DOI: 10.55643/fcaptp.2.49.2023.4025

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Received: 13/03/2023
Accepted: 12/04/2023
Published: 30/04/2023

DEVELOPMENT OF THE MODEL FOR FORECASTING INDICATORS OF BANKING MICROCREDITING OF SMALL BUSINESS ENTITIES

ABSTRACT

In the context of the need to rebuild the economy of Ukraine, one of the important tasks is to support domestic business structures in terms of providing them with a sufficient amount of financial resources for the development of competitive business. The article proposes a model for forecasting the main indicators of microcrediting of small business entities carried out by domestic commercial banks, defines its functional structure and main structural components. In the process of analysis, basic, easy-to-calculate and adapt models of forecasting indicators of microcrediting of small business subjects by domestic banks were used using linear regression, which made it possible to establish the influence of certain types of banking products on complex indicators of microcrediting. Calculations were made on the basis of data obtained as a result of a survey of employees of commercial banks (JSB "Ukrgasbank", JSC "Idea Bank", JSC "Kredobank", JSC "ProCredit Bank") and their clients - representatives of small businesses. Based on the results of the analysis, the forecast values of the specific weight of specific microcredit products in the portfolios of the four investigated banks were determined.

The optimization parameters of the bank's microloans portfolio are substantiated. The calculation and optimization of the overall efficiency of the bank and its portfolio of microloans were carried out. It has been proven that this method makes it possible to adjust the placement of bank funds in different areas of activity in order to minimize risk at a satisfactory level of bank performance in general.

The authors have developed and proposed for use at all levels of the credit system a risk level optimization model: for each individual microcredit contract; for each individual type of microcredit; for the microcredit portfolio of each individual bank. The proposed risk optimization models are simple and universal, it is possible and appropriate to use them at any stage of the credit process.

Keywords: microcredit, credit portfolio, credit products, regression models, Markowitz curve, risk

JEL Classification: C50, C53, C80, E43, G24

INTRODUCTION

According to the estimates of scientists and practicing economists, the share of own financial resources in the structure of sources of financial support of small business entities is on average 35-40% [1, p. 18-19]. Consequently, own financial resources are insufficient, so the development of small enterprises requires the search and consolidation of financial resources due to their involvement in external and internal financial markets. According to analysts, in the structure of external sources of financing, the share of accounts payable is the largest (49-54%), which is evidence of the suboptimality of their formation given the fact that in highly developed countries, the accounts payable of small enterprises lies within 15-20%, and loans bank funds and loans make up 45-55% [2, p. 43].

One of the most common ways of raising funds in the world for small businesses is bank lending. The interest of banks in the development of small businesses is determined by

the prospect of expanding the market for their services at the expense of a new sector of the economy and a number of advantages that lending to small businesses has compared to large ones. Special microcredit programs are being developed to take into account the entire spectrum of features of small business lending.

"In the economic literature, microcredit is usually understood as the process of providing small business entities (usually small businesses and private entrepreneurs) with small (up to UAH 50,000) loans by banking and non-banking institutions on the basis of payment, term and repayment" [3, p. 38]. "In banking practice, a loan amount from 100 to 50,000 US dollars is considered a microcredit" [4, p. 81]. Each bank determines the upper limit independently.

It should be noted that microcredit is also considered a loan issued to an individual for consumer purposes or the purchase of a certain product (consumer lending at points of sale of household appliances, mobile phones, furniture, etc.). However, in the article, we consider microcredit as a service for small business entities.

LITERATURE REVIEW

P. Druker [5], G. Mankiv [6], P. Samuelson [7] examined the issue of consideration of conditions, principles of functioning, principles and functions of small entrepreneurship in their works. Classical economists, such as A. Marshall [8], Zh.-B. Sey [9], A. Smith [10], F. Hayek [11], J. Schumpeter [12] devoted their works to the study of the content and role of entrepreneurship in the market economy.

Domestic economic science in the context of research into the essence of microcredit and the possibility of conditions for its provision for the development of entrepreneurship is represented by the works of O. Baranovskyi [13], P. Buryak [14], Z. Varnaliya [15], V. Korneev [16] and others.

O. Vovchak [17], A. Kuznyetsova [18], V. Oparin [19], A. Poddyerogin [20] and others were engaged in the study of financial support for the functioning and development of small business, including its microcrediting.

These scientists considered a whole range of attracting financial resources for the functioning of small business structures, namely: "obtaining loans from entrepreneurship support funds; obtaining loans from banks; receiving state loans; loans from friends, relatives, relatives, trusted financial structures; obtaining state guarantees for attracting off-budget investments; receiving equity state investments; attraction of loans and investments of state firms; attracting loans and investments from international financial institutions and small business development support programs; obtaining loans from credit unions; guarantee of lending; financing from regional budgets and the budgets of districts and cities for the implementation of regional programs to support small businesses" [21, p.89].

Varnaliy Z. interprets microcredit as "a specific form (variety) of lending to small business entities. The peculiarity of a microloan, in his opinion, is that it is limited in size (from several hundred dollars to 10-15 thousand dollars), does not require collateral, is provided within three days for a short period (from several months to a year), can be allocated even to those entrepreneurs who do not have a credit history" [15, p. 26].

Modern economists highlight the following features of microcredit:

- "focusing on specific groups of clients: start-up companies or those planning to expand; small enterprises that do not have access to other sources of financing, etc.;
- the possibility of using such a non-traditional type of security as a group guarantee, i.e. the formation of credit groups, the members of which mutually guarantee the return of received loans;
- step-by-step issuance of loans - from a small amount to a large one;
- customer service is carried out without requirements regarding the results of their previous economic activity" [28, p. 62].

Despite numerous developments, the problem of financial support of small businesses with the help of microcredits continues to be the subject of discussion and research by theoreticians and practitioners.

AIMS AND OBJECTIVES

The purpose of this scientific article is to improve the mechanism of microcrediting of small businesses by banking institutions based on the development of a model for forecasting indicators of bank microcrediting of small business entities. To realize the goal, the following tasks were set and solved:

DOI: 10.55643/fcaptp.2.49.2023.4025

- develop a model for forecasting indicators of microcrediting for a commercial bank, propose its functional structure and determine the main structural components;
- determine the parameters for optimizing the portfolio of microloans of a commercial bank.

