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Credit Risk Management: Marketing Segmentation, Modeling, Accounting, Analysis and Audit

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Abstract. The relevance of the research is determined by the urgency of implementing the systems of credit risk management in bank activities based on the international accounting and reporting standards. The high level of complexity of the mentioned problem is related to a significant number of credit market segments and a variety of credit forms. The aim of the research paper is to identify the risk level of individual segments in the loan portfolio at the microeconomic level taking into account macroeconomic factors. The research methods used to identify the credit risk are migration matrices, nonlinear approximation, correlation-regression analysis, statistical distributions, and forecasting. The main research results are as follows: credit segmentation of the loan portfolio was performed, a matrix of credit risk sources was constructed, default probability and default losses were quantified to reflect the expected credit losses in accounting, and the audit of construction of credit risk models was performed. The significance of the research results is determined by the possibility to measure the factors of non-stable macroeconomic situation in Ukraine while estimating the risks of functioning of banking establishments. The proposed approaches to solving the problem of credit risk management allow decreasing the volume of non-operating credits and increasing the profitability of the loan portfolio of a bank. It can be considered that the merits of the research are determining the causal relations between the separate components of credit risk, which can be effectively used to neutralize and decrease them. The emphasis was made on the tools of credit risk management represented by marketing segmentation, modeling, accounting, analysis, and audit. The prospects of further studies include clarification of the methodical approaches to credit risk management in part of the separate market segments

Keywords: bank, reporting standards, loan, risk, migration matrices, control, market, forecasting

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INTRODUCTION

Risks are the category inherent in all spheres of human life and society in general. For banking institutions, they are an integral attribute of almost all transactions, mostly active, as well as of providing services to customers and making agreements with counterparties. In the system of banking risks, credit risk is most significant taking into account the great share of loans in the structure of assets and in the formation of income of banking institutions (both interest and commission). For self-insurance against credit risks, banks form reserves for possible losses, which are recorded in contractual accounts, reducing the initial cost of loans. The procedure for credit risks calculation in Ukraine has seen a complex evolutionary development – from their strict regulation, establishment of mandatory rules for loans classification, determining specific levels of creating reserves to assess the probable losses based on the internal models.

The interest in credit risk management is growing under conditions of implementing by Ukrainian banks the International Financial Reporting Standard 9 Financial Instruments (IFRS 9) (2022), which determines the mandatory nature of modeling to forecast expected credit losses, costs of financial instruments and risky state of credit institutions and investment companies. The complexity of the problem is determined by a significant number of segments of the credit market, the variety of forms of credit, significant differences between consumers – borrowers, the motives for their purchase and behavior.

The problems of credit risk management are the object of research for many scientists. Their views can be grouped as follows: the influence of crises on the level of credit risks was revealed by M. Bofondi *et al.* (2018). The approaches to the management of the systemic aspects of credit risks were developed by such scientists as A. Clements & Y. Liao (2020), A. Kabundi & F. De Simone (2020), J. Kolari *et al.* (2020), A. Zhang *et al.* (2020). The specific features of manifestation of credit risk in certain countries of the world were explored by E. Nedumparambil & A. Bhandari (2020). The models for assessing credit risks as a particular case of the models of risk management are studied by T. Kosova *et al.* (2021). They formalized the content and the purpose, requirements for the information base and the methods for their construction, approaches for their description, practical application, and validation. Special attention is paid to the assessment of the model risk which will contribute to an increase in the quality of the models of credit risk and their adequate application.

The marketing aspects of credit risk management were emphasized by E. Webb & S. Shu (2018), the influence of borrowers' default on the level of credit risk of banking institutions was studied by B. Gopalakrishnan & S. Mohapatra (2020). Estimation of credit risks in agriculture in terms of natural and climatic conditions is rather specific, which was outlined in papers by O. Laktionova *et al.* (2019). The important scientific outcome is the contribution of the authors who explore the influence of the openness of economic systems, liquidity, the innovative component on the level of credit risks (Bui & Bui, 2020; Costello, 2020; Ganushchak-Efimenko *et al.* 2020).

