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CONCEPTUAL BASES FOR THE RESEARCH OF THE PROCESS OF EVALUATING THE EFFECTIVENESS OF THE BANK'S ACTIVITIES

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An analysis of the factors of economic growth that determine the development of the banking sector and the banking industry. The main factors of economic growth include financial, human and information technology resources. The basis of information and technological support of banks are the processes of digitalization. Methods and models for solving structured, poorly structured and unstructured problems that have the necessary mathematical tools are analyzed for sound analysis and evaluation of the efficiency of banks. The article proposes a conceptual model for evaluating the efficiency of the bank, which is based on the use of fuzzy logic tools, and allows the analysis of production (operational), financial, economic and management subsystems of the bank and form an integrated indicator of efficiency of the banking system. The model of assessing the efficiency of the bank is based on the method of assessing the competitive status of the enterprise in the market, modified taking into account approaches to assessing the financial condition. The developed conceptual model for evaluating the effectiveness of banks can be used to improve decision-making systems used in the activities of banking institutions. Implementation of the conceptual model in each bank will allow at the system level to conduct model experiments to assess the effectiveness of the bank's operation and development, develop practical recommendations and ways to improve the efficiency of Ukrainian banks, take into account the introduction of banking services to provide customers with banking services.

КОНЦЕПТУАЛЬНІ ЗАСАДИ ДОСЛІДЖЕННЯ ПРОЦЕСІВ ОЦІНЮВАННЯ ЕФЕКТИВНОСТІ ДІЯЛЬНОСТІ БАНКІВ

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Ключові слова:
інформаційно-комунікаційні технологій, інноваційні технології в банківській сфері, процеси діджиталізації, діяльність банку, концептуальна модель, оцінювання ефективності, нечітка логіка

Проведено аналіз факторів економічного зростання, які обумовлюють розвиток банківської сфери та банківської індустрії в цілому. До основних факторів економічного зростання віднесено фінансові, кадрові та інформаційно-технологічні ресурси. Основою інформаційно-технологічного забезпечення банків є процеси впровадження діджиталізації. Для обґрунтованого аналізу та оцінювання ефективності діяльності банків проаналізовано методи та моделі для розв'язання структурованих, слабоструктурованих і неструктурованих задач, які мають необхідний математичний інструментарій. В статті запропоновано концептуальну модель оцінювання ефективності діяльності банку, яка базується на використанні інструментарію нечіткої логіки, та дозволяє проводити аналіз показників виробничої(операційної), фінансово-економічної та управлінської підсистем банку та формувати інтегральний показник ефективності роботи всієї банківської системи з урахуванням зовнішніх та внутрішніх факторів розвитку банків. В основу моделі оцінювання ефективності роботи банку покладено методику оцінювання конкурентного статусу підприємства на ринку, модифіковану з урахуванням підходів до оцінювання показників фінансового стану. Розроблена концептуальна модель оцінювання ефективності діяльності банків може бути використана для удосконалення систем прийняття рішень, які використовуються в діяльності банківських установ. Реалізація концептуальної моделі в кожному конкретному банку дозволить на системному рівні проводити модельні

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експерименти з оцінювання ефективності функціонування та розвитку банку, розробляти практичні рекомендації і шляхи підвищення ефективності досліджуваних українських банків, враховувати особливості впровадження технологій банківських сервісів для надання клієнтам банківських послуг.

Formulation of the problem

Accumulating the country's monetary resources, banks play a key role in ensuring economic development through money circulation, capital turnover, enterprise financing, introduction of innovative banking products, ensuring the security of banks in the economic, financial and information sectors, and, to a large extent, from quality of used information technologies and banking systems. Using the latest information technologies, telecommunications systems, banks can significantly expand the market of banking services, improve the quality of customer service, improve the culture of banking.

Building intelligent banking information systems using the Amazon Athena online query service, Amazon Machine Learning cloud service, Amazon RDS web service and artificial intelligence tools provides an opportunity to significantly improve the process of sending messages to bank customers with the possibility of further services. Another important component of intelligent systems is the integration with the mobile application, which allows the bank to provide notifications more efficiently.

