

We are pleased to present to readers the work that is a result of co-operation between the Bronisław Markiewicz State Higher School of Technology and Economics in Jarosław (Poland) and Simon Kuznets Kharkiv National University of Economics (Ukraine).

The monograph is dedicated to the 90th anniversary of the Simon Kuznets Kharkiv National University of Economics.

The findings provided herein address the development aspects of the risk-based approach to combating money laundering. The analysis includes international standards applied to regulate and develop the risk-oriented financial monitoring system; financial intermediaries' functioning peculiarities under the economy digitalization conditions and the peculiarities of primary financial monitoring conducted in the insurance industry and by banks; theoretical and methodological provisions for assessment and banks' risk management from the standpoint of the factors influencing the money laundering processes.

The monograph is intended for lecturers, scientists, students of economic universities, specialists of public authorities, financial institutions and businesses.



ISBN 978-83-65823-45-8

pws te / The Bronisław Markiewicz
State Higher School of Technology
and Economics in Jarosław

PAŃSTWOWA
WYŻSZA SZKOŁA
TECHNICZNO
EKONOMICZNA



Simon Kuznets
Kharkiv National University of Economics



Edited by Ryszard Pukala & Iryna Chmutova

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RISK-BASED APPROACH TO COMBATING MONEY LAUNDERING

Edited by Ryszard Pukala & Iryna Chmutova

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The Bronislaw Markiewicz State Higher School of Technology and
Economics in Jaroslaw

Simon Kuznets Kharkiv National University of Economics

RISK-BASED APPROACH TO COMBATING MONEY LAUNDERING

MONOGRAPH

Editors:

Ryszard Pukala
Iryna Chmutova

2020

Reviewers

Doctor of Science (Economics), Professor *Iryna D'yakonova*

Doctor of Science (Economics), Professor *Iryna Otenko*

The monograph is based on the International Project results

"Best International Practices for Implementing a Risk-based Approach to Combating Money Laundering" (Solution of Simon Kuznets Kharkiv National University of Economics Academic Council, Protocol number 4 dated September 23, 2020)

The international project was implemented in accordance with the Cooperation Agreement between the Bronislaw Markiewicz State Higher School of Technology and Economics (Jaroslaw city, Poland) and the Simon Kuznets Kharkiv National University of Economics (Ukraine) dated November 24, 2014

International Project Head

Ryszard Pukala (The Bronislaw Markiewicz State Higher School of Technology and Economics in Jaroslaw)

Editors

Ryszard Pukala – The Bronislaw Markiewicz State Higher School of Technology and Economics in Jaroslaw

Iryna Chmutova – Simon Kuznets Kharkiv National University of Economics

ISBN 978-83-65823-45-8



PUBLISHING HOUSE OF THE BRONISLAW MARKIEWICZ
STATE HIGHER SCHOOL OF TECHNOLOGY
AND ECONOMICS IN JAROSLAW

Jarosław 2020

TABLE OF CONTENTS

PREFACE	5
AUTHOR CREDENTIALS.....	6
INTRODUCTION	11
 PART 1. INTERNATIONAL STANDARDS AIMED TO REGULATE AND DEVELOP THE RISK-ORIENTED FINANCIAL MONITORING SYSTEM.....	 15
1.1. International recommendations background for Development the Basics of a Concept for Formation a Risk-based AML/CTF system....	16
1.2. The main concepts for the formation of a risk-based AML/CTF system	23
1.3. Implementation of a risk-based approach in the field of AML/CTF at the public level in Ukraine.....	40
 PART 2. TRANSFORMATIONAL CHANGES IN FINANCIAL MONITORING IN THE CONTEXT OF DIGITALIZED FINANCIAL RELATIONS	 48
2.1. Features of defining and structuring the financial service market in the economy digitalization environment.....	49
2.2. Digital Development of Anti-Money Laundering in the Insurance Industry	60
 PART 3. IMPLEMENTING THE RISK-BACED APPROACH TO FINANCIAL MONITORING IN THE BANKING SYSTEM.....	 66
3.1. Risk-based approach to the formation of the financial monitoring system in Ukrainian banks	67
3.2. Applying the risk-based approach to banks' primary financial monitoring.....	81

Table of contents

PART 4. RISKS MET BY BANKS IN THE SYSTEM OF FACTORS	
INFLUENCING THE MONEY LAUNDERING PROCESSES	94
4.1. Use of monitoring to reduce bank risk in the area of money laundering and terrorist financing	95
4.2. Tools for assessing the strategic risk faced by banks, and its relation to the compliance with legal requirements in the field of combating money laundering	106
4.3. Methodological and practical aspects of analyzing the borrowers’ creditworthiness to minimize credit risks faced by banks	117
 CONCLUSIONS.....	 135
REFERENCES.....	138
APPENDIX.....	164

PREFACE

The “Risk-Based Approach to Combating Money Laundering” monography is based on the results of studies conducted within the framework of an international project titled “Best international Practices for Implementing a Risk-based Approach to Combating Money Laundering”, executed as part of the agreement between the Bronislaw Markiewicz State Higher School of Technology and Economics in Jarosław and the Simon Kuznets Kharkiv National University of Economics – which celebrates its 90th anniversary this year.

The monograph comprises four sections exhibiting a consistent structure, corresponding to the subject matter of the study. It presents the main provisions of the FATF International Standards. The first one deals with the introduction of a risk-oriented approach. The authors presented a concept of a risk-oriented solution within the system designed to countering money laundering and financing of terrorism in Ukraine, developed in line with international recommendations and capable of being used by various countries as an example of innovative solution within the discussed scope.

Moreover, the monograph reflects changes taking place in the financial services market, including its digitalisation, that call for creating conditions that ensure stability of processes in the scope of developing financial monitoring. A separate part of the study is devoted to the processes of countering money laundering in the field of insurance. Two sections are dedicated to introducing a risk-based approach to financial monitoring in the banking system, since it is the banks that have the highest degree of risk control as part of basic financial monitoring. Practical aspects of analysing borrowers’ creditworthiness for the purpose of minimising credit risk of the banks have also been presented.

A characteristic feature of the monograph is broad international literature, which is a subject of interest not only among specialists in the field of finance, but also among information processing professionals.

The execution of the international project has been successful. The project has contributed to forming a team of scientists from Poland and Ukraine and creates conditions for solving new international problems not only in the scope of financial monitoring, but also as regards the development of the financial services market as well as digitalisation of the economy and finance.

Head of the international project
Ryszard Pukala

AUTHOR CREDENTIALS

RYSZARD PUKALA (general management, scientific editor), is Ph.D. (Economics), The Bronislaw Markiewicz State Higher School of Technology and Economics in Jaroslaw, Poland. The main issues he deals with as part of the conducted research work focus on systemic risk, financial markets, identifying and managing business activity risks, using instruments aimed at financing the effects of risk materialization, with particular attention paid to insurance and the issues of innovation in the economy and enterprises. An author of many scientific publications and conference materials issued in prominent magazines as well as domestic and foreign publishing houses as well as a head of national and international research projects. Member of the Polish Economic Society.

IRYNA CHMUTOVA (scientific editor, Subsection 1.3), is Doctor of Science (Economics), Professor at the Department of Management and Business (Simon Kuznets Kharkiv National University of Economics, Ukraine). Author and co-author of monographs and scientific papers in the field of finance, management, combating money laundering. She is the member of specialized scientific council in Simon Kuznets Kharkiv National University of Economics. Editor-in-Chief in scientific journal «Development management». Editorial board member in scientific journals «Banks and Banking Systems», «Public and Municipal Finance». Member of the Ukrainian Association of Management Development and Business Education. Her main scientific interests are: money laundering risks, banking risks, financial management in banks, modern financial management technologies, financial controlling, cyclicity, financial stability.

VOLODYMYR PONOMARENKO (subsection 3.2), is Doctor of Science (Economics), Professor, Rector Simon Kuznets Kharkiv National University of Economics, Honored Worker of Science and Technology of Ukraine, Cavalier of the Order of Merit, III, II degrees, «Orden of Prince Yaroslav the Wise» V degree, corresponding member of the Academy of Pedagogical Science of Ukraine.

Author credentials

NATALIYA VNUKOVA (subsections 1.1–1.3), Honored Economist of Ukraine, is Doctor of Science, Professor, Professor of the Department of Banking and Financial Services at Simon Kuznets Kharkiv National University of Economics, Leading Researcher of Scientific and Research Institute of Providing Legal Framework for the Innovative Development of National Academy of Law Sciences of Ukraine. Research refers to development of market for financial services, the main areas of prudential supervision, anti-money laundering (AML) and development of financial monitoring. Has been a member of the Union of Economists of Ukraine, corr.-member of the Academy of Technological Sciences of Ukraine, a member of the Union of Entrepreneurs of the Kharkiv region, member of specialized council on defense of dissertations on specialty «Money, Finance and Credit», a member of the editorial «Insurance Business», «Economics of development».

OLEH KOLODIZIEV (subsections 2.1 and 4.3), is Doctor of Science (Economics), Professor, Head of the Department of Banking and Financial Services at Simon Kuznets Kharkiv National University of Economics, Academician of the Academy of Economic Sciences of Ukraine on specialty of finances. Member of the editorial board of scientific journals: Chief Editor of «Economics of Development»; «Banks and Bank Systems», which is indexed in scientific base Scopus; «Economic Theory and Law». Deputy Chairman of the Academic Council Д 64.055.02 at Simon Kuznets Kharkiv National University of Economics according to specialties 08.00.07 – Demography, labor economics, social economy and politics; 08.00.08 – Money, Finance and Credit. Research interests: innovative development of national economics; ensuring the stable functioning of the banking sector; building up a regional finance policy; risk-oriented approach in the system of combating money laundering, terrorist financing and proliferation of weapons of mass destruction; compliance control of the subjects of primary financial monitoring.

VIKTORIYA VOVK (subsection 3.1), is Doctor of Sciences (Economics), Professor of the Department of Banking and Financial Services (Simon Kuznets Kharkiv National University of Economics, Ukraine). Her main research interests are strategic management of the banking sector competitiveness in the

Author credentials

context of globalization of financial markets, anti-crisis management of banks, stimulating the interaction between banks and real sectors of the national economy, and digitalization of the banking business. Being the member of the specialized academic council at Simon Kuznets Kharkiv National University of Economics, she has repeatedly acted as an official opponent in defending the PhD and Doctor of Sciences theses; is a member of the Editorial Committee of the electronic scientific journal «Financial Research».

