financial flexibility and sustainable development. At the same time, the lack of a clear classification of digital financial instruments narrows the practical application of the results. The discourse is deepened in study [9], which emphasizes the importance of a balanced approach to the use of financial resources. The level of influence of digital and environmental orientations on the innovative efficiency and financial capacity of enterprises is interesting; it contributes to increasing their resilience to the challenges of sustainable development. At the same time, it is the management paradigm focused on the synergy of financial, digital, and social determinants of development that requires rethinking, which ensures the integration of the principles of transparency, responsibility, and adaptability into the strategic management of enterprises.

The results of scientific research indicate that digital technologies increase the competitiveness of business and play a significant role in achieving financial sustainability of enterprises. A key contribution to the solution of this issue was made in works that reveal the content of digital innovations for optimizing resources [10] and differentiating barriers that hinder the achievement of sustainability by small and medium-sized enterprises [11]. However, the issue of integrating these solutions into the system of financial provision for enterprises is left out of consideration. Studies [12, 13] bring this issue closer by devising a scientific approach that emphasizes the synergy of sustainable entrepreneurship, innovation, and digitalization in increasing financial sustainability. However, there is a shortage of tools for quantifying this synergy, which complicates its practical implementation.

This gap is compensated by the results reported in study [14], which presents approaches to assessing the effectiveness of innovative transformations of socio-economic

systems of enterprises under the conditions of Industry 5.0, and proves the importance of integrating innovations and digital technologies. Paper [15] gives a review of strategies for strengthening the resilience of small and medium-sized enterprises, where the emphasis is on financial flexibility as a key factor for survival in turbulent conditions. At the same time, the aspects of digital financial instruments in the structure of these strategies under turbulent conditions remain insufficiently studied.

The cornerstone is the transition to a circular economy, which strengthens the ability of enterprises to transform and increases financial stability, which is proven in work [16]. On the other hand, the lack of adapted financial models for assessing the effects of such a transition necessitates further understanding of the existing issues. A certain solution is offered in [17], which highlights the concept of systemic sustainability of enterprises in the context of the circular economy, and pays attention to multi-level challenges, local aspects, and economic efficiency of circular strategies. However, there is a lack of practical methods for its implementation, taking into account digital transformations, financing, and determining financial indicators of economic efficiency. The emphasis on practical tools for implementing financial development strategies is made by the authors who dedicated their study [18] to methodological approaches to building a financial control system in small business management. In this context, paper [19] deserves attention, demonstrating the positive effect of sustainable practices on economic efficiency. However, it lacks attention to the role of digital technologies as a driver of financial and environmental sustainability. The importance of the interaction of digital and environmental strategies for increasing economic efficiency through strengthening innovation potential is highlighted by study [20]. However, insufficient attention is paid to the assessment of financial aspects of sustainability and risk management in the context of these strategies. To some extent, this gap is compensated in work [21] whose authors proposed a digital management model based on a balanced scorecard. However, its application in the context of digital transformation ensures increased efficiency of management influences and contributes to the sustainability of high-tech bio clusters.

It should be noted that the factors of success of enterprises and their sustainability in the digital environment, in particular the financial one, are quite widely studied by scientists. Thus, in [22, 23] the authors emphasize the role of digital initiatives, tools, and strategic innovative solutions in the formation of socially oriented business models, the integration of sustainable development and financial sustainability into the transformation process. Relevant in this context is study [24], which analyzes the interaction of artificial intelligence and green finance in leading European countries through the concept of "environmentally friendly algorithms". Importantly, paper [25] proves the existence of certain obstacles and limitations on the way to the implementation of digital tools and the successful digital transformation of enterprises. At the same time, existing studies are limited to a fragmentary consideration of financial factors and the analysis of their economic efficiency in the context of digital changes and sustainable development.

Thus, the analyzed scientific plane of theoretical and practical reflection of worldview changes regarding the financial provision of enterprise sustainability requires the development of comprehensive methodological solutions.

3. The aim and objectives of the study

The purpose of our study is to design a methodological toolkit for financial provision of enterprise sustainability in the context of digital transformations, ensuring their adaptability to changes in the financial environment and consistency with the principles of balanced economic development.

To achieve this aim, the following objectives were accomplished:

– to build a model of financial provision of balanced enterprise development in the context of digital transformations;

– to construct an economic and mathematical model and conduct optimization calculations of the enterprise's capital structure, taking into account the asset financing policy, solvency, and financial stability.

4. The study materials and methods

The object of our study is the processes and mechanisms of financial provision for the sustainable functioning of enterprises in the context of digital transformations of the economy.

The subject of the study is the methodological toolkit for the formation of the financial architecture of the enterprise, based on the optimization of the capital structure and aimed at ensuring its sustainability in the context of digital transformations.

The principal hypothesis of the study assumes that the use of the designed methodological toolkit for optimizing the capital structure of the enterprise allows for the formation of a rational ratio of equity and debt capital according to the criteria of maximizing net profit and minimizing the weighted average cost of capital.

The methodological basis of the study is the integration of methods for assessing the cost of capital and linear programming tools for quantitative substantiation of decisions in the field of financial provision for the sustainability of enterprises. It involves determining financial benchmarks and permissible alternatives to the capital structure); forming a system of constraints (liquidity, financial stability, consistency with the asset financing policy); constructing an objective function (maximizing net profit and minimizing the weighted average cost of capital); performing optimization calculations (linear programming); interpreting the results (determining the optimal capital structure and developing recommendations for the financial policy of enterprises).