Under such conditions, an important area of research is to assess the effectiveness of modern information systems and technologies in the banking sector, which necessitates the development of a conceptual model for evaluating the effectiveness of banks to make management decisions aimed at improving the efficiency of individual banks and the banking system.

Analysis of recent research and publications

Innovative development of the banking sector in the direction of modeling the implementation of information technology to support innovative products of banks and services is extremely important. In this direction, Vadym Hetman Kyiv National University of Economics is conducting research (R&D), in particular on the topics: «Development of methods and technologies of intellectual support for the management of organizational structures in the context of digital economy» state registration number 0119 U002604 «And» Modeling of processes of introduction of information technologies of support of innovative products of banks and services «state registration number 0122U001987 (scientific supervisor Doctor of Economics, Prof. Ustenko S.V.). Based on the current results of these works, scientific articles have been published in international monographs [1–5]. The relevance of the research topic is due to the fact that in market conditions, banking products, services and services play a key role in the functioning of the financial system and market. This causes an urgent need to build intelligent information systems for the interaction of banking institutions with the user, to attract artificial intelligence, including neural networks. The main feature and innovation of such systems is that they have the property of machine learning and with each new training the system improves its performance.

In [1; 5] information and communication systems and technologies to support information security of banking and conceptual approaches to sustainable development of Ukrainian banks on the general principles of banking education, the main of which are the principles of integrity, stability, digitization and structural and logical links elements and the banking system as a whole, which requires the generalization of approaches to model research and technologies for the use of banking systems.

The work [7] is devoted to the study of the conceptual foundations of the processes of information support of digital educational activities, which does not take into account the production (operational) sphere of activity of enterprises and organizations.

Publications [8–11] provide approaches, trends and factors of economic growth in the most technologically advanced countries. Technological development [10; 11] is one of the important factors of economic growth and includes the use of a set of production techniques and scientific methods that must be considered for sound analysis and evaluation of banks' performance.

At the same time, there is an urgent need to develop a general (conceptual) model for assessing the effectiveness of the bank, which can take into account key performance indicators of a number of subsystems of the bank, including operational, economic, financial, management, information technology and more. Implementation of the conceptual model in each bank will allow at the system level to conduct model experiments to assess the effectiveness of the bank's operation and development, develop practical recommendations and ways to improve the efficiency of Ukrainian banks, take into account the introduction of banking services to provide customers with banking services.

Formulation of the objectives of the article

The purpose of this work is to improve and develop a conceptual model for evaluating the effectiveness of banks to make informed management decisions aimed at improving the efficiency of individual banks and the banking system of Ukraine.

The main material of the research

Since the beginning of 2014, the banking system of Ukraine has experienced one of the strongest crises in its history. In terms of banking assets as a percentage of gross domestic product, Ukraine's banking sector was similar to Poland. However, by 2016, bank closures and reduced lending have led to a sharp reduction in the role of banks in the economy. Today, Ukraine lags far behind many European banks. As of October 2020, out of 180 banks operating at the beginning of 2014, 104 banks were declared insolvent or liquidated by the National Bank of Ukraine,

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which is almost 60% of the country's banks. It should be noted that the assets of some Ukrainian banks in 2014 were overstated due to concealment of loans to related parties, but many banks unfortunately did not have the ability to model and predict the impact on the financial institution of internal and external destabilizing factors, leading to search for tools and approaches for strategic analysis, evaluation of efficiency and development of banks.

Banks are at the epicenter of these changes. Technological evolution and social change have a deeper and more direct impact on the financial industry than on most other sectors, as its main raw materials are information and money. And money, in turn, can be dematerialized and converted into accounting records, in other words, into data that can be stored, processed and transmitted in real time at low cost [3; 4].

Banking has not yet undergone the transformation that other information sectors have undergone. This is largely due to the fact that banking has historically been a strictly regulated industry, subject to close scrutiny and control by government agencies.

However, the transformation of the industry is not only inevitable, but is gaining momentum every day. The main reason is that the technological revolution is introducing new ways of doing business every day and increasing the potential for cost reduction, and the number of users who resort to non-traditional methods of banking continues to grow.

