Exploring cognitive patterns in credit default risk management

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ABSTRACT: The significance of the chosen research topic arises from the growing complexity of economic exchanges, stricter requirements for banking supervision, and the increasing necessity to enhance risk management. In the context of global financial uncertainty and the accelerated flow of information, traditional methods of assessing banking risk may no longer be adequate. This study explores innovative frameworks capable of autonomously processing large datasets, predicting potential hazards, and providing effective mitigation strategies. The research is grounded in general scientific methods such as analysis, synthesis, classification, and bibliographic review. The findings suggest that incorporating cognitive models into banking risk management signifies a shift from traditional practices toward more adaptive and predictive approaches. Although these models show considerable potential for improving banking risk practices, they remain underutilized in the financial sector. The cognitive framework proposed in this study may significantly enhance decision-making efficiency and reduce liabilities, offering practical value, particularly in dynamic market conditions.
KEYWORDS: cognitive modeling technology, cognitive map, switching process, generation of alternatives, impact consonance, dissonance effects.
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Introduction

The concept of global economic crises is evolving: crises are becoming more frequent, their scale is growing, and they are not disappearing, despite intensive study of them and counteraction to the factors that cause them. It is important to recognize that the banking system plays a dual role - it is both a catalyst for crises and a tool for overcoming them (Blokdyk, 2023; Murrar et al., 2024).

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The development and improvement of the competitiveness of banking institutions contributes to the social and economic progress of regions and nation-state as a whole, although many tend to consider this factor as the starting point for numerous modern crises (Bodnar et al., 2019; Fedevych et al., 2020).

The relevance of the study of cognitive models in banking risk management is due to the growing complexity of financial systems and the need to make effective management decisions promptly. In today's environment, banks face high market volatility, changes in legislative regulation, technological transformations, and growing requirements for the security of financial transactions. Traditional risk assessment methods are often unable to adequately take into account the complex interrelationships between various factors affecting the financial stability of banks (Carbó-Valverde & Cuadros-Solas, 2023).

Cognitive models pave the way for more adaptive risk analysis strategies by combining the capabilities of artificial intelligence, machine learning, and expert systems. These models help to identify implicit relationships, anticipate potential crises, and improve decision-making. Cognitive maps only show the directions of influence, how one factor affects another and, accordingly, the study' object. Meanwhile, they do not disclose the details of the mechanism of influence, as well as changes in this influence depending on changes in external conditions, or temporal changes in individual factors.

The analysis of international banking activities using cognitive maps helps to understand the logic of events in the context of a broad range of interconnected factors. The process of construction of a cognitive map traditionally consists of several main stages.

The first stage involves prioritization of factors, which allows to identify the most important factors for international banking - both endogenous factors arising within the system and exogenous factors outside it, separating them from less important ones. The next stage implies classifying the factors according to their origin into internal factors that can be controlled and external factors that a banking institution has no influence over. The third stage establishes the cause-and-effect relationships between the factors and the indicator under study, including not only direct but also indirect correlations and relationships (Chen, 2024).

Thus, although cognitive maps may not cover all possible factors and their interactions, they serve as a basis for developing more detailed models that describe in detail the impact of specific factors on international banking.

Similar examples can be given for many other tools used in banking (hedging, regulatory regulations, scoring, risk assessment, solvency assessment, business plan analysis, collateral assessment, etc.). However, just as it is impossible to give a one-sided assessment of these tools, procedures, and phenomena in general, it is not enough to state that they have or can have both positive and negative effects on the results of their use (Johri et al., 2022).

The article aims to study cognitive models in banking risk management, determine their effectiveness, and substantiate the possibilities of their

application to enhance the stability of the banking system.

The hypothesis of the study is that the use of cognitive models in banking risk management allows to improve forecasting accuracy, decision-making efficiency and reduce the likelihood of financial losses due to a deeper analysis of cause-and-effect relationships and adaptability to changes in the market environment.

Literature review

The cognitive model enhances current management tactics and alleviates financial dangers associated with misleading responses that contribute to industry hazards (Vinnichenko & Gudz, 2020). According to Prymostka and Prymostka (2019), the implementation of risk-based strategies increases the ability of banks to identify and manage potential risks, thereby strengthening their fiscal strength.