ZHANNA ANDRIICHENKO (subsections 1.1–1.3), is Ph.D. (Economics), Associate Professor of the Department of Banking and Financial Services at Simon Kuznets Kharkiv National University of Economics (Ukraine). She is the author and co-author of more than 100 scientific and educational works. Her research interests are: AML/TF; functioning of financial markets; organization and management on enterprises; work motivation. She is a lecturer at the Academy of Financial Monitoring at the State Financial Monitoring Service. As executive secretary she participated in organising three international scientific and practical conferences on the field of financial monitoring.

OLENA BEZRODNA (subsection 4.2), is Ph.D. (Economics), Associate Professor of the Department of Banking and Financial Services at Simon Kuznets Kharkiv National University of Economics (Ukraine). She is the author and co-author of more than 35 scientific and educational works. Her main scientific interests are: money laundering risks, risk management, compliance risk, systemic risks, balanced scorecard (BSC), strategic management, bank's financial stability.

DARIA HONTAR (subsections 1.1–1.2), is Ph.D. (Economics), Lecturer of the Department of Banking and Financial Services at Simon Kuznets Kharkiv National University of Economics, accountant (Ukraine). She has more than 40 works, including: collective monographs, textbooks, scientific articles. Her research is focused on bank liquidity, bank's financial stability, financial statistics, risk management, estimation of the bank's value.

Author credentials

YULIIA ZHEZHERUN (subsection 3.1), is Ph.D. (Economics), Associate Professor at Finance and Banking Department (Cherkassy educational-scientific institute of Banking University, Ukraine). Her research is focused on digital economy, banking management, crisis management in the bank, small and medium-sized bank lending.

OLENA KORVAT (subsection 2.2), is Ph.D. (Economics), Associate Professor (Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine). Her research is focused on insurance, actuarial calculations, financial statistics, risk management, state regulation of financial services market, prudential supervision, financial policy.

SVITLANA KYRKACH (subsection 3.2), is Ph.D. (Economics), Accountant at the company «Itomych Studio», Associate Professor of the Department of Banking and Financial Services at Simon Kuznets Kharkiv National University of Economics (Ukraine). She is an accountant with more than 8 years of experience. She has a number of diplomas from Simon Kuznets Kharkiv National University of Economics, diplomas and certificates Courses of 1C: Enterprise (the course of the Chief Accountant and the Complete Advanced Accounting Course). Also she has more than 30 works, including: collective monographs, textbooks, scientific articles, abstracts (materials) of conferences. Her research is focused on Development of the Banking System of Ukraine, Financial Planning of the Bank, Problems of Doing Business in Ukraine and the World, Development of FinTech Technologies.

OKSANA OMELCHENKO (subsections 4.1, 4.3), is Ph.D. (Economics), Head of the Management Department at Kharkiv Technical University "STEP", Associate Professor of the Banking Department at Simon Kuznets Kharkiv National University of Economics, Associate Professor of the Department of Customs and Taxation at Simon Kuznets Kharkiv National University of Economics (Ukraine). She has a number of diplomas from the Department of Science and Education of Kharkiv, Department of Education of Kharkiv, diplomas from Simon Kuznets Kharkiv National University of Economics. Also

Author credentials

she has more than 80 works, including: collective monographs, textbooks, multimedia interactive electronic textbooks, scientific articles. Her research is focused on Development Economics, Human Resources and Organizations, IT Management.

OLGA RATS (subsection 4.1), is Ph.D. (Economics), Associate Professor, Associate Professor of the Department of Banking and Financial Services at Simon Kuznets Kharkiv National University of Economics (Ukraine). Her research is focused on theoretical and methodological support evaluation of the efficiency of the company, assessment of the efficiency of strategic bank management, forming a strategy of crisis management banking institution, technology benchmarking as a tool to ensure the financial security of the bank, organisation of fraud monitoring in the system of bank economic security management.

INTRODUCTION

The growth of economic risks aggravates the need to create an effective risk-oriented system that can prevent the legalization of money received by illegal means (money laundering), terrorist financing, and proliferation of mass destruction weapons. This purpose invokes the creation of respective international organizations that apply appropriate sanctions to those countries that commit violations in the financial monitoring sphere, and specially authorized domestic bodies for financial monitoring whose activities aim to prevent money laundering, terrorist financing, and proliferation of mass destruction weapons. Therefore, at present, implementing the international standards established by the Financial Action Task Force on Money Laundering (FATF), the norms stipulated in the EU Directives (including Directive 2015/849 on the prevention of the use of the financial system for the purposes of money laundering or terrorist financing), and introducing a risk-oriented approach in the field of preventing and combating money laundering is a modern trend aimed to build the national financial monitoring system; it is in the focus of many scientists not only in the European community, but throughout the world.

Specially authorized bodies and other entities exercising regulation and supervision in the field of financial monitoring are unable to function without cooperation with the primary links of the financial monitoring system, namely the primary financial monitoring subjects. In turn, the establishing and use of risk-oriented criteria to determine their risks of being involved in money laundering schemes provide means for systematizing, generalizing these criteria, and creating a theoretical basis for increasing the efficiency of the state financial monitoring.

Today, Ukraine, like most of the developed countries of the world, is pursuing an active policy to implement international standards for combating corruption and crime in the financial sector, as defined in the FATF Recommendations. In particular, on April 28, 2020, the new Law of Ukraine “On preventing and countering the legalization of money received by illegal means (money laundering), terrorist financing, and proliferation of mass destruction weapons” came into force, which defined a transparent instrument of prosecution for money laundering and unfair withdrawal of accumulated funds, as well as introducing a risk-oriented approach by the primary financial monitoring subjects

Introduction

when verifying their clients. The risk-oriented approach eliminates total control over financial transactions, which helps to reduce bureaucratic procedures for client identification and verification. However, in order to duly protect the rights and legitimate interests of citizens, society, and the state, and to ensure national security, it is necessary to determine the main provisions for the formation of a risk-oriented system for combating money laundering, terrorist financing and proliferation of mass destruction weapons. This will improve the process of detecting, verifying and investigating crimes related to money laundering and other illegal financial transactions.

Banks and other financial intermediaries hold a specific place in the financial monitoring system. The economy digitalization being one of the drivers for the developing financial relations, the expanding types and channels of the provision of their services, is marked by an increase in the risks associated both with the specifics of their activities and other risks threatening the entire financial system. In particular, the volume and complexity of financial crime have increased dramatically in the context of the economy digitalization. Money launderers use different types of services, as well as various combinations of businesses, to clean up dirty money. As a result, the regulatory requirements to prevent and combat money laundering are becoming more stringent. The evolution of the regulatory landscape, the business environment for financial intermediaries, digital and anti-money laundering technologies explains the need for research into the digital development of anti-money laundering in the financial sector.

Taking into account the peculiarities of banks' activities and their functions, the banking sector represents a financial system component with the highest vulnerability to money laundering risks. The risk of using banking institutions for money laundering is in one way or another associated with their other risks (operational risk, credit risk, strategic risk, market risk, liquidity risk, reputational risk, compliance risks, etc.). Its occurrence may result from one risk transforming into another one, or vice versa, entail additional consequences. Therefore, the comprehensive risk-oriented approach offers the foundation for identifying AML threats and developing an operational algorithm for tracking them. As part of its implementation, it is critical to consider the connection between the risks to be involved in money laundering schemes faced by financial institutions with primary and secondary factors-causes of occurrence and their consequences that may have a

Introduction

recurring nature. In this respect, ensuring an increase in the efficiency of the functioning and/or adequacy of the risk management system using tools for identifying threats, assessing, controlling, monitoring and minimizing money laundering risks is a platform for eliminating and/or preventing them in further activities performed by the primary financial monitoring subjects, preventing the involvement in the money legalization processes by taking appropriate measures and preventing the facts of violating legal requirements in the relevant area.

The monograph intends to develop theoretical and methodological provisions and recommendations for the application of the risk-oriented approach to counter money laundering.

The specified goal stipulates the following tasks:

- developing the main provisions of the concept for forming a risk-oriented system applied to combat money laundering and terrorist financing based on international experience;
- systematizing the provisions for the legal regulation of the implemented risk-oriented approach in the field of combating money laundering and terrorist financing at the state level to determine risk-oriented signs indicating the possible involvement of a primary financial monitoring subject in money laundering schemes;
- exploring the specifics of defining and structuring the financial service market in the economy digitalization environment and analyzing the digital development of countering money laundering in the insurance sector;
- developing theoretical and methodological foundations and preparing recommendations for the practical implementation of the risk-oriented approach by Ukrainian banks as a crucial element of the primary financial monitoring of banks;
- determining the fundamental nature and characteristics of the banking system risks, in particular, those associated with the money legalization, and preparing recommendations for leveling these types of risks using monitoring tools;
- providing recommendations on analyzing the borrowers' creditworthiness to minimize credit risks faced by banks;
- investigating the fundamental nature of the banks' strategic risk, developing recommendations for its assessment, and analyzing the relationship

Introduction

between failures in the banking strategy implementation and the compliance risk in the field of financial monitoring.

The monograph consists of three sections, which address the following problems: international standards applied to regulate and develop a risk-oriented financial monitoring system; changes in the financial monitoring in the context of the digitalized financial relations; the peculiarities of using the risk-oriented approach during the primary financial monitoring implemented by banks; and individual risks met by banks in the system of factors influencing the money laundering processes.

The monograph includes the results obtained during the fundamental research work “Risk-oriented approach to combating money laundering, terrorist financing and proliferation of mass destruction weapons” (No. 0118U000058) performed by the Simon Kuznets Kharkiv National University of Economics. The theoretical provisions and practical developments presented in the monograph constitute a part of scientific publications submitted by its authors and conceptually synthesize conclusions on the development and implementation of the risk-based approach to combating money laundering.

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

In conditions of transformations of the world economy, one of the main tasks of the banking system is the creation of favorable conditions for the stable reproduction process and entrepreneurial activity development because the prospects for further growth of economic entities largely depend on the ability of banks to meet their needs by necessary financial resources. Research the directions of activization of economic entities credit activity and bank's activity as a powerful lever of influence and ensuring the development of entrepreneurship are actualized in terms of lack of own funds to finance the production. In its turn, the complex system of management of credit portfolio on the basis of grounded analysis and assessment of its quality is essential for increasing the capacity of the banking system and development the credit relations.