METHODS

To achieve the defined goal and solve a number of interrelated tasks, a number of scientific methods were used in the work, such as: abstract-logical - when summarizing and formulating conclusions; economic-mathematical – when modelling the calculation of the need for microloans of small enterprises; generalization - when identifying common and specific features of microcredit; graphic interpretation - to visualize the received data; observation - to obtain initial information.

In the process of analysis, the simplest models for forecasting indicators of microcrediting of Ukrainian banks were used, as well as regression linear models of the influence of individual types of credit products on generalized indicators of microcrediting.

RESULTS

The market environment of the functioning of banks, their close relationship with all economic agents introduces an element of uncertainty regarding the final results of the activity. And therefore, in the process of ensuring its successful long-term development, forecasting of the financial results of the banking institution's activity occupies an important place as one of the most important tools of the bank's financial development strategy.

The effectiveness of the credit policy is determined by the correct choice of the parameters of credit relations, among which the most important are: the amount of the loan interest; loan availability conditions for small business clients; credit risk level; loan term, etc. The parameters of microcredit should be built in such a way as to stimulate the final results of the economic activity of commodity producers.

We will consider the simplest models for forecasting indicators of microcrediting of individual banks of Ukraine, as well as regression linear models of the influence of individual types of credit products on generalized indicators of microcrediting.

To do this, first of all, we will summarize the results of the survey of employees of commercial banks and their clients - representatives of small businesses (Tables 1-5).

Table 1. Shares of microcredits in the assets of individual banks as of January 1, 2018-2022.

Indexes, %	I half 2018	II half 2018	I half 2019	II half 2019	I half 2020	II half 2020	I half 2021	II half 2021	I half 2022	II half 2022
Ukrgasbank	4.4	10	17.5	25	26.6	30	37.2	56	59.4	66
Idea Bank	44.8	46	42.7	40	41.1	46	44.3	46	50.0	59
Credobank	54.1	55	52.7	56	54.0	53	52.7	55	49.8	55
Procreditbank	50.9	53	56.2	59	61.5	63	60.8	64	66.1	67

Table 2. Structure of the loan portfolio of JSB "Ukrgasbank" by types of loan products as of January 1, 2018-2022.

Types of credit products	Years, %									
	I half 2018	II half 2018	I half 2019	II half 2019	I half 2020	II half 2020	I half 2021	II half 2021	I half 2022	II half 2022
1. To replenish working capital	35	40	42	40	38	40	48	50	55	60
2. Express - credit	29	40	40	40	41	40	34	30	26	20
3. Investment loan	-	-	-	-	-	-	-	-	-	0,5
4. Pledge of property rights to funds placed on a deposit account	-	-	-	-	-	-	0.02	0.1	0.3	0.5
5. Other	36	20	18	20	21	20	18	19.9	18.7	19
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 3. Structure of the loan portfolio of JSC "Idea Bank" by types of loan products as of January 1, 2018-2022.

Types of credit products	Years, %									
	I half	II half	I half	II half	I half	II half	I half	II half	I half	II half

	2018	2018	2019	2019	2020	2020	2021	2021	2022	2022
1. To replenish working capital	65	70	74	80	78	75	75	80	82	75
2. Express - credit	11	20	14	10	12.5	15	18	10	12	15
3. Investment loan	-	-	-	-	-	-	-	-	-	-
4. Pledge of property rights to funds placed on a deposit account	-	-	-	-	-	-	-	-	-	-
5. Other	24	10	12	10	9.5	10	7	10	6	10
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 4. Structure of the credit portfolio of JSC "Kredobank" by types of credit products as of January 1, 2018-2022.

Types of credit products	Years, %									
	I half 2018	II half 2018	I half 2019	II half 2019	I half 2020	II half 2020	I half 2021	II half 2021	I half 2022	II half 2022
1. To replenish working capital	54	45	37	35	33	35	29	25	18	15
2. Express - credit	15	20	27	30	23	30	38	40	46	50
3. Investment loan	-	-	-	-	-	-	-	-	-	-
4. Pledge of property rights to funds placed on a de-posit account	30	30	30	30	27	30	32	35	36	35
5. Other	1	5	6	5	17	5	1	-	-	-
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 5. Structure of the loan portfolio of JSC "ProCredit Bank" by types of loan products as of January 1, 2018-2022.

Types of credit products	Years, %									
	I half 2018	II half 2018	I half 2019	II half 2019	I half 2020	II half 2020	I half 2021	II half 2021	I half 2022	II half 2022
1. To replenish working capi-tal	80	80	55	50	50	50	54	50	58	50
2. Express - credit	20	20	45	50	50	50	46	40	30	30
3. Investment loan	-	-	-	-	-	-	-	-	-	-
4. Pledge of property rights to funds placed on a deposit account	-	-	-	-	-	-	-	5	4	5
5. Other	-	-	-	-	-	-	-	5	8	15
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Based on the data of Tables 1-5, using the "STATGRAPHICS" application program package, we will calculate the dynamics of microcrediting of individual banks of Ukraine and the dynamics of credit products of individual banks of Ukraine (Tables 6-7).

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Table 6. Dynamics of microcredit of individual banks of Ukraine, %. *(Source: compiled by the authors based on data [24-27])*

Year, half-year	y_1	y_2	y_3	y_4
2018, 1	4.4	44.8	54.1	50.9
2018, 2	10	46	55	53
2019, 1	17.5	42.7	52.7	56.2
2019, 2	25	40	56	59
2020, 1	26.6	41.1	54.0	61.5
2020, 2	30	46	53	63
2021, 1	37.2	44.3	52.7	60.8
2021, 2	56	46	55	64
2022, 1	59.4	50.0	49.8	66.1
2022, 2	66	59	55	67

Table 7. Dynamics of loan products of individual banks of Ukraine, %. *(Source: compiled by the authors based on data [24-27])*

Year, half-year	y_5	y_6	y_7	y_8
2018, 1	35	29	65	11
2018, 2	40	40	70	20
2019, 1	42	40	74	14
2019, 2	40	40	80	10
2020, 1	38	41	78	12.5
2020, 2	40	40	75	15
2021, 1	48	34	75	18
2021, 2	50	30	80	10
2022, 1	55	26	82	12
2022, 2	60	20	75	15
Year, half-year	**y9**	**y10**	**y11**	**y12**
2018, 1	54	15	80	20
2018, 2	45	20	80	20
2019, 1	37	27	55	45
2019, 2	35	30	50	50
2020, 1	33	23	50	50
2020, 2	35	30	50	50
2021, 1	29	38	54	46
2021, 2	25	40	50	40
2022, 1	18	46	58	30
2022, 2	15	50	50	30

