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CREDIT RISK MANAGEMENT MODEL IN THE ENTREPRENEURIAL ACTIVITIES OF THE BANK

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Abstract

The article shows the development of the model for credit risk management of the bank. The authors propose to use a set of characteristics of borrowers-individuals to calculate the level of credit risk of the Bank. Each characteristic is specified and receives a quantitative score. The total number of borrower score shows degree of credit risk of the Bank. Characteristics of borrowers are factors of credit risk for the Bank. The relationships between these factors are evaluated by verbal numerical scale of Harrington. The data obtained about the factors of credit risk of the Bank allow to build a linear dynamic model for the system with discrete time. Further studies should be conducted towards the use of cognitive modeling in the construction of analytical models for managing other types of risks of commercial banks.

Keywords: **Commercial Bank, Management, Credit Risk, Cognitive Model, Scale of Harrington**

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INTRODUCTION

The credit risk of the commercial Bank is a type of financial risks. Financial risk refers to the probability of financial loss to the organization for various reasons. Financial loss may be associated with unnecessary increased costs, lower incomes, lower profits, losses, capital reduction, and inability to repay its obligations. Any factors, both internal and external (including acts or omissions of a business entity) that affect the conditions and results of operations of the organization, can be causes and sources of financial risk [1]. Factors of financial risks are divided into internal and external. The internal factors of financial risks arising from banking activities include:

- Inefficient structure of liabilities, assets, own capital of the Bank;
- Ineffective strategy of the Bank;
- Lack of professional staff;
- Poor economic security of the Bank.

External factors and sources of financial risk are the adverse processes and phenomena in the external environment over which the Bank has no influence. These processes and phenomena can be of different nature: political, social, legal, economic and financial, competitive, information.

The list of banking risks contains: credit risk, interest rate risk, equity risk, currency risk, liquidity risk, risk of loss, risk reduction of capital to dangerously low levels, the risk of insolvency [2].

Credit risk is the probability of default by the borrower of the Bank of its obligations under the loan agreement. Bank should gradually gather and organize information about the selected object of study to develop a model of credit risk management. The selection of the underlying factors and causal relations between them and the corresponding variables are defined by results of the analysis of the information-analytical database [3] and expert survey. The basis of information-analytical database research is publications of specialists in the banking sector, the documents of the Central Bank of Russia [4].

LITERATURE REVIEW

Theoretical basis of the research consists of scientific works of the authors involved in the study of this issue. Among the Russian sources it is assessment of experience of

Russian banks [5], the data of official agencies [6], including government agencies [7].

Credit risk management of banks acquired relevance in the XVIII-XIX centuries [8]. Modern foreign experts consider credit and banking risks in connection with the problems of state property management [9]. Tsuruta [10] evaluates the role of information aspect for small business lending. Mulder et al. [11] take into account risks apply when assessing the financial capacity of the bank. Pastor [12] considers the credit risk in identifying the effectiveness of European banking system as a whole. Much attention is also paid to the problem of regulation of credit, labor and business banking activities in the European Union [13], risk management in international banking markets [14].

The literature highlights the importance of adequate coverage and risk sharing [15]. Experts note the need for a clear statement of objectives and a clear system of delegation of authority [16]. Credit and other records and documents used as a basis for banking operations must be of high quality [17]. Banks should carefully monitor risks when entering into credit agreements [18,19]. Information and control in banks should focus on risk reduction [20,21]. The effectiveness of the services involved in reduction of losses from the bank's lending operations should be improved [22-24]. Introduction of financial instruments and services specifically designed to take control of the risks assessed as a response to the crisis [25-27].

Credit agreements constitute loan portfolios of banks. Banks create various financial instruments to minimize their potential losses through the purchase and sale of individual “risk packets" [28].

RESEARCH METHODOLOGY

Requirements to identify key trends and prospects in the Russian banking system, taking into account international experience define the research methodology. Methods of economic and statistical analysis, methods of theory of economic modeling, system approach and methodological pluralism [29] are key components of the methodology employed.

Possibility of reducing the credit risk in the entrepreneurial activities of the bank is based on an integrated approach. Entrepreneurial activity is the creation of a new capital [30]. Entrepreneurial activity of the bank is the creation of a new financial capital. Concepts and fuzzy linguistic variables are used to describe the factors of reducing the credit risk. Harrington scale is used to quantify the interactions of factors. Cognitive map is constructed to reflect the causal structure of credit risk (Figure 1). Simulation occurs at the conceptual and mathematical level.

