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THE RELEVANCE OF THE USE OF NEURAL NETWORK TECHNOLOGIES IN THE IMPLEMENTATION OF VARIOUS INNOVATIVE METHODS TO IMPROVE THE FINANCIAL EFFICIENCY OF THE ENTERPRISE

Abstract: One of the most important indicators in the enterprise economy is the indicator of the enterprise stability point. However, at present, in the age of rapid economic and technological development, the same rapid and correct response to changes in market relations and the market environment is required. In turn, this requires the company to fully control the strategy and current indicators of financial stability in order to quickly generate a variety of solutions that will also be quickly analysed and applied to accounting when choosing the final solution and subsequent monitoring of the results. Therefore, the implementation of innovative methodologies requires the use of the most modern digital and other technologies. The author discusses two innovative methodologies aimed at solving the problem of effective use of the wage fund and calculating the financial stability area. A brief analysis of these methodologies shows the need to use neural networks for their implementation as the most advanced programmes to date. The study purpose was to determine the relevance of using modern technological advances to solve new complex problems that realise the problems of stabilisation and stability of economic indicators of a modern enterprise. In the course of the study, the author used the works of such scientists and researchers as A. Buychik, G. C. Chow, K. Cox, D. N. Gujarati, P. V. Komissarov, P. D. McNelis, L. Zadeh etc. The author concludes that these methodologies require significant expenditures of classical programmes in economics, therefore, it is proposed to use neural networks, e.g., networks of the GTP family, to teach them these methodologies, principles of algorithmisation and analysis of effective ways to solve current and strategic economic problems, based on the triplicity or five-variative principle, which will allow the enterprise financial system avoiding fundamental decisions, monitor and correct critical indicators.

Keywords: financial stability area, economic innovative methods, neural networks in economics.

Introduction

One of the most important indicators in the enterprise economy is the indicator of the enterprise stability point. However, at present, in the age of rapid economic and technological development, the same rapid and correct response to changes in market

relations and the market environment is required. In turn, this requires the company to fully control the strategy and current indicators of financial stability to quickly generate a variety of solutions that will also be quickly analysed and applied to accounting when choosing the final solution and subsequent monitoring of the results. Therefore, the implementation of innovative methodologies requires the use of the most modern digital and other technologies.

The author discusses two innovative methodologies aimed at solving the problem of effective use of the wage fund and calculating the financial stability area. A brief analysis of these methodologies shows the need to use neural networks for their implementation as the most advanced programs to date.

The study object was innovative methodologies in economics.

The study subject was to determine the complexity level and complexity of mathematical modelling of innovative methodologies.

The study purpose was to determine the relevance of using modern technological advances to solve new complex problems that realise the problems of stabilisation and economic indicators' stability of a modern enterprise.

Based on the study purpose, the following tasks were developed:

– briefly describe the innovative ABC methodology used for financial optimisation of the wage fund at the enterprise;
– briefly describe the innovative methodology of the calculating principle of the enterprise financial stability area;
– identify the complexity of the presented innovative methodologies;
– substantiate the relevance of attracting the most modern technologies to the implementation of innovative methodologies in enterprise economics on the example of neural networks.

Analytical, logical, comparative, historical methods and methods of mathematical analysis were applied to achieve the study purpose and solve the tasks set.

In the course of the study, the author used the works of such scientists and researchers as G. C. Chow [4], K. Cox [5], D. N. Gujarati [6], P. V. Komissarov [8; 9], P. D. McNelis [10], L. Zadeh etc.

The basic principles of the ABC methodology applicable to the financial optimisation of the enterprise wage fund

The ABC methodology is based on the triplicity of such parameters of human resource management at the enterprise as business processes and the qualifications of an employee or worker. It is assumed that to facilitate the perception of the labour optimization system, it is sufficient to categorise three levels of complexity since a larger number of parameters will significantly complicate the system and will not contribute to a high degree of accessibility of the methodology for middle managers.

The business processes set can be represented in the form of three sets divided according to the principle of the complexity of their execution without accounting for the parameter of the execution time duration. The complexity degree is determined in a comparative form concerning each enterprise department or division separately since

the complexity of business processes is determined by the features of the functional unit.