Notes for Tables 6-7: y_1 – the share of microloans in the assets of JSB "Ukrgasbank", %; y_2 – the share of microloans in the assets of JSC "Idea Bank", %; y_3 – the share of microloans in the assets of JSC "Kredobank", %; y_4 – the share of microloans in the assets of JSC "ProCredit Bank", %; y_5 – the share of the loan to replenish the working capital of the loan portfolio of JSB "Ukrgasbank", %; y_6 – the share of express credit in the loan portfolio of JSB "Ukrgasbank", %; y_7 – the share of the loan to replenish the working capital of the loan portfolio of JSC "Idea Bank", %; y_8 – the share of express credit in the credit portfolio of JSC "Idea Bank", %; y_9 – the share of the loan to replenish the working capital of the credit portfolio of JSC "Kredobank", %; y_{10} – the share of express credit in the credit portfolio of JSC "Kredobank", %; y_{11} – the share of the loan to replenish the working capital of the JSC "ProCredit Bank" loan portfolio, %; y_{12} – the share of express loans of the loan portfolio of JSC "ProCredit Bank", %.

Linear ($\tilde{y}^{ln}$), parabolic ($\tilde{y}^{pr}$) and exponential ($\tilde{y}^{exp}$) trend models of the studied indicators of microcredit have the form:

$\tilde{y}_1^{ln}$ = -4,54667 + 6,86485*t (1)

$\tilde{y}_1^{pr}$ = 1,67833 + 3,75235 + 0,28296* t (2)

$\tilde{y}_1^{exp}$ = exp {1.78054 + 0.26650*t} (3)

$\tilde{y}_2^{ln}$ = 39.65533 + 1.15212*t (3.1) (4)

$\tilde{y}_2^{pr}$ = 50.0533 – 4.04788*t + 0.47273*t^2 (5)

$\tilde{y}_2^{exp}$ = exp {3.69435 + 0.02335*t} (6)

$\tilde{y}_3^{ln}$ = 54.6533 - 0.16788*t (7)

$\tilde{y}_3^{pr}$ = 54.8533 – 0.26788*t + 0.009091* t^2 (8)

$\tilde{y}_3^{exp}$ = exp {4.00127 + 0.003237*t} (9)

$\tilde{y}_4^{ln}$ = 50.7333 + 1.71212*t (10)

$\tilde{y}_4^{pr}$ = 48.0667 + 3.04545*t – 0.12121* t^2 (11)

$\tilde{y}_4^{exp}$ = exp {3.93366 + 0.028992*t} (12)

$\tilde{y}_5^{ln}$ = 31.6 + 2.4*t (13)

$\tilde{y}_5^{pr}$ = 39.2667 – 1.43333*t + 0.34848* t^2 (14)

$\tilde{y}_5^{exp}$ = exp {3.50321 + 0.051819*t} (15)

$\tilde{y}_6^{ln}$ = 42.2667 – 1.50303*t (16)

$\tilde{y}_6^{pr}$ = 26.4333 + 6.41364*t-0.71970 * t^2 (17)

$\tilde{y}_6^{exp}$ = exp {3.77878 - 0.05036*t} (18)

$\tilde{y}_7^{ln}$ = 69.2 + 1.27727*t (19)

$\tilde{y}_7^{pr}$ = 61.95 + 4.75227*t – 0.32954 * t^2 (20)

$\tilde{y}_7^{exp}$ = exp {4.23561 +0.1547*t} (21)

$\tilde{y}_8^{ln}$ = 14.2 - 0.08182*t (22)

$\tilde{y}_8^{pr}$ = 14.3667 – 0.16515*t – 0.007576* t^2 (23)

$\tilde{y}_8^{exp}$ = exp {2.61287 – 0.003158*t} (24)

$\tilde{y}_9^{ln}$ = 53.1333 – 3.73333*t (25)

$\tilde{y}_9^{pr}$ = 54.3 – 4.31667*t + 0.05303* t^2 (26)

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$\tilde{y}_9^{exp}$ = exp {4.1001 – 0.12368*t} (27)

$\tilde{y}_{10}^{ln}$ = 12.1333 + 3.59394 * t (28)

$\tilde{y}_{10}^{pr}$ = 15.3833 + 1.96894 * t + 0.14773 * t^2 (29)

$\tilde{y}_{10}^{exp}$ = exp {4.2.74692 + 0.11882*t} (30)

$\tilde{y}_{11}^{ln}$ = 72.2667 – 2.64848 * t (31)

$\tilde{y}_{11}^{pr}$ = 92.1833 – 12.6068*t + 0.90530 * t^2 (32)

$\tilde{y}_{11}^{exp}$ = exp {4.26232 – 0.04077*t} (33)

$\tilde{y}_{12}^{ln}$ = 34 + 0.74545 * t (34)

$\tilde{y}_{12}^{pr}$ = 2.91667 + 16.2871*t – 1.41288* t^2 (35)

$\tilde{y}_{12}^{exp}$ = exp {3.39713 + 0.03423*t} (36)

Predicted values of indicators of credit activity of individual banks of Ukraine and corresponding estimates are presented in Table. 8–9.

Table 8. Forecast values and corresponding estimates of microcredit indicators of some Ukrainian banks, %.

Indicator	Indicator forecast		ME	MSE	MAE
	for 2023, 1st semester	for 2023, 2nd semester			
$\tilde{y}_1^{ln}$	70.967	77.831	0	14.5422	3.2254
$\tilde{y}_1^{pr}$	**77.192**	**87.452**	0	10.3149	2.6056
$\tilde{y}_1^{exp}$	111.281	145.265	-0.6929	54.9678	5.2530
$\tilde{y}_2^{ln}$	52.327	53.479	0	15.0720	3.1725
$\tilde{y}_2^{pr}$	**62.727**	**69.552**	0	3.2727	1.6112
$\tilde{y}_2^{exp}$	51.998	53.226	0.1561	14.5356	3.0569
$\tilde{y}_3^{ln}$	52.807	52.639	0	2.5976	1.3204
$\tilde{y}_3^{pr}$	**53.007**	**52.949**	0	2.5932	1.3204
$\tilde{y}_3^{exp}$	52.756	52.585	0.0246	2.5982	1.3221
$\tilde{y}_4^{ln}$	69.567	71.279	0	1.9288	1.1897
$\tilde{y}_4^{pr}$	**66.900**	**67.158**	0	1.1530	0.8164
$\tilde{y}_4^{exp}$	70.286	72.353	0.0159	2.2880	1.3287

Table 9. Forecast values and corresponding estimates of microcredit indicators of some Ukrainian banks, %.