A considerable role in understanding the causes and effects of banking crises under the national conditions belongs to the research by Barna, & Ruschyshyn (2020), in which it is stated that solving the problem of the stabilization of the national economy is complicated by the lack of the banking system that is stable enough to external and internal risks and threats, financial and economic shocks. To decrease financial risks of bank loans, it is proposed that systemic reforms should be based on effective decreasing the discount rate of the NBU, which should be accompanied by strengthening the protection of lenders' rights, de-shadowing, de-offshorization of economy, an increase in the level of capital transparency and solvency of the corporative sector, development of the mortgage market and real estate market, etc. The article by national researchers Sus & Onyshchuk (2019) deals with the influence of the activity of state banks on the risks of the banking system. The risk decreasing factor is a high part of their own capital in total capitalization, at the same time, the leadership of the state banks in the composition and the structure of the deposit portfolio of individuals increases the risk of the burden on the Deposit Guarantee Fund for individuals in case they are recognized insolvent.

Highly estimating the scientific outcome of the above-mentioned authors, it should be acknowledged that the problems of using specific tools, represented by marketing segmentation, modeling, accounting, were not explored enough. The problem under consideration is of interest to science as it explains the dependence of Probability of Default on Loss Given Default. The value of the obtained results for business is the development of the tools for increasing the profitability of the equity capital: for borrowers – an increase of the credit worthiness assessment, for banks – a decrease in losses from borrowers' default.

The scientific problem causes the need to clarify approaches to identification of the sources of risk for separate segments of the loan portfolio at the microeconomic level under condition of universal banking institution, which must be considered to forecast expected credit losses.

The purpose of the paper is to identify the tools of credit risk management: marketing segmentation, modeling, accounting, analysis, and audit.

The objects of the present research are: credit risk management, marketing segmentation, modeling, accounting, credit organizations and their clients, exemplified as corporate enterprises, leasing companies, and households. The research objects include creditworthiness of borrowers, assessment of default probability,

loss given default and forecasting expected credit losses. The research subject lies within the area of credit risk management, financial relations of banks and their customers, marketing segmentation of borrowers by the loan type (commercial, consumer, mortgage loans; leasing; overdrafts).

LITERATURE REVIEW

The problems of multidimensional credit risk management determine the interdependence of its studying at the macro- and microeconomic level from the standpoint of prudential regulation, the realization of business interests of banking institutions and meeting the credit needs of their customers. The main segments of the credit market are bank loan and trade finance. The tools for reducing the risk of the trade finance are bonds and exchange bills (Laktionova *et al.*, 2019). When it comes to crediting innovative projects by a bank, it is reasonable to take into account the risks of their implementation and to use the optimization models of investment management (Ganushchak-Efimenko *et al.*, 2020). The results obtained by Gopalakrishnan & Mohapatra (2020) prove "that a stronger insolvency regime moderates the adverse effects of economic shocks on firms' default risk". According to classical theory of asset pricing, there is a direct relationship between risk and return, and credit risk is measured by credit ratings (Nedumparambil & Bhandari, 2020).

The number of losses from the bank lending activities is determined by the systemic risk and individual risk of borrowers. Development of a structural autoregressive model indicates a systemic risk increase in the banking sector of euro, as well as vulnerability increase of the banking sector due to the spread of negative influences (Kabundi & De Simone, 2020). For example, in the context of the European sovereign debt crisis in 2011, credit restrictions on Italian banks were tougher than those on foreign banks, which suffered less from the sovereign debt crisis, but the credit market had a cumulative deficit (Bofondi *et al.*, 2018).

An increase in the transparency of banking systems could compensate the non-linear impact of financial market integration, reduce systemic risk, as it opens the channel of market discipline, which stabilizes the activities of banking institutions (Bui & Bui, 2020). On the contrary, the level of systemic risk objectively increases in the context of financial crises, shock changes in macroeconomic parameters, sharp depreciation of national currencies and the development of the inflationary spiral (Zhang *et al.*, 2020). The assessment of systemic risk is based on loss of equity, namely: systemic expected shortfall, marginal expected shortfall and delta conditional value at risk (Kolari *et al.*, 2020). Based on these indicators, the risk rating of financial institutions is calculated. Banks with the highest rating are toxic in terms of the spread of crisis and the multiplication of financial risks.