Business processes are grouped according to the degree of complexity:

A – complex execution of business processes,

B – average complexity of business processes,

C – business processes that are light in complexity [1].

Because the number of complex business processes should be less than light ones, and medium-complexity business processes should dominate the total number of the processes, implemented in the enterprise department, a proportion was practically developed (Table 1).

Table 1 shows the percentages of the three levels of complexity of business processes, based on their median proportion and the two extreme indicators of the system, i.e., minimin and maximax relative to business processes of category A. The principle of triplicity is also used to categorise the level of competence of office or working personnel concerning basic qualification requirements:

A – higher qualification,

B – average qualification,

C – low qualification [1].

Based on experimental data, median indicators of the difference in the time of execution of business processes of each category by specialists of each skill level were obtained while maintaining an equal quality indicator (Table 2).

The verification of the coefficients of the time parameters of business processes execution is carried out according to the principle of compliance, i.e., the execution time of each business process of level (A) is checked on the performance of qualification employees from 3 to 5 times to calculate the true median of the duration of execution. In the same way, the execution time of each business process of level (B) is checked on the B-qualification employees from 3 to 5 times. The execution time of each business process of level (C) is checked on the C-qualification employees.

Based on these indicators, a matrix of effective business processes' distribution at various levels of complexity among employees of three competence levels was formed (Table 3).

Thus, the basic principles of the ABC methodology correspond to the basic requirements of labour optimisation after the stage of automation or regulation of business processes of a separate division of the enterprise

The ABC methodology application model assumes that clear planning of its implementation process will be performed:

- compilation of the register of business processes of the enterprise department;
- differentiation of business processes into three comparative categories by levels of complexity of execution: 15% (A), 50% (B), 35% (C) or within the limits of "minimin-maximax";
- differentiation of personnel by three categories of competence;
- testing the implementation of business processes by personnel of the appropriate level of competence;

– testing the implementation of business processes by related categories of specialists for the verification of time coefficients;
– test formulation of business processes according to the matrix of distribution of volumes of business processes by categories of employees of three levels of competence;
– regulation of business process planning within one department of the enterprise.

Thus, the ABC methodology optimises and limits the wage fund, excluding the expenditure of funds on the factor of work absence. At the same time, the methodology motivates the average enterprise management to address business processes of the appropriate level to the employees who meet the requirements and the right to execute the named processes.

Methodology for the development of quantitative indicators of algorithmisation and automation of calculations in the field of financial stability of the enterprise

The second part of the article provides a methodology for developing the quantitative indicators that will be used to model the financial stability area.

The ABC (triplicity of indicators) methodology is used in modern financial management to determine extreme and median indicators, which are later used in production or strategic planning, as well as calculations in complex mathematical models of decision-making and obtaining results under uncertainty [1].

From the economic side of modelling innovative production and economic projects, which include the calculation of the financial stability area, the most important condition is the presentation of a model that can be determined during the relevant analysis. The analysis of the enterprise financial stability was performed using the calculation of the coefficients of eight multicomponent key indicators:

– the coefficient of autonomy (K_A),
– the coefficient of own and borrowed funds (K_{OBF}),
– the coefficient of the enterprise's own working capital (K_{EOWC}),
– the coefficient of financial stability (K_{FS}),
– the coefficient of equity's maneuverability (K_{EM}),
– the coefficient of solvency (K_S),
– the coefficient of short-term debt (K_{STD}),
– the coefficient of current liquidity (K_{CL}) [9].

Consequently, the methodology for developing the quantitative indicators took into account the above indicators:

$$N = \sum K \times n_a, \qquad (1)$$

there:

N is sum of indicators,

$$\sum K = \{K_A, K_{OBF}, K_{EOWC}, K_{FS}, K_{EM}, K_S. K_{STD}, K_{CL}\}$$

n_a is number of alternatives.

Since eight indicators are used in the calculation, the following formula is used:

$$N = 8 \times n_a. \qquad (2)$$

In the course of modelling, the analysis of the inclusion of key indicators set calculations for determining the enterprise financial stability an in a set of criteria for choosing an alternative was performed. The criterion of indifference was excluded from the criteria, since the study was conducted considering the definition of financial stability indicators set, in which an alternative with the maximum average result is calculated, which by definition is included in financial stability [11].