Indicator	Indicator forecast		ME	MSE	MAE
	for 2023, 1st semester	for 2023, 2nd semester			
$\tilde{y}_5^{ln}$	58.000	60.400	0	11.6400	2.8000
$\tilde{y}_5^{pr}$	**65.667**	**72.248**	0	5.2279	1.8618
$\tilde{y}_5^{exp}$	58.746	61.870	0.1316	9.6941	2.4408
$\tilde{y}_6^{ln}$	25.733	24.230	0	30.7624	4.3964
$\tilde{y}_6^{pr}$	**9.900**	**-0.239**	0	3.4139	1.4891
$\tilde{y}_6^{exp}$	25.148	23.913	0.4774	34.5898	4.6520
$\tilde{y}_7^{ln}$	81.600	82.727	0	12.7564	3.0618
$\tilde{y}_7^{pr}$	**74.350**	**71.523**	0	7.0223	2.1391
$\tilde{y}_7^{exp}$	81.922	83.199	0.0852	13.0915	3.0757
$\tilde{y}_8^{ln}$	13.300	13.218	0	10.0073	2.6582
$\tilde{y}_8^{pr}$	**13.467**	**13.476**	0	10.0042	2.6582
$\tilde{y}_8^{exp}$	13.172	13.131	0.3462	10.1399	2.6542
$\tilde{y}_9^{ln}$	12.067	8.333	0	8.6533	2.5200
$\tilde{y}_9^{pr}$	**13.233**	**10.136**	0	8.5048	2.5624
$\tilde{y}_9^{exp}$	15.480	13.679	0.0705	9.8525	2.6504
$\tilde{y}_{10}^{ln}$	51.667	55.261	0	10.1297	2.4824
$\tilde{y}_{10}^{pr}$	**54.917**	**60.283**	0	8.9774	2.3051
$\tilde{y}_{10}^{exp}$	57.628	64.899	0.1456	9.0489	2.3742
$\tilde{y}_{11}^{ln}$	43.133	40.485	0	73.3406	7.4945
$\tilde{y}_{11}^{pr}$	**63.050**	**71.265**	0	30.0671	4.5321
$\tilde{y}_{11}^{exp}$	45.325	43.515	0.5923	70.1034	7.1483
$\tilde{y}_{12}^{ln}$	42.200	42.945	0	127.905	10.4800
$\tilde{y}_{12}^{pr}$	**11.117**	**-5.092**	0	22.5047	3.8764
$\tilde{y}_{12}^{exp}$	43.540	45.057	1.8572	136.524	10.9870

Here $\tilde{y}_i^{ln}$, $\tilde{y}_i^{pr}$, $\tilde{y}_i^{exp}$ (i – 1, 2, ...,12) – theoretical or averaged values of microcredit indicators of individual banks of Ukraine;

ME – the average value of the error;

MSE – root mean square error value;

MAE – the mean absolute error.

The closer the value of the average error (ME), mean square error (MSE) and mean absolute error (MAE) is to zero, the better or more likely is the forecast of the studied indicator of microcredit.

Based on the data of Tables 8-9, the following conclusions can be drawn.

The best forecast of the share of microloans in the assets of JSB "Ukrgasbank" is obtained on the basis of the parabolic trend model (2):

$\tilde{y}_{1,2010,1}^{fcst}$ = 77.192% and $\tilde{y}_{1,2010,2}^{fcst}$ = 87.452%.

The best forecast of the share of microloans in the assets of JSC "Idea Bank" is obtained using the parabolic trend model (5):

$\tilde{y}_{2,2010,1}^{fcst}$ = 62.727% and $\tilde{y}_{2,2010,2}^{fcst}$ = 69.552%.

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The forecast of the share of microloans in the assets of PJSC "Kredobank" was obtained on the basis of the parabolic trend model (8):

$\tilde{y}^{fcst}_{3,2010,1}$= 53.007% and $\tilde{y}^{fcst}_{3,2010,2}$= 52.949%

is quite close to the forecast obtained on the basis of linear (7)

$\tilde{y}^{fcst}_{3,2010,1}$= 52.807% and $\tilde{y}^{fcst}_{3,2010,2}$= 52.639%

and exponential (9)

$\tilde{y}^{fcst}_{3,2010,1}$= 52.756% and $\tilde{y}^{fcst}_{3,2010,2}$= 52.585%

trend models, respectively.

The best forecast of the share of microloans in the assets of JSC "ProCredit Bank" is obtained using the parabolic trend model (11):

$\tilde{y}^{fcst}_{4,2010,1}$= 66.9% and $\tilde{y}^{fcst}_{4,2010,2}$= 67.158%.

The best forecast of the loan share for replenishment of working capital in the credit portfolio of JSB "Ukrgasbank" is obtained on the basis of the parabolic trend model (14):

$\tilde{y}^{fcst}_{5,2010,1}$= 65.667% and $\tilde{y}^{fcst}_{5,2010,2}$= 72.248%.

The best forecast of the share of express credit in the loan portfolio of JSB "Ukrgasbank" is obtained on the basis of the parabolic trend model (17):

$\tilde{y}^{fcst}_{6,2010,1}$= 9.9% and $\tilde{y}^{fcst}_{6,2010,2}$= -0.239%.

The best forecast of the loan share for replenishment of working capital in the loan portfolio of JSC "Idea Bank" is obtained using the parabolic model (20):

$\tilde{y}^{fcst}_{7,2010,1}$= 74.35% and $\tilde{y}^{fcst}_{7,2010,2}$= 71.523%.

Forecast of the share of express credit in the loan portfolio of JSC "Idea Bank", obtained on the basis of the parabolic trend model (23):

$\tilde{y}^{fcst}_{8,2010,1}$= 13.467% and $\tilde{y}^{fcst}_{8,2010,2}$= 13.476%

is quite close to the prediction obtained using linear (22)

$\tilde{y}^{fcst}_{8,2010,1}$= 13.300% and $\tilde{y}^{fcst}_{8,2010,2}$= 13.218.

and exponential (24)

$\tilde{y}^{fcst}_{8,2010,1}$= 13.172% and $\tilde{y}^{fcst}_{8,2010,2}$= 13.131.

trend models.