Another reason for the transformation is that the current crisis is causing changes in different directions. Banks are perceived as the «culprits» of the recession, and rightly so, as many institutions have made very serious mistakes and decided to ignore the basic principles of banking: prudence, transparency and even honesty. As a result of these mistakes, many banks have faced serious difficulties, with some banks failing and others undergoing a complete restructuring, which is usually financed by public funds. The colossal amount of taxpayers' resources invested in savings banks has severely damaged the reputation of financial institutions and the entire industry in the eyes of ordinary citizens.

The crisis has also provoked a process of radical changes in banking regulation: borrowing limits, higher requirements for capital and reserves, the need for large investments to improve risk systems and compliance, and so on. All this comes down to lower revenues and higher costs, in other words, lowering the current and future profitability of financial institutions.

Banks must respond to the new demands of their customers and society, meet this challenge with a damaged reputation, lower profits and slow growth of traditional banking business. This situation requires a radical transformation: banks must radically reconsider the way they interact with their customers and make a qualitative leap forward in efficiency.

To some extent, these efficiency gains will be achieved through the sharp consolidation of the banking sector that has already begun. But the real transformation of the industry will be achieved through the wide and, above all, smart use of technology as part of a long process of innovation.

In recent decades, banks have been one of the most important users of information and communication technologies, which they have adopted with two main goals: to reduce costs and optimize processes to increase profits, as well as to develop communication channels other than conventional ones.

With the development of banking, the Internet has become a leading source of information, indispensable business communication, and even a forum for personal relationships: more than a billion people around the world now use various social networks. The Internet is also a driving force behind the fragmentation of banks' production chains, facilitating the outsourcing of services. Banking services offered by cloud computing are a major breakthrough in universal access to storage and data processing at very low costs and will have far-reaching consequences. The use of the Internet has also gained enormously thanks to the advancement of mobile phone technology. Thanks to these new devices, almost 4.5 billion people are online and have almost universal access to a certain level of information services, which has a huge impact on productivity [5; 6]. Mobile phones are equipped with more and more powerful and various functions, which will be gradually included in other devices, additional services and services of banking systems («Internet of Things», «Internet Banking»).

The methodology of research of processes of functioning and development of banks is based on the general analysis and principles of development of banks and taking into account the complex approach to research of processes of effective development of banks [5].

An integrated approach to the study of banking development processes is focused on the holistic development of all processes, rather than its individual processes, which contributes to the comprehensive development of the bank. This approach allows to take into account the information and technological aspects of banking services, development of new banking products and the use of modern information technology and banking systems. The basis of information and technological support of banks are the processes of implementation of digitalization as a tool for development and scaling of the bank. Digitalization is a direction of development of banks in understanding the introduction of modern digital technologies aimed at the transition to automated digital technologies controlled by real-time intelligent systems in constant interaction with the external environment beyond one bank, with the prospect of unification in the global network of the Internet of Things and Services. Today, the first steps in the implementation of digitalization are the introduction of technologies such as machine learning, blockchain systems, blockchain systems, AR technologies (augmented reality), cloud technologies AWS (cloud technologies), systems for processing large data sets (data processing) [3; 4; 8].

For sound analysis and evaluation of the efficiency of banks, it is necessary to choose methods and models, the necessary mathematical tools. It is possible to solve this problem by dividing methods and models into three groups:

- methods and models for solving structured problems that have a homogeneous relationship between the elements

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of the system. To solve such problems, it is advisable to use classical and scenario methods and models (regression, classification, clustering, etc.);

• methods and models for solving poorly structured problems, which are characterized by the presence of partial relationships (quantitative, qualitative) between the elements of the system. To solve such problems, it is possible to use both classical methods and models, and models using fuzzy logic;

• methods and models for solving unstructured problems, in which calculations are performed on the basis of verbal descriptions of elements only and in the absence of direct relationships between elements of the system. Artificial intelligence methods and models are best suited for solving unstructured problems.

Let's build a conceptual model for evaluating the effectiveness of the bank on the basis of fuzzy logic. The model of assessing the efficiency of the bank will be based on the method of assessing the competitive status of the enterprise in the market [12], modified taking into account approaches to assessing the integrated indicator of financial condition [13].

We will evaluate the effectiveness of the bank in the following areas and subsystems of the bank:

• operation of production (operational) subsystem (this includes production and technological aspects of the bank's development potential) – S_1;

• *work of financial and economic subsystem (includes financial and sales aspects of potential)* – S_2;

• *work of the management subsystem (includes such aspects of capacity as efficiency and innovation management)* – S_3.

