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Exploring Cognitive Patterns in Credit Default Risk Management

Explorando Padrões Cognitivos na Gestão do Risco de Incumprimento de Crédito

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ABSTRACT
The study aims to encapsulate methodologies for implementing cognitive models, focusing on tactics and strategies to predict financial risks. The methodology employs general scientific methods: analysis, synthesis, classification, and bibliographic review. The topic's significance arises from complex economic transactions, stricter banking supervision, and the need to enhance risk management. Traditional risk assessment methods are insufficient amid global financial uncertainty and the rapid flow of information. Thus, innovative frameworks that autonomously process large datasets, predict risks, and provide mitigation strategies are needed. Incorporating cognitive models marks a shift towards adaptive, predictive risk management, promising better decision-making but remaining underexplored. The research's applied value lies in mitigating risks in volatile markets.
Keywords: Cognitive modelling technology, Cognitive map, Switching process, Generation of alternatives, Impact consonance, Dissonance effects

JEL Classification: G21; G32; C63; D83

RESUMO
O estudo visa sintetizar metodologias para a implementação de modelos cognitivos, com foco em táticas e estratégias para prever riscos financeiros. A metodologia emprega métodos científicos gerais – análise, síntese, classificação e revisão bibliográfica. A relevância do tema decorre da complexidade das transações económicas, da supervisão bancária mais rigorosa e

da necessidade de reforçar a gestão de riscos. Os métodos tradicionais de avaliação de risco revelam-se insuficientes perante a incerteza financeira global e o rápido fluxo de informação. Assim, são necessários enquadramentos inovadores que processem autonomamente grandes volumes de dados, prevejam riscos e proponham estratégias de mitigação. A incorporação de modelos cognitivos representa uma mudança para uma gestão de riscos adaptativa e preditiva, prometendo uma melhor tomada de decisão, embora ainda pouco explorada. O valor aplicado da investigação reside na mitigação de riscos em mercados voláteis.

1. 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 (Yevenko, 2017). The development and improvement of the competitiveness of banking institutions contributes to the social and economic progress of regions and the nation-state as a whole, although many tend to consider this factor as the starting point for numerous modern crises.

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 consider the complex interrelationships between various factors affecting the financial stability of banks (Makedon et al., 2024).

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 large number of interrelated factors. The process of building a cognitive map traditionally consists of several main stages. The first stage involves prioritization of factors, which allows for identifying 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 both direct and indirect relationships (Morozova et al., 2019). 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 for improved forecasting accuracy, decision-making efficiency, and reduces the likelihood of financial losses due to a deeper analysis of cause and effect relationships and adaptability to changes in the market environment.

2. 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 Pymostka and Pymostka (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, analysing market trends, predicting downside potential, and adjusting banking strategies to address different circumstances. According to researchers such as Arndorfer and Minto (2015) 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. Kovalenko (2017) 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 (Leo et al., 2019).

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 (Dang and Nguyen, 2020). Another study (Samorodov et al., 2019a) considers 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.

3. Methodology

The research methodology employed in this study integrates a range of general scientific methods alongside specialized analytical techniques to comprehensively investigate cognitive patterns in credit default risk management. Central to the approach are fundamental methods such as analysis and synthesis, which enable the decomposition of complex phenomena into constituent elements and their subsequent integration into coherent conceptual frameworks. Classification methods facilitate the systematic categorization of diverse risk factors and cognitive models, providing structure to the multifaceted domain of banking risk management.

A thorough bibliographic analysis underpins the theoretical foundation of the research, involving a critical review and synthesis of contemporary and classical scholarly works across several intersecting disciplines. These include banking management, risk management theory, decision-making theory, situational management, and cognitive modelling. This literature review serves not only to identify existing knowledge gaps but also to contextualize the current study within the broader scientific discourse.

Furthermore, the study draws upon mathematical modelling techniques specifically tailored to processes in weakly structured systems, which are characteristic of financial markets and banking environments. These models enable the simulation and prediction of risk dynamics in conditions of uncertainty and incomplete information, thereby reflecting the complex nature of credit default phenomena.

Cognitive modelling forms a methodological core, emphasizing the replication of human cognitive processes in automated systems to enhance decision-making in risk assessment. This includes the use of frameworks capable of processing large-scale datasets, identifying latent patterns, and generating adaptive strategies for risk mitigation. By combining theoretical constructs with computational approaches, the methodology supports the development of innovative, predictive models that address the limitations of conventional risk management practices.

4. **Results and Discussion**

The cognitive modelling of weakly structured systems implies the development 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) (Zhyhaylo, 2019).

