

## THE METHODOLOGICAL FRAMEWORK OF THE DEVELOPMENT OF AN ADEQUATE MODEL OF ESTIMATION OF CREDIT RISK OF THE BANK

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### Abstract

It was considered the modern methods of assessment of credit risk which are used by the foreign banks, in particular, their essence, advantages and disadvantages were discovered in this article. It was proposed and characterized the criteria of judgmental estimate adequacy of the models intended for analysis and forecast of borrower creditworthiness assessment, in particular such criteria as general accuracy of the model, the errors of 1st and 2nd kind, ROC – curve and GINI index.

**Keywords:** Bank, Credit Risk, Borrower Creditworthiness, Borrower Creditworthiness Assessment, Criteria Of The Models Adequacy Assessment

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### Introduction

The necessity of the further mechanisms development of lending to the economy is firstly defined by the circumstance that nowadays under the conditions of economy destabilization one should provide financial support of economic sectors to create new working places, significant part of budget incomings, working out and implementation of innovative production and services with the least state interference. Credit is been used as a necessary element of the country economy stabilization and the only one source of economic growth. Upon that crediting efficiency is defined by the scientific assurance of the points which economic relations between the creditors and the borrowers are based on. According to the official data the part of the problematic credits in the banking sector has increased significantly for two last years and in August, 2015 reached 19,4% of general credit. This dynamics is stipulated by a general state of economic and political situation, ineffective state regulation and unsatisfactory management, disability of the banks to adjust to the crisis and the post-crisis conditions, mainly by complex approaches lack to borrower creditworthiness assessment as a means of the credit risk minimization which is one of the important banking risks, the management of which has definite peculiarities. The important point is that the effective assessment of a certain borrower's credit risk does not only allow the banks to ensure a profit and credit activity efficiency but assists a banking credit to play its role in the money turn-over. Thus, outstanding and unrecovered credits in a certain term increase money stock in the country and arrange for inflation.

According to the above mentioned the potential to borrower creditworthiness assessment has an important significance for next successful of the banking institutions. When the banks choose ineffective methods of assessment, credit risk increases, losses and expenses of banked recourses are likely to grow. That's why the analysis and to borrower creditworthiness assessment should be increased to reduce the risk which can appear in the process of proper borrower's fulfillment of the credit agreement conditions.

The fundamental rudiments of crediting researches and assessment of credit risk are described in the scientific works of the scientists: Y. Blahodyr, V. Bordyug, I. Buchko, I. D'yakonova, N. Verhusha, L. Gerasymenko, M. Degtyareva, A. Dzyublyuk, L. Dadechko, O. Kryklii, Ye. Mordan, L. Pryidun, A. Ursulenko, M. Yurkiv and other. With it despite the fact that the borrower creditworthiness assessment is paid more and more attention as well as in the scientific researches and in the practice, the criteria of the judgmental estimate of the models adequacy being used by banks to analyze borrower creditworthiness are still not studied enough.

The aim of the research is to study modern methods and characteristics of the model adequacy criteria of the borrower creditworthiness assessment.

### Results

The problem of the timely credit reimbursement is urgent for most banks. Its solution significantly depends on potential borrower creditworthiness assessment. Detailed selection of the borrowers according to the ability of calling in a credit, the analysis of the conditions of granting a credit,

permanent control over the financial borrower state are one of the basic components which prevent problematic bank credits.

Today there are a lot of models of the borrower creditworthiness assessment which foreign banks use: microeconomic, financial, market. There are also a lot of methods of the borrower creditworthiness

assessment (ratio analysis, neural network modeling, rating system, complex risk rating, statistical models (parametric, scoring models)), expert methods. Generalized methods evaluation of the borrower creditworthiness assessment is represented in the table 1.