The systemic risk of separate companies is significantly influenced by information and news concerning the events related to an economic agent at the level of the world economy, economy of a country, industry, region, etc. (Clements & Liao, 2020). Shocks of the banking sector are transmitted to the corporate economy by reducing the volume of bank lending, appearance of a lack of liquidity among customers. The opposite effect is manifested in the deterioration of the quality of a loan portfolio, an increase in borrowers' defaults and the unemployment rate (Costello, 2020). Credit constraints of households are affected by the level of their income, consumption, and the borrower's status of being unemployed.

The analysis of the marketing behavior of consumers – individuals (Webb & Shu, 2018) examine how perceived similarity between sequential risks affects individuals' risk-taking intentions. The results demonstrate that the similarity structures that exist between risks have a significant effect on risk-taking preferences in dynamic choice settings. Adapting these provisions to the area of consumer lending, it is possible to assume that the more experience of this kind is gained, the higher the borrower's tendency to take credit risk will be. Mortgage risk is regulated by the dependence of the interest rate of a mortgage loan on its amount. An increase in the availability of mortgages has been influenced by the deregulation of the mortgage market and the use of securitized lending as a tool for risk redistribution.

Each country has its own institutional specific features of management of credit risks of banking institutions. Chernenko *et al.* (2020) include in the characteristics of the banking system the parameters of its liquidity and financial stability, a sufficient capitalization level, profitability, protection from internal and external risks and threats, financial and economic security, adaptability to the development of the global and macroeconomic environment. Sus *et al.* (2020) acknowledge that the guarantee of successful risk management is the existence of the adequate banking capital, in other words, meeting the mandatory economic standards of regulatory capital. The scientific community, specifically, Zaburanna *et al.* (2020), explore the problems of identification and management of systemic risks in the bank sector. Thus, the specialization of banks in servicing separate groups of clients requires to intensify the management of assets, credit risks, to perform diversification in resources distribution, special control over high-risk credit operations, to form the reserves for possible loan portfolio depreciation based on the international standards, etc.

MATERIALS AND METHODS

The methodology of the research is based on the theory of credit risk management, implementation of more effective methods of its evaluation, application of more

transparent and effective procedures for checking the solvency and creditworthiness of borrowers, including those taking into account the experience of foreign banks, systematized by Bodnar *et al.* (2019).

The period of the research covers five years (2017-2021). The information was accumulated on a monthly basis, with each target variable having 60 observations. The sources of analysis were: in terms of macroeconomic indicators – official reporting materials of the State Statistics Service of Ukraine and the National Bank of Ukraine; in terms of microeconomic indicators – the accounting system of the banking institution, default statistics of borrowers, the actual data on losses of the banking institution from loans impairment. Such methods as migration matrices – for forecasting PD (probability of default), non-linear approximation – for prediction of LGD (loss given default); correlation-regression analysis and statistical distributions – to determine the dependence of historical PD and LGD segments of the bank's loan portfolio on macroeconomic indicators, were used in the research. Financial Instruments (IFRS 9, 2022) does not contain a clear definition of default and delegates the establishment of its criteria to the organization that performs credit risk management. For its current assessment, the sign of default is a delay in financial assets: for banks – a 30-day delay, for legal entities and individuals – a 90-day delay; the concept of expected credit losses provides a net default period of 12 months. The research methods also include the evaluation of risk level of individual segments in the loan portfolio at the microeconomic level with regard to macroeconomic factors and designing a matrix of risk sources that must be taken into account in the preliminary, subsequent assessment of credit risk and its forecasting.

Modeling of credit risk of a banking institution is performed for the purposes of reflection of loan portfolio impairment in accounting in accordance with National Bank of Ukraine (2016) bas ed on the forecast calculations of the PD and LGD. The basic formula for the magnitude of Credit Risk (CR) is:

$$CR=PD*LGD*EAD \quad (1)$$

where PD – Probability of Default; LGD – Loss Given Default; EAD – Exposure at Default.