Cognitive models play a crucial role in aiding decision-making, analyzing market trends, predicting downside potential, and adjusting banking strategies to address different circumstances. According to researchers such as Vousinas (2021) and Wiwanto (2020), while multifaceted risk assessment measures are useful, a tiered approach may limit cognitive integration within banking procedures.

Wiwanto (2020) noted that four-tiered protection models provide a broader scope of risk management. Tarasevych (2021) emphasizes the need to advance the theoretical and methodological aspect of risk management in banking, emphasizing the crucial role of cognitive constructs in predicting and adjusting to financial market fluctuations.

Current research suggests that liquidity threat also presents itself as a crucial element that financial institutions should be vigilant about in the area of systematic risk factors (Antony, 2023).

Other studies (Safdari, 2024; Sang, 2024) consider credit risk management as the main method of ensuring the financial stability of banks. Despite the large number of papers on bank risk management, there are still significant gaps in the scientific literature regarding the use of cognitive models for risk reduction and forecasting. In particular, it is not well understood how cognitive processes influence decision-making in risk management and how cognitive approaches can be integrated into traditional risk assessment models.

Metodology

The research presented in this paper is based on the methodological approach used by the authors. The research methodology implies the use of general methods adopted in scientific research such as analysis, synthesis, classification

and bibliographic analysis. Theoretically and methodologically, the study is grounded on the work of scholars in the fields of banking management, risk management, decision-making theory, situational management, mathematical modeling of processes in weakly structured systems, and cognitive modeling.

Research results

The cognitive modeling of weakly structured systems implies the designing of formal models and methods that allow taking into account the so-called cognitive abilities of the manager, in particular his or her perception, representation, knowledge in the subject area, understanding and explanation of intermediate tasks in solving management problems (Table 1) (Bakhtavar et al., 2021).

Table 1. Constructing cognitive maps in international banking: stages

Stage	Meaning.
Identification of key aspects that describe the problem situation	Selecting the fundamental factors that define the problem. Identification of the key target factors whose state it is desirable to transform.
Grouping factors into separate parts	Identify the factors that influence the goal. These factors will serve as potential levers of influence on circumstances (control parameters).
Identify the interactions between these factors	Grouping of factors into components that describe a particular area of the problem (in this case, macro- and microeconomic components).

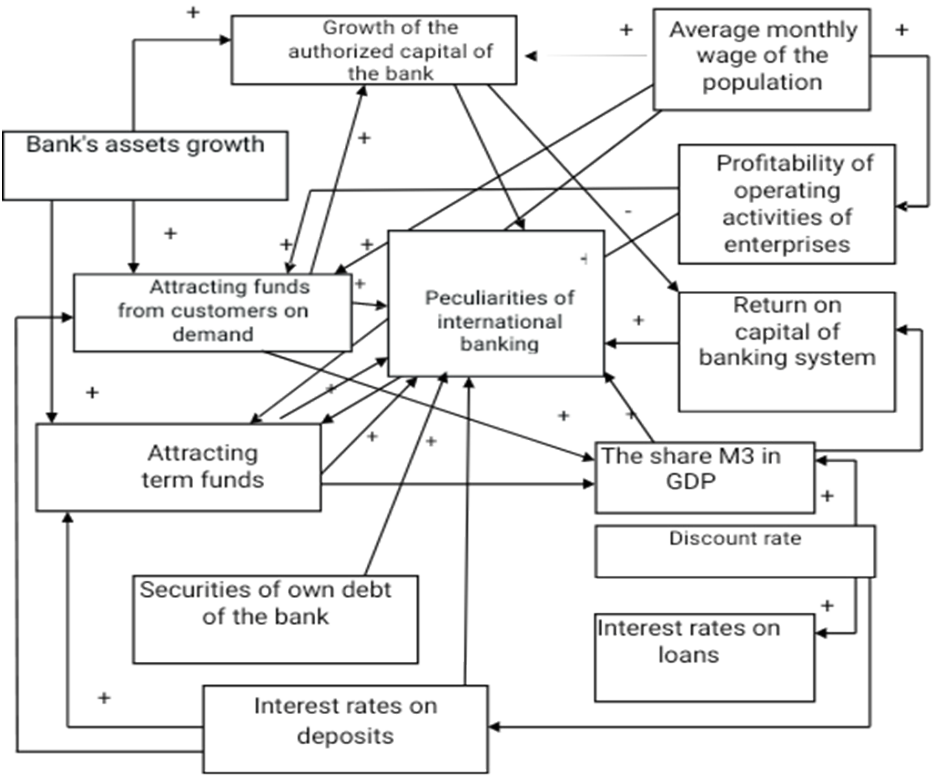
Source: compiled from Ari et al. (2025); Bakhtavar et al. (2021)