Today banks as one of the main parts of the economic system of the state are often faced with borrowers who cannot repay the loan. And a lot of bad loans in the total bank assets are the cause of the banking system losses.

The credit activity of banks is complicated by the absence of grounded methods of assessing the creditworthiness of the borrower, lack of information base for a full analysis of financial standing of customers, also modern economic conditions require the use of new information technologies and computerized tools for collecting, processing and providing information. Therefore, solving the problem of assessing the creditworthiness of customers is one of priority for the bank. That is why it is reasonable to determine the ways of improving the assessment of the creditworthiness of borrowers by the justification the appropriate methodical approach and forming the model of assessment of the creditworthiness of potential borrowers of the bank.

It should be noted that in the scientific literature researchers pay much attention to the investigation of the mechanism of bank's participation in the monetary relations both at the macro level [108; 84; 79; 114; 65; 39; 44; 55; 132; 155; 172] and micro level [57; 65; 194; 56; 120].

However, the analysis of existing viewpoints showed that depending on economic conditions and goals of research, approaches to management of the bank

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

credit portfolio quality based on the assessment of the creditworthiness of potential borrowers are formulated by scientists controversial. The assessing the creditworthiness of potential borrowers of the bank is the subject of many scientists' research. Despite the significant contribution of scientists to study the ways of effective formation and evaluation of the credit portfolio this issue is still important today and needs further study in both theoretical and in practical terms.

It should be noted that most scientific works devoted to the research of separate aspects of credit activity of banks. Thus, according to the work [172] the impact of the monetary policy of banks is essential to the development of production, is especially noticeable with changes in interest rates on loans, which reduction increases the industrial growth in the country.

F. Ali-Shawtari, M. Ariff and S. Abdul-Razak [27] assessed the viability of the banking sector and proposed policy concerning the restructuring the industry in order to increase its effectiveness. In other words, there were identified common directions of intensification of bank's work.

C. Carvajal [50] investigated the impact of the credit restriction on macroeconomic instability and emphasized the importance of credit facilities for business entities. Rad (2016) studied the link between risk management and system of management in banks, in particular, studied the management intent underlying the forming of bank's activity control system.

Ch. Mertzanis [115] emphasized the importance of developing a risk management system and grounded analysis in the process of regulating the bank's activity. E. Osei-Assibey and J. Asenso [131] presented the results of modeling interconnection between indicators of bank's activity, industrial and macroeconomic changes, examined in detail the regulatory capital and its impact on credit expansion, the role of credit and credit debt impact on the efficiency of the bank. N. Gaillard [72] investigated the lack of clear and reliable information about potential borrowers and the impact of limited information on the activity of banks.

W. Hsu-Che, H. Ya-Han, and H. Yen-Hao [83] analyzed credit ratings for assessing credit risk. Ordinary credit rating approaches mainly focus on two classes classification (good or bad credit), which leads to a lack of adequate accuracy for

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

assessment of credit risk in practice. Scientists had proved that most previous studies focused on the use of different methods of data analysis, but the issue of selection and data processing are still remained scarcely explored.

Acknowledging the importance and practical significance of these results, we emphasize that the overall there is a lack of deep theoretical research and practical recommendations for solving the problem of improving and managing exactly the process of assessing the creditworthiness of the borrowers based on advanced information technologies.

The purpose of this work is the examining of existing approaches to determine the creditworthiness of the borrower, analyzing characteristics of such approaches and justification the methodology of evaluating the creditworthiness of the borrower – individual, that let's decide most effectively in the specific conditions of activity of banks.

Each bank uses its own procedures and criteria for assessing the creditworthiness and financial position of the borrower based on analysis of financial statements, following the recommendations of the central bank. For this purpose, there are used advanced applications of express-analysis of the financial standing of companies and dynamic of cash flow. However, there is a lack of recommendations for determining the validity and normative values of some parameters. In the absence of powerful analytical tools in most banks, this problem remains unresolved or solved subjectively in practice.

The main problem of assessing the creditworthiness of borrowers, both individuals and legal entities in banks, there is a great complexity of this work. The process of assessing the creditworthiness is mostly not automated, so there are plenty of busy workers. In addition to the above, search for the required information about the client and its documents is often difficult, because several departments and workers are engaged simultaneously in the assessment of the creditworthiness of the borrower. The main problem with the bank credit process is the inherent uncertainty of it. Not having full information about potential borrowers and changes in the environment, banks have to deal with credit risk almost every day. The development of information technology and information systems allows

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

solving almost no limited number of tasks related to decision-making under uncertainty.

Most frequently to assess the creditworthiness of the borrower used: statistical methods; decision tree; genetic algorithms; neural networks.

Statistical methods based on discriminant analysis are used in solving problems of classification. Thus, the famous Altman model using for analyzing the creditworthiness of entities is based on multiple discriminant analysis. Linear or logistic regression is used to analyze the creditworthiness of individuals. All regression methods are sensitive to the correlation between characteristics, so there should not be strongly correlated characteristics of the borrower in the model.

Statistical methods are based on averaging indicators, but during the study of real difficult phenomena of life, these characteristics may be inapplicable. Assessment of creditworthiness of the borrower through these methods requires a lot of data about the credit history, that is not always possible. Also typical is the problem of lack of examples of borrowers that were unable to repay their debts. A significant drawback of statistical methods is the requirements for special training of the user.

The method of decision trees is high-speed processing and training while maintaining the properties of fuzzy inference. When using the method of decision trees for classification of loan applications a set of rules is used that formed in the construction the tree based on the training set. The tree includes interrelated initial (root), intermediate and end nodes. Each node meets the condition (rule) of the classification of objects. To build a tree at each internal node you need to find a condition that would break the set associated with this node in the subset.

With selected characteristic, the set is divided. As result, the obtained subset is consisted of objects belonging to the same class, or is as close as possible to this. The number of objects from other classes in each of these sets should be as less as possible.

But the method of decision trees has significant drawbacks. It is not suitable for tasks with a large number of possible links and when the condition (rule) can be formulated only in terms of "more/less". That hinders its application to tasks where the class is determined by a complex combination of variables.

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

Genetic algorithms are based on a stochastic search of a global optimum objective function. The idea of genetic algorithms is borrowed from nature and means an organization the process of evolution, the ultimate objective of which is the optimal solution. Such algorithms have a lot of drawbacks. The criterion of selection the indicators does not guarantee finding the "best" solution. You must also have available a fairly large amount of input data to complete the procedure.

Neural networks are the computational structures that model simple biological processes commonly associated with processes in the human brain. According to D. Michie et al. [118], neural networks are a set of elements (artificial neurons) connected by synoptic links. The disadvantage of using neural networks is that they are a "black box". It means that they work on the principle of transferring information from one level of neurons to others, certain input signal corresponds to a certain output and the mechanism of such work is still unknown. Knowledge recorded as the weight of several hundred interneuronal relationships and it is difficult for a person to analyze and interpret them. Also, there is a lack of hard rules of the choice of network speed training for solving specific problems.

There are many architectures of neural networks. For example, to classify clients of German and Australian banks use the following networks: network of Kohonen, Back Propagation network, radial basis network, cascading network.

General disadvantages for practical application of the above methods are requirements to the volume of input and stringent requirements for characteristics and selection criteria for the borrower. In real life borrower's environment is constantly changing, as a result his marital and financial status is changing too. This brings uncertainty to the information about the client. Incorrect assessment of the borrower in these conditions can increase the risk of bank or loss potentially reliable customers.

Turtle, G. Friedlob and L.Schleifer [71], J. Allen, S. Bhattacharya and F. Smarandache [28], E. Chi-Man-Hui, O. Muk-Fai-Lau and T. Kak-Keung-Lo [52], C. Kahraman [87] and others show that the most effective methods are the combined methods of intelligence that combines the benefits of natural and artificial intelligence (for example, methods of fuzzy sets theory).

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

Based on this theory, methods of building information models significantly expand the traditional areas of application computer and create an independent direction of scientific and applied research. Recently, fuzzy modeling is one of the most active and perspective directions of modeling in management and decision-making. In the management of technical facilities, fuzzy modeling allows obtaining more adequate results, compared with the results based on the use of traditional analytical models and control algorithms.

Fuzzy modeling process can be represented in the form of interconnected stages, at each stage, there are carried out specific actions directed to building and further using of information and logical models of systems. In addition, each stage is performed in order to build and use the fuzzy model system to solve the initial problem.

Separate stages of the process fuzzy modeling are: analysis of the problem situation; structuring of the subject area and building a fuzzy model; execution of computing experiments with the fuzzy model; application of the results of computational experiments; correction or completion fuzzy model.

Thus, a fuzzy model of the original or a fuzzy system is first of all characterized by uncertainties type of ambiguity (fuzziness) of the system's limits and its individual states, input and output impacts.

The task of assessing the creditworthiness can be formulated as follows. Every credit application is given by the vector, another word by formalized in a certain way data from the borrower's questionnaire and chosen loan parameters. Then according to the chosen vector, it is necessary to make a decision on the loan, the borrower should be classified as "reliable" or as "not reliable."

In world practice, still there is no single standardized system of assessing the creditworthiness of borrowers, that's way banks use different methods that are complemented each other. At present sector of loans to individuals is the most sensitive to changes in the socio-economic sphere and many existing methods for assessing the creditworthiness of clients has appeared inefficient. Because of growing competition in the market of credit services and unsatisfied demand for different banking products, credit institutions have to look for ways to attract

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

creditworthy customers with saving the possibility of control losses. So there is a need for better selection of borrowers.

Assessment of the creditworthiness of the borrower – individual based on the ratio of the requested loan and its personal income, overall assessment of the financial situation of the borrower and the cost of its property, on the results of studying personal characteristics and credit history. Lending to borrowers – individuals allows banks, on the one hand, to increase their income in a short period of time, and on the other hand, it is always associated with the risk of late payment or no repayment of the loan in full. Accurate assessment of the ability of borrowers to meet their loan obligations allows reducing possible losses. Therefore, a competent organization of assessing the creditworthiness of borrowers very is important.

Permanent improvement of the lending system in the face of rising interbank competition is a necessary condition for the bank for forming its public image as a universal credit institution and serves as an additional source of income of credit operations with individuals. Despite intense development in recent years this area of banking business still has huge reserves of growth. Assessment of the creditworthiness of a potential borrower is carried out to determine its class of reliability and financial ability to timely and fully implement repayment in terms and conditions established by the credit agreement.