The main stages of credit risk modeling are: marketing segmentation of a loan portfolio; identification of historical PD for segments; formation of migration matrices; selection of macroeconomic factors that are closely correlated with historical PD; constructing a correlation-regression model of dependence of historical PD on macro-factors; checking the level of its adequacy; search for the forecast values of macro-factors for 12, 24 and 36 months according to three scenarios (pessimistic, baseline, optimistic) with determining the probability coefficient, as well as the resulting indicator – forecasted PD.

RESULTS AND DISCUSSION

The level of credit risk of the national banks is extremely high. It influences negatively the stability of functioning of the entire banking system and the country's economy as a whole due to the crisis phenomena in the economy, low solvency of the population, a high level of the actual (effective) interest rate for credits. The adequate evaluation of credit risk allows forming the necessary reserves for possible losses and protecting a bank from the loss of its own capital and from the risk of the violation of the necessary economic rules through the problem and bad loans. K.L. Larionova & T.V. Donchenko (2020) express the reasonable thought that a high level of the latter is a result of the credit expansion of the previous years, when the standards of evaluation of borrowers' solvency were low and the lenders' rights were not protected enough.

To enhance the situation, the research that includes the collection of statistical material, formation of migration matrices, construction of correlation-regressive models and their interpretation was performed.

The marketing segmentation of a loan portfolio is carried out on a hierarchical basis. The two main segments are loans to corporate business and loans to retail business. The first segment includes auto leasing, loans and guarantees, overdraft and factoring, the second segment includes consumer loans, cash loans, car loans, credit cards and overdrafts, mortgage loans. The mortgage loans are divided into loans in national and foreign currency.

The actual level of PD is determined based on the annual matrices of migration of the number of credit agreements differentiated by risk groups (group 1 – the lowest risk, group 5 – default). The purpose of their construction is to determine the probability of a client's movement between risk groups. The cells of the matrix are filled according to the principle: vertically – the number of the client's group at the start, horizontally – the number of the client's group at the finish.

Statistical studies have shown that the following factors have a close correlation with historical PDs for particular segments of a loan portfolio (Table 1):

***Table 1**. Import duty rates for certain Ukrainian goods when imported to the EU*

Number in order	Loan portfolio segment: macroeconomic factors of credit risk (correlation coefficient)	Symbol	Forecast period in months	Forecasted PD, %/Probability coefficient			
				Pessimistic/0.25	Baseline/0.5	Optimistic/0.25	Weighed
1	Loans to corporate business	LCB					
1.1	Auto leasing: – the number of registered unemployed, in % of the working-age population (0.5978)	AL	12	5.09	4.76	4.11	4.68
			24	5.61	4.98	4.49	5.02
			36	6.13	5.44	4.97	5.50
1.2	Loans and guarantees: – actual Gross Domestic Product (-0.6319)	LG	12	7.30	6.23	5.97	6.43
			24	7.78	6.33	5.99	6.61
			36	7.89	6.42	6.17	6.73
1.3	Overdraft and factoring: – weighted average rate of UAH/USD in the interbank market (0.7090)	OvF	12	8.19	7.45	6.83	7.48
			24	8.23	8.17	7.14	7.93
			36	9.12	8.63	7.92	8.58
2	Loans to retail business	LRB					
2.1	Consumer loans: basic consumer price index (cumulatively to the corresponding period of the previous year, %) (0.5919)	CL	12	12.36	11.63	11.12	11.69
			24	13.42	12.52	12.24	12.68
			36	14.60	13.83	12.76	13.76
2.2	Cash loans: – basic consumer price index (cumulatively to the corresponding period of the previous year, %) (0.6863)	Cash_L	12	18.18	17.45	16.78	17.47
			24	19.43	18.31	17.56	18.40
			36	20.93	19.58	18.66	19.69
2.3	Car loans: index of real wages (to the corresponding month of the previous year, %) (-0.7113)	Car_L	12	10.12	9.45	8.13	9.29
			24	11.09	10.33	8.56	10.08
			36	11.97	10.78	9.02	10.64
2.4	Credit cards and overdrafts: – the number of registered unemployed, in % of the working age population (0.6760)	Cards_O	12	6.17	6.03	5.89	6.03
			24	6.26	6.08	5.95	6.09
			36	6.32	6.21	6.07	6.20
2.5	Mortgage loans	ML					
2.5.1	– in national currency: index of real wages (to the corresponding month of the previous year, %) (-0.6908)	ML_NC	12	14.07	12.56	10.11	12.33
			24	16.27	14.78	13.14	14.74
			36	18.92	16.94	15.62	17.11
2.5.2	in foreign currency: – weighted average rate of UAH/USD in the interbank market (0.7498)	ML_FC	12	24.54	16.65	12.17	17.50
			24	30.76	25.87	17.18	24.92
			36	40.17	31.17	24.16	31.67