Forecast of the share of credit for replenishment of working capital of JSC "Kredobank", obtained using the parabolic trend model (26):

$\tilde{y}^{fcst}_{9,2010,1}$= 13.233% and $\tilde{y}^{fcst}_{9,2010,2}$= 10.136%

is similar to the forecast obtained on the basis of the linear trend model (25):

$\tilde{y}^{fcst}_{9,2010,1}$= 12.067% and $\tilde{y}^{fcst}_{9,2010,2}$= 8.333%.

The best forecast of the share of express credit in the credit portfolio of JSC "Kredobank" is obtained using the parabolic trend (29):

$\tilde{y}^{fcst}_{10,2010,1}$= 54.917% and $\tilde{y}^{fcst}_{10,2010,2}$= 60.283%.

The best forecast of the loan share for replenishment of working capital in the loan portfolio of JSC "ProCredit Bank" is obtained on the basis of the parabolic model (32):

$\tilde{y}^{fcst}_{11,2010,1}$= 63.050% and $\tilde{y}^{fcst}_{11,2010,2}$= 71.265%.

The best forecast of the share of express credit in the loan portfolio of ProCredit Bank JSC is obtained using the parabolic trend model (35):

$\tilde{y}^{fcst}_{12,2010,1}$= 11.117% and $\tilde{y}^{fcst}_{12,2010,2}$= -5.092%.

Using the data in Tables 1-2, we will form linear even and multiple regression equations of the dependence of the general indicators of microcredit on individual types of credit products. The corresponding regression equations have the following form:

$\tilde{y}_1$= -75.40652 + 2.42448 * y_5;

R^2 = 0.86218; F = 50.0487 (37)

$\tilde{y}_1$= -90.81411 + 2.59008 * y_5 + 0.23495 * y_6;

R^2 = 0.86492; F = 22.4111 (38)

$\tilde{y}_u$= 113.89177 – 0.67401 * y_{11} + 0.38980 * y_{12};

R^2 = 0.8709; F = 23.,6143 (39)

The reliability or plausibility of regression models (37-39) is confirmed both by the values of the multiple coefficients of determination *R2*, which are close to 0.9, and by the values of *F* - Fisher's test, which are greater than the corresponding tabular values

F (α = 0.5; ν_1 = 1; ν_2 = 7) = 5.59 < 50.05;

F (α = 0.5; ν_1 = 2; ν_2 = 6) = 5.14 < 22.4 and 23.6,

where: α - level of significance, ν_1 = m-1 – number of degrees of freedom, ν_2 = n-m-1 – denominator, m – the number of factors of the regression model,n – the volume of the input sample.

Consider the econometric interpretation of the regression coefficients.

The value of the regression coefficients *b1 = 2.42448* of the regression equation (37) shows that with an increase in the share of credit for replenishment of working capital of the loan portfolio *y5* by 1%, an increase in the share of microloans in the assets of JSB "Ukrgasbank" (*y1*) is expected to increase by 2.42448% on average.

The analysis of the multiple regression equation (38) shows that with an increase in the share of credit for replenishment of working capital (*y5*) by 1% and some constant or average value of the share of express credit in the credit portfolio (*y6*), an increase in the share of microloans in the credit portfolio of JSB "Ukrgasbank" is expected in on average by 2.59%; with an increase in the share of express credit in the credit portfolio (*y6*) by 1% and some constant or average value of the share of credit for replenishment of working capital (*y5*) will lead to an increase in the share of microloans in the assets of JSB "Ukrgasbank" by an average of 0.23495%.

Analysis of the multiple regression equation (39) shows that an increase in the share of credit for replenishment of working capital (*y11*) and the share of express credit (*y12*) will lead to a decrease in the share of microloans in the assets of JSC "ProCredit Bank". In particular, with an increase in the share of credit for replenishment of working capital (*y11*) by 1% and some constant or average value of the share of express credit (*y12*), a decrease in the share of microloans in JSC "ProCredit Bank" assets is expected by an average of 0.674%. And with an increase in the share of express credit in the loan portfolio (*y12*) by 1% and some constant or average value of the share of credit for replenishing the working capital of the loan portfolio (*y11*), a decrease in the share of microloans in the assets of JSC "ProCredit Bank" is expected by an average of 0.3898 %.

Obviously, the bank will be interested in the calculation of efficiency in such a direction of its activity as microcredit. And on the basis of the received data - calculation and optimization of the overall efficiency of the bank and its portfolio of microloans.

DOI: 10.55643/fcaptp.2.49.2023.4025

Let the bank conduct activities in *N* directions. Let *S* denote the total amount of funds invested by the bank in these *N* directions.

The overall efficiency of the bank's work is defined as the sum of the efficiency of activity in each area with the corresponding weighting coefficients.

It is natural to assume that *Ei* are random variables. Then the distribution of *Ei* for each can be obtained by analyzing the activities of the bank in the *i-th* direction for several previous years.

Let's denote the average expected efficiency of activity in each direction by *Mi*:

$$M_i = M(E_i)$$

We also consider the variance *Ei* and denote it as

$$D(E_i) = \sigma^2{}_i$$

The greater the variance, the greater the probability that the actual performance of the *i-th* direction will differ from the average expected one. Therefore, the mean square deviation can be considered a risk. It should also be noted that under risk we will understand both a decrease and an increase in interest income.

Therefore, under such assumptions, the average expected efficiency of the bank is equal to:

$$M[E] = E(\sum_{i=1}^{N} \alpha_i E_i) = \sum_{i=1}^{N} \alpha_i M_i \quad (40)$$

and the variance (risk) of overall banking efficiency –

$$D[E] = D\left(\sum_{i=1}^{N} \alpha_i E_i\right) = \sum_{j,i=1}^{N} \alpha_i \alpha_j \, cov\left(E_i, E_j\right) \quad (41)$$

where cov(E_i,E_j) – covariance, or the strength of the relationship between efficiencies in the i-th and j-th areas of activity.

Therefore, when distributing the total amount of initial cash flows between directions according to the vector *(α_1, …, α_N)*, we have the average expected efficiency in the amount of *M[E]* at risk *D[E]*.