RESULTS

On the basis of the Regulations on the procedure of formation of a commercial Bank reserves for possible losses on loans, loan and similar debts and the chosen strategy

planning to build the model in the entrepreneurial activities [31] of the bank are considered complex features (concepts) (Table 1).

Figure 1: Cognitive Map.

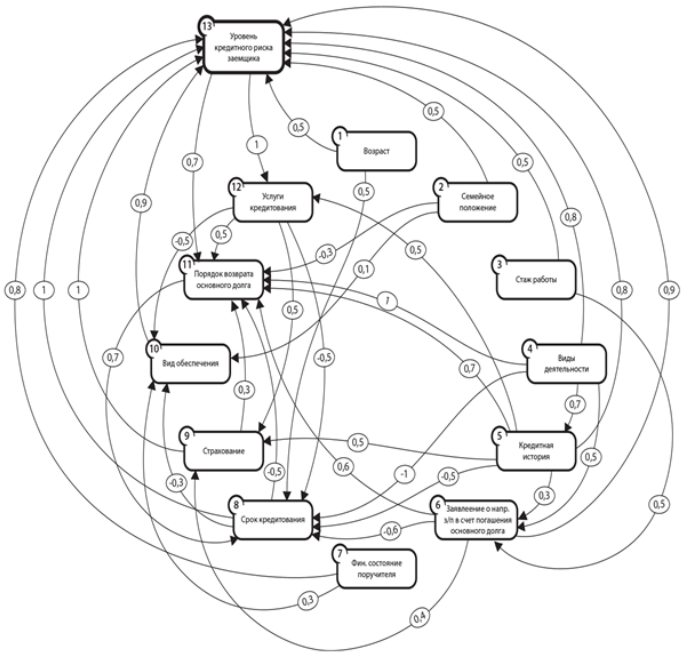


Table 1: Specifications for calculating the level of credit risk of the borrower (natural person).

Variables	Specifications
x1	1 Age
x2	2 Marital Status
x3	3 Work Experience
x4	4 Activity
x5	5 Credit History
x6	6 The Use a Salary to Pay a Debt
x7	7 The Financial Condition of the Guarantor
x8	8 Loan Period
x9	9 Insurance
x10	10 Type of Security
x11	11 The Procedure of Repayment of Principal
u1	12 Lending Services
u2	13 The Level of Credit Risk of the Borrower

Description of the linguistic variables in Table 2 allows giving them quantitative characteristics.

Table 2: Calculation of the level of credit risk of the borrower (natural person).

The name of the criterion	The number of points for calculation of reserve
1 Age	
30-50	3
50-55	2
18-30, more than 55	1
2 Marital Status	
Married	3
Unmarried	2
Divorced/civil marriage	1
3 Work Experience	
Less than 6 months	1
From 6 up to 1 year	2
More than 1 year	3
4 Activity	
Own business	3
Employment in the category of the head	2
Employment in the category of employee or technical staff	1
5 Credit History	
Positive	2
Positive in other banks	1
No	0
6 The Use a Salary to Pay a Debt	
Yes	1
No	0
7 The Financial Condition of the Guarantor	
Good/average	1
Bad	0
8 Loan Period	
up to 1 year and 1 year	2
more than 1 year	1
9 Insurance	
Insuring the collateral in favor of the Bank	2
Insuring the collateral in favor of the borrower	1
Life insurance in favor of the Bank	2
Life insurance in favor of the borrower	1
No insurance	0
10 Type of Security	
Deposit 1 or 2 quality category	2
Guarantee	1

The name of the criterion	The number of points for calculation of reserve
No	0
11 The Procedure of Repayment of Principal	
Monthly	3
Quarterly	2
Otherwise/at the end of the period	1
12 Lending Services	
The interest rate on the loan	3
The package of documents for loan	2
13 The Level of Credit Risk of the Borrower	

The amount of risk on loans is determined by the amount of points of credit risk of the borrower according to Table 3.

The decision on issuance of credit is accepted on the basis of these data and the results of the security check, the legal Department and is at the discretion of the head units of the Bank. The notions of fuzzy and linguistic variables are used to describe factors. All the factors and, accordingly, their changes have a quantitative measurement.