***Source:** authors' calculation (National Bank of Ukraine, 2022; State Statistics Service of Ukraine, 2022)*

– the number of registered unemployed, in % of the working-age population – correlation coefficient with AL and Cards O is 0.5978 and 0.6760, respectively. The relation is direct because a deteriorating situation in the labor market stimulates the growth of default loans;

– actual Gross Domestic Product has an inverse correlation coefficient (-0.6319) with the LG segment as an increase in the level of defaults occurred against the background of reduced production volumes;

– weighted average rate of UAH/USD in the interbank market has direct correlation with the OvF and ML_FC segments as evidenced by correlation coefficients of 0.7090 and 0.7498, respectively. The logic is as follows: the devaluation of UAH leads to an increase in defaults, because, firstly, corporate clients have a shortage of funds, which leads to an increase in their demand for rapid fundraising in the form of overdrafts and factoring; secondly, retail clients have an increasing debt burden on mortgage holders who finance it through loans in foreign currency;

– basic consumer price index (cumulatively to the corresponding period of the previous year, %) has direct correlation with the segment s CL and Cash L, and correlation coefficients are 0.5919 and 0.6863, respectively. It can be explained from the economic standpoint by the deterioration of the welfare of borrowers – individuals under conditions of rising prices, which complicates their repayment of loans and leads to defaults;

– index of real wages (to the corresponding month of the previous year, %) has a close inverse correlation with the segments Car_L and ML_NC; the corresponding coefficients are (-0.7113) and (-0.6908). This can be explained by the reduction of sources of repayment of car loans and mortgages in terms of declining incomes, which leads to an increase in defaults.

The results of the study are summarized in the matrix (Table 2), which allows identifying clearly the relationship between macro-factors and a loan portfolio segment.

***Table 2**. The matrix of risk sources for a loan portfolio segment*

Loan portfolio segment		Macro-factors			
	Number of registered unemployed	Basic consumer price index	Weighted average rate of UAH/USD	Actual gross Ukrainian product	Real wages
Auto leasing	X				
Credit cards and overdrafts					
Consumer loans		X			
Cash loans					
Overdraft and factoring			X		
Mortgage loans in foreign currency					
Loans and guarantees				X	
Car loans					X
Mortgage loans in national currency					

***Source:** authors' calculation (National Bank of Ukraine, 2022; State Statistics Service of Ukraine, 2022)*

To calculate Forecast PD Weighed, the Probability coefficient was determined: 0.25 – for the pessimistic and optimistic scenarios, 0.5 – for the baseline scenario. The levels of Forecast PD increase as they move from the 12-month horizon to the 36-month horizon and decrease from the pessimistic to optimistic scenarios. According to the results of the assessment of forecast PD for the segments of the loan portfolio (Table 1), their rating places were determined as credit risk decreased for ranges in %: ML_FC (17.50-31.67), Cash_L (17.47-19.69), ML_NC (12.33-17.11), CL (11.69-13.76), Car_L (9.29-10.64), OvF (7.48-8.58), LG (6.43- 6.73), Cards_O (6.03-6.20), AL (4.68-5.50). In general, the PD of loans to retail business is higher compared to those to corporate business. The bank bears the greatest risks when giving mortgage loans in foreign currency and cash loans to borrowers – individuals. The risks in auto leasing transactions between the bank and corporate clients are the lowest because the credit object and the collateral match.

