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DEVELOPMENT OF MODELS AND SOFTWARE SOLUTION For THE PROBLEM OF DIAGNOSTIC OF FINANCIAL STATES OF IT-ENTERPRISE

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Abstract*. Currently, the Ukrainian economy is relatively volatile, so enterprises require efficient management, which requires knowing what the management state is. Solving the problem of diagnosing the financial state of an enterprise in the future will allow developing an apparatus of effective management decisions that will help maintain the enterprise at the proper level of functioning and ensure further development of both the enterprises and the economy as a whole.*

The problem is in the need to obtain a more accurate solution for the problem of diagnosing the financial state of the enterprise with the parameters that characterize the financial situation best of all. The main objective of the research was to solve the problem of diagnosing the financial state of an IT company, using a model that implements a certain approach in order to obtain a qualitative conclusion about the state of a company. A method based on the use of a fuzzy logic apparatus, namely, production models with a Mamdani fuzzy inference algorithm is proposed for solving the problem. In order to determine the financial position, input parameters were estimated, which were used to evaluate the financial state and represent the quantitative and qualitative indicators of the company's activity for the selected period. The obtained results explain what indicators and how they affect the financial position of the company and can be used to solve the forecasting problem. Implementation of the research results will help to accelerate the diagnosis of financial status at the enterprise and make a management decision in time, which is the relevance of the research.

Keywords*: diagnosing, financial state, financial indicator, fuzzy logic, production model.*

I Introduction

Today, the economy of Ukraine is in a relatively unstable position; therefore, Ukrainian enterprises require effective management. But in order to effectively manage the business, you need to know in what state it is in order to take certain actions in the future. Thus, the task of diagnosing the financial state of the enterprise plays an important role.

The urgency of solving the problem is obvious, since a precise determination of the financial position gives an adequate idea of the situation, and in what direction to move and what actions should be taken in order to maintain the enterprise at the proper level of functioning and to ensure its future development.

Thus, an important task is to solve the problem of diagnosing the financial condition of the enterprise. The problem is the need to obtain an accurate solution to the problem of diagnosing financial conditions in order to form effective management of the enterprise, as well as the lack of software that can solve this problem, and takes into account the parameters that characterize the financial situation best of all.

Therefore, in the current conditions of information technology development, there is a need for the availability of approaches and software solutions for automation of the diagnosis process, as it will significantly improve the efficiency of the enterprise, and, consequently, its profitability and competitiveness.

Timely and accurate determination of the financial status of an enterprise is one of the basic conditions for its successful activity. Therefore, the purpose of this work is to solve the problem of diagnosing the financial status of an IT-company, using models that implement certain approaches.

The subject of the study is the approaches to determining the financial status of the enterprise, on the example of the object of study of the IT-company in truncated form, namely in the context of the process of diagnosing the financial condition.

II Analytical review of literature

2.1 Analysis of the problem, its relevance, the essence of the problem of diagnosis

Now enterprises of Ukraine require effective controls to prevent bankruptcies, which in turn can cause a sharp economic downturn. It should be noted that among a number of tasks that are solved in the field of effective management, such as the task of identification, the task of optimal management, etc., the task of diagnosing the financial states of the enterprise plays an important role. The relevance of the research is reflected in the application of the results obtained for the prompt and effective management.

Analysis of Ukrainian and foreign literary sources showed that the existing models and methods of diagnosis do not take into account the parameters that are important enough in the current conditions, because they are not put into consideration, therefore, the financial situation can not be determined with sufficient accuracy.

The task of diagnosing the financial state of the enterprise is characterized by difficulties in obtaining information, large amount of data, multicriteria, so the solution of the problem requires a lot of processing time, which causes a rather high cost of the diagnostic research.

This work is aimed at the development and implementation of the practical side of diagnosing the financial condition of the enterprise, which is expressed in the following:

1 It is planned to construct a model of diagnosing financial condition of the company such that it is possible to consider the optimal number of basic indicators that have a significant impact on the accuracy of diagnosis;

2 It is suggested to use different methods of diagnosis, which allows to be sure of the result as the task is quite important and difficult.