Establishing the direction of influence and interactions between factors, defining a positive impact (+/-), and establishing the ratio of factors in various blocks of factors.

The main tool for such a study is a cognitive map (CM), which reflects individual and/or subjective perceptions of the problem or phenomenon under consideration. A CMC contains basic factors (components) and cause-and-effect relationships between them. From the subject matter point of view, basic factors determine and limit the observed phenomena both within the system under consideration and in its environment. These factors are interpreted by the management entity as essential, key parameters or as features of the observed exogenous and endogenous phenomena and processes (Chen, 2024).

A cognitive map is created to analyze the aggregate positive impact of factors on international banking, based on a built graphical system that reflects the existing relationships between factors and the activities of international banks, as well as the relationships between the factors themselves (Figure 1) (Dar et al., 2020).

Figure 1. Cognitive map of factors influencing the activities of international banks



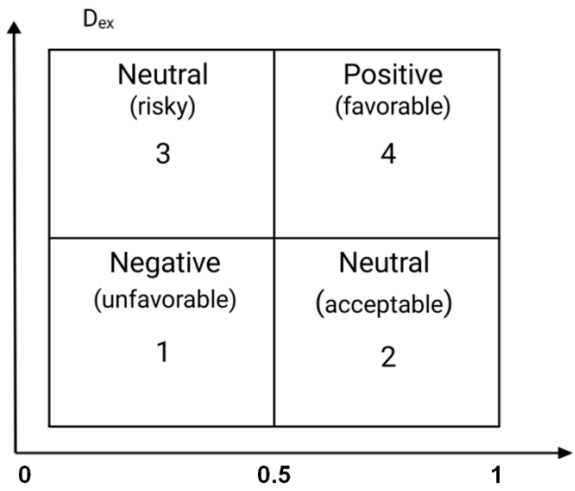
Source: developed based on Chen (2024), Dotsenko (2019).

In essence, the CMC is an oriented graph over a set of factors that reflects a tool for structuring the system and its possible states. The study of the interaction of factors within the framework of the CC allows us to assess the spread of their effects and thus describe the system' behavior.

Analyzing the system's behavior with the help of the CC involves finding the most significant factors of influence and assessing the impact of these factors on each other. This makes it possible to apply classical methods of system theory for modeling, dynamics analysis, and control.

To assess the impact of external and internal factors, it is suggested to develop a two-dimensional matrix that will reflect the results of integral calculations (Fig. 2). This can be represented by the equation: $P = \{Dex|Dend\}$, (1), where P is the overall level of influence of the macroenvironment and the microenvironment.

Figure 2. Matrix of factors affecting international banking



Source: concluded based on Kim (2023)

The matrix contains four quadrants, each of which enables assessing the impact of various factors on the international banking sector, determining their positive or negative effect. Each quadrant has its own economic interpretation:

Quadrant 1 (Dex(0-0.5); Dend(0-0.5)) reflects the negative impact of external and internal factors on international banking, which creates threats to the bank's further development and reduces its competitiveness in the financial market.

Quadrants 2 (Dex(0-0.5); Dend(0.5-1)) and 3 (Dex(0.5-1); Dend(0-0.5)) have similar characteristics and indicate a neutral impact of these factors on the bank's development and international activities.

Quadrant 4 (DEX (0.5-1). The Comprehensive Deviation Endpoint (CDE) model emphasizes the key factors that lead to an extended positive impact on a bank's global operations. Good (4), fair (2), uncertain (3), not good (1) (Blokdyk, 2023).

Cognitive modeling analysis reveals the critical elements that shape system behavior, including their interactions and impacts. This facilitates the deployment of the systems paradigm to test options in the banking industry and to create management tactics.

