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A METHODOLOGICAL APPROACH TO DEVELOPMENT AND OPTIMIZATION A SET OF PARAMETERS FOR A COMPANY'S CREDITWORTHINESS EVALUATING

Abstract. Under the conditions of market economy during a period of financial instability, it is becoming particularly significant to be able to provide an objective analysis of the financial condition of domestic enterprises and evaluate their creditworthiness. Such an analysis is essential for the effectiveness of crediting activity in general.
Nowadays, the banks of Ukraine use a wide variety of creditworthiness evaluation methods which differ in terms of the number of parameters on the borrower's overall credit rating scale, indicative approaches and a priority given to each of them. If the set of parameters remained universal for all banks and countries, it would be possible to exchange statistics and systematize information on a global scale. However, the fact is that there is no uniformity in the system of parameters across countries, banks or researchers. Proceeding from the topicality of the issues regarding the selection of a creditworthiness evaluation method, it is important to develop and optimize a set of parameters for analyzing the financial condition of a business entity, which is the goal of this research.
The basic principle of optimizing the selection of financial parameters is to avoid the duplication of information about a certain aspect of financial condition. As a rule, the correlation and regression analysis within the framework of econometric modeling is used with a view to identifying dependence among parameters.
The authors propose complementing the current econometric analysis of a set of parameters with the following methods: the Hellwig non-parametric method; the methods of systematizing parameters on the basis of a dendrite building; the hierarchical agglomerative methods; the method of principal components on the basis of factor analysis. A comparative analysis of the latter two methods as well as contrasting them with the discriminate analysis can optimize the parameters under analysis and provide a comprehensive picture of the financial and economic condition of the bank's customer in terms of various parameters such as liquidity, financial stability, business activeness, cost efficiency, and other supplementary characteristics.
Keywords: banking; creditworthiness; discriminate function; financial and economic condition; statistical methods.
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МЕТОДИЧНИЙ ПІДХІД ДО ФОРМУВАННЯ І ОПТИМІЗАЦІЇ СУКУПНОСТІ ПОКАЗНИКІВ ОЦІНКИ КРЕДИТОСПРОМОЖНОСТІ ПІДПРИЄМСТВА
Анотація. Запропоновано методичний підхід до формування та оптимізації сукупності показників оцінки кредитоспроможності підприємства. Економетричний аналіз сукупності показників доповнено методами Хельвіга, дендритним, кластеризації і головних компонент. Здійснено порівняльну характеристику пропонованих методів із використовуваною нині методикою.
Ключові слова: банківська діяльність, кредитоспроможність позичальника, фінансово-економічний стан, дискримінантна функція, статистичні методи.

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МЕТОДИЧЕСКИЙ ПОДХОД К ФОРМИРОВАНИЮ И ОПТИМИЗАЦИИ СОВОКУПНОСТИ ПОКАЗАТЕЛЕЙ ОЦЕНКИ КРЕДИТОСПОСОБНОСТИ ПРЕДПРИЯТИЯ
Аннотация. Предложен методический подход к формированию и оптимизации совокупности показателей оценки кредитоспособности предприятия. Эконометрический анализ совокупности показателей дополнен методами Хельвига, дендритным, кластеризации и главных компонент. Осуществлена сравнительная характеристика предлагаемых методов с используемой методикой.
Ключевые слова: банковская деятельность, кредитоспособность заемщика, финансово-экономическое состояние, дискриминантная функция, статистические методы.

Introduction. Under conditions of market economy during a period of financial instability, it is becoming particularly significant to be able to provide an objective analysis of the financial condition of domestic enterprises and evaluate their creditworthiness. Such an analysis is essential for the effectiveness of crediting activity in general. Creditworthiness evaluation gives the borrowing company an opportunity to estimate its prospects for a loan.

Brief Literature Review. Nowadays the banks of Ukraine use a wide variety of creditworthiness evaluation methods. At the same time, creditworthiness evaluation is subject to the National Bank's Resolution «On introducing the Regulation on developing and using reserves by the banks of Ukraine for the reimbursement of possible losses in active banking operations» [1], which determines the norms of building reserves by commercial banks in case of possible losses in credit operations.