The periodicity of assessment of the financial condition of borrowers – individuals is defined by the bank based on the state of debt servicing and maturity of the loan. If the credit debt service is characterized by delay or prolongation, then an assessment of the financial condition of borrowers – individuals should be constant for a period of delayed repayment of debt, except when it is related to valid reasons. The world banking practice distinguishes a number of components that together allow determining the level of creditworthiness of the borrower. In order to create an effective methodology of the complex system of assessment the creditworthiness of borrowers in indicators of creditworthiness should be included not only the value that is relatively easily calculated using quantitative data but also those that may be described by the evaluative judgments.

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

Yue Jiao, Yu-Ru Syau, and E. Stanley Lee [213] in their work presented a model for assessing the credit rating of small financial enterprises based on the fuzzy adaptive network. There are deep mathematical calculations and a lot of specification of the neural network. The authors use a set of specific indicators taking into account the object of their research.

Based on the research work of scientists there were generalized main qualitative and quantitative characteristics of the borrower, that should be taken into account in assessing the creditworthiness of the borrower – individual. Particular attention is paid on considering the quality indicators of the creditworthiness of borrowers in the regulation of credit activity of banks. This question was so emphasized by Tammi [184] in his works. Also, questions of security of credit were investigated by A. Ghosh [75] by the example of specialized banks.

For the proposed model of the creditworthiness assessments of bank's potential borrowers (individuals) on the basis of fuzzy logic the input indicators were selected taking into account the recommendations of the central bank, internal instructions of Ukrainian banks, the experience of using the system of indicators in domestic banking practice by an expert survey of employees of the largest banks in Ukraine.

The authors constructed a model assessing the creditworthiness of the borrower based on fuzzy logic taking into account selected indicators with further the possibility of expanding the list of assessment criteria. According to these indicators, we make a linguistic score for generalizing indicator of creditworthiness.

General indicator (R) is a three-level convolution where partial indicators (a1, a2, a3, b1, b2, b3, c1, c2, c3, d1, d2, d3) combined in the components of evaluation (A, B, C, D), and the components in their turn – in the resulting indicator. Model of assessment of the creditworthiness of the borrower – individual is based on predefined parameters and the chosen method (figure 4.3).

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

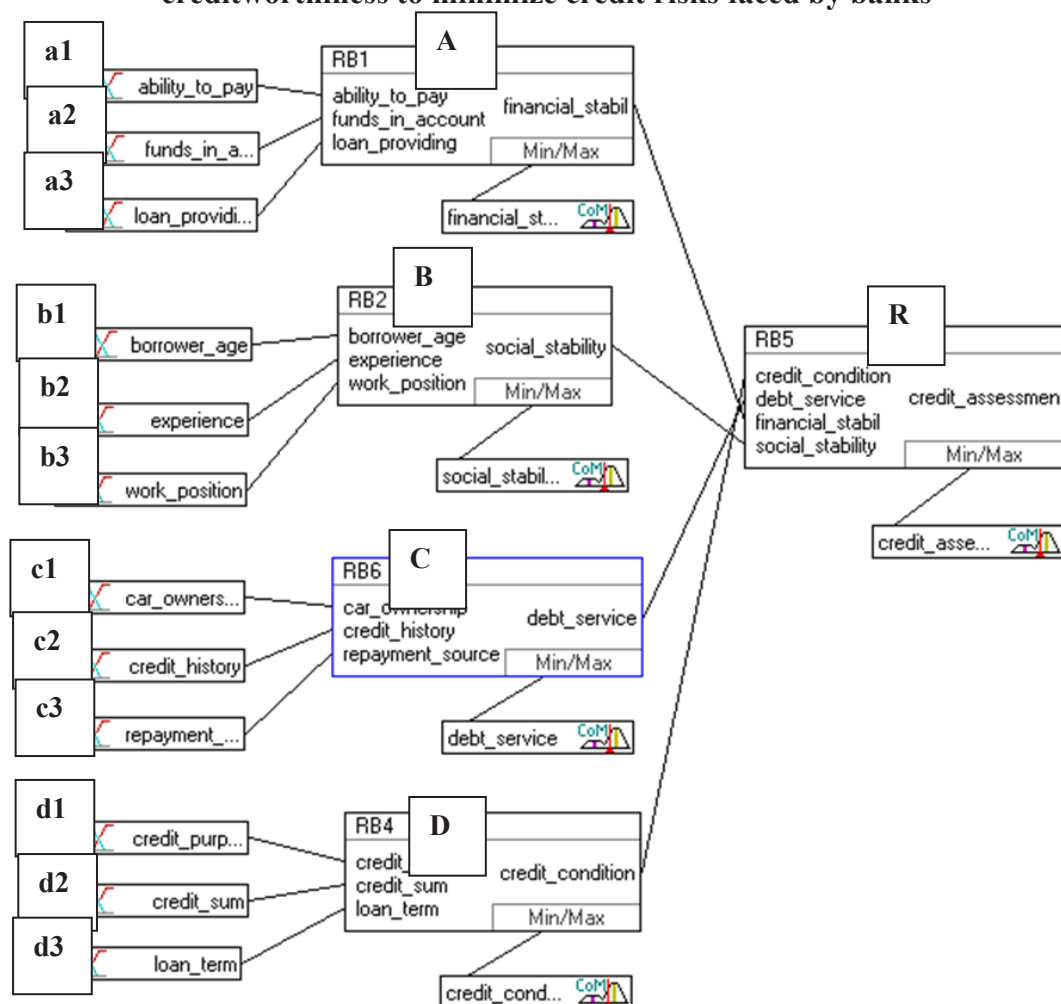


Figure 4.3. The structure of the model of assessing the creditworthiness of potential borrower-individual (realization in FuzzyTech program tool)

Source: formed by the authors [127]

Thus, input and output options were identified and each of them is characterized by a set of linguistic terms of linear (triangular and trapezoidal) membership function.

On the upper level, the input parameters are the borrower's financial stability, social stability, debt service, credit conditions. They are also output parameters of the lower level. For each input parameter has constructed membership function depending on the deviation from the schedule of passing

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

control points (table 4.6).

Intervals of changes of such components as the financial stability of the borrower, debt service of the borrower, credit conditions are based on the "golden ratio" or Fibonacci numbers as the basis of harmonious division.

Table 4.6. The components (characteristics of membership functions) for assessing creditworthiness of borrower (R)

Symbol	Name	Symbol	Linguistic assessment	The trapezoidal numbers for the values of linguistic variable				Interval
A	Financial stability of the borrower	A1	weak	0	0,118	0,382		0 – 0,382
		A2	enough	0,375	0,499	0,558	0,618	0,382 – 0,618
		A3	strong	0,600	0,735	0,853	1	0,618 – 1
B	Social stability of the borrower	B1	weak	0	0,12	0,25		0 – 0,25
		B2	enough	0,20	0,35	0,5	0,75	0,25 – 0,75
		B3	strong	0,65	0,85	0,95	1	0,75 – 1
C	Debt service	C1	satisfactory	0	0,236	0,382		0 – 0,382
		C2	good	0,370	0,499	0,618		0,382 – 0,618
		C3	excellent	0,550	0,735	1		0,618 – 1
D	Credit conditions	D1	low risky	0	0,127	0,254	0,382	0 – 0,382
		D2	risky	0,375	0,508	0,618		0,382 – 0,618
		D3	very risky	0,500	0,744	1		0,618 – 1

Source: formed by the authors [127]

As already noted general indicator of assessment of the creditworthiness of the borrower – individual (R) consists of four components, which have three terms in accordance with the range of variation: financial stability of the borrower, social stability of the borrower, debt service and credit conditions.

In table 4.7 terms and intervals of an overall assessment of the creditworthiness of the borrower for the model are given. Intervals of changes of the assessment of the creditworthiness of the borrower and its linguistic assessment are based on Harrington's Desirability Function (Harrington, 1965).

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

Table 4.7. Overall assessment of creditworthiness of the borrower for the model

Indicator	Intervals	Linguistic assessment
R1	0 – 0,37	Low
R2	0,30 – 0,65	Satisfactory
R3	0,55 – 0,80	Good
R4	0,70 – 1	very good

Source: formed by the authors [127]

Each of the components of an overall assessment of the creditworthiness of the borrower combines a number of partial indicators. In annex 1–4 the structure of each component in the context of the partial indicators is given. The intervals of changing of the indicator of the current ability to pay are selected in accordance with the generally accepted practice of its use in the bank's work, as well as the intervals for the indicator of ensuring the credit, the loan term, lending amount.

For indicators funds on accounts in banks, sources of debt repayment and purpose of lending intervals are based on the results of a survey of experts of the banking sector. The "age of the borrower" and "work experience" are broken at intervals, taking into account the logic and objective trends of the labor market in Ukraine.

Intervals for the indicator "place of work (position)" correspond to the logic of construction the Unified Tariff Grid in Ukraine. The intervals of the indicator "Automobile ownership" (the cost of cars) are due to the general tendency of prices in the car market and the purchasing power of Ukrainian citizens.

Depending on the input variables and possible options of its combination (rules for assessing the creditworthiness of the borrower) we received general characteristics R (table 4.8). The full set of rules is given in annex 5–9.

Computer representation of membership functions for input component (A, B, C, D) of the general indicator of the creditworthiness of the borrower (R) is shown on figure 4.4. Computer representation of membership functions for input variables of the structural components (A, B, C, D) is given in annex 10.