It is clear that the bank will be interested only in those cases in which it will receive maximum efficiency from microcrediting with minimal risk. Therefore, we should solve the optimization problem (42) with respect to the vector *(α_1, …, α_N)*.

$$\begin{cases} M[E] = \sum_{i=1}^{N} \alpha_i M_i = \tilde{E} \\ D[E] = \sum_{i,j=1}^{N\Sigma} \alpha_i \alpha_j \, cov(E_i E_j) \to min \\ \alpha_1 + \ldots + \alpha_N = 1 \\ \alpha_i \geq 0, i = 1..N \end{cases} \quad (42)$$

where α – runs through all valid values between the smallest average expected efficiency by directions and the largest.

After solving problem (42), we get the so-called Markowitz curve, which consists of optimal distributions of funds by direction. That is, if we want to distribute expenses by *N* directions of banking activity in order to obtain the average expected efficiency of the bank's activity *E1* with the least risk of its deviation from the forecast, then for this it is necessary to distribute funds by directions in accordance with the vector of weighting coefficients *(α1 , … , αN)*.

It should be noted that when solving similar problems in practice, in most cases it is not necessary to construct the entire Markowitz curve. It is sufficient to determine the most realistic efficiency of work *E1*, and to solve problem (42) in relation to it. Unfortunately, in practice, the results obtained are not always satisfactory, because very often it turns out that a certain line of activity has to be completely or almost completely curtailed, which is not always advisable for the bank, since the efficiency of work is not determined only by financial efficiency, but also by marketing policy etc. Especially in the case of microcredit. Therefore, in practice, when solving problem (42) for a specific institution, it is also necessary to introduce certain restrictions on αi. In this way, the problem will take the following general form [22]:

$$\begin{cases} M[E] = \sum_{i=1}^{N} \alpha_i r_i = \tilde{E} \\ D[E] = \sum_{i,j=1}^{N\sum} \alpha_i \alpha_j cov(E_i E_j) \to min \\ \alpha_1 + \ldots + \alpha_N = 1 \\ \alpha_1 \geq A1; \ldots . \alpha_N \geq AN \end{cases} \quad (43)$$

Therefore, this method makes it possible to adjust the placement of bank funds in various areas of activity in order to minimize risk at a satisfactory level of bank performance in general.

As an example of the optimal distribution of funds between areas of activity, consider a bank engaged in lending to small businesses. Let the main directions of microcrediting be:

- 1. Express - lending - New road construction projects.
- 2. Lending to small businesses to replenish working capital - Lending to motor vehicle enterprises.
- 3. Long-term financing of means of production - Lending to the railway.
- 4. Lending to small businesses for the purpose of purchasing equipment - Investing in innovative projects.
- 5. Lending to small businesses for the purpose of purchasing a car for use in business activities - Activities on the securities market.

At the same time, the bank's policy and its marketing strategy provide that for each of the five types of microcredit listed above, the initial cash flows should be at least 10% of the total amount of funds for small business financing. That is, in the optimization problem (43), the last constraint takes the form:

$\alpha_1 \geq 0{,}1;\ \alpha_2 \geq 0{,}1;\ \alpha_3 \geq 0{,}1;\ \alpha_4 \geq 0{,}1;\ \alpha_5 \geq 0{,}1;$

In Table 10, indicators of the performance of each of the directions for the past 7 years are given.

Table 10. Performance indicators of the bank for various types of microcredit.

Direction	2016	2017	2018	2019	2020	2021	2022
1	0.988	0.990	0.990	1.236	1.000	1.000	1.000
2	2.000	1.980	2.203	1.095	1.095	3.961	3.939
3	1.100	1.150	1.400	1.230	1.300	1.199	1.150
4	1.541	1.600	1.600	1.969	2.358	2.624	1.100
5	1.453	1.667	1.962	1.500	3.015	1.340	2.425

Using formulas (44) and (45) to calculate the mathematical expectation and the covariance matrix based on the sample from the Table. 10:

$$M[E_i] = \frac{1}{5}\sum_{j=1}^{5} E_i^j \quad (44)$$

$$cov(E_i, E_j) = \frac{1}{5}\sum_{l,k=1}^{5}(E_i^l - M[E_i])(E_j^k - M[E_j]), \quad (45)$$

we get the following results (Table 11):

Table 11. Calculation of mathematical expectation *M[Ei]*.

	Mathematical expectation *M[Ei]*
$M[E_1]$	1.029
$M[E_2]$	2.325
$M[E_3]$	1.218
$M[E_4]$	1.827
$M[E_5]$	1.909

DOI: 10.55643/fcaptp.2.49.2023.4025

The covariance matrix of the work efficiency of individual areas has the form (Table 12):

Table 12. Calculation of the covariance matrix of work efficiencies of individual areas of the bank's activity.

	1-st	2-nd	3-rd	4-th	5-th
1-st	0.007	-0.040	0.000	0.006	-0.013
2-nd	-0.040	1.220	-0.031	-0.071	-0.104
3-rd	0.000	-0.031	0.009	0.012	0.020
4-th	0.006	-0.071	0.012	0.230	-0.018
5-th	-0.013	-0.104	0.020	-0.018	0.320

The values of this matrix are the values of the covariance between the efficiency of the *i*-th and *j*-th directions (*i, j*=1..5).

Having now solved the optimization problem (43) for the obtained data under the above-mentioned restrictions, we will obtain the following optimal distribution of funds (Table 13):

Table 13. Calculation of the optimal distribution of funds. (Note: *M[E]* is the average expected efficiency of the bank's microcredit work; *min D[E]* is the minimum variance for this efficiency; *R* is the degree of riskiness. Next, in the corresponding lines, data on the proportions in which cash flows should be divided by directions with the aim of achieving minimal risk).

M [E]	min D[E]	R	α_j	Δ_2	α_2	α_3	α_4
1.340	0.0109	0.077	0.6	0.1	0.1	0.1	0.1
1.440	0.015	0.085	0.279	0.1	0.36724	0.131076	0.121886
1.540	0.025	0.102	0.1	0.1	0.443991	0.194608	0.161401
1.640	0.03	0.105	0.1	0.11783	0.302083	0.260773	0.219314
1.740	0.054	0.133	0.1	0.138258	0.162044	0.324371	0.275326
1.840	0.094	0.166	0.1	0.257799	0.1	0.23287	0.309331
1.940	0.25	0.257	0.1	0.472244	0.1	0.1	0.227756
1.990	0.41	0.321	0.1	0.6	0.1	0.1	0.1

We also note that the minimum possible efficiency of the bank under these restrictions will be equal to 1.34 with a degree of risk of 0.077, and the maximum is 1.99 with a degree of risk of 0.32.