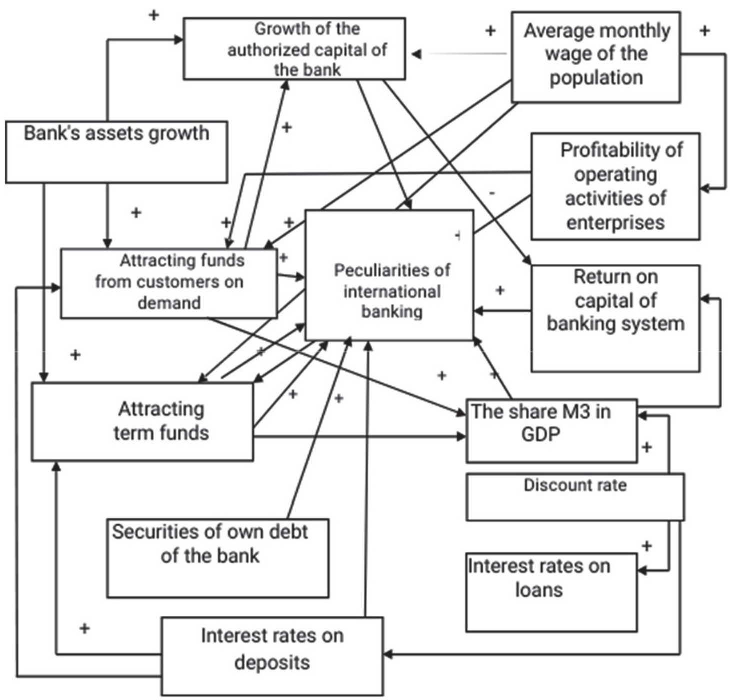
Table 1 – Stages of building cognitive maps in international banking

Stage	Meaning
Identification of key aspects that describe the p roblem 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 Bodnar et al. 2019; Fedevych et al. 2020; Morozova et al. 2019.

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 CM 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 (Ramlall, 2018). A cognitive map is created to analyse 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) (Apostolik et al., 2012).

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



Source: Developed based on Vinnichenko, Gudz (2020).

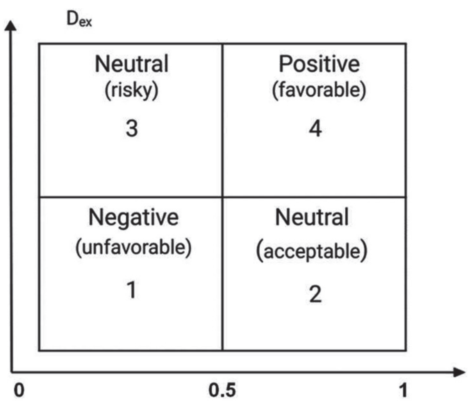
In essence, the CM is an oriented graph over a set of factors that reflects a tool for structuring the system and its possible states. The study of the interaction of factors within the framework of the CM allows us to assess the spread of their effects and thus describe the system' behaviour. Analysing the system's behaviour with the help of the CM 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 modelling, dynamics analysis, and control.

To assess the impact of external and internal factors, it is proposed to develop a two-dimensional matrix that will reflect the results of integral calculations (Fig. 2). This can be represented by the equation:

$$P = \{Dex \mid Dend\} \tag{1}$$

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 Samorodov et al. (2019b).

The matrix contains four quadrants, each of which allows to assess 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) (Alwan Ali Naser, 2018).

Cognitive modelling analysis reveals the critical elements that shape system behaviour, 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 favourable 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 – favourable, acceptable, risky, and unfavourable - provides a comprehensive approach to risk management, which is necessary for the stable functioning of the banking system in the context of international activities.

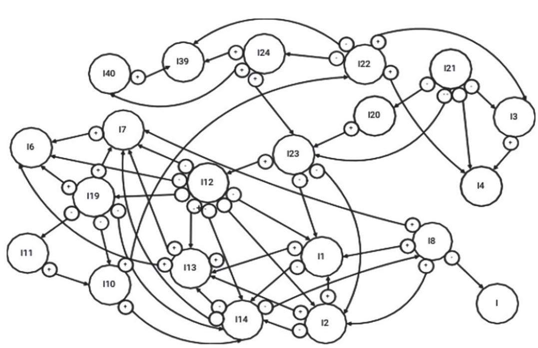
Analysis of the system's behaviour using cognitive modelling allows us to identify the most significant factors of influence and assess their interaction. This facilitates the application of systems theory methods to study the dynamics of changes in the banking sector and develop effective management 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 favourability 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 favourable, unfavourable or neutral impact. The study found that 19% of the components are in the primary sector, 31% in the secondary sector, 26% in the tertiary sector, and 24% in the quadrant, demonstrating the marked diversity in the banking sector's operational environment (Torban, 2020).