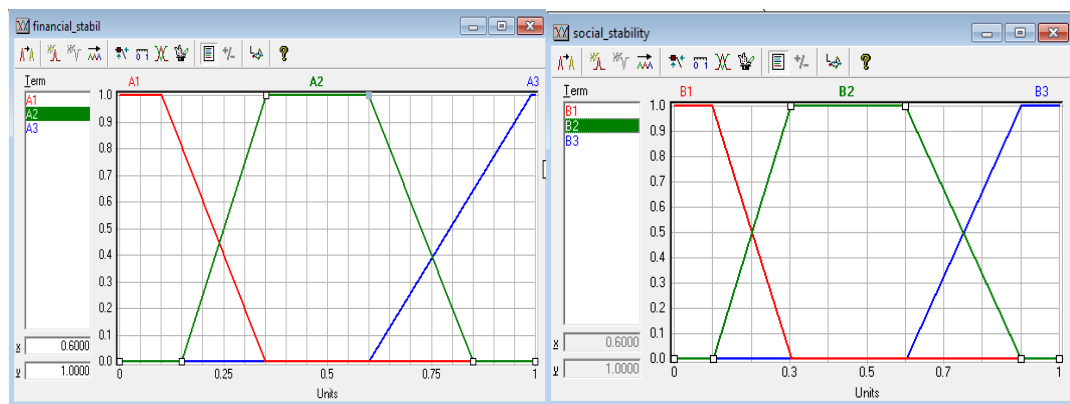
4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

Table 4.8. Rules for assessing the creditworthiness of the borrower (fragment)

Rule	Financial stability	Social stability	Debt service	Credit conditions	Overall assessment of creditworthiness
1	2	3	4	5	6
1	weak	weak	satisfactory	low risk	low
2	weak	weak	satisfactory	risk	low
.....					
15	enough	enough	satisfactory	risk	satisfactory
16	enough	weak	satisfactory	risk	low
.....					
81	enough	strong	excellent	low risk	very good

Source: formed by the authors [127]

For effective practical use of the model following steps should be done on the stage of implementation of the model: accumulating a sufficient base for each of the input parameters; conducting adaptation; clarification and correction the model (look and membership functions parameters, decision-making rules). Based on data about individuals an approbation of the model of the assessing the creditworthiness of borrowers has been conducted.



4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

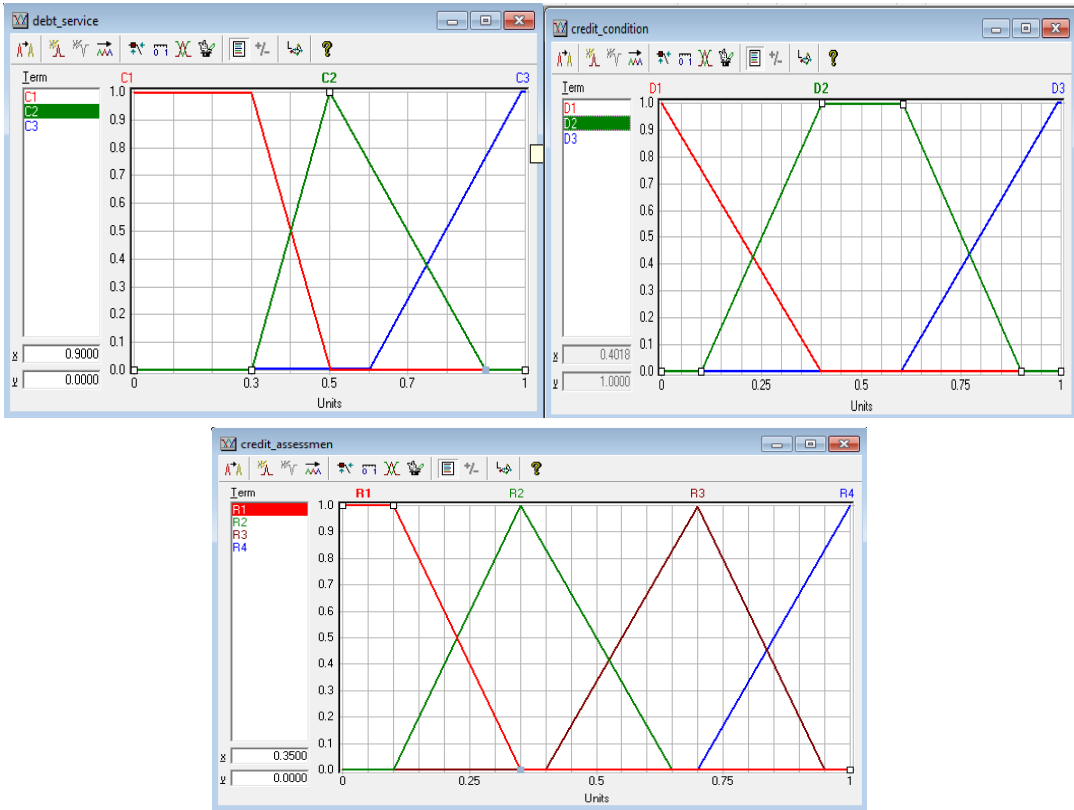


Figure. 4.4. Computer representation of membership functions for input components (A, B, C, D) of the general indicator of the creditworthiness of the borrower (R)

Source: formed by the authors [127]

The results of assessing the creditworthiness of borrowers are given on figure 4.5, for all potential clients we have received a summary assessment of creditworthiness.

On the left side of each interactive window while working in the program user enters a numerical value (assessment) of input parameters, and on the right side, the program displays the results of calculations for all output parameters (interim and final).

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

1.2800		0.7000	
Inputs:		Inputs:	
ability_to_pay	1.2800	ability_to_pay	2.0000
borrower_age	25.0000	borrower_age	45.0000
car_ownership	3500.0000	car_ownership	4000.0000
credit_history	5.0000	credit_history	1.0000
credit_purpose	1.5000	credit_purpose	2.5000
credit_sum	36.0000	credit_sum	100.0000
experience	2.0000	experience	7.0000
funds_in_account	1.0000	funds_in_account	4.0000
loan_providing	110.0000	loan_providing	125.0000
loan_term	3.0000	loan_term	5.0000
repayment_source	0.2000	repayment_source	0.7000
work_position	10.0000	work_position	10.0000
Outputs:		Outputs:	
credit_assessmen	0.0500	credit_assessmen	0.7000
credit_condition	0.4018	credit_condition	0.9950
debt_service	0.1500	debt_service	0.1516
financial_stabil	0.3216	financial_stabil	0.9950
social_stability	0.0500	social_stability	0.4514

1.1000		0.8000	
Inputs:		Inputs:	
ability_to_pay	1.1000	ability_to_pay	1.2000
borrower_age	30.0000	borrower_age	50.0000
car_ownership	5500.0000	car_ownership	2000.0000
credit_history	8.0000	credit_history	8.5000
credit_purpose	2.5000	credit_purpose	1.0000
credit_sum	80.0000	credit_sum	31.0000
experience	4.0000	experience	14.0000
funds_in_account	1.2000	funds_in_account	1.5000
loan_providing	115.0000	loan_providing	122.0000
loan_term	8.0000	loan_term	2.0000
repayment_source	0.8000	repayment_source	0.7000
work_position	10.0000	work_position	18.0000
Outputs:		Outputs:	
credit_assessmen	0.2393	credit_assessmen	0.3153
credit_condition	0.9950	credit_condition	0.4018
debt_service	0.4539	debt_service	0.2654
financial_stabil	0.0508	financial_stabil	0.1763
social_stability	0.3145	social_stability	0.6888

14.0000		14.0000	
Inputs:		Inputs:	
ability_to_pay	1.3000	ability_to_pay	1.4000
borrower_age	37.0000	borrower_age	42.0000
car_ownership	12000.0000	car_ownership	17000.0000
credit_history	6.0000	credit_history	7.0000
credit_purpose	0.5000	credit_purpose	2.5000
credit_sum	17.0000	credit_sum	95.0000
experience	12.0000	experience	6.0000
funds_in_account	1.4000	funds_in_account	1.3000
loan_providing	135.0000	loan_providing	140.0000
loan_term	1.0000	loan_term	5.0000
repayment_source	0.6000	repayment_source	1.0000
work_position	14.0000	work_position	14.0000
Outputs:		Outputs:	
credit_assessmen	0.4177	credit_assessmen	0.7000
credit_condition	0.1948	credit_condition	0.9943
debt_service	0.1500	debt_service	0.9635
financial_stabil	0.3825	financial_stabil	0.4763
social_stability	0.4514	social_stability	0.4514

0.5000		16.5000	
Inputs:		Inputs:	
ability_to_pay	1.3700	ability_to_pay	1.5200
borrower_age	27.0000	borrower_age	45.0000
car_ownership	2000.0000	car_ownership	18000.0000
credit_history	5.0000	credit_history	8.9000
credit_purpose	1.5000	credit_purpose	2.0000
credit_sum	25.0000	credit_sum	79.0000
experience	2.5000	experience	8.0000
funds_in_account	1.0000	funds_in_account	3.5000
loan_providing	117.0000	loan_providing	152.0000
loan_term	3.0000	loan_term	9.0000
repayment_source	0.5000	repayment_source	0.8000
work_position	14.0000	work_position	16.5000
Outputs:		Outputs:	
credit_assessmen	0.1204	credit_assessmen	0.7743
credit_condition	0.4018	credit_condition	0.9898
debt_service	0.1500	debt_service	0.8443
financial_stabil	0.4763	financial_stabil	0.9950
social_stability	0.1302	social_stability	0.5552

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

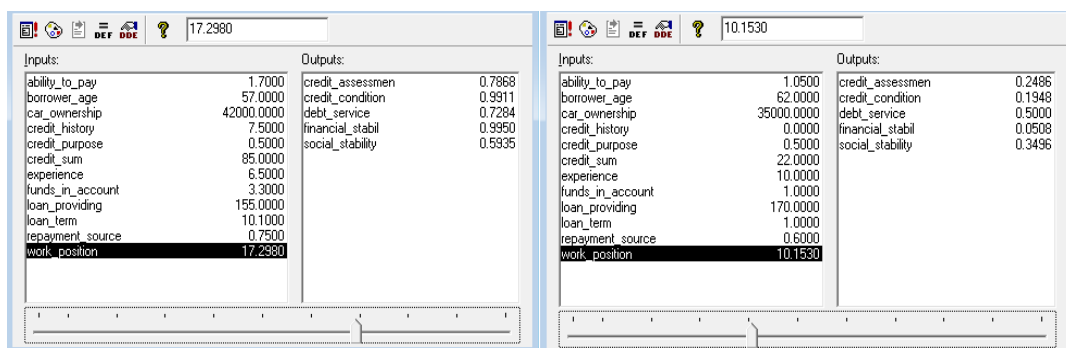


Figure 4.5. Computer representation of the results of assessing the creditworthiness of borrowers

Source: formed by the authors [127]

There are input variables of the model and the results of assessing the creditworthiness of borrowers in table 4.9.