The empirical basis of the study is represented by data from accounting and statistical reporting of enterprises. The sample includes enterprises of various organizational and legal forms and scales that carry out profitable activities, have their own fixed assets, and meet the standards of financial independence, which ensures the representativeness of the analysis and the reliability of our results.

5. Results of designing a methodological toolkit for optimizing the capital structure for the financial stability of enterprises

5. 1. Modeling the financial provision of balanced enterprise development in the context of digital transformations

The key factor in achieving a balance of proper financing and effective use of capital is the implementation

of strategies to strengthen the financial stability of enterprises in the context of the digital transformation of the economy. The synergy of financial provision for digital changes is manifested in the interaction of capital sources, resource allocation mechanisms and strategic guidelines of financial policy. It is the financial architecture of the enterprise in this context that appears as a dynamic system aimed at maintaining the stability and adaptability of enterprise activities by optimizing the capital structure. Financing digital transformations occurs in a multi-level system of financing sources, which includes state, private, international, and alternative resources and mechanisms of capital accumulation. State funding forms the institutional basis for the digitalization of the economy through budget programs, grant initiatives, and specialized funds focused on the development of digital infrastructure, e-government, and research in the field of artificial intelligence and big data. Along with this, private investments ensure the acceleration of transformation processes through venture financing of startups, strategic corporate investments in digital platforms and financial technologies, as well as the introduction of digital financial tools.

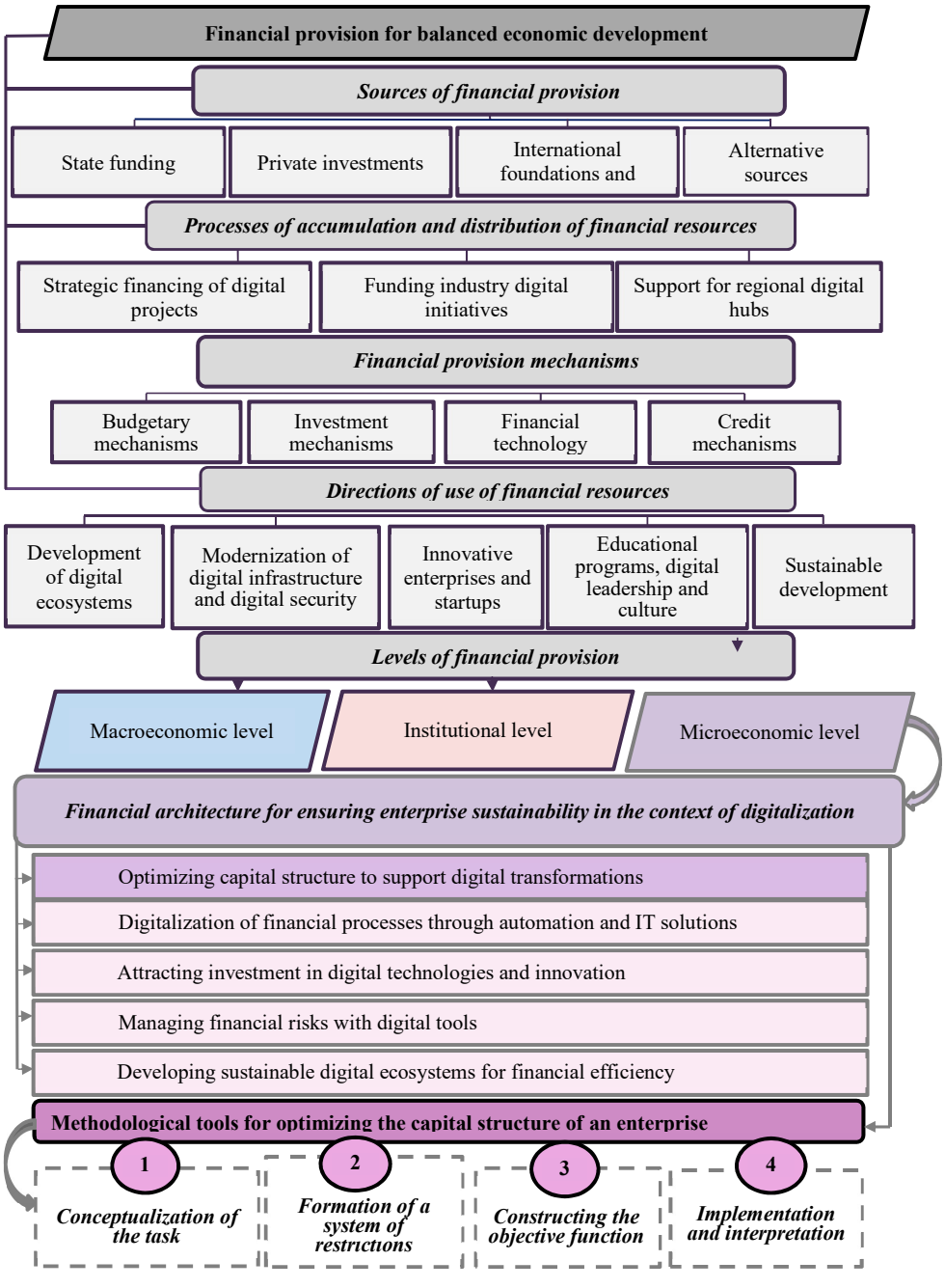

Fig. 1. Reference model of financial provision for balanced enterprise development in the context of digital transformations

Based on the generalization of these mechanisms, a reference model of financial provision for the balanced development of an enterprise in the context of digital transformations is proposed (Fig. 1).