So, for this case, the Markowitz curve will look like Figure 1.

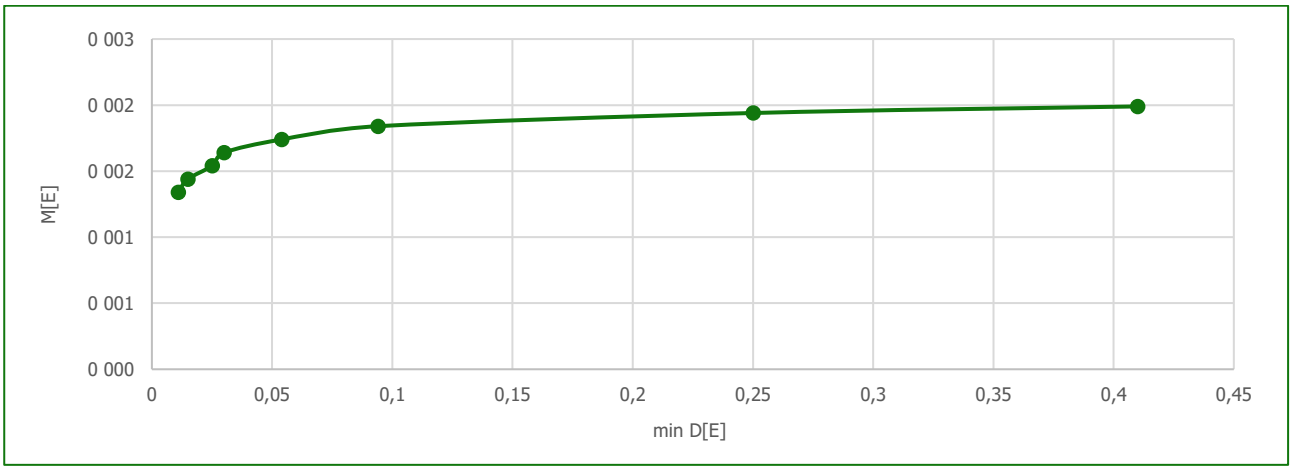

Figure 1. Markowitz curve

From the shape of the curve, we can see that the degree of risk increases very strongly when the efficiency becomes slightly greater than 1.7. Therefore, it is possible to advise credit experts and financial analysts of the bank to work

precisely with such efficiency, and at the same time, in the appropriate manner described above, to optimally distribute the flows of funds for various types of microcredit.

It is worth noting that the problem of regulating and optimizing the credit risk of small business entities is largely reduced to the creation of an adequate methodology for assessing the quality of a specific loan. This technique involves the formalization of credit analysis procedures and credit decision-making procedures.

We have developed the following microcredit risk optimization models:

- a model for optimizing the level of risk in relation to a specific microcredit contract;
- a model for optimizing the level of risk in relation to a specific type of microcredit;
- a model for optimizing the risk level of a specific bank's microcredit portfolio.

Let's consider them in more detail.

The risk level optimization model for a specific microcredit contract is built on the basis of the factors we have identified that affect the reliability of the borrower. In general, this model can be represented as a linear programming problem [22]:

$$y_i = f(x_i) = \sum_{i=1}^{n} a_i \cdot x_i \to min$$

restrictions:

- x_i\geq0;
- dependencies between factors;
- ai=1,

where n – number of microcredit contracts (number of micro borrowers), i – a specific borrower, x_i – a specific factor, y_i – the risk level of the contract, a_i – parameters characterizing the i-th factor (level of annual gross income, duration of business activity, number of employees, availability of own and/or leased real estate used in production activities, cost of security).

The risk level optimization model for a specific type of microcredit is built on the basis of the established risk levels according to the previous model [23].

$$Z_j = F(y_i) = \sum_{j=1}^{m} b_j y_i \to min$$

restriction:

- $y_i \geq 0$;
- dependencies between priorities of types of microcredits;
- $\sum b_j = 1$,

where m – the number of types of microcredit, j – specific type of microcredit, y_i – the level of riskiness of the i-th microcredit contract, bj – parameters of priority types of microcredit (profitability, demand from micro borrowers, processing speed, need for collateral), Zj – the risk level of the jth type of microcredit.

A model for optimizing the risk level of a specific bank's microcredit portfolio:

$$P = Q(Z_j) = \sum_{k=1}^{e\Sigma} c_k z_j \to min$$

restrictions:

- $Z_j \geq 0$;
- $\sum c_k = 1$;
- the ratio between the types of microcredit,

DOI: 10.55643/fcaptp.2.49.2023.4025

where e – the total number of portfolio components, к – a specific component of the portfolio, ск - the weight coefficient of the portfolio component (by types of credit products, by terms of use, by types of activities of micro-borrowers, by risk groups), Zj - the level of riskiness of the type of microcredit, P – the overall level of riskiness of the microcredit portfolio.

Let's consider how each of the developed models works.

1. A model for optimizing the level of risk in relation to a specific microcredit contract.

$$y_i = f(x_i) = \sum_{i=1}^{n} a_i \cdot x_i \rightarrow min$$

Let's consider three credit agreements for small business customers for different credit products. Data on each of them are included in Table. 14. So, according to the initial data, we will consider the level of risk for each microcredit contract:

Loan agreement №1 – y1 = 240.0*0.3 + 278.0*0.25 + 0*0.2 + 5*0.15 + 5*0.1 = 147.2.

Loan agreement №2 – y2 = 87.0*0.3 + 123.8*0.25 + 1*0.2 + 3*0.15 + 1*0.1 = 57.8.

Loan agreement №3 – y3 = 183.5*0.3 + 385.2*0.25 + 1*0.2 + 7*0.15 + 3*0.1 = 152.9.

Loan agreement №4 – y4 = 380*0.3 + 591*0.25 + 0*0.2 + 4*0.15 + 11*0.1 = 263.45.

Thus, taking into account that this function (as an indicator of the risk level of a specific credit agreement) should be the lowest of the four considered, the lowest level of risk is credit agreement №2 - level 1. While credit agreement №1 - level 2, credit agreement №3 is level 3, and loan agreement №4 is level 4, the maximum level of risk.