The LGD model is based on the RR (Recovery Rate) indicator as the ratio of the amount of repayment of default loans to the number of debts on default loans for each Month After Default (MAD) (IFRS 9, 2022). By constructing a cumulative curve (RRcum), it was determined that the effective horizon of collecting payments to repay overdue loans is 36 months. After

this period, a monthly increase in the return of funds becomes insignificant. To smooth out the time fluctuations, the RRcum index and the time factor x are linearized according to the formulas:

$$Y=ln(-ln(1-RRcum_t) \quad (2)$$

$$x=ln(t\ in\ years) \quad (3)$$

Based on the correlation-regression model design, the parameters of linear function $Y=x+b$ are determined, and the scale factor is calculated from formula (4). The above-mentioned indicators are presented in Table 3.

$$\lambda = e^{\frac{-a}{b}} \quad (4)$$

***Table 3**. Results of calculation of RR and LGD indicators for loan portfolio segments*

Number in order	Symbol	RR model				LGD model		Maximum	
		Parameters		Coefficients		Equation	R^2	LGD	PD*LGD
		a	B	γ	R^2				
1	LCB								
1.1	AL	0.340	0.4369	0.4588	0.8593	y=-0.136ln(x)+0.5946	0.9902	0.058	0.0032
1.2	LG	-1,221	0.2132	307,34	0.7799	y=-0.053ln(x)+0.8326	0.9935	0.612	0.0412
1.3	OvF	-1,191	0.2291	180,78	0.7802	y=-0.058ln(x)+0.8349	0.9929	0.591	0.0507
2	LRB								
2.1	CL	-1,498	0.4062	39,949	0.6734	y=-0.093ln(x)+0.9534	0.9767	0.554	0.0762
2.2	Cash_L	-1,166	0.2411	125,82	0.6763	y=-0.063ln(x)+0.8364	0.9925	0.574	0.1130
2.3	Car_L	-0.958	0.4644	7,871	0.8302	y=-0.144ln(x)+0.9162	0.9867	0.312	0.0332
2.4	Cards_O	-1,326	0.5454	11,374	0.9161	y=-0.148ln(x)+1,0069	0.9719	0.376	0.0233
2.5	ML								
2.5.1	ML_NC	-1,493	0.5088	18,808	0.8872	y=-0.124ln(x)+1,0014	0.9687	0.469	0.0802
2.5.2	ML_FC	-1,577	0.5376	18,773	0.9735	y=-0.127ln(x)+1.02	0.964	0.474	0.1501

***Source:** authors' calculation (National Bank of Ukraine, 2022; State Statistics Service of Ukraine, 2022)*

From the mathematical point of view, a-parameter reflects the inclination angle of the straight line, constructed on the linearized indicators RR and MAD and varies significantly from (-1,577) in the segment ML_FC to 0,340 in the segment AL; from the economic point of view, it significantly affects LGD, which are respectively 0.474 and 0.058, in other words, an increase in a-parameter causes a decrease in LGD. As a mathematical magnitude, b-parameter reflects the height of location of the straight line above the X axis, the range of its variation is smaller – from 0.2132 for the LG segment to 0.5454 for the Cards_O segment. The LGD values are 0.612 and 0.376, respectively.

Thus, an increase in b-parameter is accompanied by a decrease in LGD. The generalizing indicator related to the nature of loan repayment is λ-coefficient. Its minimum value (0.4588) corresponds to the minimum value of LGD (0.058) for the AL segment, the maximum value (307.34) corresponds to the maximum value of LGD (0.612) for the LG segment. The value of multiple coefficients of determination R^2 of the linear function reflects the degree of compliance with the exponential law of receipts in loan repayment RR: it is the lowest (about 0.67) for segments CL and Cash_L, it is the highest for ML_FC (0.9735). Approximation of R^2 to 1 means an increase in the predictive power of the RR model.

The RR is approximated according to the formula:

$$RRcum_{apr} = \left(RR_{fact}, if\ MAD \geq 36; 1 - e - (\frac{MAD/12}{\lambda})^b\right) \quad (5)$$

The LGD value is determined using the following model:

$$LGD = 1 - \max(RRcum_{fact}; RRcum_{apr}) \quad (6)$$

LGD models that are constructed based on RR-models are represented by logarithmic functions. The accuracy of their approximation is much higher because R^2 is in the range of 0.964-0.9935. The generalizing indicator of risk is the product of PD and LGD. Its lowest level is characteristic of the following segments: AL (0.0032), Cards_O (0.0233), Car_L (0.0332), its highest level is in the segments Cash_L (0.1130) and ML_FC (0.1501).