Diagnosing is the process of determining and studying indicators, which characterize the state of an object. It consists in certain research methods, analysis of the obtained results and their generalization in the form of a conclusion (diagnosis) to determine possible deviations and prevent disturbances in the normal functioning of an object. The main purpose of diagnosis is to obtain a small number of key, most informative indicators that give an objective and accurate determination of the financial condition of the company [2].

Financial state is the most important characteristic of the economic activity of the enterprise, a set of economic and financial indicators that characterize the enterprise's ability to sustainable development [1].

The financial position is determined on the basis of a number of indicators that most objectively reflect trends in the financial position, as a rule, they consist of four groups: indicators of liquidity, indicators of financial stability, profitability indicators, business activity indicators.

Diagnosis allows to identify cause and effect relationships in management dysfunctions, and then move on to building explanatory and predictive patterns of functioning [4].

Analysis of the existing software solutions to the problem of diagnosing financial conditions showed that they all have and advantages and disadvantages, such as high cost, the need to use a large number of parameters, etc.

2.2 Approaches to solving the problem of diagnosing the financial state of the enterprise

2.2.1 Classic approaches to diagnosing financial state

All current methods can be divided into two main groups: financial analytics methods and intellectual methods. Methods of financial analytics based on mathematical and economic apparatus (traditional methods). At present, quite stable traditional approaches have developed, which can be divided into four main groups of methods:

Transformational techniques. Transformational techniques for diagnosing financial condition are primarily intended to transform reporting into a more readable format. However, these techniques do not have an analytical function and do not directly lead to any conclusions and recommendations [3].

3 Qualitative techniques. Qualitative methods of assessment of financial condition are divided into methods: vertical analysis, horizontal analysis, analysis of liquidity balance, formalized questionnaire schemes.

In vertical analysis, it is difficult to interpret the current structure of funds unambiguously. Horizontal analysis is also rather limited due to changes that characterize the effects of past periods, and there is no reason to believe that they will be retained in the future. Balancing liquidity analysis and existing formalized questionnaire schemes face limitations as they offer formulations that are difficult to quantify [5].

Thus, the techniques presented in the block of qualitative analysis also do not lead to practical conclusions and recommendations.

1 Coefficient methods. Coefficient analysis is one of the most common tools in financial and analytical practice for assessing financial condition, but its relevance to user goals raises some doubts. [5].

2 Integral techniques for diagnosing financial condition. Integral techniques for assessing financial condition involve synthesizing financial indicators into complex constructions in the following areas: bankruptcy regression models, bank credit ratings, fuzzy set analysis, and consolidated rating models [5].

2.2.2 Modern methods of diagnosing financial state

With the development of information technology, a number of intelligent methods of diagnosis have been proposed, for example:

1 Based on the application of neural network technology. Neural Networks – a very powerful modeling method, allows to reproduce extremely complex dependencies, nonlinear in nature. [6].

The main appeal of using artificial neural networks is the ability to use a large number of different input parameters – financial data over a certain past period. The

expediency of transition to algorithms for diagnosis based on neural networks, due to the need to significantly accelerate the computational experiment, the need to reduce the cost of creating software implementation models [6].

2 Based on the apparatus of fuzzy logic. Often, raw data and knowledge about a managed object when setting the task of effective management contains indeterminate or fuzzy information that cannot be processed by traditional quantitative methods. [7].

Fuzzy productive diagnostics are particularly effective when processes are very complex to analyze using conventional quantitative methods, or when the raw data is interpreted inaccurately or uncertainly. Fuzzy production models are quite complicated to implement compared to fuzzy and conventional neural networks [8].

Therefore, based on the above and based on a critical review of existing mathematical approaches to solving the problem and the need to automate the process, it is proposed to use:

1) the classic coefficient method with the calculation of the rating;

2) apparatus of fuzzy logic, namely production models using some fuzzy inference algorithm (Mamdani algorithm).

III Object, subject matter and methods of research

The object of the research and the possible further implementation of the results of the work is the enterprise – an international IT-company working in the field of software development outsourcing. To diagnose the financial state of the company use indicators of financial reporting forms of the head office. The goals of the company are as follows: development of information technologies within the framework of business, support of the company in working condition, saving of funds due to the use of new management systems. Thus, the subject area is the financial side of the enterprise, and more precisely the process of determining the financial state of the company, which is necessary to further solve the problem of effective management of the enterprise.