The recommended model forms a methodologically sound platform for ensuring the financial stability of enterprises. The conceptual core of the model is the financial architecture of the enterprise, which integrates the methodological tools for optimizing the capital structure, digitalization of financial processes, attracting investments in digital technologies and innovations, and managing financial risks. At the same time, the traditional interpretation of the capital structure, which is based on finding the optimal ratio between own and borrowed funds, is supplemented by new challenges and efficiency criteria.

The technology for implementing the capital structure optimization mechanism is focused on the sequential implementation of stages that ensure the logical completion of the process and the scientific validity of the results. At the first stage, the task is conceptualized, which involves determining the goal of optimization, formulating research hypotheses, and selecting relevant parameters. At this stage, initial conditions are formed, strategic guidelines are outlined, the value of the optimal capital structure for ensuring the stability of the enterprise is specified, and a range of external and internal factors that should be taken into account in further modeling is determined.

The second stage is the formation of a system of constraints, which sets the framework for building an optimiza-

tion model. The system of constraints covers the asset financing policy, liquidity conditions, solvency level and financial stability parameters. The inclusion of such constraints makes it possible to ensure the adequacy of the model to the real conditions of the enterprise's functioning, to prevent excessive concentration of loan capital and to take into account the enterprise's ability to service debt obligations. The improvement of this stage under the conditions of digitalization consists in the use of digital analytical systems, which make it possible to quickly model scenarios of changes in financial indicators.

The third stage involves the construction of an objective function that formalizes the main goal of capital structure optimization and reflects the desire to minimize the weighted average cost of capital while maintaining an appropriate level of return on equity. The use of economic and mathematical modeling, in particular the linear programming method, made it possible to describe the problem as a function with many variables and find the optimal ratio of own and borrowed sources of financing.

The final stage is the implementation and interpretation of the results, which includes calculating the optimal capital structure, checking the model for correctness and assessing its suitability for practical use. The interpretation of the results takes place in a strategic dimension, that is, it is determined how the resulting capital structure would contribute to strengthening the financial stability of the enterprise, supporting digital transformations and achieving sustainable development goals.

Thus, the methodological toolkit for optimizing the capital structure is formed as a holistic algorithm, where each stage is a necessary prerequisite for the next, and the end result is the construction of a financial architecture of the enterprise that can ensure its stability and development.

5. 2. Economic and mathematical model of optimization of the capital structure of an enterprise

Financial architecture should combine not only hierarchical relations that are orderly and established but also form an optimal configuration to achieve financial stability. Target capital efficiency indicators are achieved by integrating internal resource potentials and external economic determinants of the enterprise's functioning. The implementation of this process occurs through the construction of a complex system of constraints that outlines the permissible space of strategic alternatives and guarantees a scientifically sound choice of financial policy. In this context, the financial architecture of an enterprise in the context of digitalization appears as an integration mechanism that ensures coordinated management of equity and debt capital and optimization of financing costs. Its functioning is aimed at maintaining a balance between profitability, the level of financial risks and long-term stability, which forms the basis for the sustainable development of the enterprise. The procedure for optimizing the capital structure is represented as an extreme task, focused on determining parameters that meet the established constraints and reflect the target priorities of the financial management of the enterprise. Its implementation is aimed at maximizing net profit at a given level of profitability or minimizing the weighted average cost of capital under the condition of rational costs of financing assets.

To solve the set problem, a linear programming method was used, whereby the objective function is determined based on the net profit indicator taking into account the level of profitability of all structural components of capital. These include return on equity (Return on Equity) $\left(R_E^{SE}\right)$, return on retained earnings (Return on Retained Earnings) $\left(R_{RE}^{SE}\right)$. Also return on contributed equity (Return on Contributed Equity) $\left(R_{CE}^{SE}\right)$, return on long-term debt (Return on Long-term Debt) $\left(R_{LTD}^{TC}\right)$. And, finally, return on short-term debt (Return on Short-term Debt) $\left(R_{STD}^{TC}\right)$ and return on financed capital (Return on Financed Capital) $\left(R^{FC}\right)$.

The proposed objective function of the optimization problem of the capital structure of the enterprise is based on the use of a system of variables that reflect the specificity and parameters of financing sources. In particular, the sought volumes of shareholders' equity $\left(x_E^{SE}\right)$, retained earnings $\left(x_{RE}^{SE}\right)$, contributed equity $\left(x_{CE}^{SE}\right)$ in the process of financial and economic activity. The model also takes into account the sought volumes of long-term debt $\left(x_{LTD}^{TC}\right)$ and short-term debt $\left(x_{STD}^{TC}\right)$ of the enterprise and the volume of the enterprise's attracted capital (financed capital x^{FC}), which ensures the integration of external sources into the overall capital structure.

Within the framework of this optimization problem, the system of constraints is determined by the ratio between the constituent elements of the enterprise's capital, taking into account the regulatory permissible volumes. When forming it, the asset financing policy, conditions for ensuring solvency, and maintaining financial stability were taken into account. The proposed system of constraints integrates the relationships between individual components of capital and outlines the permissible space of alternative solutions, which makes it possible to ensure a rational balance between equity and debt capital and contributes to the financial stability of the enterprise (Fig. 2). Taking into account that in the structure of the enterprise's equity capital, the owners' capital $\left(x_E^{SE}\right)$, created $\left(x_{RE}^{SE}\right)$ and received $\left(x_{CE}^{SE}\right)$ equity capital are distinguished, the total amount of equity capital must exceed the value of the owners' capital $x_E^{SE} \le SE$.