The remaining four criteria were used to construct the calculation of the set of alternatives:

$$M = 4N, \qquad (3)$$

there:

M is number of alternatives,

N is the sum of the indicators of each alternative.

The alternative assumes the presence of at least two options; therefore, the following formula is applicable in an expanded form:

$$M = 4 \times 8 \times n_a = 32 \times \sum_{i=2}^{n} n_a. \qquad (4)$$

Thus, if one scenario (a set of indicators) obtained under the conditions of modelling one situation, i.e., one set of parameters, is included in the calculations, at least 64 solutions are presented as a set of financial stability points within the relevant area.

When considering the variation of the indicators of the share of equity and the reserve of the value of assets that issue as a private coefficient of financial autonomy, at least six options are generated, which, in turn, determine the appropriate number of alternatives [8]. As part of the decision-making process to determine the financial stability point, four criteria are applied for the financial stability area under conditions of uncertainty, which increases the number of alternatives:

$$M = 4 \times 8 \times n_a \times 6 = 192 \times \sum_{i=2}^{n} n_a. \qquad (5)$$

As a result of the use of a variety of options for only one of the financial stability coefficients, when it is limited exclusively to tenths, a variation that is a multiple of 192 when considering each subsequent alternative, arises.

When obtaining such a large set of indicators, it is proposed to introduce the triplicity principle of final indicators (ABC methodology) into the algorithm at each

stage of calculations, i.e., the output of *maximax*, *minimin*, and *median* (*mid*) indicators. Thus, each of the eight coefficients in the final form is represented as three indicators, forming a more specific and optimal set of 24 final financial stability indicators, forming areas of total financial stability:

$$M = 8 \times n_a \times 3 = 24n_a. \qquad (6)$$

In the course of a natural experiment at the enterprise of the Viaduct LLC, specialising in the production of crackers, biscuits, and other breadcrumbs, the production of flour confectionery, cakes, pastries, pies, and biscuits intended for long-term storage, the minimum, median and optimal coefficients were used for calculations (Table 4).

To describe the development of quantitative indicators, it is necessary to present all the coefficients of financial stability of an enterprise in the form of mathematical expressions (Table 5).

Thus, the calculation of the total coefficients in the mathematical model can be represented as follows:

$$\sum k_{min} = k_{afs}^{min} + k_{rfs}^{min} + k_{pfs}^{min} + k_{jfs}^{min} + k_{mfs}^{min} + k_{sfs}^{min} + k_{dfs}^{min} + k_{lfs}^{min}, \qquad (7)$$

$$\sum k_{mid} = k_{afs}^{mid} + k_{rfs}^{mid} + k_{pfs}^{mid} + k_{jfs}^{mid} + k_{mfs}^{mid} + k_{sfs}^{mid} + k_{dfs}^{mid} + k_{lfs}^{mid}, \qquad (8)$$

$$\sum k_{max} = k_{afs}^{max} + k_{rfs}^{max} + k_{pfs}^{max} + k_{jfs}^{max} + k_{mfs}^{max} + k_{sfs}^{max} + k_{dfs}^{max} + k_{lfs}^{max}. \qquad (9)$$

Based on the total indicator of the minimum coefficients, the average indicator will be calculated as follows:

$$M_{min} = \frac{\sum k_{min}}{8}. \qquad (10)$$

Therefore, according to the economic indicators of financial stability, the average minimum indicator will be as follows:

$$M_{min} = \frac{\sum k_{min}}{8} = \frac{0.5 + 0.5 + 0.2 + 0.8 + 0.3 + 0.5 + 0 + 1}{8} = 0.475.$$

Based on the total indicator of the median coefficients, the average indicator will be calculated as follows:

$$M_{mid} = \frac{\sum k_{mid}}{n}. \qquad (11)$$

Therefore, according to the economic indicators of financial stability, the average median indicator will be as follows:

$$M_{mid} = \frac{\sum k_{mid}}{n} = \frac{0.6 + 0.6 + 0.3 + 0.9 + 0.45 + 0.6 + 0.1 + 1}{8} = 0.569.$$

Based on the total indicator of the maximum coefficients, the average indicator will be calculated as follows:

$$M_{max} = \frac{\sum k_{max}}{n}. \qquad (12)$$

Therefore, according to the economic indicators of financial stability, the average maximum indicator will be as follows:

$$M_{max} = \frac{\sum k_{max}}{n} = \frac{0.7 + 0.7 + 0.4 + 1 + 0.6 + 0.7 + 0.2 + 1}{8} = 0.663.$$

Accordingly, the financial stability area of the Viaduct LLC enterprise is within the range of indicators from 0.475 to 0.663, which will contain 24 indicators.