To build the model we use the following development algorithm [13; 14]:

– stage 1: Selection of indicators to be taken into account in the model;

– stage 2: Description of linguistic variables;

– stage 3: Defining the types of membership functions and their construction;

– stage 4: Building a fuzzy knowledge base;

– stage 5: Adjust the model parameters and determine the initial characteristics.

Here is the process of building a model.

The initial parameter Z – an integrated indicator of the efficiency of the bank – is determined on the basis of quantitative and qualitative indicators s_{ij}, that characterize the production (operational) (S_1), financial and economic (S_2) and management subsystems (S_3) of the bank:

$$Z = f(S_1 \dots S_m),\ S_i = f(s_{i1} \dots s_{in}),\ s_{ij} = f(s_{ij1} \dots s_{ijh}),$$
$$i = \overline{1,m},\ j = \overline{1,n},\ l = \overline{1,h},$$

where Z – an integrated indicator of the level of efficiency of the bank; S_i – generalizing signs of states of subsystems, $i = \overline{1,m}$; i – subsystem status characteristic number; m – the number of subsystem states, $m = 3$; s_{ij} – generalizing signs of estimation of parameters of subsystem states, $j = \overline{1,n}$; j – number of parameters i; n – the number of parameters that characterize the state i, (technical and economic parameters, parameters of use of production resources, parameters of financial stability and autonomy, parameters of turnover of current assets, parameters of solvency and liquidity assessment, profitability parameters, parameters of evaluation of innovations and technologies, management parameters); s_{ijl} – evaluation indicators that are part of s_{ij}; l – subsystem status parameter indicator number; h – the number of indicators in the group of parameters j, the nomenclature of which is ranked depending on the period of analysis (current, operational, strategic).

To reflect the relationship between input and output parameters of the model using the linguistic rules «If – then» to form the linguistic characteristics of quality terms of the production, financial, economic and management subsystems of the bank $\{ДН, H, C, B, ДВ\}$: *ДН* – very low, *H* – low, *C* – average, *B* – high level, *ДВ* – very high.

Denote the given term sets as follows:

$$A_{i*} = \left\{a_{i*}^1, a_{i*}^2, a_{i*}^3, a_{i*}^4, a_{i*}^5\right\} =$$
$$= \left\{a_{i*}^1 = "ДН", a_{i*}^2 = "H", a_{i*}^3 = "C", a_{i*}^4 = "B", a_{i*}^5 = "ДВ"\right\},$$

where a_{i*}^p – p-й linguistic term i*-ї variable, $p = \overline{1,5}$, $i* = \overline{1,11}$; $i*$ – through number of input linguistic variables.

The resulting parameter Z makes it possible to assess the level of efficiency of the bank on such a scale of term sets $\{П, З, НЗ, К\}$: *П* – positive, *З* – satisfactory, *НЗ* – unsatisfactory, *К* – critical. Denote this term set as follows:

$$G = \left\{g^1, g^2, g^3, g^4\right\} =$$
$$= \left\{g^1 = "П", g^2 = "З", g^3 = "НЗ", g^4 = "К"\right\},$$

where g^k – k-й linguistic term of the original variable Z, $k = \overline{1,4}$.

In the table. 1 shows the values of fuzzy terms of the above-set terms of input and output variables.

The membership function performs the task of generalizing the values of expert assessments regarding the distribution of elements in sets.

Suppose there is some universal set U, which includes a set of possible values i*-ї variable. Then there is a fuzzy subset A, which describes the constraints on the possible values of the variable a_{i*}.

Then A can be defined as $A = \left\{s_{ij},\ \mu^{a_{i*}^p}(s_{ij});\ s_{ij} \in U\right\}$ and $A = \left\{S_i,\ \mu^{a_{i*}^p}(S_i);\ S_i \in U\right\}$, where $\mu^{a_{i*}^p}(s_{ij})$ and $\mu^{a_{i*}^p}(S_i)$ – membership functions, which acquire values in the range from 0 to 1, and:

$$\mu^{a_{i*}^p}(S_i) > 0,\ \forall S_i \in U,$$

$$\mu^{a_{i*}^p}(S_i) = 0,\ \forall S_i \notin U,$$

$$\sup_{S_i \in U}\left[\mu^{a_{i*}^p}(S_i)\right] = 1.$$

Similarly determined $\mu^{a_{i*}^p}(s_{ij})$.