At the same time, the share of received capital in its structure must be in the range from the minimum value ($k_{\min}$), which guarantees the appropriate level of financial stability and autonomy, to the maximum value ($k_{\max}$). This makes it impossible to over-dependence on borrowed resources and ensures the maintenance of a diversified and balanced configuration of equity $\left(k_{\min} \le \frac{x_{CE}^{SE}}{SE} \le k_{\max}\right)$. This approach contributes to the formation of an adaptive financial architecture capable of supporting the sustainability of the enterprise in the long term.

In turn, $\left(x_{LTD}^{TC} + x_{STD}^{TC} \le 1.5 \times SE\right)$ regulates the maximum amount of long-term and short-term borrowing relative to equity, which ensures control over financial leverage and maintaining an acceptable level of debt burden [22]. In the practical activities of enterprises, there may be cases of free receipt of assets from other legal entities or individuals, which leads to an increase in the total amount of equity.

Therefore, it is advisable to set limits on the share of equity formed as a result of operating activities, which should not exceed the difference between total equity (*SE*), owners' capital $\left(x_E^{SE}\right)$ and capital created in the process of operating activities $\left(x_{RE}^{SE}\right)$. This limit is formalized by the corresponding inequality – $x_{CE}^{SE} \le SE - SE_E - SE_{RE}$.

When determining the inequality of the components of loan capital, the principles of maintaining balance sheet liquidity, solvency and financial stability of the enterprise were taken into account. In accordance with these principles, the volumes of long-term and short-term borrowed and attracted capital should not exceed the available assets: slowly sold (A_3), quickly sold (A_2), and absolutely liquid (A_1). To maintain liquidity and ensure solvency in the long term, the volume of long-term loan capital is limited to the amount of slow-realized assets (A_3), which is formalized by the inequality $x_{LTD}^{TC} \le A_3$.

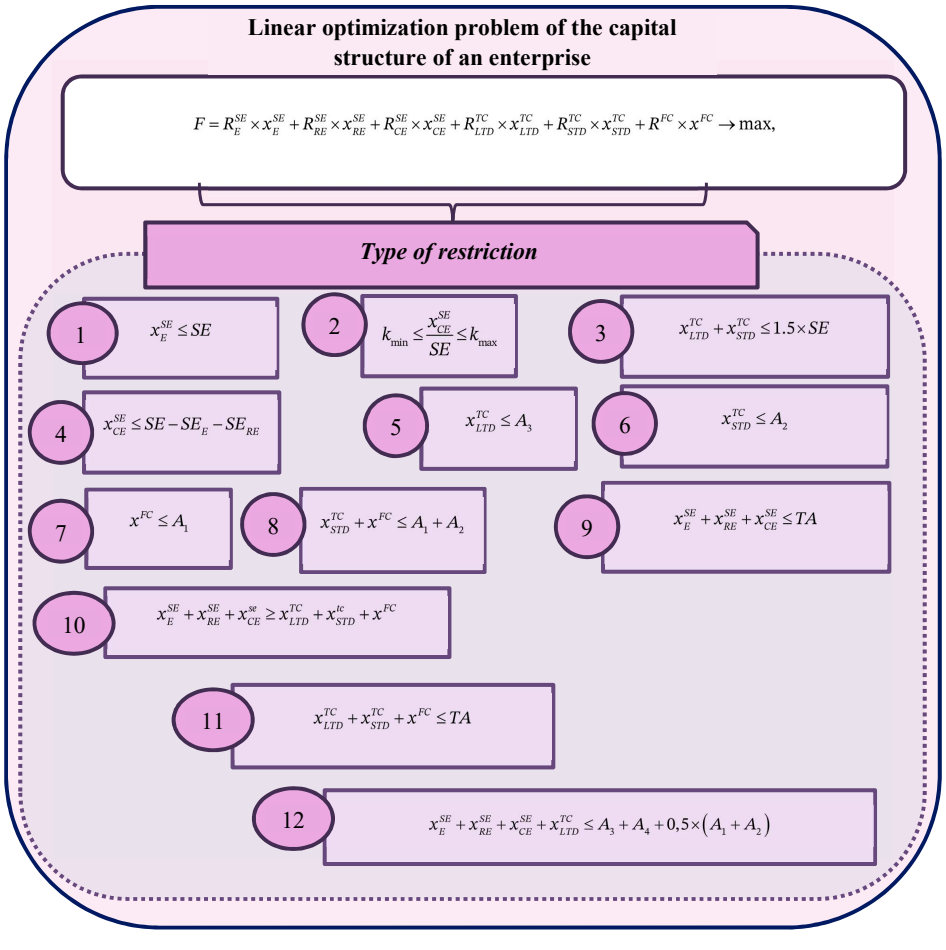

Fig. 2. Technology for forming a system of constraints for optimizing the capital structure of an enterprise