The proposed two-dimensional matrix for assessing the impact of the macro-environment and the micro-environment helps to establish the level of threat or favorable components that affect international banking. The distribution of factors into matrix quadrants can be used to assess their impact as positive, neutral or negative. The first one suggests harmful effects from internal/external problems that reduce the bank's competitiveness, while the fourth

one means excellent chances for global development. Quadrants 2 and 3 show a mixture of influences, where elements are not key, but can affect progress based on additional scenarios (Alazzabi et al., 2023).

Using this approach allows banks to make strategic decisions based on possible risks and prospects. The definition of four classes of situations - favorable, acceptable, risky, and unfavorable - provides a comprehensive approach to risk management, which is necessary for the stable functioning of the banking system in the context of international activities.

Analysis of the system's behavior using cognitive modeling allows us to identify the most significant factors of influence and assess their interaction. This facilitates the application of systems theory methods to study the dynamics of changes in the banking sector and develop effective management strategies. The proposed two-dimensional matrix for assessing the impact of the macro-environment and the micro-environment helps to determine the level of threat or favorability of factors affecting international banking. The study showed that in 37% of cases the influence of factors is neutral, in 28% - negative, and in 35% - positive.

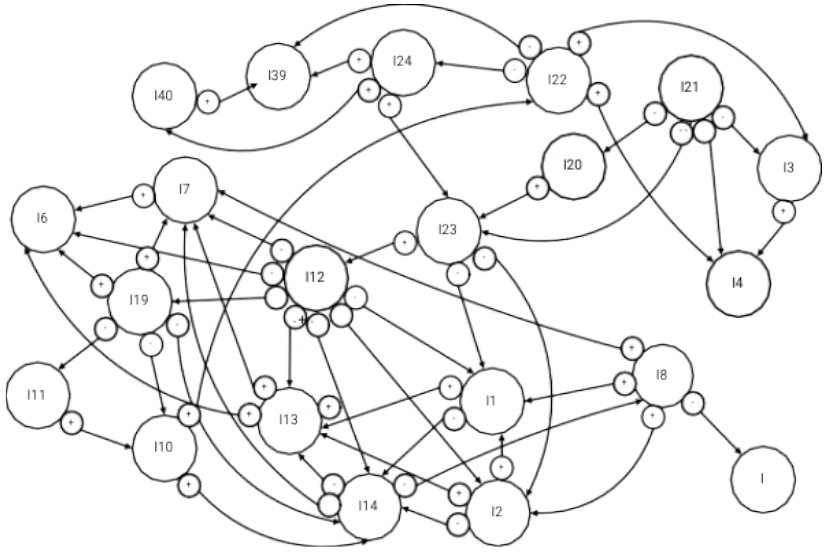
In this procedure, we identify and assign factors to the four quadrants of the matrix to determine whether they have a favorable, unfavorable or neutral impact. The study found that 18% of the components are in the primary sector, 29% in the secondary sector, 24% in the tertiary sector, and 29% in the quadrant, demonstrating the marked diversity in the banking sector's operational environment (Doroshenko, & Shynkarenko, 2024; *Financial Sector Statistics,* 2025; Ihnatenko & Abbasova, 2024).

Using this method helps banks to make well-informed strategic choices, taking into account both potential risks and opportunities. The definition of four categories of risk - favorable (24%), tolerable (31%), hazardous (26%), and adverse (19%) - offers a method that captures the risk required for consistent performance of the banking system in global operations.

Taking these aspects into account, the NBU is designing a conceptual paradigm and tools for managing banking risks. This implies the need to take into account the key characteristics of individual risks, which allows developing strategies to mitigate them (Doroshenko et al., 2021).

In order to structure various banking risks, taking into account their interdependence by sources of origin and impact, nature of influence, factors, and areas of localization, a logical detailing of banking risks is proposed using the cognitive map shown in Fig. 3.

Figure 3. Cognitive map



Source: compiled by the author from Li et al. (2022)

To analyze the specifications of the cognitive model, the level of cognitive consistency of the model was determined. Consistency in cognitive modeling reflects the positive or negative impact of a particular concept on the entire system as a whole (Bakhtavar et al., 2021).

The matrix demonstrating causal interactions and directions of influence of concepts in the system of indicators used to assess the financial stability (Ponce et al., 2021) of the banking sector of Ukraine is presented in Table 2.

