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Риски и надзор за цифровыми валютами центральных банков: инсайты из управления рисками

Се Фэнци

В данном исследовании применяется метод, основанный на изучении литературных источников, при этом методы ученых интегрируются с рамками Базельского соглашения для создания систематизированной системы классификации рисков ЦВЦБ (центрально-банковской цифровой валюты). Исследование классифицирует риски на макро- (системные) и микро- (правовые, экономические, политические) риски, причем экономические риски дополнительно подразделяются на рыночные, кредитные, операционные и ликвидностные риски, что облегчает управление рисками ЦВЦБ и развитие национальной цифровой валюты. В будущем исследования должны интегрировать существующие методы для решения проблем, связанных с специфическими рисками ЦВЦБ, с целью долгосрочной стабильности глобальной финансовой системы.

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КЛЮЧЕВЫЕ СЛОВА

Цифровые валюты центральных банков, управление рисками, системный риск, юридический риск, экономический риск, политический риск.

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Risks and supervision of central bank digital currencies: insights from risk management

Fengqi Xie

This study employs a literature-based approach, integrating scholars' methods with the Basel Accord framework to establish a systematic CBDC risk-classification system. It categorizes risks into macro (systemic) and micro (legal, economic, policy) risks, with economic risks further divided into market, credit, operational, and liquidity risks, facilitating CBDC risk management and national digital currency development. Future research should integrate existing methods to address CBDC-specific risks for the long-term stability of the global financial system.

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KEYWORDS

Central bank digital currencies, risk management, systemic risk, legal risk, economic risk, policy risk.

INTRODUCTION

In the era of rapid digital transformation, central bank digital currencies (CBDCs) have emerged as a revolutionary innovation in the global financial landscape. As countries around the world actively explore and experiment with CBDCs, their potential to reshape the traditional monetary and financial systems has attracted extensive attention from academia, policymakers, and the financial industry [1].

Central bank digital currencies, or CBDCs, represent a novel form of digital currency issued by central banks, embodying the endeavors of various nations to adapt to digital transformation. The objective of CBDCs is to offer appealing financial instruments for both wholesale and retail sectors. Moreover, through the utilization of new monetary policy tools, fiscal policy measures, and programmable capabilities, CBDCs aim to enhance the central bank's influence and control over the economy [2].

However, while CBDCs present numerous opportunities, they also bring about a series of risks. From the perspective of risk management, these risks span multiple dimensions.

Risk management theory serves as a comprehensive framework that aids enterprises, organizations, and individuals in better dealing with risks and achieving sustainable development. It underscores the significance of several key aspects: risk identification and assessment, risk control and mitigation, risk monitoring and response, risk dissemination and communication, as well as evaluation and continuous improvement. Through effective risk management, the accuracy and feasibility of decision-making can be enhanced, thereby promoting the stability and sustainable development of businesses [3].

This study aims to draw inspiration from both risk management theory and technology to comprehensively analyze the risks associated with CBDCs and explore effective supervision mechanisms. By integrating theoretical knowledge and technological solutions, the authors aspire

to gain a more in-depth understanding of the complex relationship among CBDCs, risks, and supervision. This research is of great significance for central banks, financial regulators, and other stakeholders in formulating appropriate policies and strategies to ensure the safe and stable development of CBDCs in the global financial system.

MATERIALS AND METHODS

Employing a comprehensive literature-based approach, this study traces the Basel Accord's historical development, analyzing the key points and limitations of each version. Through a comparison of the risk characteristics between traditional banking and central bank digital currencies (CBDCs), it reveals the Accord's inadequacies in CBDC risk management. By integrating scholars' methods with the Accord's framework, a systematic CBDC risk-classification method is formed. Analyzing literature on risk-management results helps understand how theories adapt to different economic and financial settings, contributing to CBDC supervision.

RESULTS AND DISCUSSION

To effectively address the challenges of risk management in the financial sector, the Basel Committee on Banking Supervision was established in 1974, with strong support from the Bank for International Settlements and the central banks of the Group of Ten. Endowed with far-reaching vision, the committee has formulated a series of comprehensive and forward-looking principles that comprehensively cover the essential conditions for enhancing the efficiency of risk management [4].