Using this method helps banks to make well-informed strategic choices, considering both potential risks and opportunities. The definition of four categories of risk – favourable (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 developing a concept and mechanisms for managing banking risks. This implies the need to consider the key characteristics of individual risks, which allows developing strategies to mitigate them (Makedon et al., 2025).

In order to structure various banking risks, considering 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 Figure 3.

Figure 3 – Cognitive map



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

To analyse the specifications of the cognitive model, the level of cognitive consistency of the model was determined. Consistency in cognitive modelling reflects the positive or negative impact of a particular concept on the entire system as a whole (Abdi and Williams, 2010). The matrix of causal interactions and directions of influence of concepts in the system of indicators used to assess the financial stability of the banking sector of Ukraine is presented in Table 2.

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 (Von Solms and Langerman, 2020).

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	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	0
I4	0	0	← +		0	0	0	0	0	0	0	0	0	0	0	0	← -	← +	0	0	0	0	0
I6	0	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	0
I10	0	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	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	0		← -	0	1	0	0	0	0
I21	0	0	→ -	→ -	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	0	0	← -	→ +		→ +	→ +	0
I39	0	0	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	0	0	0	← +	→ +		0
I	0	0	0	0	0	0	← -	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Source: Compiled from Statistics of financial sustainability indicators (n.d.).

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

If xk1 is Ak1 and xk2 is Ak2 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;
– Akj – 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).

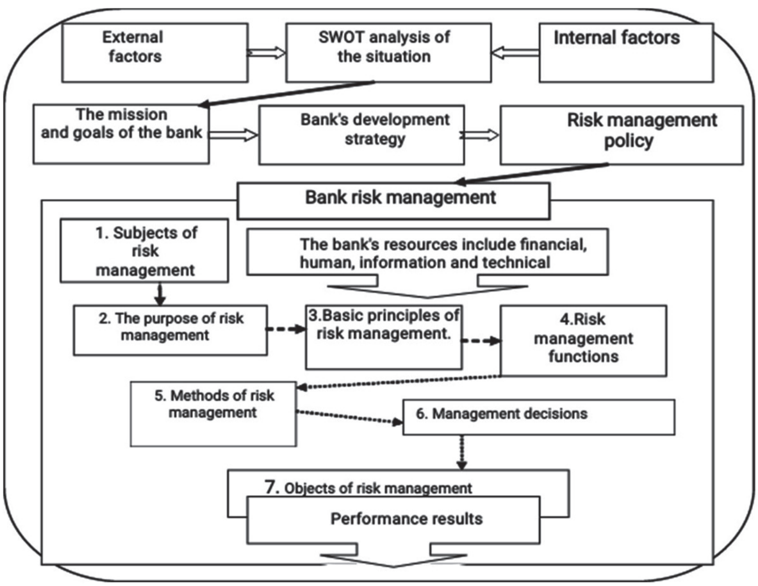
The need to create a well-built and independent risk management system in a banking institution, given the complexity of banking products and the current crisis in the financial sector, does not require additional justification. The issue of developing effective banking risk management systems is extremely relevant today, which makes it the subject of research by a significant number of scholars and practitioners (Torban, 2020).

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 (Figure 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 (Arndorfer and Minto, 2015). 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 are divided into the following groups

Group of banking risk management methods	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 Modernizing the three lines of defense model (2018).

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 and 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 analyse 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 et al. 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 modelling 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 (Prymostka and Prymostka, 2019). 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.

5. Conclusion

A cognitive framework for controlling monetary risk can significantly improve decision-making efficiency and reduce liabilities for the banking sector. Modelling these procedures is essential for assessing and predicting risks associated with human elements, a critical factor contributing to asset volatility in the trading domain. Such an approach enables a more structured and psychologically informed understanding of risk perception, tolerance, and behavioural biases that directly influence financial outcomes.

Therefore, the applied value of this study lies in the potential for using the developed methods to mitigate hazards, especially in changing and high-uncertainty market situations. The results may also serve as a basis for integrating cognitive models into algorithmic trading strategies, adaptive banking risk management systems, and regulatory compliance tools. At the same time, further research aimed at improving mental frameworks for enhanced monetary practices and the development of new systems to automate them in real-time execution is essential. Expanding this work to include cross-cultural decision-making patterns and stress-resilience testing could further strengthen its applicability and reliability in diverse financial contexts.

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