**Table 1.** The peculiarities of the borrower creditworthiness assessment

The name of the method of bankruptcy risk assessment	The essence of the method	Advantages	Disadvantages
Neural Network modeling	Mathematical model is built according to the principle of organization and functioning of the biological neural networks i.e. the neural networks are trained through the training examples and the ratios of the connection between the neurons are found.	<ul style="list-style-type: none"> <li>- independence of the neural networks on the incoming data peculiarities (division type, lineation of the target functions, etc.)</li> <li>- simplicity of the modeling;</li> <li>- problem deficiency of the dimension - neural networks can be dependent even with a lot of variables</li> </ul>	<ul style="list-style-type: none"> <li>- complication of network construction for a concrete task – there is no standard scheme which forces to make the construction in any case from the beginning;</li> <li>- complication of the results interpretations of the training due to explanation inability of the elements parameters in the network in the terms of a current task</li> </ul>
Ratio Analysis)	This method is based on the financial data reporting and includes calculation of one or a few rates.	<ul style="list-style-type: none"> <li>- simplicity and efficiency of the analysis;</li> <li>-trend determination in the changes of the financial company position</li> </ul>	<ul style="list-style-type: none"> <li>- plurality of the proposed ratios; rapid response to the data analysis quality;</li> <li>- cancellation of the methodology which is used to form financial data reporting, in particular, different methods of active asserts valuation, stipulate different values of the financial ratios.</li> </ul>
Rating Systems	Credit rating consists of the components (sometimes integral), received using the expert way or the simplest mathematical operations with reporting data.	<ul style="list-style-type: none"> <li>- complex and system approach to evaluate the probable default due to a scrupulous study of the company;</li> <li>- allows to easy compare the rated companies.</li> </ul>	<ul style="list-style-type: none"> <li>- delay of the rating analysis that's why the rating is made after the financial data reporting of the enterprise and the expert agency expresses its resulting opinion in some time (3-4 months);</li> <li>- as the result the subjectivity of the received evaluation in the expert approach is widely practiced with the transformation of the quality characteristics into quantity ones and the weight categorization in the rating formula</li> </ul>
Statistical models	Are worked out due to the different statistical methods of the classification (discriminant analysis, logit\probit model, regressive analysis, etc. )	<ul style="list-style-type: none"> <li>- a high accuracy of the forecast;</li> <li>- interpretation simplicity of the analysis results</li> </ul>	<ul style="list-style-type: none"> <li>- accuracy of the forecast depends on the choice of the most descriptive variables – financial ratios;</li> <li>- reducing of the statistic credibility of the forecast as for the far future</li> </ul>
Expert Methods	Private criteria are chosen by the experts. The criteria characterize different aspects of the financial stability.	<ul style="list-style-type: none"> <li>- allow to estimate not only a probable bankruptcy of the enterprise but in general a financial state of the company</li> <li>- simplicity and efficiency of the analysis</li> </ul>	<ul style="list-style-type: none"> <li>- subjectiveness of the analysis;</li> <li>- plurality of the proposed ratios</li> </ul>

The disadvantage consists in their unsuitability for borrower creditworthiness assessment in the Ukrainian reality.

PJSC CB “Privatbank” as other Ukrainian banks makes the assessment of the individual credit risk on the ground of the methods worked out by the National Bank of Ukraine. But unfortunately it is not thorough because it does not completely take into account the available economic and political situation in the country.

That’s why we have proposed some criteria of the models adequacy assessment which are intended for the analysis and forecast borrower creditworthiness. Proposed methods can be used by PJSC CB “Privatbank” as well as most of Ukrainian banks.

It’s proposed to the use the following criteria of the models adequacy assessment to analyze the models quality of borrower creditworthiness assessment and to choose the best model for credit risk controlling to prevent from problematic debt growth [2]:

- a common accuracy of the model (CA);
- errors of 1<sup>st</sup> and 2<sup>nd</sup> kind;
- ROC-curve and GINI index.

Common accuracy of the model (CA) is defined as:

$$CA = \frac{\text{CorrectForecast}}{N}, \quad (1)$$

where, CorrectForecast is the quantity of correctly forecasted cases;

N – the common quantity of the cases.