In order to ensure financial stability and maintain an appropriate level of short-term solvency of the enterprise, the volume of short-term loan capital should be limited to the amount of assets that can be quickly sold (A_2). At the same time, the attracted capital should not exceed the amount of absolutely liquid assets (A_1). These restrictions are formalized by the corresponding inequalities – $x_{STD}^{TC} \le A_2$ and $x^{FC} \le A_1$. In order to maintain the liquidity of the balance sheet, the total amount of short-term sources of financing the assets of the enterprise should remain less than the amount of absolutely liquid and quickly sold assets, which is reflected by the inequality $x_{STD}^{TC} + x^{FC} \le A_1 + A_2$. The functioning of a business entity is determined by the presence of equity, the parameters of which are determined by the balance sheet principle as an invariant condition of financial equilibrium between assets and liabilities. In this context, equity is interpreted as the difference between the balance sheet currency and attracted resources, the value of which objectively cannot exceed the total value of assets. In the structure of the enterprise's equity capital, owners' capital $\left(x_E^{SE}\right)$, created $\left(x_{RE}^{SE}\right)$ and received $\left(x_{CE}^{SE}\right)$ equity are distinguished, which determines the restrictions in the form of an inequality $x_E^{SE} + x_{RE}^{SE} + x_{CE}^{SE} \le TA$.

To ensure the financial autonomy of the enterprise, the total amount of equity capital must be no less than the amount of borrowed capital, which includes long-term and short-term borrowed and attracted capital. It follows that the total amount of sources of borrowed capital does not exceed the amount of equity capital, which is formed from the capital of owners created and received as a result of operating activities and the total capital of the enterprise. The corresponding restrictions are formalized by inequalities

$$x_E^{SE} + x_{RE}^{SE} + x_{CE}^{se} \ge x_{LTD}^{TC} + x_{STD}^{tc} + x^{FC}$$

and

$$x_{LTD}^{TC} + x_{STD}^{TC} + x^{FC} \le TA.$$

Minimization of financial risk is ensured by a conservative asset financing policy, according to which equity capital and long-term loans must cover non-current assets (assets with limited liquidity A_4). Also, the constant part of current assets (usually slowly realized A_3) and half of the variable part of current assets. the restriction, which takes into account the level of risk of financing assets, is formalized by the inequality

$$x_E^{SE} + x_{RE}^{SE} + x_{CE}^{SE} + x_{LTD}^{TC} \le A_3 + A_4 + 0.5 \times (A_1 + A_2).$$

Thus, the inequalities formed are based on the comparison of generally accepted asset liquidity categories with the maturity dates of the enterprise's liabilities. They are constructed in such a way as to ensure the timeliness and completeness of settlements with counterparties by using those assets whose maturity date corresponds to the maturity date of the relevant liabilities.

The system-forming factor creates the emergence of the system, and the proposed technology for forming a system of constraints for optimizing the capital structure of the enterprise is a systemic analytical tool that integrates the principles of financial modeling, liquidity assessment, and risk-oriented approaches. It takes into account the architecture of the enterprise's financial resources and

the possibilities of digital transformations to increase the efficiency of capital management, ensuring capital balance and financial stability.

Taking into account the established constraints, a model was formed using the linear programming method to determine the rational configuration of sources of financial resources, which is capable of ensuring the strengthening of the financial stability of the enterprise. When forming the objective function, the numerical characteristics of the distribution of profitability indicators of the reference enterprise (confidential data that are not subject to publication due to commercial secrecy) for the period 2022–2024 were taken into account. In particular, for the coefficients of the objective function that determines the maximization of the net profit of the enterprise under study, the median values of the profitability indicators for each structural element of capital were used, calculated using the Statgraphics Centurion statistical package.

The selected coefficient of the objective function is explained by the high statistical stability of the median. Accordingly, the economic and mathematical model of the optimization problem regarding the capital structure of the reference enterprise according to the criterion of maximization of net profit takes the following form (1)

$$F_{\max} = 0.0523 \times x_E^{SE} + 0.0079 \times x_{RE}^{SE} + 0.0016 \times x_{CE}^{SE} + \\ + 0.0216 \times x_{LTD}^{TC} + 0.0088 \times x_{STD}^{TC} + 0.00921 \times x^{FC}. \quad (1)$$

The key task is to ensure maximum net profit at optimal costs for servicing all sources of financing the company's assets. Accordingly, the logic of the study assumes that the second optimization task is to optimize the capital structure according to this criterion, taking into account the results of solving the first optimization task. The constraints of the first and second tasks remain identical; the difference is only in the formulation of the objective function.

When constructing the second objective function, it is advisable to use the weighted average cost of capital of the enterprise as an optimization criterion. It is calculated taking into account the cost of each structural element of capital: the capital of the owners $\left(K_E^{SE}\right)$, of the created $\left(K_{RE}^{SE}\right)$ and received $\left(K_{CE}^{SE}\right)$ equity. Also, the cost of long-term $\left(K_{LTD}^{TC}\right)$ and short-term $\left(K_{STD}^{TC}\right)$ loan capital and the cost of attracted capital (K^{FC}) taking into account the tax burden. On this basis, the objective function of the capital structure optimization task according to the criterion of minimizing the weighted average cost of capital takes the following form (2)