Table 4.9. Input numerical data for each client and the results of assessing the creditworthiness of borrowers

Client	Creditworthiness of the borrower												
	Financial stability (A)			Social stability (B)			Debt service (C)			Credit conditions (D)			Creditworthiness assessment R
	ability to pay	funds in account	loan providing	experience	borrower age	work position	repayment sources	credit history	car ownership	credit purpose	loan term	credit sum	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1,28	1	110	2	25	0,5	0,2	5	3500	1,5	3	36000	0,05
2	2	4	125	7	45	1	0,7	1	4000	2,5	5	100000	0,7
3	1,1	1,2	115	4	30	0,5	0,8	8	5500	2,5	8	80000	0,239
4	1,2	1,5	122	14	50	2	0,7	8,5	2000	1	2	31000	0,315
5	1,3	1,4	135	12	37	3	0,6	6	12000	0,5	1	17000	0,418
6	1,4	1,3	140	6	42	1,5	1	7	17000	2,5	5	95000	0,7
7	1,37	1	117	3	27	1,5	0,5	5	2000	1,5	3	25000	0,12

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

1	2	3	4	5	6	7	8	9	10	11	12	13	14
8	1,52	3,5	152	8	45	2	0,8	8,9	18000	2	9	79000	0,774
9	1,7	3,3	155	7	57	2,7	0,8	7,5	42000	2	12	85000	0,787
10	1,05	1	170	10	62	1	0,6	0	35000	0,5	1	22000	0,249

Source: calculated by the authors [127]

There are grouped assess of the creditworthiness of clients and their linguistic assessment in table. 4.10. Of course, these recommendations are not exhaustive, they are carefully developed by employees of the bank, approved by the credit committee, and then provided to credit manager for further work. Also, a more detailed analysis of direct numerical modeling of our model is the subject of further research.

We assume, in particular, consider such questions as construction of membership functions based on statistical analysis of expert interviews; the use of more complex forms of membership functions, including non-standard; opportunities for learning and adjustments constructed system fuzzy inference using the neural network; increasing the number of initial model parameters; determine the weights of parameters; development model using different values of weighting coefficients for different initial, intermediate parameters and appropriate decision-making; creation the modules by adding models in the programming language C.

Table 4.10. Summary results of the assessment creditworthiness of clients

Linguistic assessment of the creditworthiness of client: «low»	Recommended actions by the bank	Linguistic assessment of the creditworthiness of client: «satisfactory»	Recommended actions by the bank
1	2	3	4
client 1 client 3 client 4 client 7 client 10	Refuse to provide credit	client 5	Refuse to provide credit, but provide recommendations for correct deficiencies and improve indicators

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

1	2	3	4
Linguistic assessment of the creditworthiness of client: «good»	Recommended actions by the bank	Linguistic assessment of the creditworthiness of client: «very good»	Recommended actions by the bank
client 2 client 6	Satisfy an application for credit, but on a lower amount	client 8 client 9	Satisfy an application for credit

Source: formed by the authors [127]

The main problem in the analysis of the creditworthiness of borrower – individual is the inaccuracy of data, lack of a base of knowledge of customers' past and the necessity to work with linguistic characteristics that are difficult to mathematical processing. In specific terms of banks functioning methods based on fuzzy logic, including methods based on fuzzy neural network and Mamdani controller give good results. They allow getting grounded decision considering the fuzzy evaluation, fuzzy information about the object, initial settings, that are characterized by fuzzy criteria.

Thus, the work provided practical recommendations for improving the approach to evaluating the quality of the credit portfolio of the bank and ensure its quality on the basis of the model of assessment creditworthiness of borrower – individual. Implementation of advanced methodical tools of modeling the analysis of the creditworthiness of borrower based on fuzzy logic allows the bank's management to implement grounded decisions at the stage of customer service more effectively.

Because complex automation of processing parameters, calculations of results based on these parameters is becoming increasingly important for modern banking systems, the model for evaluating the creditworthiness of borrowers – individuals based on fuzzy logic was developed based on specified parameters and offered to practical use. It is timely to ensure the quality of banks' activity.

The results of research can be used in practical activities of banks to assess the financial status of bank's client according to the established criteria and make a decision by bank's managers concerning expediency granting credit in each case. Formulated theoretical-methodological and practical arrangements may be used for

4.3. Methodological and practical aspects of analyzing the borrowers' creditworthiness to minimize credit risks faced by banks

further research in evaluating the quality of the credit portfolio and credit risk management.

Of course, there is certain subjectivity about building a model. It manifests itself at the initial stage, when on the basis of expert assessments (groups or even one specialist) sets of membership functions, numerical characteristics and the form of sets of terms of linguistic variables.

Therefore, the example given in the article only shows the possibility of developing and using such models on the basis of fuzzy sets theory and fuzzy modeling. Therefore, in practical use, a preliminary adjustment, adaptation of the model, based on specific loan conditions and other features, is required, which can only be identified and accounted for in the practical application of the model.

Considering the interaction of the proposed approach with other existing ones, two main points should be noted.

The first is that in practice it is advisable to simultaneously use several different approaches to solve this problem. And if the results obtained by different methods are the same or almost the same, the decision to lend the borrower can be considered correct. That is, the results confirm each other. Otherwise, additional calculations or use of other methods of developing and making decisions, including, possibly, correcting the calculation models themselves are necessary.

The second point to be noted is that the proposed fuzzy modeling approach requires good statistical preparation at the stage of initial model development. This concerns the definition of a set of evaluation parameters, the numerical values of their individual levels, the nature (kind) of membership functions and linguistic variables. At this stage it is necessary to make maximum use of methods of expert evaluation and statistical processing of their data.

The practical value of the results investigation confirmed the real trends and existing needs of the banking system of Ukraine. Proposed analytical tools can be used by banks in practice. The competitive advantages of it include the flexibility to expand the base of input parameters and the ability to adapt according to the requirements that can permanently change.

CONCLUSIONS

The economy development and the success of implementing the integration vector are largely determined by the effectiveness of the state financial monitoring system, which is primarily oriented at counteracting such a social phenomenon as the legalization of money received by illegal means and terrorist financing.

The monograph elaborates the main provisions for building a risk-oriented system aimed to combat money laundering, terrorist financing, and proliferation of mass destruction weapons; their application will contribute to implementing the state policy in the fight against these negative phenomena. It has been established that four out of six regulators in the Ukrainian financial service market (namely, the National Securities and Stock Market Commission, the Ministry of Finance, the Ministry of Justice, and a specially authorized body) still use outdated, formal, and ineffective criteria for assessing the risks to be involved in the money legalization faced by primary financial monitoring subjects. The Ministry of Digital Transformation, as a newly created regulator, has not yet developed such criteria. And only the National Bank of Ukraine has already considered the requirements of FATF, AMLD4, and the new Law on Financial Monitoring in its criteria. The National Securities and Stock Market Commission received a proposition to unify risk-oriented signs identifying the possible involvement of a primary financial monitoring subject in money laundering schemes, and to introduce its own procedures, which will be identical to the mechanisms implemented by the National Bank of Ukraine, aimed at the state financial monitoring for professional participants in stock markets, taking into account the specifics of their activities.

The research also addressed the features of the financial service market functioning in the digitalized economy environment. It was determined that traditional insurers are ill-prepared for digital activities in the digital markets of the future and, accordingly, for combating money laundering and terrorist financing in the digital economy. However, online market conditions force insurance companies to implement digital technologies in this area, in particular, digital identification of policyholders. As it was identified while analyzing the digital development of anti-money laundering in insurance, the digitalization process comprises three directions: InsurTech, RegTech, and SupTech. Insurance companies are implementing digital client identification procedures for online sales and claim

Conclusions

settlement, as well as analyzing clients' digital experiences. Automation is seen in the processes related to insurers' compliance with anti-money laundering regulations, including the submission of reports to financial monitoring bodies. Supervisors digitize and improve control and analysis of anti-money laundering operations. The integrated application of digital technologies will provide means for improving the insurers' ability to duly verify clients, identify, and monitor suspicious transactions through joint efforts.

Acting as intermediaries between the owners of temporarily free funds and those who need them, banks quite often underestimate the risks of being attracted to money laundering and terrorist financing schemes. The research determined that the crucial element that provides banks, as primary financial monitoring subjects, with the ability to counter money laundering, is a risk-oriented approach. The risk-oriented approach provides for the formation of money laundering risk management system and the adoption of appropriate measures in a manner and volume that ensure the effective minimization of these risks.

The researchers investigated the legal regulation of the financial monitoring system in European countries and Ukraine, considered the main risks associated with the legalization of money received by illegal means (money laundering), terrorist financing, and/or proliferation of mass destruction weapons, their types, and evaluation criteria, which allowed determining the specifics of the risk-oriented approach in the banking sector for Ukraine and developing recommendations aimed to improve the procedure for financial monitoring based on the implementation of the positive experience acquired by European countries. It was proposed to identify threats subject to the type and jurisdiction of clients, as well as the financial transaction types and channels for their implementation, which intends to effectively manage the ML/TF risks with a focus on minimizing and/or avoiding them.

Proceeding from the relation between the risks of being involved in money laundering processes faced by banks and other banking risks, the researchers suggest recommendations concerning the following: improving the efficiency of credit risk and strategic risk management; application of monitoring tools to identify potential threats in the banks' activities.

Taking into account the lack of recommendations for solving the problem of the significance and normative values of individual indicators when assessing the

Conclusions

bank borrowers' (individuals') creditworthiness, the work presents a toolkit to solve this problem. The module for assessing the individual borrowers' creditworthiness, developed using fuzzy logic, addresses such parameters as the borrower's financial stability, social stability, sources and servicing of the borrower's debt, and credit conditions. The input and output parameters are investigated as a set of linguistic terms with a linear (triangular and trapezoidal) membership function. The use of the proposed tools will ensure the quality of banking institutions' work with regard to preventing the growth of distressed assets and minimizing credit risks.

To assess the bank's strategic risk, it is proposed to consider the ratio of the actual and planned values of the parameters for measuring the degree of achieving the financial and non-financial strategic goals set by the bank and the development level identified for the system of organizational and economic support for the bank's strategic management. The synthesis of results in certain assessment areas characterizing the primary and secondary strategic risk, respectively, provides means for determining its generalizing level (high, medium, or low) and foreseeing the emergence of other risks associated with it, including the money laundering risk and compliance risk. It is concluded that the overestimation of the planned values calculated based on the indicators for measuring strategic goals, in particular, the bank's performance parameters, increases the possible realization of the strategic risk and may induce banks to fail to comply with the legislation requirements in the field of financial monitoring in order to obtain financial benefits.

In general, the conclusions and proposals presented in this monograph aim to develop theoretical and methodological tools and practical recommendations for the implementation of the risk-oriented approach to combating money laundering.

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APPENDIX

Annex 1

Indicators (characteristics of membership functions) for assessing of the borrower financial stability (A).