Creditworthiness evaluation methods differ in terms of the number of parameters on the borrower's overall credit rating scale, indicative approaches and the priority given to each of them. If the set of parameters remained universal for all banks and countries, it would be possible to exchange statistics and systematize information on a global scale. However, the fact is that there is no uniformity in the system of parameters across countries, banks or researchers.

The issues of evaluating the creditworthiness of enterprises have been explored by A. Hidulyan [2], L. Hrytsenko [3], O. Derevyahin [4], W. English [5], D. Hunziker [6], A. Daldrup [7] and others; they address the issues of selecting and evaluating a system of parameters used for analyzing the creditworthiness of an enterprise mostly by means of traditional methods such as the horizontal and vertical analysis, the trend analysis, the comparative analysis, the analysis of relative indicators, scores, etc. The traditional financial analysis methods share a common feature in that they involve studying basic mathematical connections among the items of financial reports on the basis of calculating a selection of parameters (financial coefficients), comparing their values with normative values, industry-average indicators and observing them in dynamics. The credit risk evaluation parameters used by national banks have the following common disadvantages: subjectivism in compiling a selection for analysis (overlooking multicollinearity, etc.); ignoring (or being subjective about) the differences in the impact of certain parameters on the overall results of the analysis; using different sets of parameters to identify financial condition, which provides distorted results; failure to take into account all of the financial parameters which influence credit risk; lack of objectivity in report data (manipulating parameters at some management levels); disregarding the parameters which characterize net monetary flow, neutralize the impact of local taxation regulations, depreciation charges, etc.

At present, the discriminant method of evaluating a company's creditworthiness is particularly significant. This issue has been extensively researched by O. Tereshchenko [8]; moreover, this method is the basis for the current Regulation of the National Bank of Ukraine «On Ukraine's banks developing and using reserves for reimbursement of possible losses in active banking operations» [1]. In comparison with the traditional methods, there are obvious advantages to this method. However, it also needs improvement. For instance, as regards the selection of parameters, the following issues remain unresolved: overestimation of qualitative parameters and underestimation of qualitative parameters, uncontrolled selection of a system of basic qualitative parameters, distorting initial data (e.g. financial reports, which is more characteristic of domestic borrowing enterprises), relative cumbersomeness, the influence of many factors which cannot be recorded on declaring an enterprise bankrupt.

Purpose. Proceeding from the topicality of the issues regarding the selection of a creditworthiness evaluation method, it is important to develop and optimize a set of parameters for analyzing the financial condition of a business entity, which is the goal of this research.

Results. As mentioned above, creditworthiness evaluation parameters need to be able to provide a comprehensive analysis of a borrowing company's current condition as well as prospects for its further development with a view to making forecasts which will help to minimize possible financial risks. It should be borne in mind that using an excessive number of financial coefficients may lead to losing time on mathematical and analytical research of functionally interdependent parameters. This, in turn, will considerably reduce creditworthiness evaluation effectiveness.

The basic principle of optimizing the selection of financial parameters is avoiding the duplication of information about a certain aspect of financial condition. As a rule, the correlation and regression analysis within the framework of econometric modeling is used with a view to identifying dependence among parameters. We suggest complementing the current econometric analysis of a set of parameters with the following methods: the Hellwig non-parametric method; the methods of systematizing parameters on the basis of building a dendrite; hierarchical agglomerative methods; the method of principal components on the basis of factor analysis. A comparative analysis of the latter two methods as well as contrasting them with the discriminant analysis can optimize the parameters under analysis and provide a comprehensive picture of the financial and economic condition of the bank's client in terms of various parameters such as liquidity, financial stability, business activeness, cost efficiency, and other supplementary characteristics.

Therefore, let us use the above mentioned methods in order to identify a set of creditworthiness parameters for domestic enterprises in various economy sectors. The list of business entities for analysis was compiled on the basis of the Classification of Economic Activities (CEC), State Code 009:2010. Further statistical analysis involved only big and medium enterprises in the selected sectors. The primary set of variables was built on the basis of selecting the parameters (financial coefficients) listed in the Resolution [1] and identified on the basis of financial reports (Table 1). In our opinion, such an approach will allow to perform a comparative analysis of the proposed methods with the ones already in use [8].