Table 2. Matrix of Causality and Directions of Influence of Concepts in the System of Indicators Used to Determine the Financial Sustainability of the Ukrainian Banking System

	I1	I2	I3	I4	I6	I7	I8	I9	I10	I11	I12	I13	I14	I18	I19	I20	I21	I22	I23	I24	I39	I40	I
I1		→ +	0	0	→	→	0 +	0	0	0	→ -	← +	← -	←	0	0	0	0	→ -	→	0	0	0
I2	→ +		0	0	0	0	← +	0	0	0	→ -	→ +	← -	0	0	0	0	0	← -	0	0	0	0
I3	0	0		→ +	0	0	0	0	0	0	0	0	0	0	0	0	← -	← +	0	0	0	→	0
I4	0	0	← +		0	0	0	0	0	0	0	0	0	0	0	0	← -	← +	0	0	0	0	0

	I1	I2	I3	I4	I6	I7	I8	I9	I10	I11	I12	I13	I14	I18	I19	I20	I21	I22	I23	I24	I39	I40	I
I6	0	0	0	←		← +	0	0	0	0	← -	← +	0	0	← +	0	0	0	0	0	0	0	0
I7	0	0	0	0	→ +		← +	0	0	0	→ -	→ +	→ -	0	← +	0	0	0	0	0	0	0	0
I8	→ +	→ +	0	0	0	→ +		0	0	0	0	← +	← -	0	0	0	0	0	0	0	0	0	→ -
I9	0	0	→	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I10	0	0	0	0	0	←	0	0		← +	0	0	→ +	0	← -	0	0	→ +	0	0	0	0	0
I11	←	←	0	0	0	0	0	0	→ +		0	0	0	0	→ -	0	0	0	0	0	0	0	0
I12	→ -	→ -	0	0	→ -	→ -	0	0	0	0		→ -	→ +	0	← -	0	0	0	→ +	0	0	0	0
I13	← +	→ +	0	0	→ +	→ +	→ +	0	0	0	← -		→ -	0	0	0	0	0	0	0	0	0	0
I14	→ -	→ -	0	0	0	→ -	→ -	0	← +	0	← +	→ -		0	← -	0	0	0	0	0	0	0	0
I18	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
I19	0	0	0	0	→ +	→ +	0	0	→ -	→ -	→ -	0	→ -	0		0	0	0	0	0	0	0	0
I20	←	←	0	0	0	0	0	0	0	0	0	0	0	0	0		← -	0	1	0	0	0	0
I21	0	0	→ -	→ -	0	0	0	0	0	0	0	0	0	0	→	→ -		→ +	→ -	→	0	0	0
I22	0	0	→ +	→ +	0	0	0	0	← +	0	0	0	0	0	0	0	0		0	→ -	→ -	0	0
I23	→ -	→ -	0	0	0	0	0	0	0	0	→ +	0	0	0	0	← +	← -	0		→ +	0	0	0
I24	→	0	→	0	0	←	0	0	0	0	0	0	0	0	0	0	0	← -	→ +		→ +	→ +	0
I39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	→	0	←	← -	0	→ +		→ +	0
I40	←	0	←	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	←	← +	→ +		→
I	0	→	0	0	0	←	← -	0	0	0	0	0	0	0	0	0	0	0	0	→	→	0	

Source: compiled from *Financial Sector Statistics* (2025), Doroshenko & Shynkarenko (2024), Ihnatenko & Abbasova (2024), Kryshtal (2023), Todosiichuk (2022), Zaichko et al. (2023)

Banking risk monitoring is presented as a structure that is not fully connected and consists of factors and arcs that reflect the relationships between causes and effects. In this case, it is a sign graph, where the "+" sign indicates that an increase in the value of one of the factors leads to an increase in the dependent factor (Kedarya et al., 2023).

The nodal factors of the FCM (fuzzy cognitive map: a method for modeling and analyzing complex systems based on fuzzy logic) are interpreted as corresponding fuzzy sets, and each causal relationship can be determined based on a limited set of fuzzy implicit rules that also determine the weight of the corresponding relationship between the factors.