To diagnose the financial condition of a company, a set of ratios (financial multipliers) is used. Based on the degree of compliance of the calculated indicators with the permissible standards of indicators of a certain financial condition, the financial state of the company is concluded, and the coefficients that go beyond the recommended limits indicate the "weaknesses" of the company.

To improve the system, we need to find out the content and results of its operation. The performance of the company can be represented by a model, which will be characterized by the following selected input parameters:

- y_1 – current liquidity ratio;
- y_2 – quick liquidity ratio;
- y_3 – absolute liquidity ratio;
- y_4 – the ratio of collateral to own current assets;
- y_5 – autonomy ratio (equity concentration);
- y_6 – the coefficient of maneuverability of equity;
- y_7 – financial dependency ratio;
- y_8 – the ratio of debt to equity;
- y_9 – profitability index of products (sales);

– y_{10} – an indicator of return on assets;

– y_{11} – an indicator of return on equity;

– y_{12} – an indicator of overall profitability;

– y_{13} – asset turnover ratio;

– y_{14} – an indicator of working capital ratio;

– y_{15} – turnover of equity ratio;

– y_{16} – inventory turnover ratio.

The primary financial ratios for the above indicators are taken from the financial statements of the company – the balance sheet and the statement of financial performance.

The resulting output parameter will characterize the financial condition of the enterprise as excellent, good, normal, bad or critical.

The process of diagnosing a company's financial position at the time of subject matter research can be presented as diagrams in IDEF0 and DFD notation. These diagrams are intended to formalize the process of diagnosing the financial state of the enterprise, that is, to explore the existing process and to present it in a convenient way.

The main task of this work is to solve the problem of diagnosing the financial status of an IT-company, using models that implement certain approaches, the development of algorithmic software that embodies these approaches, their implementation in the developed software solution.

The subject of the study is approaches to determining the financial condition of the enterprise, on the example of the object of study – the IT-company in truncated form, namely in the context of the process of diagnosing the financial condition.

The purpose and task of the work is to analyze the financial performance of the company and to accurately determine the financial state with their help on the basis of the selected method of diagnosis on the example of the model of the IT-company under study, to develop a software solution for the automated solution of the task to improve the efficiency of the financial department and the company as a whole.

To solve this problem, we must solve the following subtasks:

1) analyze the object of study, the subject area and the essence of the problem;

2) consider known methods of diagnosis, identify their shortcomings;

3) choose the most appropriate methods of solving the problem, taking into account the various advantages and disadvantages;

4) to develop algorithmic software and software solution that implements an automated process that will allow to diagnose financial condition and will meet the necessary requirements;

5) check the decision on a test case on specific data, analyze the results.

Thus, the need for accurate diagnosis of the financial condition of the company is due to economic reasons and cause needs make correct and effective management decisions.

3.2 Research methods

3.2.1. Diagnosing of financial state in the classic way

The classic coefficient method is designed to provide a fairly complex approach to the analysis of the financial condition of an enterprise, which results in a comprehensive assessment of the financial condition. Sources of information for the analysis of the

activity of the company are the financial statements: balance sheet (form number 1), statement of financial results (form number 2). The application of the methodology is to carry out the analysis on the basis of analytical tables [9].

Financial ratio (index) – a relative index, calculated as the ratio of certain balance sheet items and their combinations [9].

The financial indicators that most objectively assess the financial position are selected. From each group of indicators, several commonly used metrics are selected. Thus, 16 financial ratios (presented above) are selected, which will be calculated on the basis of primary indicators and are components of quantitative assessment of the financial state of the enterprise.

The coefficients characterizing the liquidity, financial stability, profitability and business activity of the company are calculated using known formulas.

Then, using the method of comparing the coefficients with industry recommended standards, formed the idea of solvency, financial stability, profitability, level of business activity, on the basis of which the conclusion is made about the state of the company as a whole.