As a result, we built a primary set of data. The next stage of the primary data statistical analysis involved exploring the interrelation among the variables. For this purpose, we built a correlation matrix as well as a matrix of distances calculated according to the formula. $c_{ij} = 1 - r^2_{ij}$, where r^2_{ij} – elements of the correlation matrix. The next step is building a final set of parameters (hereinafter – diagnostic variables) with the help of one of the above-mentioned methods.

The Hellwig non-parametric method is based on studying the coefficients of the correlation matrix [10]. The criterion for selecting variables is the critical value of the correlation coefficient r^*. If its value rises, there will be an increase in the small size classes. A drop in r^* causes a decrease in the number of classes with their growth in size.

The boundary value r^* at the levels of 0.377 and 0.476 is calculated on the basis of the above-mentioned formulas. This

Tab. 1: **Developing a primary set of parameters**

Parameter	Short forms
Coverage coefficient (third level liquidity)	C1
Intermediate coverage coefficient	C2
The coefficient of financial independence	C3
The coefficient of equity coverage of noncurrent assets	C4
Return on equity coefficient	C5
Return on sales coefficient before interest and tax (EBIT)	C6
Return on sales coefficient before interest, taxes, depreciation, and amortization (EBITDA)	C7
Return on assets coefficient	C8
The coefficient of asset turnover	C9
The coefficient of loan capital turnover before interest, taxes, depreciation, and amortization (EBITDA)	C10
The coefficient of investment dynamics	C11
The coefficient of sales dynamics (adjusted)	C12
The share of net income companies in the total number of companies	C13

Source: Developed by the authors

resulted in a set of variables, out of which diagnostic variables were selected – hereinafter they are given in bold type (Table 2).

In both cases, all the variables except for the financial independence, asset turnover and investment dynamics coefficients were concentrated in the first group. Only the second and third groups have different parameters. In our opinion, the most representative is the group for r^* = 0.377 because in it the quantity of variables decreases in each of the next groups.

Tab. 2: **A set of diagnostic variables selected by means of the Hellwig non-parametric method**

Group number	*r**	
	0.377	0.476
1	**K1**, K2, K4, K5, K6, K7, K8, K10, K12, K13	**K1**, K2, K4, K5, K6, K7, K8, K10, K12, K13
2	**K3**, K11	**K3**
3	**K9**	**K9**, K11

Source: Calculated by the authors drawing on the data in [6]

The next method that was used is that of clustering parameters on the basis of building a dendrite. Variables were selected in three stages: building a dendrite, division of the dendrite into parts and selection of representatives of the groups of diagnostic variables. A dendrite is built on the basis of the distance matrix C with the formula $c_{iji} = min\{c_{ij}\}$ [8; 9]. The division of the dendrite into P parts can also be done indirectly with the help of threshold c^*. In the dendrite there is a division among branches, for which the following dependence holds $c_i > c^*$. Like in the previous method, in selecting group parameters the first variable is considered to be diagnostic and the rest of the variables for which the condition holds true are considered supplementary.

Figure is a graphic representation of the dendrite on the basis of the distance matrix. The distances between variables connected by lines are designated above the lines.

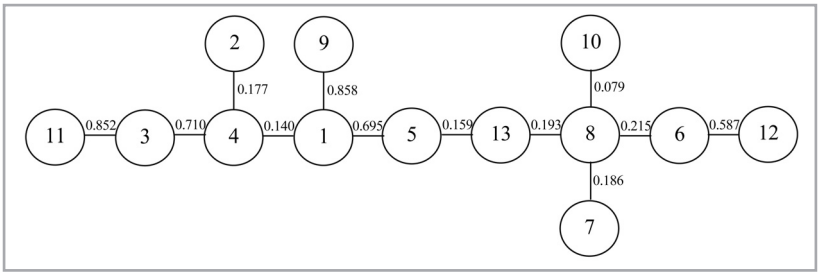

Fig.: **A dendrite for the primary set of variables**
Source: Calculated by the authors drawing on the data in [9]

Then the dendrite is split according to the approaches of the natural division and with the help of the threshold value c^* calculated at u = 0.7 (u – interval value [0.1], the closer to one u gets, the smaller is the number of groups of variables). As a result, we get a selection of representatives of the groups of variables (Table 3).