Table 3: Category quality risk.

Estimation	Category quality risk		
The number of points	**Non-standard**	**Doubtful**	**Problematic**
9 and more	1	21	51
8	1,5	22	52
7	2	23	53
6	3	25	55
5	4	27	57
4	5	30	60
3	7	35	70
2	10	40	80
1	15	45	90
0	20	50	100

Very often it is difficult to assess how the factors influence each other. In this case there is not sufficient quantitative information about the nature of relationships, as the concepts are linguistic value and they have no numeric interpretation. For this purpose, it is necessary to operate the qualitative interaction, that is, to use the qualitative assessment of "highly, moderately, and poorly".

To establish causal relations used scale to assess the nature (positive or negative) and strength of the relationship between the underlying factors. The values of the relevant variables are defined in linguistic scale in the interval [-1;1]. Harrington scale is used to quantify the relationships (Table 4).

Table 4: Scale for the formalization of the force of impact between concepts.

Scale Item	Interpretation in terms of the impact
0	Influence is not
0,1	Minimal (almost no)
0,3	Weak
0,5	Average
0,7	Significant
0,9	Strong
1	Maximum
0,2; 0.4; 0.6; 0.8	Intermediate levels

The relationship of the factors gets a quantitative assessment on the verbal-numerical scale of Harrington. The numeric values have universal application and can be used for this qualitative indicator in the framework of the object. Table 5 presents the matrix of factors adjacency.

The next step establishes causal relationships between factors (augmentative communication, destructive communication).

Table 5: Matrix of Factors Adjacency.

S. No	Criterias	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Age	1							0,5					0,5
2	Marital Status		1						0,5					0,5
3	Work Experience			1			0,5							
4	Activity				1	0,7	0,5		-1			1		
5	Credit History					1	0,3		-0,5	0,5		0,7	0,5	0,8
6	The Use a Salary to Pay a Debt						1		-0,6	0,4		0,6		0,9
7	The Financial Condition of the Guarantor							1			-0,2			0,8
8	Loan Period								1		-0,3	-0,5		1
9	Insurance									1				1
10	Type of Security										1			0,9

11	The Procedure of Repayment of Principal								0,7			1		
12	Lending Services								-0,5	0,5	-0,5	0,5	1	
13	The Level of Credit Risk of the Borrower											0,7	1	1

The next step establishes causal relationships between factors (augmentative communication, destructive communication).

Mutual influence of factors is estimated from a position of "positive, negative". Communication can be of two types. A positive relationship is a relationship that shows that the increase of the first factor leads to an increase in the second, and vice versa. A negative relationship is a relationship, which shows that the increase in the value of the first factor leads to a decrease in the value of the second.

The data of Table 5 can be visualized using cognitive maps.

The data of Table 5 characterize the interrelation of the basic factors of credit risk. They also reflect the impact of each factor on the final result. All this allows determining the size of the risk on loans.

The process of cognitive modeling occurs at two levels: conceptual and mathematical. The original model is formed as a set of concepts and causal relationships between them. Then we develop a mathematical model.

Denoting *x1*, *x2*, *x3*, *x4*, *x5*, *x6*, *x7*, *x8*, *x9*, *x10*, *x11* and *u1*, *u2*, respectively, the values of concepts (age, marital status, work experience, activities, credit history, the use a salary to pay a debt, the financial condition of the guarantor, term lending, insurance, type of security, order, return of principal, lending services, the credit risk of the borrower in relative units), we build an analytical model of the form:

$$x+=Ax+Bu,\ y=Cx \qquad (1)$$

$$A=\begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0.5 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0.5 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0.7 & 0.5 & 0 & -1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0.3 & 0 & -0.5 & 0.5 & 0 & 0.7 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & -0.6 & 0.4 & 0 & 0.6 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0.5 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0.3 & -0.5 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0.3 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}, \qquad (2)$$

C=(0 0 0 0 0 0 0 0 0 0 1),

with vector $x = \begin{pmatrix} x1 \\ x2 \\ x3 \\ x4 \\ x5 \\ x6 \\ x7 \\ x8 \\ x9 \\ x10 \\ x11 \\ \end{pmatrix}$,

The values of the vector x will be marked with superscript “+“after transformation by the matrix A.