$$F = K_E^{SE} \times \frac{x_E^{SE}}{K_{opt}} + K_{RE}^{SE} \times \frac{x_{RE}^{SE}}{K_{opt}} + K_{CE}^{SE} \times \frac{x_{CE}^{SE}}{K_{opt}} + \\ + K_{LTD}^{TC} \times \frac{x_{LTD}^{TC}}{K_{opt}} \times \left(1 - T\right) + K_{STD}^{TC} \times \frac{x_{STD}^{TC}}{K_{opt}} \times \left(1 - T\right) + \\ + K^{FC} \times \frac{x^{FC}}{K_{opt}} \times \left(1 - T\right) \to \min, \quad (2)$$

where K_{opt} is the optimal amount of capital of the enterprise, determined by the results of the first optimization problem, thousand dollars;

x_E^{SE}, x_{RE}^{SE}, x_{CE}^{SE} – the sought volumes of owners' capital, created and received equity capital, respectively, thousand dollars;

x_{LTD}^{TC}, x_{STD}^{TC} – the sought volumes of long-term and short-term capital of the enterprise, respectively, thousand dollars;

x^{FC} – the sought volume of attracted capital of the enterprise, thousand dollars;

T – corporate income tax rate.

As the coefficients of the objective function of minimizing the weighted average cost of capital, it is advisable to use the values of the assessment of the value of each structural component of capital. They are formed under the conditions of the modern functional dynamics of the enterprise in the commodity and financial markets, with an adjustment for tax obligations on attracted capital and their impact on the optimization of the capital structure.

Considering that the $\frac{K_E^{SE}}{K_{opt}}$, $\frac{K_{RE}^{SE}}{K_{opt}}$, $\frac{K_{CE}^{SE}}{K_{opt}}$, $\frac{K_{LTD}^{TC}}{K_{opt}} \times \left(1 - T\right)$, $\frac{K_{STD}^{TC}}{K_{opt}} \times \left(1 - T\right)$, $\frac{K^{FC}}{K_{opt}} \times \left(1 - T\right)$ values in the second optimization problem are constant and can be represented by specific numerical values, the economic and mathematical model of optimizing the capital structure of the reference enterprise according to the criterion of minimizing the weighted average cost of capital takes the following form (3)

$$F_{\min} = 0.0042 \times x_E^{SE} + 0.0016 \times x_{RE}^{SE} + \\ + 0.0044 \times x_{LTD}^{TC} + 0.0041 \times x_{STD}^{TC}. \quad (3)$$

The results of solving the specified optimization problem, performed in the Microsoft Excel environment, are shown in Fig. 3.

The application of the recommended model for optimizing the capital structure of the reference enterprise allowed us to determine the optimal volumes of each structural element of capital according to two criteria: maximizing net profit and minimizing the weighted average cost of capital. The results of the calculations as of 01.01.2025 are given in Table 1.

Interpretation of the results allows us to draw several key conclusions:

1. The optimal capital structure assumes the dominance of equity (approximately 70%) and a smaller share of borrowed capital (approximately 30%), which meets the criteria of financial stability and moderate risk. A comparative analysis of the actual and optimal capital structure of the reference enterprise is shown in Fig. 4.

2. The choice of the optimal capital structure according to the criterion of maximizing net profit and minimizing the weighted average cost of capital demonstrates insignificant differences in absolute values, which indicates the internal balance of the financial architecture of the enterprise.

3. The use of digital tools for modeling and optimizing the capital structure allows management to promptly adjust the financial policy of the enterprise and make informed management decisions.

Thus, the implementation of the proposed methodological approach confirms its effectiveness as an analytical tool for optimizing the capital structure and increasing the financial stability of the enterprise. The integration of the principles of digital transformation of the financial architecture allows management to form scientifically sound management decisions regarding asset financing policy, effectively use financial tools, as well as stock market mechanisms, to increase the value of the enterprise.

Table 1

Optimal volumes of structural elements of the capital of the reference enterprise

Name of the structural element of the enterprise's capital	Optimal values			
	When maximizing net profit		When minimizing the weighted average cost of capital	
	Amount, thousand dollars	Specific weight, %	Amount, thousand dollars	Specific weight, %
Owners' capital	95978.28	60.7	97831.02	60.7
Equity created	10698.29	6.8	10905.2	6.8
Equity received	–	–	–	–
Long-term debt capital	29186.96	18.5	29750.36	18.5
Short-term debt capital	14333.52	9.0	14610.16	9.0
Attracted capital	7822.51	5.0	8069.0	5.0
Total capital	158019.86	100	161165.7	100
Maximum net profit	5875.77	X	–	–
Minimum weighted average cost, %	–	–	13.13	X

1. Optimization problem to minimize the weighted average cost of capital of the enterprise

	Variables	x_E^{SE}	x_{RE}^{SE}	x_{CE}^{SE}	x_{LTD}^{TC}	x_{STD}^{TC}	x^{FC}		
	Solution	95882.4	10687.9	0	29157.8	14319.2	7814.7	Left part	Right part
Limitation	1	1	0	0	0	0	0	95882.4	95882.4
	2	0	1	0	0	0	0	10687.9	10687.9
	3	0	0	1	0	0	0	0	4211.5
	4	0	0	0	1	0	0	29157.8	45624.9
	5	0	0	0	0	0	1	7814.7	7814.7
	6	0	0	0	0	1	1	22133.9	22227.5
	7	1	1	1	0	0	0	106570.3	146795.0
	8	1	1	1	-1	-1	-1	55278.6	0
	9	0	0	0	1	1	1	51291.7	146795.0
	10	1	1	1	1	0	0	135728.1	135728.1
	11	0	0	0	0	1	0	14319.2	14319.2
	12	1	0	0	0	0	0	95882.4	71245.0
	Objective function	0.0518	0.0078	0.0016	0.0214	0.0087	0.0091	5869.7	max