Thus, the function $\mu^{a_{i*}^p}(S_i)$ determines the degree of belonging of the elements S_i and s_{ij} subset A.

To determine the parameters $\mu^{a_{i*}^p}(S_i)$ та $\mu^{a_{i*}^p}(s_{ij})$ it is expedient to use bell-shaped membership functions [13; 15], as they are smooth throughout the domain and take non-zero values.

ISSN Print 2786-5150
ISSN Online 2786-5169

Table 1 – Parametric characteristics of the bank's performance appraisal model

The number of the linguistic variable	Designation of linguistic variables	Name of linguistic variables	Basic term set of a linguistic variable	Syntactic description of the values of the linguistic variable
Input variables				
*i**1	s_{i1}	technical and economic parameters	A_1	$a_1^1, a_1^2, a_1^3, a_1^4, a_1^5$
*i**2	s_{i1}	parameters of use of production resources	A_2	$a_2^1, a_2^2, a_2^3, a_2^4, a_2^5$
*i**3	s_{i1}	parameters of financial stability and autonomy	A_3	$a_3^1, a_3^2, a_3^3, a_3^4, a_3^5$
*i**4	s_{i1}	parameters of turnover of current assets	A_4	$a_4^1, a_4^2, a_4^3, a_4^4, a_4^5$
*i**5	s_{i1}	solvency and liquidity assessment parameters	A_5	$a_5^1, a_5^2, a_5^3, a_5^4, a_5^5$
*i**6	s_{i1}	profitability parameters	A_6	$a_6^1, a_6^2, a_6^3, a_6^4, a_6^5$
*i**7	s_{i1}	parameters of evaluation of innovations and technologies	A_7	$a_7^1, a_7^2, a_7^3, a_7^4, a_7^5$
*i**8	s_{i1}	control parameters	A_8	$a_8^1, a_8^2, a_8^3, a_8^4, a_8^5$
*i**9	S_1	the level of operation of the production subsystem	A_9	$a_9^1, a_9^2, a_9^3, a_9^4, a_9^5$
*i**10	S_2	the level of financial and economic subsystem	A_{10}	$a_{10}^1, a_{10}^2, a_{10}^3, a_{10}^4, a_{10}^5$
*i**11	S_3	the level of operation of the management subsystem	A_{11}	$a_{11}^1, a_{11}^2, a_{11}^3, a_{11}^4, a_{11}^5$
Output variables				
–	Z	indicator of the effectiveness of the	G	g^1, g^2, g^3, g^4

Belonging function $\mu^{g^k}(Z)$ fuzzy terms g^k source variable Z takes value in the range from 0 to 1:

$$\mu^{g^k}(Z) = \frac{1}{1+\left|\frac{Z-c}{d}\right|^{2b}},$$

where d – concentration-stretching coefficient Π – similar membership function (bell-shaped), c – the coordinate of the maximum of the function, b – setting option.

Next, we will form a set of rules – a fuzzy knowledge base, which presents expert-logical conclusions for the basic indicators (criteria) for assessing the state of the system.

The final rule on the positive overall level of efficiency of the bank in analytical form can be represented as follows:

$$\mu^{П}(S_1...S_3) = \mu^{ДВ}(\mathrm{S}_1)\cdot\mu^{\mathrm{ДВ}}(S_2)\cdot\mu^{\mathrm{ДВ}}(S_3)\vee$$
$$\vee\,\mu^{B}(\mathrm{S}_1)\cdot\mu^{C}(S_2)\cdot\mu^{\mathrm{C}}(S_3)\vee \quad ,$$
$$\vee\,\mu^{C}(\mathrm{S}_1)\cdot\mu^{\mathrm{ДВ}}(S_2)\cdot\mu^{\mathrm{B}}(S_3)$$

where through $\vee$ – denotes the disjunction operation (corresponding to the «OR» operation), such that $\mu^{a_{i*}^p}(S_i)\vee\ \mu^{a_{i*}^p}(S_{i+1}) = \max\left(\mu^{a_{i*}^p}(S_i),\ \mu^{a_{i*}^p}(S_{i+1})\right)$; $\cdot(\wedge)$ – denotes the conjunction operation (correlated with the operation «AND»), so that $\mu^{a_{i*}^p}(S_i)\wedge\ \mu^{a_{i*}^p}(S_{i+1}) = \min\left(\mu^{a_{i*}^p}(S_i), \mu^{a_{i*}^p}(S_{i+1})\right)$.