Symbol	Name	Symbol	Linguistic assessment	Triangular and trapezoidal numbers for the value of linguistic variable				Interval
a1	The current ability to pay (CAP)	a11	low	1	1,25			$1 < CAP < 1,25$
		a12	middle	1,20	1,3	1,40	1,5	$1,25 < CAP < 1,5$
		a13	high	1,45	2			$CAP > 1,5$
a2	Funds on accounts in banks	a21	absent	0	1			No funds on accounts in banks (1 point)
		a22	insufficient	0,75	1,5	2		Funds on accounts in the amount less than the loan amount (2 points)
		a23	sufficient	1,7	3	4		Funds on accounts that exceed the amount of the loan (4 points)
a3	Ensuring the credit (EC)	a31	sufficient	100	110	125		The collateral value of the property less than 25% higher than the amount of credit debt $100\% < EC < 125\%$
		a32	middle	120	130	140	150	The collateral value of the property at least 25% higher than the amount of credit debt $125\% < EC < 150\%$
		a33	high	145	200	250		The collateral value of the property at least 50% higher than the amount of credit debt $EC > 150\%$

Appendix

Annex 2

Indicators (characteristics of membership functions) for assessing of the borrower social stability (B).

Symbol	Name	Symbol	Linguistic assessment	Triangular and trapezoidal numbers for the value of linguistic variable				Interval
b1	Work experience	b11	low	0	1	3		To 3 years;
		b12	middle	2,5	3,5	7	10	From 3 to 10 years;
		b13	high	8,5	15			More than 10 years
b2	Age borrower	b21	young	20	25	35		20-35 years;
		b22	adult	30	35	45	55	35-55 years
		b23	old	50	65	70		55-70 years ;
b3	Place of work (position)	b31	low	0,5	1			The worker or employee (0.5 or 1 point)
		b32	middle	0,75	1,5	2		Specialist, top manager of the company (2 points)
		b33	high	1,75	2,5	3		Own business or the head (3 points)

Indicators (characteristics of membership functions) for assessing of the borrower social stability (C).

Symbol	Name	Symbol	Linguistic assessment	Triangular and trapezoidal numbers for the value of linguistic variable				Interval
c1	Sources of debt repayment	c11	unstable	0	0,1	0,2		Unstable additional income (0.2 points)
		c12	stable	0,15	0,4	0,6		Stable additional income (0.6 points)
		c13	stable and reliable	0,50	0,7	0,8	1	The official salary and other confirmed income (1 point)
c2	Credit history	c21	sufficient	0	5			There is a breach of contract (0 points) Not used (5 points);
		c22	good	4	6	8		Systematic delay payments over 7 days (4 points) Systematic delay payments to 7 days (6 points) Delay payments not systematically to 7 days (8 points)
		c23	excellent	7	10			Individual cases of overdue payments (7.5 points) Debt service is good without violations (9 points)
c3	Auto-mobile ownership	c31	cheap	300	1000	2000	3000	Cost up to USD 3,000
		c32	budget	2500	5000	7000	10000	Cost from 3 000 to 10 000 USD.
		c33	medium	9000	15000	25000	30000	Cost from 10 000 to 30 000 USD
		c34	expensive	27000	50000	75000	100000	Cost from 30 000 USD.

Appendix

Annex 4

Indicators (characteristics of membership functions) for credit conditions (D).

Symbol	Name	Symbol	Linguistic assessment	Triangular and trapezoidal numbers for the value of linguistic variable				Interval
d1	The purpose of lending	d11	Consumer lending	0	0,5			Purchases of consumer goods (0.5 points)
		d12	Auto Loans	0,4	1	1,5	2	Purchase of cars (1 point-domestic, 2 points-import)
		d13	Mortgage Lending	1,75	2	2,5		Purchase of house (2 points - secondary market, construction - 2.5 points)
d2	Loan term	d21	Short	0,1	1			To 1 year
		d22	Medium	0,75	2	3	5	From 1 to 5
		d23	Long	4	10	15		From 5 to 15
d3	Lending amount	d31	Small	1000	5000	10000	20000	To 20 000 UAH
		d32	Medium	18000	25000	35000	50000	From 20 000 to 50 000 UAH
		d33	Big	48000	70000	100000		Over 50 000 UAH

Appendix

Annex 5

**The rules for forming assess of the financial stability of the borrower
(A) (A1 weak; A2 sufficient; A3 strong).**

The combination of components			Financial stability A
a11	a21	a31	A1
a11	a22	a31	A1
a11	a23	a31	A2
a11	a22	a32	A1
a11	a21	a32	A1
a11	a23	a33	A2
a11	a22	a33	A1
a11	a21	a33	A1
a11	a23	a32	A2
a12	a21	a31	A2
a12	a22	a31	A2
a12	a23	a31	A3
a12	a22	a32	A2
a12	a21	a32	A2

The combination of components			Financial stability A
a12	a23	a33	A3
a12	a22	a33	A3
a12	a21	a33	A2
a12	a23	a32	A3
a13	a21	a31	A2
a13	a22	a31	A2
a13	a23	a31	A3
a13	a22	a32	A2
a13	a21	a32	A2
a13	a23	a33	A3
a13	a22	a33	A3
a13	a21	a33	A2
a13	a23	a32	A3

Appendix

Annex 6

The rules for forming assess of the social stability of the borrower (B) (B1 weak; B2 sufficient; B3 strong).

The combination of components			Social stability B
b11	b21	b31	B1
b11	b22	b31	B1
b11	b23	b31	B1
b11	b22	b32	B2
b11	b21	b32	B1
b11	b23	b33	B2
b11	b22	b33	B2
b11	b21	b33	B1
b11	b23	b32	B1
b12	b21	b31	B1
b12	b22	b31	B2
b12	b23	b31	B1
b12	b22	b32	B2
b12	b21	b32	B2

The combination of components			Social stability B
b12	b23	b33	B2
b12	b22	b33	B3
b12	b21	b33	B3
b12	b23	b32	B2
b13	b21	b31	B2
b13	b22	b31	B2
b13	b23	b31	B1
b13	b22	b32	B2
b13	b21	b32	B2
b13	b23	b33	B3
b13	b22	b33	B3
b13	b21	b33	B3
b13	b23	b32	B2

Appendix

Annex 7

The rules for forming assess of the debt service of the borrower (C) (C1 satisfactory; C2 good; C3 excellent).

The combination of components			Debt service C
c11	c21	c31	C1
c11	c22	c31	C1
c11	c23	c31	C1
c11	c22	c32	C1
c11	c21	c32	C1
c11	c23	c33	C1
c11	c22	c33	C1
c11	c21	c33	C1
c11	c23	c32	C1
c12	c21	c31	C1
c12	c22	c31	C1
c12	c23	c31	C1
c12	c22	c32	C1
c12	c21	c32	C1
c12	c23	c33	C2
c12	c22	c33	C2
c12	c21	c33	C2
c12	c23	c32	C2

The combination of components			Debt service C
c13	c21	c31	C1
c13	c22	c31	C2
c13	c23	c31	C2
c13	c22	c32	C2
c13	c21	c32	C2
c13	c23	c33	C3
c13	c22	c33	C3
c13	c21	c33	C2
c13	c23	c32	C3
c11	c21	c34	C2
c11	c22	c34	C2
c11	c23	c34	C2
c12	c21	c34	C2
c12	c22	c34	C2
c12	c23	c34	C3
c13	c21	c34	C2
c13	c22	c34	C3
c13	c23	c34	C3

Appendix

Annex 8

The rules for forming assess the credit conditions (D) (D1 low risky; D2 risky; D3 very risky).

The combination of components			Credit conditions D
d11	d21	d31	D1
d11	d22	d31	D1
d11	d23	d31	D1
d11	d22	d32	D2
d11	d21	d32	D1
d11	d23	d33	D3
d11	d22	d33	D3
d11	d21	d33	D2
d11	d23	d32	D2
d12	d21	d31	D1
d12	d22	d31	D2
d12	d23	d31	D2
d12	d22	d32	D2
d12	d21	d32	D2
The combination of components			Credit conditions D
d12	d23	d33	D3
d12	d22	d33	D3
d12	d21	d33	D2
d12	d23	d32	D2
d13	d21	d31	D2
d13	d22	d31	D2
d13	d23	d31	D3
d13	d22	d32	D2
d13	d21	d32	D3
d13	d23	d33	D3
d13	d22	d33	D3
d13	d21	d33	D3
d13	d23	d32	D3

Appendix

Annex 9

**The rules for forming assess of the creditworthiness of borrowers (R)
(R1 low; R2 satisfactory; R3 good; R4 very good).**

The combination of components				Creditworthiness of borrowers
A1	B1	C1	D1	R1
A1	B1	C1	D2	R1
A1	B2	C1	D2	R1
A1	B2	C1	D3	R1
A2	B2	C1	D2	R2
A2	B1	C1	D2	R1
A2	B2	C1	D3	R2
A3	B1	C1	D1	R2
A1	B2	C1	D1	R1
A1	B3	C1	D1	R2
A1	B1	C1	D3	R1
A1	B3	C1	D3	R1
A2	B1	C1	D1	R2
A2	B2	C1	D1	R3
A2	B3	C1	D1	R3
A2	B1	C1	D3	R2
A2	B3	C1	D3	R2
A2	B3	C1	D2	R2
A3	B3	C1	D3	R3
A3	B1	C1	D3	R2
A3	B2	C1	D1	R3
A3	B2	C1	D3	R3
A3	B3	C1	D2	R3
A1	B2	C2	D2	R2
A1	B1	C2	D1	R1
A1	B1	C2	D3	R1
A1	B2	C2	D3	R2
A1	B3	C3	D1	R2
A1	B2	C3	D1	R2
A2	B3	C3	D1	R4
A1	B3	C1	D2	R2
A3	B3	C1	D1	R3
A3	B1	C1	D2	R2
A3	B2	C1	D2	R3
A1	B2	C2	D1	R2
A1	B1	C2	D2	R1
A1	B3	C2	D1	R2
A1	B3	C2	D2	R2
A1	B3	C2	D3	R2
A2	B2	C2	D2	R3
A2	B1	C2	D2	R3
A2	B2	C2	D1	R4
A2	B3	C2	D1	R4
A2	B3	C2	D2	R4
A3	B1	C3	D1	R3
A3	B1	C3	D2	R3
A3	B2	C3	D3	R3
A3	B2	C3	D2	R3
A3	B3	C3	D3	R3
A3	B3	C3	D1	R4
A3	B3	C3	D2	R4
A3	B1	C3	D1	R3
A3	B1	C3	D2	R3
A3	B2	C2	D3	R3
A1	B2	C3	D3	R2
A2	B2	C3	D3	R3
A3	B1	C3	D3	R3
A3	B2	C3	D3	R3
A3	B2	C3	D2	R3
A3	B2	C3	D1	R4
A3	B2	C3	D2	R4