Model (1) is a classic representation of a linear dynamic system with discrete time. Stability is a necessary condition for using this model in practice. It is known [32] that the linear discrete system is stable if the eigenvalues of a matrix lie inside the unit circle.

Find the eigenvalues of the matrix (2), using the operator "eigenvals" software package MathCad [33]. From the calculation results, it follows that all eigenvalues equal to one and, therefore, model (1) is on the boundary of stability. Model (1) can be used to assess possible changes in some of the concepts with relevant changes in the other. For example, the relative change of the concept "credit history" (variable) is equal to 0.2; the remaining concepts remain unchanged. This corresponds to the vector:

$$x = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0.2 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

Multiplying the matrix A to the right by vector x will receive:

$$x^{+} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0.14 \\ 0.2 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

This would correspond to equation (1), excluding the management components Bu.
Thus, the relative change of the concept "credit history" of 0.2 will result in a relative change of the concept of "activities" by 0.14. Note that the subsequent multiplication of the received vector by the matrix on the left (excluding the management components Bu) gives twice the value of the concept of "activities" of the vector, i.e., subsequent changes to the values of other concepts, including the concept of "credit history" does not occur. Thus, the Bank can respond to these changes differently and respectively to select the optimal response to these changes.

Changes of concepts *x1* "age", *x2* "marital status", *x3* "work experience", *x4* "activities" *x5* "credit history" *x7* "financial condition of the guarantor" does not lead to changes in other concepts, which allows the Bank to respond to changes in the values of these concepts.

Changes of concepts *x3* "work experience", *x4* "activities" *x5* "credit history" leads to changes in the value of the concept *x6* "the use a salary to pay a debt" that obligates the Bank to clarify the details of this statement in light of the new formed conditions.

Changes of concepts *x1* "age", *x4* "activities", *x5* "credit history", *x6* "the use a salary to pay a debt" entails changing concept x8 " loan period" that allows the Bank to revise the credit terms, based on the new conditions.

Changes of concepts x5 "credit history", x6 "the use a salary to pay a debt" changes the value of the concept x9 "insurance" and the Bank should review the terms of insurance in this situation.

Changes of concepts *x7* "financial condition of guarantor", *x8* "term loans" affects the value of the concept *x10* "type of security" and the Bank should respond to this change.

Changes of concepts *x4* "activities", *x5* "credit history", *x6* "the use a salary to pay a debt", *x8* "term loans", *x9* "insurance" leads to changes in the value of the concept *x11*

"return of principal" indicates the necessity for timely response in this matter.

Using the second equation of model (2) we get:

$$y = Cx = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0.2 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0.2 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

Thus, the change of the concept *x5* "credit history" will require the Bank review of lending services (change of concept *x12* "service credit"). When changing insurance conditions, the Bank needs to carefully review the credit history of the borrower and statement of direction wages for repayment of the principal debt, do they meet the insurance conditions and the level of credit risk.

Consider what happens with vector x^+ when you change the management components (Bu). Management components (Bu) can be changed. As can be seen from Table 2, the control concept *x12* "service credit" has two meanings: "Interest rate" with the value "3" and "documents" with the value "2". Construct matrix B with number of columns equal to the number of values of the concept *x12* "service credit" given the weight of the influence of this concept on the concepts of the system. Construct matrix U with the number of rows corresponding to the number of values of the given concept, the values of which will be the value of the concept *x12* "service credit".

$$B = \begin{pmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0.2 & 0 \\ 0.5 & 0.4 \\ 0 & 0.3 \\ 0.6 & 0.2 \\ 0 & 0.4 \\ 0 & 0.5 \\ 0.7 & 0.3 \end{pmatrix}, \; U = \begin{pmatrix} 3 \\ 2 \end{pmatrix}$$

As a result we get:

$$x^{+} = Ax + BU = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0.14 \\ 0.8 \\ 2.3 \\ 0.6 \\ 2.2 \\ 0.8 \\ 1 \\ 2.7 \end{pmatrix}$$