The final stage of credit risk management is taking measures for their immunization, reflection of the impairment accounting provisions in accordance with Financial Instruments (IFRS 9, 2022) in accounting and reporting, as well as undergoing internal and external audit procedures.

The results of forecasting PD and LGD indicators for loan portfolio segments are used to calculate expected credit losses based on collective assessment of three Stages. Stage 1 includes loans, for which there have been no significant changes in the migration matrix since the initial recognition, and 12-month expected credit losses are calculated for them. Stage 2 and Stage 3 are used to calculate impairment accounting provisions for the entire period until the loan is repaid. The criterion for referring a loan to Stage 2 is a significant deterioration in credit risk in the absence of default. Stage 3 includes default loans, as well as Purchased or Originated Credit Impaired (POCI).

The models that a bank uses to calculate credit impairment losses can be developed by the bank independently or by third parties, including auditing and consulting companies. They must be approved by the highest collegial bodies of a bank, undergo annual validation, preliminary and subsequent checks on the application of the internal audit service. The order of reflection of impairment losses and provisions of the loan portfolio segment in accounting is a mandatory subject of independent audit in the process of annual confirmation of the bank financial statements. In this case, if an audit company developed models of credit risk management or performed their validation, it has no right to audit financial reporting, according to the principle of ensuring independence of external control.

The results of the research carried out in the part of the evaluation of credit risks of the banking institutions of Ukraine are the development of the scientific ideas of a whole range of the national researchers. In particular, banking lending is considered through the prism of a multi-component hierarchical model, proposed by O.Ye. Hudz (2019) and used for marketing segmentation of the loan portfolio. Credit risk management is considered as a continuous process of the formation, observation, regulation and optimization of this risk. To construct this model, the idea of the life cycle of credit risk that was put forward by Moroz & Seletska (2019) was used for real-time evaluation, monitoring, stress-testing, and visualization of the data and facilities for business analysts and marketers.

When developing the methodological approach to forecasting credit risks, the advanced European experience of banking and the innovative methods of risk management systematized by K.S. Zatvornytskyi (2019) was used. The performed calculations are oriented to the protection of a banking institution from credit risks, their minimization, decreasing the volumes of non-operating credits, their restructuring based on the methods proposed by M.H. Marych *et al*. (2019). The major credit evaluated risk is the concentration risk, to which Moroz & Seletska (2019) attribute the risk of considerable concentration of credit losses related to the existence in the bank of a considerable volume of credit exposition of separate clients or a group of clients, connected in terms of organization and capital and sensitive to the changes in the common risk factors, first of all, economic, industrial, geographical, relations between economic entities. The scientific outcome of the paper is the synthesis of micro- and macroeconomic approach to the evaluation of credit risk. In particular, the factors separated by Shulha & Belianko (2019) (GDP, inflation and unemployment rates, currency exchange rate) were used for its correlation-regressive modelling and supplemented by the new ones (index of actual income of population, volume of construction and assembly works, index of producers' prices). Different approaches taking into account the specific features of the retail crediting market and credit scoring, systematized by Z.V. Yurynets (2019), were used to construct the credit models of risks of corporative and private borrowers. The experience of Pavliuk & Petrovskyi (2020) in terms of the construction of the behavioral statistical models of credit risks of retail borrowers (behavioral scoring), which is a modern-day tool of monitoring and management of limits was used to achieve the enhanced productivity of the banking business. The development of the models of behavioral scoring can be based on various quantitative modeling techniques, depending on the existence of sufficient volume of qualitative data and developer's knowledge. At the same time, behavioral models require much more attention and time compared to application data due to the necessity of check a greater number of potentially useful predictors. To assess the adequacy of econometric models of credit risk, the approaches proposed by A.V. Kolodiichuk (2020) were applied. The developed models may be used for stress testing of credit risks that L.V. Kuznietsova (2019) defines of a key tool of modern risk management and strategic planning.