Similarly, we can present the final rules for the other three terms (З, НЗ, К):

$$\mu^{З}(S_1...S_3) = \mu^{C}(\mathrm{S}_1)\cdot\mu^{\mathrm{C}}(S_2)\cdot\mu^{\mathrm{C}}(S_3)\vee$$
$$\vee\,\mu^{H}(\mathrm{S}_1)\cdot\mu^{B}(S_2)\cdot\mu^{\mathrm{H}}(S_3)\vee \quad ,$$
$$\vee\,\mu^{C}(\mathrm{S}_1)\cdot\mu^{\mathrm{H}}(S_2)\cdot\mu^{\mathrm{ДВ}}(S_3)$$

$$\mu^{НЗ}(S_1...S_3) = \mu^{H}(\mathrm{S}_1)\cdot\mu^{\mathrm{H}}(S_2)\cdot\mu^{\mathrm{H}}(S_3)\vee$$
$$\vee\,\mu^{H}(\mathrm{S}_1)\cdot\mu^{H}(S_2)\cdot\mu^{\mathrm{C}}(S_3)\vee \quad ,$$
$$\vee\,\mu^{B}(\mathrm{S}_1)\cdot\mu^{\mathrm{C}}(S_2)\cdot\mu^{\mathrm{ДН}}(S_3)$$
$$\mu^{K}(S_1...S_3) = \mu^{ДН}(\mathrm{S}_1)\cdot\mu^{\mathrm{ДН}}(S_2)\cdot\mu^{\mathrm{ДН}}(S_3)\vee$$
$$\vee\,\mu^{C}(\mathrm{S}_1)\cdot\mu^{ДН}(S_2)\cdot\mu^{\mathrm{H}}(S_3)\vee \quad .$$
$$\vee\,\mu^{ДН}(\mathrm{S}_1)\cdot\mu^{\mathrm{ДН}}(S_2)\cdot\mu^{\mathrm{B}}(S_3)$$

Consider a set of rules, for example, for parametric assessment of the financial and economic subsystem:

To ex'press the degree of relationship between the output variable and the input, the function of belonging of the input variables to the value of the output variable can be represented as follows:

$$\mu^{g^k}(S_1, S_2, S_3) = \bigvee_{p=1}^{5}\left[\bigwedge_{i*=9}^{11}\mu^{a_{i*}^p}(S_i)\right].$$

Then, based on the provisions of the theory of fuzzy sets, you can form a fuzzy set of the original variable Z:

$$\mu^{g^k}(Z) = \max_{p=\overline{1,5}}\left(\min_{i*=\overline{9,11}}\mu^{a_{i*}^p}(S_i)\right),$$

where $\mu^{a_{i*}^p}(S_i)$ – membership function of the input variable S_i to the term a_{i*}^p; $\mu^{g^k}(Z)$ – membership function of the input variable Z to the term g^k.

Determining the level of efficiency of the bank is based on an algorithm such as Mamdani, as one of the most common methods of fuzzy derivation [15].

Conclusions

The article considers aspects of the development of the banking sector and its impact on economic growth,

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the key to success is a wider range of information systems and technologies. The main driver of economic growth is innovative digital technologies to adapt services to meet the needs and demands of users, providing efficient banking products and services.

A conceptual model for evaluating the efficiency of banks based on the theory of fuzzy sets is proposed, which allows to identify groups of indicators of production (operational), financial, economic and management subsystems of the bank, and form an integrated indicator for evaluating the effectiveness of banks for effective management decisions.

The developed conceptual model for evaluating the effectiveness of banks can be used to improve decision-making systems used in the activities of banking institutions.

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