When you change the matrix U:

$$U_1 = \begin{pmatrix} 0 \\ 0 \end{pmatrix},\ U_2 = \begin{pmatrix} 0 \\ 2 \end{pmatrix},\ U_3 = \begin{pmatrix} 3 \\ 0 \end{pmatrix},\ U_4 = \begin{pmatrix} 3 \\ 2 \end{pmatrix}$$

x^{+} accordingly accepts the following values:

$$x_1^{+} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0.14 \\ 0.2 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix},\ x_2^{+} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0.14 \\ 0.2 \\ 0.8 \\ 0.6 \\ 0.4 \\ 0.8 \\ 1 \\ 0.6 \end{pmatrix},\ x_3^{+} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0.14 \\ 0.8 \\ 1.5 \\ 0 \\ 1.8 \\ 0 \\ 0 \\ 2.1 \end{pmatrix},\ x_4^{+} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0.14 \\ 0.8 \\ 2.3 \\ 0.6 \\ 2.2 \\ 0.8 \\ 1 \\ 2.7 \end{pmatrix}.$$

It is seen that adding the control components Bu changes the values of the following concepts: *x6* "the use a salary to pay a debt", *x7* "financial condition of guarantor", *x8* "term loans", *x9* "insurance", *x10* "type of security", *x11* "return of principal".

DISCUSSION OF THE RESULTS

In the theory of banking there are 3 main groups of uncertainties arising in the process of activities of credit organizations. The first group includes the uncertainty about the

state of the credit institution and the external environment. The second group of uncertainties was related to selection of indicators quality assessment of solutions (alternatives). The third group consists of the uncertainty associated with the forecast consequences of decisions.

The tasks with the uncertainty of such groups can be reduced to specific purposes after the removal of uncertainty [34]. One of the methods of removal of uncertainty is a subjective rating of a specialist (expert, leader). Expert determines its preferences and represents the only possible basis for combining the heterogeneous physical parameters of a problem to be solved in a single model which would allow assessing the adopted management decisions. The implementation of this method entails a number of difficulties. The subjective difficulties are the most multicriteria decision-making problems, particularly the control of the subject due to his professional and life experience and psychological characteristics. In addition to the subjective component in the decision-making in many criteria there is objective component, which includes the limitations of the external and internal environment on possible solutions.

These difficulties can be solved. Problems are solved with the application of particular management technologies. These technologies are the cognitive approach and management decisions on the criterion of maximization of the mathematical expectation of utility. Models, methods and software tools that are used in the implementation of this technology have made it possible to formalize semi-structured problems of decision-making about control actions on risks in the banking activities.

Cognitive analysis is the basis of the cognitive approach. Cognitive analysis involves construction of cognitive maps models of banking risks and their factors. Cognitive maps allow you to combine elements of internal and external banking environments in a single system, and also provide an opportunity to analyze the system as a whole and its separate components without losing the relationships between them.

In practice, the construction of these models is based on the results of expert assessments. The following operations are performed in the process of building cognitive maps:

- Allocation and justification of the system of risks of the credit institution, the greatest influence on the stability of its functioning and development;
- Discovery of causal relationships between the selected sources of risk factors;
- Evaluation of nature impact (positive, negative or zero) of risk factors on each other in relation to the challenge of effective management.

The presented method allows solving the problem of formalization of the procedures for the justification of choice-making and decision support for managing the risks in activities of credit organizations through the implementation of procedures and cognitive modeling probabilistic models of the decision task on the criterion of maximization of the mathematical expectation of utility.

Cognitive modeling of the process of banking risk management in the credit organization allows:

- To identify and to formalize the causal relationships that exist between the main internal risk of credit institutions, internal and external sources of their origin;
- To take into account the conditions of the rapid variability of factors of external and internal environment of the organization;
- To predict the occurrence of various situations, to analyze them and to take adequate measures for effective management.

Cognitive modeling allows obtaining a sufficient number of realizations of random processes. The existence of such implementations makes it possible to put and solve the problem of finding the optimum face value for choosing the "best" of a random process, which can later be adopted as the desired strategy for the development of the test object [35].

CONCLUSION

Using cognitive modeling in the construction of an analytical model for credit risk management allows the Bank to take into account all influencing factors and criteria (conceptual modeling level). Bank also takes into account the parameters of their influence and control points (mathematical modeling level). This allows the Bank to respond to certain changes in the factors and criteria and to foresee the consequences, to prepare for them. Further studies should be conducted towards the use of cognitive modeling in the construction of analytical models for managing other types of risks of commercial banks.

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