A common accuracy of the model of the borrower creditworthiness assessment is a subjective estimation because it depends on the part of the borrowers defaults of the model and also the cutoff threshold. The model accuracy will also have different values for the different threshold values.

ROC-curve (Receiver Operation Characteristic) – working characteristic of the receiver, shows the dependence of the quantity of the correctly classified positive examples (true borrower creditworthiness assessment) on the wrong classified negative examples (wrong borrower creditworthiness assessment).

In the terminology of ROC- analysis the first ones are called truly positive collection, the second ones – wrong negative collection. In addition it is anticipated that a classifier has a certain parameter and if we vary it we can receive one or another divide into 2 classes. This parameter is often called a threshold or a cut-off value. There will be different errors of 1<sup>st</sup> and 2<sup>nd</sup> kind depending on it.

Let’s see the table of the confusion matrix 2, which is based on the results of the model of the borrower creditworthiness assessment and factual (objective) belonging of the borrowers to the rating classes with probable default.

**Table 2.** Table of the conjunction

	Model forecast: credit reimbursement	Model forecast: Default
Credit reimbursement	Truly classified (TP)	Errors of 2nd kind (FP)
Default	Errors of 1st kind (FN)	Truly classified (TN)

There are the following table designations in this table:

- TP (True Positives) – truly classified positive examples (so called truly positive cases);
- TN (True Negatives) – truly classified negative examples (so called truly negative cases);
- FN (False Negatives) - positive examples classified as negative (the error of 1<sup>st</sup> kind). This is so called “error of omission” – when that thing which we are interested in, is not determined (falsely negative examples);
- FP (False Positives) – negative examples classified as positive (the error of 2<sup>nd</sup> kind). This is a false demonstration that’s why the decision about its availability is falsely made (falsely positive examples).

The following relative rates in percentage are used to analyze model peculiarities of the borrower creditworthiness assessment:

- the part of truly positive examples (True Positives Rate):

$$TPR = \frac{TP}{TP + FN} \quad (2)$$

- the part of falsely positive examples (False Positives Rate):

$$FPR = \frac{FP}{TN + FP} \quad (3)$$

As a rule, there are defined two characteristics for the models of the borrower creditworthiness assessment: sensitiveness and specificity.

The sensitiveness of the model of the borrower creditworthiness assessment is a part of truly positive cases:

$$Se = TPR = \frac{TP}{TP+FN} \quad (4)$$

The specificity of the model of the borrower creditworthiness assessment is a part of truly negative cases which were correctly classified by the model [2]:

$$Sp = \frac{TN}{TN+FP} \quad (5)$$

As far as the visual comparison of ROC- curves does not always allow defining the most effective model borrower creditworthiness assessment, the evaluation of the area under the curves (AUC) is used. They can be calculated, for example, by means of a numerical method of the trapezoids:

$$AUC = \int f(x)dx = \sum [(x_{i+1} + x_i)/2] * (Y_{i+1} - Y_i) \quad (6)$$

One can admit that the more AUC rate, the better the predictive power of the model of the borrower creditworthiness assessment. However one should know that AUC rate is intended for comparative analysis of a few models of the borrower creditworthiness assessment and does not include any information about the level of its sensitiveness and specificity.

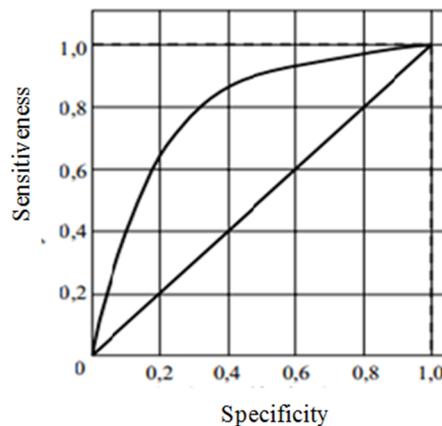
The clearest and more often recollected in the theory parameter of the model quality evaluation of the borrower creditworthiness assessment is GINI index which is tightly connected with the numerical rate of the area under the ROC-curve. GINI index is wide – spread for the model ability estimation of the borrower creditworthiness assessment to divide the clients into prone and not prone to default. If the model is able to estimate the clients in default probability, most clients being prone to default, have to get bigger default probability.