Rating is necessary in order to summarize in a word the financial condition of the enterprise. This indicator includes the calculation of the most important coefficients. A state gradation from F- "bad" to A- "excellent" is used to display the result.

The algorithm of the coefficient method with the calculation of the rating consists of the following sequence of steps:

1 In the first stage, the actual values of each coefficients for all four groups of indicators are determined in accordance with the known calculation formulas;

2 Next, a comparison of the actual and normative values of the individual coefficients, and each actual coefficient receives a corresponding score: 3 – “excellent”, 2 – “good”, 1 – “satisfactory”, 0 – “unsatisfactory”;

3 In the third step, a quantitative actual estimate of each group of indicators is calculated by the formula

$$C_i = \frac{\sum_{j=1}^{n} b_j}{n}, \quad i = \overline{1,4},$$

де b_j – is the coefficient score obtained in the previous step; n – the number of coefficients in the metric group; C_i – the actual score of the metric group.

4 Then, a quantitative assessment of each group of indicators is given, taking into account the importance of each group, by the formula $K_i = C_i \cdot w_i$, $i = \overline{1,4}$, where C_i – the actual score of the metric group, w_i – the importance of its group of indicators, K_i – a quantitative assessment of each set of metrics based on importance.

5 At the last stage, a rating of the financial and economic state of the enterprise is formed by the formula

$$S = \sum_{i=1}^{n} K_i,$$

де n – the number of indicator groups; K_i – a quantitative assessment of each set of metrics based on importance; S – obtained evaluation.

The above scheme can be used to derive a rating and to draw a conclusion about the financial position of an economic entity.

3.2.2. Diagnosing of financial state with fuzzy logic

When evaluating the activity of the company sometimes we have to operate with non-numerical data, such as: "low" – "high", "bad" – "good", etc. Many financial indicators do not have clear rationing and are highly dependent on the scope of activity of the enterprise, in such cases often resort to expert estimates. [8].

Fuzzy production models are the most common type of fuzzy models used to describe, analyze, and model poorly formalized complex systems and processes.

A fuzzy logical conclusion for a model that reflects the functioning of a company is called approximation of dependence $Y = f\left(y_1, y_2, ..., y_{18}\right)$ using a fuzzy knowledge base and fuzzy operations.

As input linguistic variables using variables, defined on the basis of selected primary financial indicators of the company (obtained from the financial accounting of the company). They are combined into two large groups:

1 $Z_0 = f(Z_1, Z_2, Z_3, Z_4)$ – quantitative indicators of financial position, where:

1) Z_1 – group of liquidity ratios, which including y_1, y_2, y_3;

2) Z_2 – group of indicators of financial stability, which including: y_4, y_5, y_6, y_7, y_8;

3) Z_3 – group of profitability indicators, which including: y_9, y_{10}, y_{11}, y_{12};

4) Z_4 – group of indicators of business activity, which including: y_{13}, y_{14}, y_{15}, y_{16};

2 Z_5 – is quality parameters, which including:

1) y_{17} – professional abilities of managers (point);

2) y_{18} – the level of wages and social protection of employees (point).

З метою отримання можливості оцінки і обробки лінгвістичних показників, формуємо єдину шкалу з п’яти якісних термів: ДН – дуже низький рівень показника, Н – низький рівень y_i, С – середній рівень показника y_i, В – високий рівень y_i, ДВ – дуже високий рівень показника y_i.

In order to be able to evaluate and process indicators $y_i (i = \overline{1, N})$ that can characterize a company in terms of financial condition, we define a single scale of three quality terms: VL – a very low level of indicator y_i, L – a low level of indicator y_i, M – a middle level of indicator y_i, H – a high level of indicator y_i, VH – very high level of indicator y_i.

Y will be used as the output linguistic variable. It is the financial state of the company. The obtained output parameter Y allows us to characterize the financial state of the company as: E – excellent, G – good, N – normal, B – bad, C – critical.

Next, we determine the possible range of change of controlled parameters y_i, and the output variable Y, specify the type of fuzzy term membership functions for different parameters, which indicate the degree of belonging of each element to different qualitative terms. In our case, input indicators may correspond or do not match to recommend or standard values, which are presented in the form of some established intervals. Therefore,

the trapezoidal membership function will be used to solve the problem, because it allows us to specify the basis of a fuzzy set as an interval and is simple to set [7].