1. Optimization problem to minimize the weighted average cost of capital of the enterprise

	Variables	x_E^{SE}	x_{RE}^{SE}	x_{CE}^{SE}	x_{LTD}^{TC}	x_{STD}^{TC}	x^{FC}		
	Solution	96862.4	10797.2	0	29455.8	14465.5	7989.1	Left part	Right part
Limitation	1	1	0	0	0	0	0	96862.4	96862.4
	2	0	1	0	0	0	0	10797.2	10797.2
	3	0	0	1	0	0	0	0	4254.6
	4	0	0	0	1	0	0	29455.8	29455.8
	5	0	0	0	0	0	1	7989.1	7894.6
	6	0	0	0	0	1	1	22454.7	22454.7
	7	1	1	1	0	0	0	107659.5	148295.4
	8	1	1	1	-1	-1	-1	55749.0	0
	9	0	0	0	1	1	1	51910.5	148295.4
	10	1	1	1	1	0	0	137115.3	137115.3
	11	0	0	0	0	1	0	14465.5	14465.5
	12	1	0	0	0	0	0	96862.4	71973.1
	Objective function	0.0042	0.0016	0	0.0044	0.0041	0	5869,7	min

Fig. 3. Results of solving the optimization problem of the capital structure of the reference enterprise (as of 01.01.25) in the Excel environment

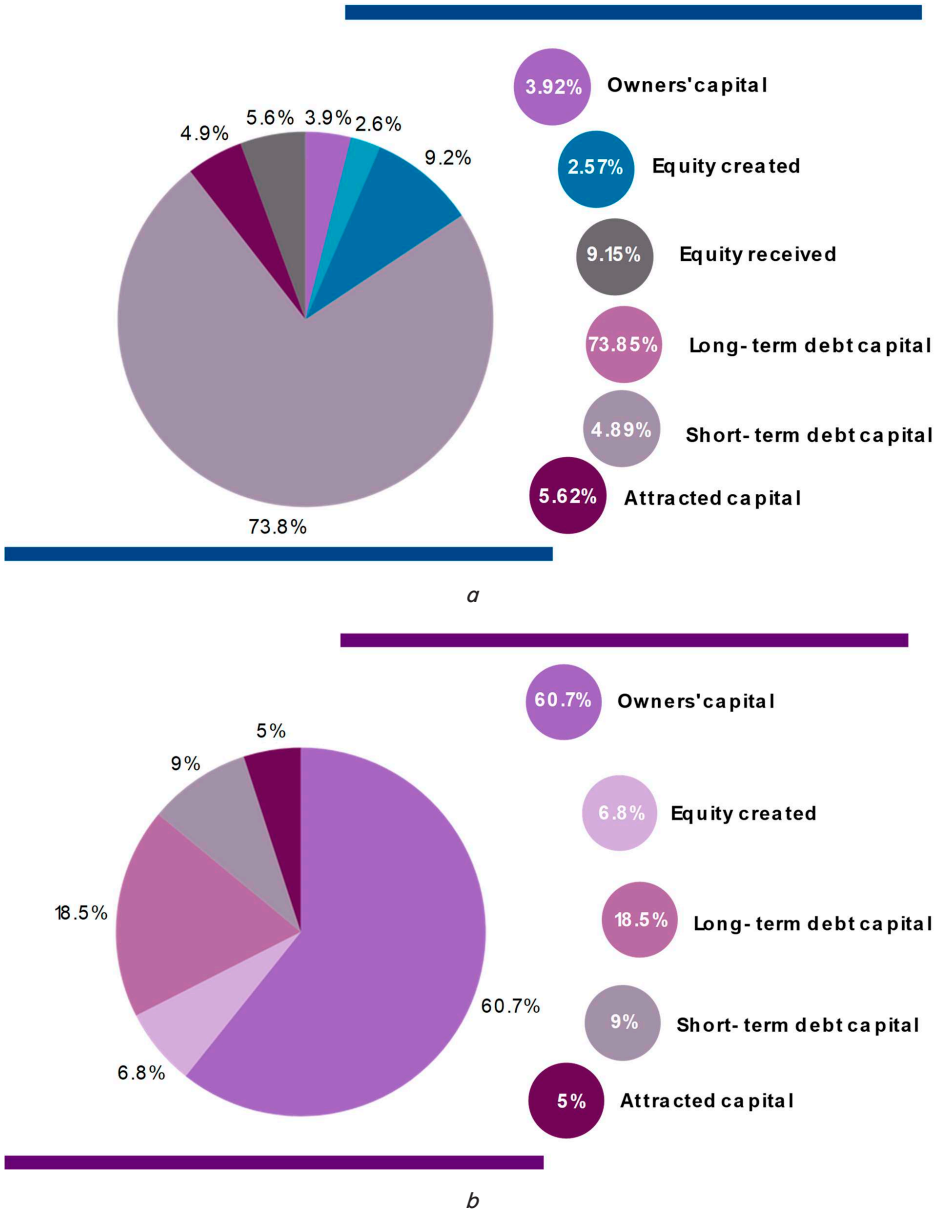

Fig. 4. Comparative characteristics of the actual and optimal capital structure of the enterprise: *a* — actual capital structure; *b* — optimal capital structure