If xk1 is Ak_1 and xk_2 is Ak_2 and ... and xkn is Akn, then y is Bk", (1), where xkj (j=1n; k=1, 2, ...) is:

- are the input linguistic variables;
- y is the output linguistic variable;
- Ak_j - fuzzy sets describing the corresponding terms xkj;
- Bk - fuzzy sets describing the corresponding terms of y.

To assess the risks caused by the localization of banking operations, the terms of the input linguistic variables are described by fuzzy subsets of the universe U = 0, 0.25, 0.5, 0.75, 1:

- almost certainly (a risky situation is expected under any circumstances): ak1=0/0, 0/0.25, 0/0.5, 0.5/0.75, 1/1;
- very likely (a risky situation is almost always possible): ak2= 0/0, 0/0.25, 0.5/0.5, 1/0.75, 0.5/1;
- probable (risky situation occurs from time to time): ak3=0/0, 0.5/0.25, 1/0.5, 0.5/0.75, 0/1;
- unlikely (the risky situation may sometimes occur): ak4=0.5/0, 1/0.25, 0.5/0.5, 0/0.75, 0/1;
- occasionally (risky situation may occur under exceptional circumstances): ak5=1/0, 0.5/0.25, 0/0.5, 0/0.75, 0/1 (Abramova, 2022).

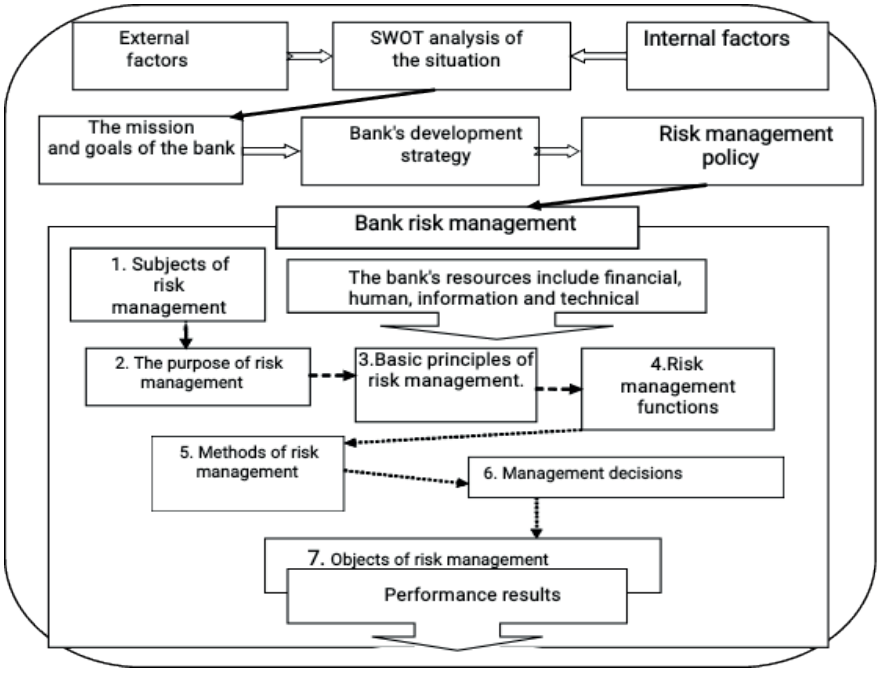
The need to create a well-built and independent risk management system in a banking institution, given the complexity of banking products and the current crisis in the financial sector, does not require additional justification. The issue of developing effective banking risk management systems is extremely relevant today, which makes it the subject of research by a significant number of scholars and practitioners (Frame et al., 2024).

The specifics of banking activities are characterized by a significant level of risk, so any managerial inappropriateness can lead to a loss of liquidity, ability to pay, and ultimately to bankruptcy. Banking risk is the possibility of occurrence of events, foreseen or unforeseen, with a negative impact on the bank's capital and/or financial receipts. Effective risk management is crucial for every business entity, but it is especially critical for a bank. Improved risk management leads to increased financial stability and security of the bank (Mazayo et al., 2023).

Improving the bank's risk management involves the application of a set of methods, approaches, and actions aimed at timely forecasting risks, determining their potential size and consequences, in order to prevent or minimize the losses associated with them. At the state level (macro level), the improvement of risk management in the banking system is realized through the creation of an appropriate legislative and regulatory framework. At the bank level (micro level), risk management improvements are aimed at increasing the bank's efficiency and preventing or reducing the risk of losses (Feyen et al., 2021).