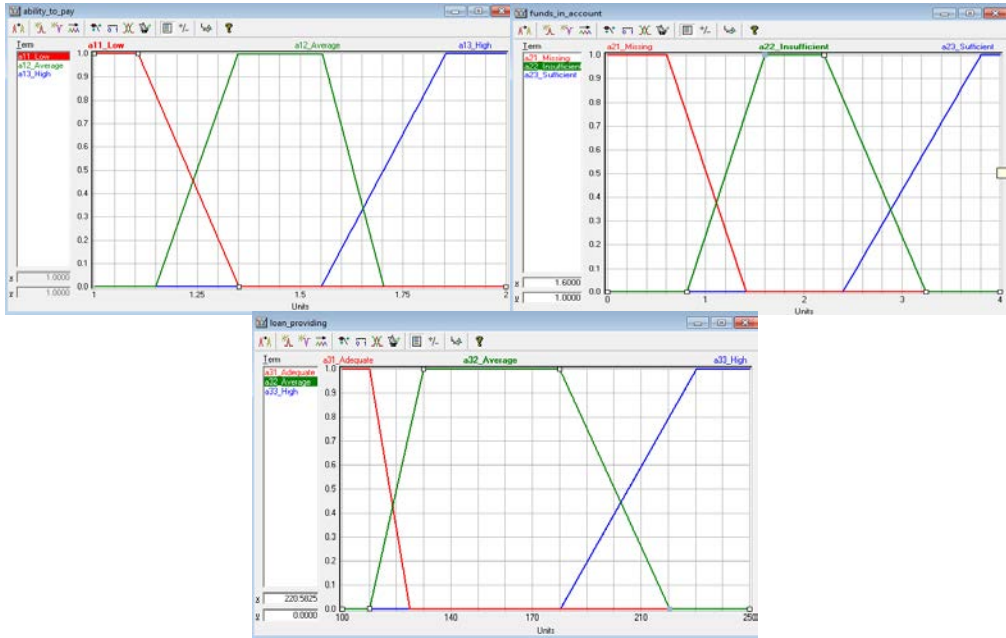


Figure 1. Computer representation of membership functions for input variables ($a1$, $a2$, $a3$) of the component "financial stability of the borrower" (A)

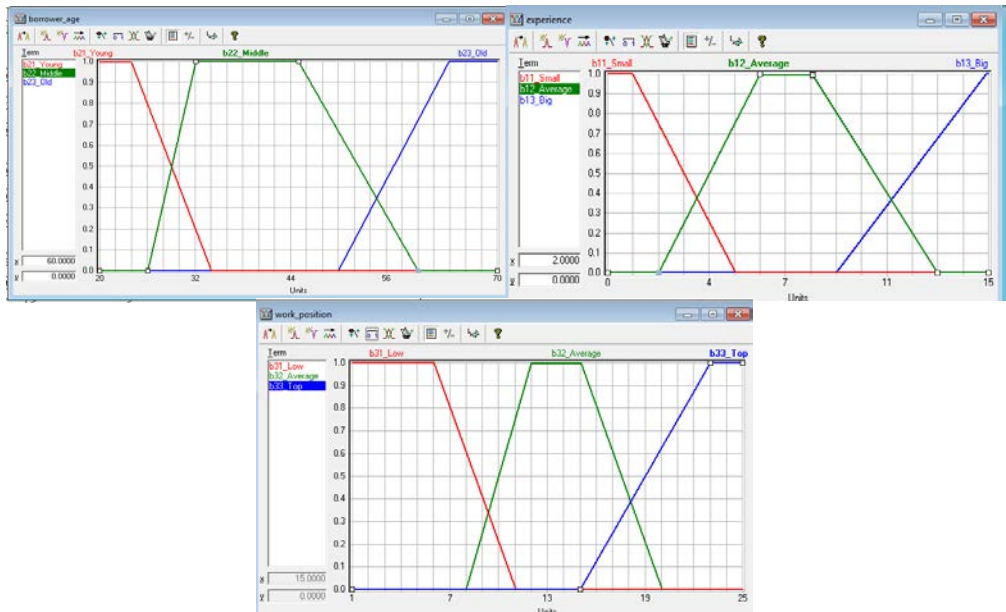


Figure 2. Computer representation of membership functions for input variables ($b1$, $b2$, $b3$) of the component "social stability of the borrower" (B)

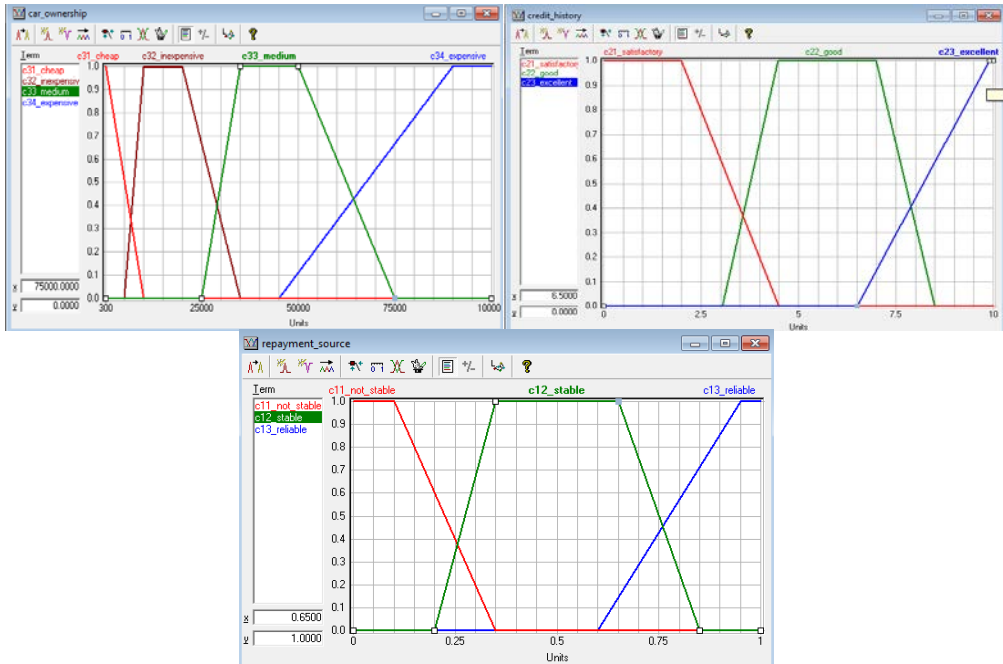


Figure 3. Computer representation of membership functions for input variables (c1, c2, c3) of the component "debt service" (C)

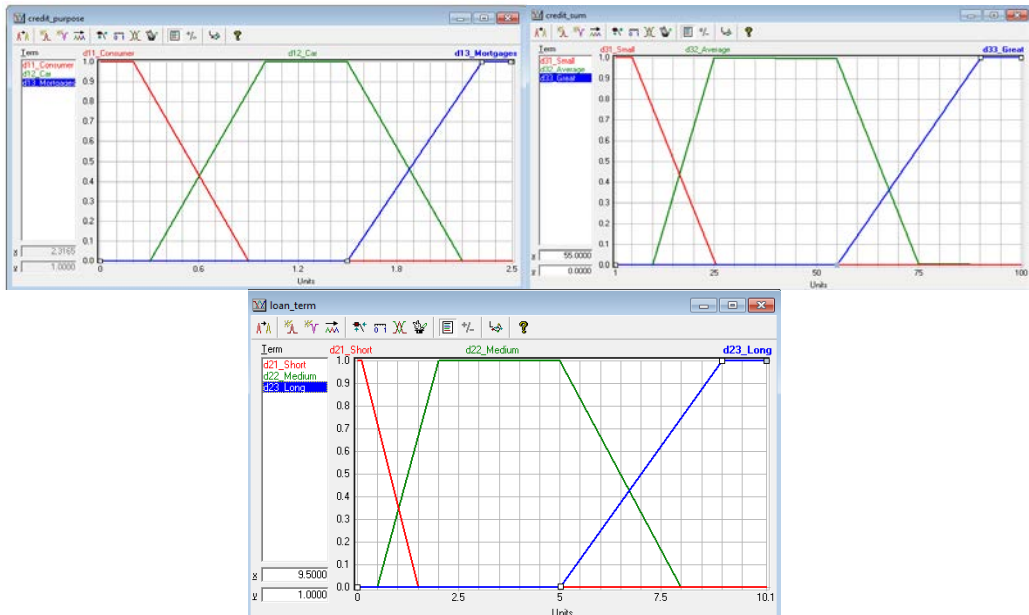


Figure 4. Computer representation of membership functions for input variables d1, d2, d3) of the component "credit condition" (D)

Published by Publishing house of the Bronislaw Markiewicz State Higher School
of Technology and Economics in Jaroslaw
First edition.

Publisher sheets 10,1; printing sheets 8,05
Passed for printing in accordance with layout original
Format $70 \times 100 \frac{1}{16}$

Printed in the Publishing house of the Bronislaw Markiewicz State Higher School
of Technology and Economics in Jaroslaw

Publishing house of the Bronislaw Markiewicz State Higher School of Technology
and Economics in Jaroslaw
e-mail: wydawnictwo@pwste.edu.pl
Tel. 16 624 40 65

We are pleased to present to readers the work that is a result of cooperation between the Bronisław Markiewicz State Higher School of Technology and Economics in Jarosław (Poland) and Simon Kuznets Kharkiv National University of Economics (Ukraine).

The monograph is dedicated to the 90th anniversary of the Simon Kuznets Kharkiv National University of Economics.

The findings provided herein address the development aspects of the risk-based approach to combating money laundering. The analysis includes international standards applied to regulate and develop the risk-oriented financial monitoring system; financial intermediaries' functioning peculiarities under the economy digitalization conditions and the peculiarities of primary financial monitoring conducted in the insurance industry and by banks; theoretical and methodological provisions for assessment and banks' risk management from the standpoint of the factors influencing the money laundering processes.

The monograph is intended for lecturers, scientists, students of economic universities, specialists of public authorities, financial institutions and businesses.



ISBN 978-83-65823-45-8