We reflect the ranges of change of parameters y_i, to a single universal set y in order to constructing the five membership functions of five fuzzy terms of the input variable {VL, L, M, H, VH}. Three fuzzy subsets are set whose membership functions are shown in Figure 3.1.

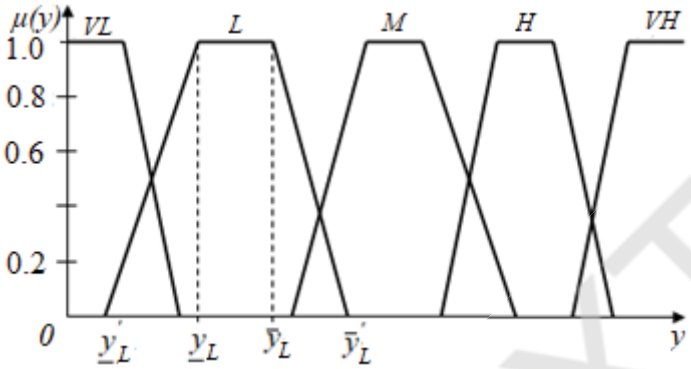

Рисунок 3.1 – Fuzzy variable y with trapezoidal membership function

The membership functions of other fuzzy terms of the input variable y and output variable Y are constructed by similarly way.

A system of fuzzy knowledge should include a mechanism of fuzzy inference. Therefore, the necessary stage of analysis is the formation of a system of rules [7]. Rules are provided for each level of the system. An example of a decisive rule is: IF the quantitative indicators are very high AND the qualitative parameters are middle, OR the quantitative indicators are high AND the qualitative parameters are very high, OR the quantitative indicators are high AND the qualitative parameters are high, THEN the state is normal.

The mathematical form of recording the decisive rule by means of membership functions is represented as:

$$\mu^N = \mu^{VH}(Z_0)\cdot\mu^M(Z_5)\vee\mu^H(Z_0)\cdot\mu^{VH}(Z_5)\vee\mu^H(Z_0)\cdot\mu^H(Z_5),$$

де $\mu^Y(Z_0,Z_5)$ – membership function of input variables vector (Z_0,Z_5)) to the output variable Y; $\mu^{a_i}(Z_i)$ – parameter membership function Z to fuzzy term a_i.

Both criteria Z_0 and Z_5, which represent the complex values of the specified groups of indicators, are presented in the form of mathematical dependencies on input variables. The entire knowledge base is formed similarly and a system of fuzzy logical equations is displayed. The levels of all terms of each indicator $y_i, i=\overline{1,18}$, enterprises are set in accordance with the normative values of the classical criteria [7].

Components of fuzzy product models may be implemented differently, which determines the fuzzy inference algorithm, such as the Mamdani, Sugeno, Larsen, or Tsukamoto models. [8].

The most common method of inference in fuzzy systems is the Mamdani algorithm, which is given below

3 The predicate rule base is formed in the subject area, for example, using the full enumeration method; next action is checking the input variables: if the variables are precise sets, then go to the next step, which is called the fuzziness introduction stage – fuzzification [10];

4 The fuzzification procedure is performed: each value of a separate input variable is associated with the value of the membership function of the corresponding term of the input linguistic variable by the formula $\mu_1(y), \mu_2(y), \ldots, \mu_n(y)$, where $\mu_1(y), \ldots, \mu_n(y)$ – membership functions for variable y [10];

5 Aggregation of prerequisites in fuzzy production rules. Paired fuzzy logic operations are used to find the degree of truth of the conditions of each of the rules of fuzzy products by the formulas:

$$\alpha_1 = \min\{\mu_{A_{11}}(y_1'), \mu_{A_{12}}(y_2'), \ldots, \mu_{A_{1n}}(x_n')\}$$

$$\alpha_2 = \min\{\mu_{A_{21}} y_1'), \mu_{A_{22}}(y_2'), \ldots, \mu_{A_{2n}}(x_n')\}$$

.....

$$\alpha_m = \min\{\mu_{A_{n1}}(y_1'), \mu_{A_{n2}}(y_2'), \ldots, \mu_{A_{mn}}(y_n')\},$$

де n – number of variables; m – number of rules in the base [10].