Table 14. Information on credit contracts for solving the problem of optimizing the level of risk in relation to a specific microcredit contract. *(Source: compiled by the authors based on the data of the conducted survey)*

x_i	Loan agreement №1 (express loan)	Loan agreement №2 (express loan)	Loan agreement №3 (for replenishment of working capital)	Loan agreement №4 (for replenishment of working capital)	a_i, the importance of each factor x_i, $\sum a_i = 1$
The level of the entrepreneur's annual gross income, thousand UAH	240.0	87.0	183.5	380.0	0.3
The cost of the proposed provision, thousand UAH	278.0	123.8	385.2	591.0	0.25
Availability of own and/or rented real estate (yes = 1, no = 0)	0	1	1	0	0.2
The term of the client's business activity, years	5	3	7	4	0.15
Number of employees, people	5	1	3	11	0.1

2. A model for optimizing the level of risk in relation to a specific type of microcredit.

$$Z_j = F(y_i) = \sum_{j=1}^{m} b_j y_i \rightarrow min$$

Calculations according to this model are based on the results of the research conducted by the authors. Data on the parameters of priority types of microcredit are given in Table 15.

Table 15. Parameters of priority types of microcredit. *(Source: compiled by the author based on the data of the conducted survey)*

Types of microcredit	bj, the importance of each factor j, $\sum b_j = 1$
To replenish working capital - profitability	0,6
Express - credit - processing speed	0,4

Taking into account the previously calculated level of credit risk of each credit agreement, we will determine the level of risk for a specific type of microcredit:

Express loans – Z1 = 0.4*147.2 + 0.4*57.8 = 82.

To replenish working capital – Z2 = 0.6*152.9 + 0.6*263.45 = 249.8.

Therefore, taking into account the condition of the model, according to which the value of the risk level should be as small as possible, the minimum level of risk in loans that are provided according to the order of express lending. Thanks to this model, the bank can maximally advertise and promote the least risky type of microcredit on the market.

3. A model for optimizing the risk level of a specific bank's microcredit portfolio.

$$P = Q(Z_j) = \sum_{k=1}^{e\Sigma} c_k z_j \to min$$

In this model, the parameters obtained by us during preliminary calculations are used - this is the level of riskiness of this type of microcredit. When working with the third model, we calculate the level of risk for a loan portfolio classified by two types of microloans - for replenishment of working capital and express lending.

Based on previous calculations, the rate of interest for express loans is equal to 0.25, and for loans to replenish working capital - 0.75.

P = 0.25*82 + 0.75*249.8 = 207.9

Thus, after calculating this indicator for the bank's loan portfolio, classifying loans according to various characteristics (by terms of use, by types of customer activity, etc.), it is possible to optimize the risk level of the overall portfolio of a particular bank.

DISCUSSION AND CONCLUSION

The method used in the article makes it possible to adjust the placement of bank funds in different areas of activity in order to minimize risk with a satisfactory level of bank performance in general. It allows credit experts and financial analysts of any bank to work with high efficiency, and at the same time, taking into account the proposed mathematical methodology, to optimally distribute the flows of funds in various areas of microcredit [29].

The risk level optimization model developed and proposed for use at all levels of the credit system allows:

- in relation to a specific microcredit agreement - to determine the level of risk for a specific microborrower, especially if several credit agreements have been concluded with the client. Based on the results of the analysis, the bank can determine whether it is worth working with such a borrower in the future;
- with regard to a specific type of microcredit - to advertise and sell to the bank the least risky type of microcredit on the market as much as possible;
- regarding the microcredit portfolio of a specific bank - after calculating this indicator for the bank's credit portfolio, classify loans according to various characteristics (by terms of use, by types of customer activities, etc.), and optimize the risk level of the overall portfolio of a specific bank.

The risk level optimization models proposed and considered in the article are simple and universal, do not require specific mathematical knowledge from the bank's credit specialists, and since we inductively moved from one borrower to the bank's portfolio in general, it is possible and appropriate to use them at any stage of the credit process.

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РОЗРОБКА МОДЕЛІ ПРОГНОЗУВАННЯ ПОКАЗНИКІВ БАНКІВСЬКОГО МІКРОКРЕДИТУВАННЯ СУБ'ЄКТІВ МАЛОГО БІЗНЕСУ

В умовах необхідності відбудови економіки України одним із важливих завдань є підтримка вітчизняних підприємницьких структур у частині забезпечення їх достатньою кількістю фінансових ресурсів для розвитку конкурентного бізнесу. У статті запропоновано модель прогнозування основних індикаторів мікрокредитування суб'єктів малого підприємництва, здійснюваного вітчизняними комерційними банками, визначено її функціональну будову та основні структурні компоненти. У процесі аналізу використано базові, зручні для розрахунку й адаптації моделі прогнозування індикаторів мікрокредитування суб'єктів малого підприємництва вітчизняними банками з використанням лінійної регресії, яка дозволила встановити вплив окремих видів банківських продуктів на комплексні індикатори мікрокредитування. Розрахунки здійснено на основі даних, отриманих у результаті анкетування працівників комерційних банків (АБ «Укргазбанк», АТ «Ідея Банк», АТ «Кредобанк», АТ «ПроКредит Банк») та їхніх клієнтів – представників малого бізнесу. За результатами аналізу визначено прогнозні значення питомої ваги конкретних мікрокредитних продуктів у портфелях чотирьох досліджуваних банків.

Обґрунтовано оптимізаційні параметри портфеля мікрокредитів банку. Проведено розрахунок та оптимізацію загальної ефективності роботи банку та його портфеля мікрокредитів. Доведено, що такий метод дає змогу корегувати розміщення банківських коштів за різними напрямами діяльності з метою мінімізації ризику при задовільному рівні ефективності роботи банку загалом.

Авторами розроблено та запропоновано до використання на всіх рівнях кредитної системи моделі оптимізації рівня ризику: для кожного окремого договору мікрокредитування; для кожного окремого виду мікрокредитування; для портфеля мікрокредитування кожного окремого банку. Запропоновані моделі оптимізації рівня ризику є прості та універсальні, використовувати їх можна й доцільно на будь-якому етапі кредитного процесу.

Ключові слова: мікрокредитування, кредитний портфель, кредитні продукти, регресійні моделі, крива Марковіца, ризик

JEL Класифікація: C50, C53, C80, E43, G24

DOI: 10.55643/fcaptp.2.49.2023.4025