On the basis of the criteria c^*, we obtained two groups of diagnostic variables, where the division is unsatisfactory in terms of forming a small number of groups. In the third case, the method of division into groups eliminates the disadvantage, and this very division will be used in the analysis that follows. The central variables represent liquidity, financial independence, asset turnover as well as all supplementary coefficients. The cost effectiveness parameters are of secondary importance.

Tab. 3: **A set of diagnostic variables selected by means of constructing dendrites**

Group number	*c**		Natural division
	0.858	0.723	
1	**K1**, K2, K3, K4, K5, K6, K7, K8, K10, K12, K13	**K1**, K2, K3, K4, K7, K8	**K4**, K8, K10
2	**K9,** K11	**K5**, K6, K9, K10, K11, K12, K13	**K13**, K1
3			**K2**, K5
4			**K12**, K6, K7
5			**K3**
6			**K11**
7			**K9**

Source: Calculated by the authors drawing on the data in [9]

Now we proceed to the hierarchical agglomerative methods such as the single-linkage algorithm, the Ward algorithm, the centroid algorithm [12]. Statistica 8.0 was used for the practical implementation of the agglomeration procedure. The analysis of distances between variables allows for identifying four groups presented in Table 4.

The diagnostic variables obtained with the help of the three methods represent groups of liquidity and cost effectiveness coefficients. The indicators of financial independence, turnover and supplementary coefficients do not have representatives in the central variables.

Finally, variables were selected by means of factor analysis. The principal component analysis is one of the varieties of factor analysis. It is based on the assumption that generalized factors are not interdependent [11-12]. Statistica 8.0 was used for determining correlation matrices and further calculations. The evaluation of factor loadings made it possible to identify groups of variables connected with the selected factors, i.e. the most correlated variables with principal components. The findings are presented in Table 5.

Despite the differences in group composition, the coefficients from the groups of liquidity, turnover and supplementary parameters are diagnostic variables in this case. This confirms their importance for research on the financial and economic condition of business entities.

Further analysis employed the characteristics selected by means of the Hellwig method (r^* = 0.377), the dendrite method on the basis of natural split, the Ward method and principal component analysis with a normalized varimax rotation. The next stage involved normalizing the parameters with a view to preventing their aggregation. Then for each group we identified an aggregated parameter of the sector condition, which was used for classifying sectors. The aggregation was done with the help of the formula

$$z_i = \sum_{k=1}^{K} \alpha_k z_{ik}, \quad (i = 1,2,...,N),$$

where z_{ik} – normalized values of parameters,

$$\alpha_k = \frac{\sum_{i=1}^{K} |r_{ki}|}{\sum_{k=1}^{K}\sum_{i=1}^{K} |r_{ki}|}, \quad (k,i = 1,2,...,K)$$ – their weight.

In order to perform a comparative analysis with the existing method, we calculated aggregated creditworthiness evaluation by means of the discriminant method [1; 5]. As a result, we obtained comprehensive characteristics of sectors according to the types of economic activity with the help of five methods (Table 6). Table 6 presents the values of aggregated evaluation, with the rank of a sector given in brackets. The debtor class was determined for the discriminant function (as per [1] from 1 to 9).