6 The activation procedure – finding the truncated membership function for the output variable, which is made according to the formulas:

$$\mu_{B_1'}(Y) = \min\{\alpha_1, \mu_{B_1}(Y)\}$$

$$\mu_{B_2'}(Y) = \min\{\alpha_2, \mu_{B_2}(Y)\}$$

.....

$$\mu_{B_m'}(Y) = \min\{\alpha_m, \mu_{B_m}(Y)\} .$$

7 The procedure of accumulating or combining the found truncated functions in order to obtain the final fuzzy set for the output variable and the resulting membership function, which is performed according to the formula $\mu_{B'}(Y) = \max\{\mu_{B_1'}(Y), \mu_{B_2'}(Y), \ldots, \mu_{B_m'}(Y)\}$ [10].

8 Defuzzification, or bringing to precision. Most often, the Mamdani model uses defuzzification by the centroid method, when a precise value of the output variable is defined as the center of gravity for the curve:

$$Y' = \frac{\sum_{i=1}^{n} Y_i \mu_{B'}(Y_i)}{\sum_{i=1}^{n} \mu_{B'}(Y_i)} ,$$

де n – the number of single-point fuzzy sets, each of which characterizes a single value of the considered output linguistic variable; Y' – financial condition of the company [10].

By having a rule base and using the above algorithm, you can get the result of a fuzzy conclusion – the financial state of the company.

IV Work results

4.1 Formation of input data

For this task, a test case was calculated using the methods of the classical coefficient method with the calculation of rating and fuzzy production model using the developed software solution and MATLAB environment. The financial ratios – input parameters and qualitative indicators were calculated On the basis of primary financial indicators.

Using the selected methods, we will determine the financial position according to the balance sheets and the financial statements for each 4 quarters of 2017, 2018.

4.2 Results of diagnosing the financial state of an IT-company

The calculations using the developed software use the primary indicators derived from the financial statements.

Then the calculations are made and the result of the diagnosis is determined by two methods at once. Similar actions are performed for the other initial data of each quarter, calculating quarterly, we obtain the results shown in Figure 4.1.

Thus, on the basis of numerical studies, the financial state of the company for the 8 quarters of 2017-2018 was diagnosed with the help of the developed software solution.

Дата	y1	y2	y3	y4	y5	z1	z2	z3	z4	z5	Результат
2017-03-31 at 11:52:59	3.78	8.032	2.798	0.456	0.709	4.52	3.078	0.687	2.539	2.75	NORMAL
2017-06-30 at 12:02:48	15.259	12.355	11.504	0.267	0.816	4.52	2.314	0.687	2.481	3.978	NORMAL
2017-09-30 at 12:06:35	5.383	7.094	6.914	-0.458	0.855	4.52	1.768	0.687	1.693	4.795	BAD
2017-12-30 at 12:07:41	68.589	71.398	69.964	0.086	0.756	4.52	2.581	0.687	2.536	3.978	NORMAL
2018-03-31 at 12:09:14	25.179	18.927	18.351	0.342	0.808	4.52	2.575	0.687	2.542	3.978	NORMAL
2018-06-30 at 12:11:44	29.171	14.398	14.398	0.484	1.198	4.52	2.585	0.687	1.692	2.75	NORMAL
2018-09-30 at 12:12:51	198.985	126.536	107.83	0.418	1.78	4.52	2.577	0.687	1.994	3.978	NORMAL
2018-12-30 at 12:14:19	51.762	47.72	47.012	-0.095	1.834	4.52	1.769	0.687	3.012	3.978	BAD

Figure 4.1 – The result of diagnosing of states for 2017-2018.

Next, we will diagnose the financial state of the IT company with the help of a fuzzy production system using the tools of MATLAB. For carrying out the numerical study the 16 quantitative indicators and 2 qualitative indicators ($y_1 - y_{18}$), which were described earlier were calculated.