Thus, the study revealed a phenomenon associated with the inverse relation of PD and LGD. The prospects for further research are to harmonize the methods for assessing objective factors of counterparty risk that affect PD and subjective factors that determine the state of debt service (LGD).

CONCLUSIONS

The article formalizes some stages of credit risk management based on marketing segmentation of a loan portfolio, quantification of probability of default and loss given default, use of the obtained forecast indicators to reflect expected credit losses in accounting, as well as the audit of credit risk models. A matrix of credit risk sources was developed, which links macro factors with specific segments of a loan portfolio. It was established that the variation spread of indicators was: for

PD – 3.73 times on the horizon of up to 12 months; 5.76 times – on the horizon of up to 36 months; for LGD – 10.6 times, for their maximum product on the horizon of up to 36 months – 46.9 times.

The conducted research has the following benefits: for studies – the development of key skills in management, modeling, analysis, accounting and audit of credit risks, their differentiation for individual segments of a loan portfolio; for science – identification of macroeconomic factors – credit risk stimulators and its immunizers, which may become objects of regulatory influence of a bank; identification of inverse relation of PD and LGD, which requires harmonization of their calculation methods; for business – simplification of credit risk modeling procedures according to certain algorithms, reduction of complexity of calculations related to the identification of sources of credit risk for segments.

The obtained results will contribute to the rationalization of the processes of making credit decisions with regard to achieving the balance between the assessment of the financial state of a borrower and the guarantees of a credit agreement. Unlike the existing approaches, the proposed approaches make it possible to coordinate the estimation of the systemic and individual risk based on the marketing segmentation of borrowers. The designed methodical recommendations on modelling credit risk for the segments of a loan portfolio contribute to the harmonization of the institutional specific features of the credit activities in Ukraine and the requirements of the international standards of financial reporting. The proposed tools of credit risk management allow performing an adequate assessment of credit risks based on the construction of a complex of economic and mathematical models, their objective reflection in the accounting system and decreasing the losses of owners of banking institutions due to borrowers' default.

The prospects of further research are clarification of the methodical approaches to the evaluation of credit risks in particular marketing segments.

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Управління кредитними ризиками: сегментація маркетингу, моделювання, облік, аналіз та аудит

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Анотація. Актуальність дослідження зумовлена необхідністю впровадження банківськими установами систем управління кредитними ризиками на основі міжнародних стандартів бухгалтерського обліку та звітності, а складність проблеми пов'язана зі значною кількістю сегментів кредитного ринку та різноманітністю форм кредитування. Метою роботи є дослідження рівня ризику окремих сегментів кредитного портфеля на мікроекономічному рівні у зв'язку з макроекономічними факторами. Методи дослідження: матриці міграції, нелінійна апроксимація, кореляційно-регресійний аналіз, статистичні розподіли, прогнозування. Основні результати: проведено маркетингову сегментацію кредитного портфеля, побудовано матрицю джерел кредитного ризику, визначено кількісну оцінку ймовірності дефолту та збитків у разі дефолту для відображення в обліку очікуваних кредитних збитків, а також проведено аудит в частині побудови моделей кредитного ризику. Значущість результатів дослідження визначається можливістю вимірювання чинників нестабільної макроекономічної ситуації в Україні при оцінці ризиків функціонування банківських установ. Запропоновані підходи до вирішення проблеми управління кредитними ризиками дозволять зменшити обсяг непрацюючих кредитів та збільшити дохідність кредитного портфеля банків. Перевагами дослідження є визначення причинно-наслідкових зв'язків між окремими компонентами кредитного ризику, які можуть бути ефективно використані для їх нейтралізації та зниження. Акцент зроблено на інструменти управління кредитним ризиком, представлені маркетинговою сегментацією, моделюванням, обліком, аналізом і аудитом. Перспективами подальших досліджень визначено уточнення методичних підходів до оцінки кредитних ризиків у частині окремих маркетингових сегментів

Ключові слова: банк, стандарти звітності, кредит, ризик, міграційні матриці, контроль, ринок, прогнозування