The best classification was chosen on the basis of the maximal value of the variation coefficient and the highest degree of relevance to the rest of the classifications. The first criterion ensures a high differentiation of the aggregated parameter and, consequently, a lower probability of error in the calculated ratings. The second criterion allows for the possibility of identifying the rating which is the most similar to the rest of the ratings. In order to do that, the Pearson correlation and the Spearman rank cor-

Tab. 4: **A set of diagnostic variables selected by means of the agglomerative method**

Group number	Single-linkage algorithm	Ward algorithm	Centroid algorithm
1	**K5**, K8, K10	**K5**, K8, K10	**K5**, K8, K10
2	**K2**, K3, K13	**K2**, K3, K13	**K2**, K3, K13
3	**K1**, K4, K9, K11, K12	**K1**, K4, K9, K11, K12	**K1**, K4, K9, K11, K12
4	**K6**, K7	**K6**, K7	**K6**, K7

Source: Calculated by the authors drawing on the data in [9]

relation coefficients were used. In terms of correlation coefficient levels, the factor analysis yielded the most compatible classifications for the model, that is why this model is suggested as an alternative for such a kind of research.

Tab. 5: **A set of diagnostic variables obtained by means of the principal component analysis**

Group number	Principal component analysis, normalized varimax	Principal component analysis, centroid
1	**K13**, K5, K8, K10, K6, K7	**K8**, K7, K10, K6, K5, K13, K4, K2
2	**K2**, K1, K4	**K9**, K12, K11, K3, K1
3	**K11**, K3	-
4	**K9**	-
5	**K12**	-

Source: Calculated by the authors drawing on the data in [9]

To conclude, judging from the analysis of the model built by means of factor analysis, the following sectors were in the best financial and economic condition over the period under study: professional, research, technical, construction, hotels and catering, recreation and sport. Finance, insurance, trade, repair, administrative service and utilities, and transportation have the lowest rating values.

Conclusions. Therefore, the proposed approach to optimizing a set of parameters for evaluating the creditworthiness of domestic enterprises can be used not only by banking institutions (credit experts) but also by enterprise managers with a view to a fast and accurate diagnostics of creditworthiness at the stage of a preliminary consideration of the loan application.

Further research should deal with not only determining the borrower's credit rating but also the possibility of default which correlates with a certain rating. These aggregated parameters can be useful tools of credit risk management because they not only consider the differences naturally arising during the borrower's activity but because they are able to determine the risk level for the near future. Additionally, this will save banks the necessity of developing calculation methods for the everyday monitoring of credit risks.

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Tab. 6: **Comprehensive analysis of sectors in terms of types of economic activity**

Type of economic activity	Code as per CEC	Discriminant function	Hellwig method	Dendrite method	Clustering	Factoring
Agriculture, forestry, fishery	A	0.094(1)	0.037(9)	0.028(1)	0.100(3)	0.021(8)
Industry	B+C+ +D+E	0.019(1)	0.011(4)	0.043(7)	0.120(9)	0.014(6)
Construction	F	0.002(4)	0.088(15)	0.041(4)	0.074(2)	0.062(14)
Wholesale and retail trade; automobile and motorcycle repair	G	0.021(1)	0.014(5)	0.046(10)	0.060(1)	0.004(3)
Transportation, warehousing, postal service, courier service	H	0.023(1)	0.007(2)	0.044(9)	0.138(12)	0.000(1)
Temporary accommodation and food catering	I	0.027(8)	0.061(13)	0.044(8)	0.116(8)	0.040(13)
Information and telecommunication	J	0.041(1)	0.026(6)	0.053(15)	0.123(10)	0.013(5)
Financial and insurance activity	K	0.012(2)	0.009(3)	0.035(2)	0.151(13)	0.007(4)
Real estate operations	L	0.034(9)	0.038(10)	0,043(6)	0.113(7)	0.027(10)
Professional, research and technical activity	M	0.002(4)	0.084(14)	0.036(3)	0.108(5)	0.063(15)
Administrative and utility service	N	0.031(1)	0.003(1)	0.047(12)	0.158(15)	0.003(2)
Education	P	0.050(1)	0.029(7)	0.048(14)	0.153(14)	0.015(7)
Health care and social security	Q	0.004(4)	0.031(8)	0.048(13)	0.123(11)	0.022(9)
Art, sport, entertainment, recreation	R	0.124(9)	0.050(12)	0.046(11)	0.112(6)	0.030(12)
Other services	S	0.003(6)	0.040(11)	0.043(5)	0.107(4)	0.029(11)

Source: Calculated by the authors drawing on the data in [9]