The fuzzy system has one output variable Y – financial state of the company. Each of the variables is characterized by a set of terms of the following form:

$$y_n = \{"Very\ Low","Low","Middle","High","Very\ High"\},\ n = \overline{1,18},$$

$$Y = \{"Critical","Bad","Normal","Good","Excellent"\}.$$

Using the MATLAB software and its Fuzzy Logic module, a fuzzy production rule system was learned with the Mamdani fuzzy inference algorithm.

All parameters were broken down into the following groups: liquidity ratios, financial sustainability ratios, profitability ratios, business activity ratios, and quality indicators. Each group is applied the Mamdani fuzzy inference algorithm and builds its own rule base. Further, by performing similar actions for the common metrics for each group, we obtain a common quantitative metric and a total qualitative metric, for which we again formulate a rule base and apply the Mamdani fuzzy inference algorithm.

The value of the output variable is calculated as the weighted average of the output of each rule, since the Mamdani algorithm is used.

As the input values we set the values of the calculated indicators: the absolute liquidity ratio is 3.7802, the current liquidity ratio is 8.0319, the quick liquidity ratio is 2.7984. Output variable - total liquidity ratio is 4.53.

Similar steps are taken to obtain intermediate values. Calculating intermediate indicators, we get the final result – the company's financial state. In this case, the resulting value of the financial state is 2.96, which corresponds to the qualitative characteristic "normal". The results of the calculations are shown in table 4.1.

Table 4.1 – Obtained results

		z_1	z_2	z_3	z_4	y_{17}	y_{18}	z_5	Y_{fl}	State
2017	I quar.	4.53	3.08	0.676	2.54	7.75	5.61	2.75	2.96	Normal

4.3 Analysis of the results

Research has shown that qualitative indicators also affect the financial position of an enterprise, but to a lesser extent than quantitative indicators.

This conclusion can be drawn from the fact that the result calculated by the classical method, which uses only qualitative indicators, is somewhat different from the result obtained by the use of fuzzy logic, which includes both qualitative and quantitative parameters.

As a result of the research we can say that fuzzy logic techniques are more effective in diagnosing the issue, but if necessary analyzing only quantitative parameters, the classical method of calculation of the rating is also acceptable to use.

As a result of the conducted numerical studies, we obtained data on the financial state of the company for the 8 quarters of 2017-2018. Some results are presented in table 4.2, where z_1 – the general indicator of liquidity ratios group, z_2 – the general indicator of financial stability ratios group, z_3 – the general indicator of profitability ratios group, z_4 – the general indicator of business activity ratios group, z_5 – general indicator of quality parameters, Y_{cl} – financial state obtained by the classical method with the calculation of the rating, Y_{fl} – financial state by the method of fuzzy production rules system. As the table shows, the financial state of the enterprise is usually normal, but in some circumstances it may deteriorate, the analysis of such circumstances should be done by an expert.

Comparing the results for the first quarter of 2017, obtained with the developed software solution and with the MATLAB package using the Fuzzy Logic tool, we can see that the results are almost identical, except that MATLAB rounds the results.

Comparing the classical method and the fuzzy system method, it can be said that the majority still prefers the classical method since it is much simpler and requires only ordinary mathematical knowledge. While the fuzzy system method is more complicated and takes more time to prepare data, calculations, analysis, numerical experiments and requires special knowledge, and the use of special mathematical packages. Therefore, the use of scientific methods based on fuzzy logic, for example, is justified only in developed

information systems, where ordinary employees do not need to understand the intricacies of using these methods.