The procedure for optimizing the capital structure is represented as an extreme task, which is focused on determining parameters that meet the established constraints and reflect the target priorities of the financial management of the enterprise. The application of the criteria for maximizing net profit and minimizing the weighted average cost of capital allowed us to ensure a balance between the profitability of capital and the cost of its financing. It was determined, using the linear programming method, that the system of constraints takes into account the regulatory permissible amounts of capital, the asset financing policy, as well as the conditions for maintaining the liquidity, solvency and financial stability of the enterprise (Fig. 2). The results of solving the specified optimization problem were performed in the Microsoft Excel environment (Fig. 3). Based on economic and mathematical modeling, rational amounts of structural components of capital were determined for the reference enterprise and its optimal structure was formed (Table 1). According to the modeling results, about 70% of the sources of financing of assets were formed at the expense of equity, and the remaining 30% at the expense of borrowed funds (Fig. 4). The choice of the optimal capital structure according to the criterion of maximizing net profit and according to the criterion of minimizing the weighted average cost of capital demonstrates insignificant differences in absolute values, which indicates the internal balance of the financial architecture of the enterprise.

6. Discussion of impact of capital structure optimization on the financial stability of the enterprise

Analysis of the interaction of capital sources and mechanisms for resource allocation and strategic guidelines of financial policy of enterprises allowed to build a reference model of financial provision for balanced development of the enterprise under the conditions of digital transformations (Fig. 1). The model is based on a harmonized financial architecture of the enterprise, which integrates methodological tools for optimizing the capital structure, digitalization of financial processes, attracting investments in digital technologies and innovations, and managing financial risks. It is proved that determining the optimal capital structure should be based on an integrated analysis of financial indicators and correspond to the strategic goals of the enterprise.

The designed methodological toolkit as a result of qualitative modeling of financial provision for balanced development of the enterprise has a number of differences from existing scientific developments. Thus, unlike study [8], where digital transformation is considered as a factor in increasing the overall sustainability of the business, the proposed toolkit provides a quantitative assessment of the impact of the capital structure on the financial results of the enterprise. In work [12], the main attention is paid to the relationship between digitalization, innovation and entrepreneurial sustainability, while in this study digital tools are integrated directly into the process of optimizing the financial architecture of the enterprise. Unlike [16], which emphasizes the role of the circular economy in increasing business resilience, the proposed toolkit makes it possible to assess the impact of digital financial solutions on the capital structure of the enterprise, taking into account the

financing policy. It is the combination of linear programming methods with the principles of digital adaptability of capital management that increases the accuracy of forecasting the financial sustainability of the enterprise.

The main advantage of the recommended methodological tools compared to traditional methods is the possibility of adaptive management of the capital structure in the short term, which contributes to sustainable economic growth, innovative convergence and synergistic effect. The disadvantage is the limited ability to take into account the rapid processes of digitalization, which are able to reformat the financial parameters of the enterprise and have destructive consequences of market disruptions. There are also some limitations due to the generalized nature of the initial data and the assumption of the stability of the macroeconomic environment. Partial simplification of the structure of financial flows may affect the accuracy of the assessment when applied to enterprises with a high level of financial diversification. In addition, the integration of digital tools for enterprise management assumes a sufficient level of its digital maturity, which may vary depending on the industry specifics and market position.

Further research may involve modifying the recommended model by taking into account the dynamics of market rates and the impact of macroeconomic factors on the cost of capital.

7. Conclusions

1. A model of financial provision for the balanced development of an enterprise in the context of digital transformations has been built, which has deepened the understanding of the role of capital structure optimization in strengthening financial stability. It is substantiated that an effective financial architecture should be based on the integration of digital technologies that ensure transparency, adaptability, and speed of management decisions.

2. An economic and mathematical model of structural optimization has been constructed, combining the criteria of profit maximization and cost of capital minimization, determined by the established system of structural constraints, which takes into account the asset financing policy, liquidity indicators, solvency, and the level of financial stability of the enterprise. The implementation of this model ensures the optimal balance between the shares of own (approximately 70%) and borrowed capital (approximately 30%), compliance with financial regulations, and the formation of an adaptive capital management system in a balanced economy.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

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Data availability

All data are available, either in numerical or graphical form, in the main text of the manuscript.

Use of artificial intelligence

The authors confirm that generative artificial intelligence tools were used exclusively for language editing, grammar checking, and technical formatting of the manuscript under full human control. Artificial intelligence was not used to create, process, or interpret scientific data, form conclusions, or other elements of the scientific results of the paper. Tool used: ChatGPT (OpenAI GPT-5, version 2025).

The authors bear full responsibility for the content, reliability, and scientific correctness of the submitted material.

Authors' contributions

Dmytro Tyshchenko: Conceptualization, Methodology, Writing – original draft; **Olha Hlushchenko**: Conceptualization, Investigation, Data curation; **Nataliia Kashchena**: Investigation, Methodology, Formal analysis; **Nataliia Savytska**: Investigation, Validation, Writing – review & editing; **Hanna Chmil**: Investigation, Project administration; Supervision; **Oksana Chumak**: Investigation, Validation, Writing – review & editing; **Iryna Nesterenko**: Investigation, Methodology, Writing – original draft; **Andrii Konstantinov**: Investigation, Formal analysis, Visualization; **Olga Diachek**: Investigation, Visualization, Data curation; **Vadym Koniukhov**: Investigation, Writing – original draft, Visualization.

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