ROC-curve is formed in the following way [3]:

- the values of the sensitiveness Se and the specificity Sp are calculated for each value of the cutoff threshold which is changed from 0 to 1 with the step dx (for example 0,01). As the alternative, the threshold can be each next value of the example in the selection;

- the graph of dependence is constructed: sensitiveness Se is laid off along the axis Y, along the axis X – 100 % – Sp (100% minus specificity) or the same: FPR – the part of falsely positive cases.

**Figure 1.** ROC-curve for the analysis of the models quality of the borrower creditworthiness assessment



The example of the ROC-curve of the borrower creditworthiness assessment is shown on the picture 1.

The range of GINI index values is  $0 < G < 1$ , where the customer being not prone to default, receives the highest value of the ratio. On practice the analysis of the model quality of the borrower creditworthiness assessment significantly depends on

the data which it is constructed on. In general GINI index takes the value higher than 70 % to use scoring (the estimation of the returning customers financial state).

There is the model quality evaluation of the area AUC and GINI index in the table 3.

**Table 3.** Model quality evaluation of the borrower creditworthiness assessment of AUC area and GINI index

Interval AUC	Index GINI	Model quality
0.9-1.0	0.8-1.0	Perfect
0.8-0.9	0.6-0.8	Very high
0.7-0.8	0.4-0.6	Appropriate
0.6-0.7	0.2-0.4	Medium
0.5-0.6	0-0.2	Unsatisfactory

The values of the points of the ROC-curve can be used to find the optimal cutoff threshold – the compromise between the sensitiveness and the

specificity of the model of the borrower creditworthiness assessment.

The criteria of the cutoff threshold can be the following points:

- the demand of the minimal value of the model sensitiveness (the specificity);
- the demand of the maximal value of the total model sensitiveness and the specificity;
- the demand of the balance between the sensitiveness and the specificity, when  $Sp > Se$ .

The ROC-curve graph goes through the upper left angle as for an ideal classifier where the part of truly positive cases is 100% or 1.0 (ideal sensitiveness), and the part of falsely positive examples is equal to zero. That's why the closer the curve to the upper left angle, the higher the ability of the evaluation model forecast of the borrower creditworthiness assessment. Vice versa, the less the knee of the curve and the closer its position to the diagonal straight line, the less effective the model.

The diagonal straight line responds to "the ineffectiveness" of the classifier, i.e. the full inconsistency of two classes.

## Conclusion

The study of the customer creditworthiness is one of the important credit risk reducing and a successful realization of the credit banking policy because it allows to avoid groundless risk at the stage of application processing for credit.

In particular, there is a general assessment of the existing methods of credit risk, also it's defined their essence, advantages and disadvantages in the article. It was considered the following methods such as ratio analysis, neural networks simulation, rating systems, complex risk assessment, statistical models (parametric, scoring models), experts methods. It's defined that almost all above mentioned methods can't be used to estimate the borrower creditworthiness assessment in the national banks activity.

It was proposed and described the criteria which allow evaluating models quality intended to define the banking borrowers' creditworthiness, in particular such as a common accuracy of the model (CA), the errors of 1<sup>st</sup> and 2<sup>nd</sup> kind, ROC-curve and GINI index.

Thus, the adequate methods of the borrower creditworthiness assessment will allow to reduce the probable borrower duties neglect, to minimize possible financial losses in case of borrower duties neglect, to reduce the quantity and a large scale of subprime credit operations, to take appropriate measures in case of risk and to produce the profitability and the efficiency of credit operations for the bank.

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