A set of interrelated and interdependent components involved in risk management form the bank's risk management system. The key components of this system are: management entities, management objects, principles, functions, methods, and management decisions (Fig. 4) (Blahun, 2021).

Figure 4. Bank risk management



Source: compiled by the author after Blahun (2021).

In fact, the risk management process does not stop; its phases (stages) consistently follow each other. The bank's protective mechanisms against risks include operational risk management and ways to reduce it (Eceiza et al., 2020).

Operational risk management means monitoring important indicators and making immediate decisions on banking operations. The regulator pays most attention to credit risk, as it is often the cause of bank failures.

Due to the large number of banking risks, there is a problem of choosing methods of managing them, which will allow making informed decisions on the expediency or inexpediency of entering into certain transactions or performing certain operations, and reducing their riskiness. For this purpose, there are certain methods of banking risk management (Table 3).

Table 3. Banking risk management methods divided into groups

Group of methods applied for managing banking risk	Description
Methods of avoiding banking risks	Provides for the rejection of risky activities that lead to a loss of potential profit. They are used only for the bank's internal risks.
Methods of accepting banking risks	They include three subgroups:
Methods of reducing banking risks	Improvement of organizational structure, staff training, technical improvement, diversification, limitation, monitoring and control.
Methods of independent counteraction to banking risks	They involve covering losses from own funds and creating reserve funds for self-insurance. They require a balance between the amount of reserves and possible financial losses.
Methods of transfer of banking risks	Provides for the distribution of risks among other market participants: banks, insurance, investment, leasing companies and other financial organizations.

Source: compiled by the author based on Am et al. (2021), Vousinas (2021)

There are methods of transferring banking risks such as insurance, hedging, asset sales and securitization, consortia and parallel loans, guarantee and surety contracts, factoring, and leasing (Chen et al., 2022).

Effective risk management protects investors' capital, enhances mutual trust, and becomes a cornerstone of long-term stability in a constantly changing environment. The field of risk management is in a state of continuous evolution, driven by market fluctuations, regulatory requirements, and continuous advances in methodologies and tools. This evolutionary process of risk management is inextricably linked to the features and advances of machine learning, in particular, based on cognitive models (Heß & Damásio, 2025).

In the market risk management system of Ukrainian banks, the most effective approach is to set limits that will limit banks' open positions in assets with the highest market risk (Alazzabi et al., 2023).

The studies demonstrated the prospects of using available data to analyze problem areas in order to make the most informed management decisions. However, certain aspects of the findings contrast with some approaches of other scholars, in particular, the use of cognitive models to enhance financial stability and minimize liquidity and credit insolvency risks. This can be justified

by the diversity of methodological tools and analysis, as well as by differences in approaches to model building in different financial industries (Feyen & Natarajan, 2021).

The results confirm the effectiveness of cognitive frameworks for interpreting and managing disordered systems, particularly in financial risk sectors.

The study found that financial risks exhibit a multifaceted pattern of interconnectedness that cannot be invariably formalized using standard mathematical approaches. The use of a fuzzy cognitive model explains the uncertainty and instability of financial activities, improving the accuracy of risk forecasting and management efficiency (Interest over time, 2023).

Cognitive modeling helps us spot dangers early and guess what might happen next. This method quickly identifies risks, considers what might happen next, and finds ways to deal with them. This facilitates insightful management choices, thereby ensuring an effective response to risk and circumventing adverse consequences (Chen, 2024).

The proposed mental assessment scheme adjusts the probability of danger with environmental shifts, contributing to the bank's financial security and reducing the chances of a crisis.

Conclusions

A cognitive framework for controlling monetary risk can significantly improve decision-making efficiency and reduce liabilities for the banking sector. Modeling these procedures is essential for assessing and predicting risks associated with human elements, a critical factor contributing to asset volatility in the trading domain.

Therefore, the applied value of this study is the potential for using the developed methods to mitigate hazards, especially in changing market situations. At the same time, further research aimed at improved mental frameworks for enhanced monetary practices and the development of new systems to automate them in real-time execution is essential.

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