To calculate the limits of the conditions of the financial stability area, the sums of the extreme corresponding coefficients of the indicators and the remaining two averaged indicators are used.

To calculate the lowest extreme indicator of the financial stability area, it is used the formula:

$$M_{minimin} = \frac{k_{min}^{min} + M_{mid} + M_{max}}{3}. \qquad (13)$$

To calculate the extreme highest indicator of the financial stability area, it is used the formula:

$$M_{maximax} = \frac{k_{max}^{max} + M_{min} + M_{mid}}{3}. \qquad (14)$$

Consequently, further calculations of the extreme conditions of the area, based on the minimum coefficient indicators in each group of indicators, were made:

$$M_{minimin} = \frac{k_{min}^{min} + M_{mid} + M_{max}}{n} = \frac{0 + 0.569 + 0.663}{3} = 0.411,$$
$$M_{maximax} = \frac{k_{max}^{max} + M_{min} + M_{mid}}{n} = \frac{1 + 0.475 + 0.569}{3} = 0.681.$$

Consequently, the Viaduct LLC's financial stability area will be a set of 192 indicators that fall within the limits of indicators from 0.411 to 0.681.

These indicators and limits of the set are fully confirmed by the accounting financial stability of Viaduct LLC for the fiscal year 2021 as an experimental example.

Thus, the second part of the article provides a methodology for developing the quantitative indicators that will be used to model the financial stability area. In the course of modelling, the analysis of including calculations of key indicators set for determining the enterprise financial stability in criteria set for choosing an alternative was performed. The criterion of indifference was excluded from the criteria, since the study was conducted considering the definition of financial stability indicators set, in which an alternative with the maximum average result, which by definition is included in the financial stability area, is calculated. When obtaining a large set of indicators, it is proposed to introduce the principle of final indicators triplicity into the algorithm at each stage of calculations. Thus, in the final form, each of the eight coefficients is represented as three indicators, forming a more specific and optimal set of 24 final financial stability indicators of, forming the financial stability areas. The approbation of this methodology on the materials of the economic indicators of Viaduct LLC for the 2021 fiscal year confirmed its effectiveness and compliance with the financial analysis of the enterprise according to the accounting documentation.

The use of neural network technologies for implementing innovative methodologies for calculating economic indicators

Digital technologies can significantly advance the implementation of innovative methodologies in enterprise economics. The main direction of economic development in the digital environment is to use actively developing products of quantum calculus, which gave rapid development of the “neural network”.

For synchronous neural networks, only one neuron changes its state at a time. In asynchronous networks, the states of a group of neurons or usually the entire layer change at the same time. Two basic architectures of neurons can be distinguished – layered and fully connected networks. A layer is one or more neurons, to which one common signal is applied to the input. Layered neural networks are neural networks in which neurons are divided into separate groups (layers) so that information processing is performed in layers. In one layer, data is processed in parallel, and on the scale of the entire network, processing is performed sequentially, i.e., from layer to layer. Layered neural networks include, e.g., multilayer perceptrons, networks of radial basis functions, and others. Layered networks can also be single-layer and multi-layer. In a multi-layer network, the first layer is called the input, and the subsequent layers are internal or hidden, the last one is the output. The input layer of the multilayer network, respectively, organises communication with the input data, and the output with the output. Therefore, neurons are divided into input, output and hidden.

According to the architecture of connections, neural networks can be grouped into two classes:

1) direct distribution networks in which connections do not have loops, i.e., they cannot refer to themselves.
2) recurrent type networks in which feedbacks are possible.

Direct distribution networks include single-layer and multi-layer networks.