Table 4.2 – Obtained results

	2017					2018			
	I		II	III	IV	I	II	III	IV
y_1	3.7802		15.258	5.382	68.58	25.179	29.17	198.98	51.76
y_2	8.0319		12.354	7.09	54.84	18.926	14.39	126.57	47.72
y_3	2.7984		11.503	6.914	53.41	18.351	14.39	107.82	47.02
…	…		…	…	…	…	…	…	…
y_{16}	13.0897		7.402	15.588	7.41	9.673	1.490	0.4909	1.537
	I		II	III	IV	I	II	III	IV
	ПЗ	Matlab							
y_{17}	7.713	7.75	7.721	9.336	9.276	7.713	5.475	6.704	7.704
y_{18}	5.583	5.61	7.713	9.336	7.713	6.704	7.721	7.713	7.713
z_1	4.52	4.53	4.52	4.520	4.520	4.520	4.520	4.520	4.520
z_2	3.078	3.08	2.914	1.768	2.581	2.575	2.585	2.577	1.769
z_3	0.687	0.676	0.687	0.687	0.687	0.687	0.687	0.687	0.687
z_4	2.539	2.54	2.481	1.693	2.536	2.542	1.692	1.994	3.012
z_5	2.750	2.75	3.978	4.795	3.978	3.978	2.750	3.978	3.978
Y_{cl}	Norm.	–	Norm.	Norm.	Norm.	Norm.	Norm.	Norm.	Norm.
Y_{fl}	Norm.	Norm.	Norm.	Norm.	Bad	Norm.	Norm.	Norm.	Bad

V Conclusions

The problem and its relevance was analyzed, the subject area and the process of functioning of the IT company were conducted in the work. In order to formalize the process of operation, namely the determination of financial state, diagrams were developed in IDEF0 and DFD notation.

As a result of the analysis the main task was formulated, the existing approaches to its solution were considered. As a result of the survey, approaches based on fuzzy production systems and the classical coefficient method with the calculation of the rating were selected.

To solve the problem, a mathematical model was developed that reflects the process of functioning of the enterprise, as well as algorithmic support, which implements the selected approaches to solving the task, was developed.

As a result of the work the requirements for automation of the decision of the problem of diagnosing the financial state of the company were determined, on the basis of which the software was designed and developed.

Thus, software that automates the process of solving the task was developed. It was used to perform a test example on specific data and analyze the results compared to the example in MATLAB.

References.

1 Ковальов В.В. Фінансовий аналіз: управління капіталом 2-е видання. – М .: Фінанси і статистика, 2014. – 512 с.

2 Економіка підприємства: підручник для вузів / під ред. проф. В.Я. Горфинкеля, проф. В.А. Швандара – 4-е изд., Перераб. і доп. – М .: ЮНИТИ-ДАНА, 2017. – 670 с.

3 Плишевский Б.П. Фінансове становище: нові тенденції // Фінанси. – 2015. – N2. – 422 с.

4 Самсонов Н.Ф. Фінансовий менеджмент / Н.Ф. Самсонов, А.А.Володін. – М .: Фінанси і статистика, 2016. – 336 с.

5 Заваліщін К.А., Ончукова Г.Є. Діагностика фінансового стану підприємства // Нижній Новгород: НГО «Професійна наука», 2016. – 342с.

6 Єріна А.М. Статистичне моделювання та прогнозування: Навч.посібник / А.М. Єріна. – К.: КНЕУ, 2015 – 168 с.

7 Матвійчук А. В., Сметанюк О. А. Діагностування фінансового стану підприємства із застосуванням інструментарію нечіткої логіки. // Фінанси України, 2007. № 12. – с. 115-128.

8 Зайченко Ю. П. Нечіткі моделі і методи в інтелектуальних системах. Навчальний посібник для студентів вищих навчальних закладів. / Ю. П. Зайченко – К.: Слово, 2015. – 344 с.

9 Кількісні методи фінансового аналізу: Пер. з англ. / Под ред. С. Дж. Драун і М. П. Кріцмені. – М: ИНФРА – М, 2016.

10 Борисов В. В., Круглов В. В., Федулов А. С. Б82. Нечіткі моделі та мережі. – 2-е изд., Стереотип. – М.: Гаряча лінія –Телеком, 2014. – 284 с.

DEVELOPMENT OF A PROTOTYPE OF AN ACTIVE TRACTION PROSTHESIS

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Abstract. *The analysis of the current prostetic market was made. Features, advantages and disadvantages of the forearm prostheses were described. The urgency of this research was shown.*

The prototype of prosthesis was chosen. Drive type has been selected with the selection rationale. The prosthesis control method has been developed. Kinematic scheme was drawn up.

Driving power of the prosthesis was calculated. The corresponding drive has been selected.