After the uploaded data, the neural network begins its training using the selected guided learning algorithm. The most popular algorithm is the back propagation method, in which the downloaded data is used to change the weights and thresholds of the network so that the probability of an error in the prediction on the training set is reduced. If the network is trained well enough, it will be able to further simulate an unknown function, using the example of primary data. The network independently connects the values of input and output variables, and subsequently such a network can be used for forecasting in tasks when the output values are unknown.

Consequently, when loading the initial data of the innovative methodologies presented in the brief description, the neural network is trained to calculate triplets and quintets, depending on whether we use a triple calculation system "mini-medium-maxi" or a more complex five-dimensional calculation system "minimin-minimax-medium-maximin-maximax". Since threefold and, moreover, five-dimensional calculations are quite complex and cumbersome for the financial matrix of standard enterprise software adopted in various European countries, the installation of a neural network and its training will present a unique opportunity for both strategic financial planning using a variety of limits, and current planning based on financial scenarios plurality, which will be generated by the neural network in real time.

Thus, the use of a neural network will allow to develop and include in the operating mode promising innovative methodologies that are created for the purpose of correctly calculating the enterprise financial stability area.

Discussion

The two basic discussion issues of this research topic are the following:

1. What kind of neural network can be used for algorithmisation of methodologies? At the moment, the most promising is GTP 5.0, which should be released in December 2023. However, two dozen alternative neural networks have already been developed for this period of time, allowing to generate mathematical models of economic development of the enterprise.
2. What should be the methodology of neural network training to obtain an effective result of mathematical modelling and apply its results to calculate the enterprise financial stability area? The solution of this issue will provide the enterprise with a unique opportunity for strategic foresight and effective temporal control over the financial indicators of the economic condition of the organisation.

Conclusion

Thus, this article presents two innovative methodologies that are aimed at improving the efficiency of the enterprise economic activity. Since these methodologies require significant expenditures of classical programmes in economics, it is proposed to use neural networks, e.g., GTP family networks, to teach them these methodologies, principles of algorithmisation and analysis of effective ways to solve current and strategic economic problems, based on the triplicity or five-variative principle, which will allow the enterprise financial system, avoiding fundamental solutions, monitor and correct critical indicators.

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Appendix

Table 1. Proportional distribution of business processes by their complexity of execution [1]

	A	B	C
Optimal	15%	50%	35%
Mini optimal	10%	50%	40%
Maxi optimal	20%	50%	30%

Table 2. Median coefficients of the business process' execution time ratio [1]

		Stuff qualification		
		A	B	C
Business processes	A	K_1	$K_{1,3}$	$K_{1,6}$
	B	$K_{0,7}$	K_1	$K_{1,3}$
	C	$K_{0,5}$	$K_{0,7}$	K_1

Table 3. Distribution matrix of business processes volumes by categories of employees of three competence levels [1]

		Stuff qualification		
		A	B	C
Business processes	A	75%	25%	–
	B	25%	50%	25%
	C	–	25%	75%

Table 4. Indicators of economic coefficients of the Viaduct LLC enterprise by the end of 2021 [3]

Coefficient		Mini	Mid	Maxi
The coefficient of autonomy	K_A	0.5	0.6	0.7
The coefficient of own and borrowed funds	K_{OBF}	0.5	0.6	0.7
The coefficient of the enterprise's own working capital	K_{EOWC}	0.2	0.3	0.4
The coefficient of financial stability	K_{FS}	0.8	0.9	1
The coefficient of equity's maneuverability	K_{EM}	0.3	0.45	0.6
The coefficient of solvency	K_S	0.5	0.6	0.7
The coefficient of short-term debt	K_{STD}	0	0.1	0.2
The coefficient of current liquidity	K_{CL}	1	1	1

Table 5. Definition of mathematical notation for the financial stability area system (FSAS) [3]

Coefficient	Economic notation	Mathematical notation
The coefficient of autonomy	K_A	k_{afs}
The coefficient of own and borrowed funds	K_{OBF}	k_{rfs}
The coefficient of the enterprise's own working capital	K_{EOWC}	k_{pfs}
The coefficient of financial stability	K_{FS}	k_{jfs}
The coefficient of equity's maneuverability	K_{EM}	k_{mfs}
The coefficient of solvency	K_S	k_{sfs}
The coefficient of short-term debt	K_{STD}	k_{dfs}
The coefficient of current liquidity	K_{CL}	k_{lfs}