In 1988, the Basel Committee issued the International Agreement on the Harmonization of Capital Measurement and Capital Standards, commonly known as Basel I. This agreement primarily focused on credit risk management, it clearly stipulates the minimum requirements for bank capital adequacy ratios, thus charting a course for the stable development of the banking industry [5].

As the financial market continued to evolve and innovate, the limitations of Basel I gradually became evident. Consequently, in 2004, the Basel Committee introduced Basel II. This agreement represents a significant upgrade, introducing a more comprehensive risk management framework that encompasses credit risk, market risk, and operational risk. It also adopts a more refined risk measurement approach [6].

The 2008 global financial crisis revealed some deficiencies in Basel II, prompting the Basel Committee to release Basel III in 2010. Basel III further strengthened capital requirements and added liquidity regulatory indicators to enhance the risk-resistance capacity of the banking system [7].

However, the Basel Accord has certain limitations and is not fully adaptable to the requirements of Central Bank Digital Currency (CBDC) risk management. The Basel Accord is mainly designed for traditional banking business. For emerging financial innovation products such as CBDC, their risk characteristics and transmission mechanisms differ significantly from those of traditional business. For instance, the technical risks [8] and policy risks [9] of CBDC are not fully reflected in the Basel Accord. Moreover, the Basel Accord is formulated based on the general situation of the international banking industry. Given the differences in the development and supervision of CBDC across different countries, it is challenging to adopt a unified standard for CBDC risk management.

Scholars hold diverse views on the risks of central bank digital currencies. From the perspective of risks at the overall financial level, financial risks can be divided into price risks, credit risks, liquidity risks, operational risks, policy risks, technology risks and other risks according to their forms [10]. From the perspective of the expression mode of financial risk, it can be divided into credit risk, market risk, liquidity risk and operational risk. From the perspective of currency risk, the primary risk faced by digital currency is exchange rate risk. Particularly in international transactions and cross-border financial activities, exchange rate fluctuations can have a substantial impact on the value of digital currencies [11]. Additionally, the risks of digital currency can be divided into micro and macro aspects. The former includes five major types of risks: price volatility risk, policy and legal risk, account security risk, confidence risk, and regulatory risk.

However, the above risk classifications are only theoretically detailed classification methods. They do not fully provide targeted and focused classifications based on the actual status of central bank digital currencies and the specific national conditions of various countries. In recent years, with the continuous deepening of research on central bank digital currencies, people have found that the risks faced by national digital currencies at the international level can be mainly divided into five categories, namely credit risk, policy risk, legal risk, operational risk and market risk [12, p. 92-93].

Based on comprehensive research, combined with the Basel Accord and other scholars' related research findings, the author further systematically classifies the risks faced by central bank digital currencies

(Figure 1). The risks are divided into macro risks (systemic risks) and micro risks (legal risk, economic risk, and policy risk). Among them, economic risks are further subdivided into market risks, credit risks, operational risks and liquidity risks. This classification method takes into account multiple factors, providing a more comprehensive and detailed perspective for in-depth understanding and addressing the risks of central bank digital currencies. It also assists relevant departments and market participants in better identifying, evaluating, and managing the various risks faced by central bank digital currencies, thereby promoting the healthy development of national digital currencies in a safe and stable environment.

The systemic risk of digital currency refers to the peril where, owing to elements such as digital currency market fluctuations, technical glitches, and inadequate supervision, risks can propagate within the digital currency ecosystem and between digital currency and the traditional financial system. This, in turn, poses a threat to the stability and security of the entire financial system [13].

The origins of systemic risks in digital currencies are both extensive and intricate, primarily encompassing four aspects: price volatility, technology, regulation, and credit. Notably, the influence of technological factors on the systemic risks of digital currencies warrants special attention. Empirical research has indicated that the rapid advancement of digital technology has heightened systemic financial risks across various countries. Moreover, this escalation is associated with disparities in the development stage of digital technology and the structure of the financial system [14].

Further results from heterogeneity analysis demonstrate that in countries with a high-level of digital technology development and a deeply market-oriented financial system, the impact of digital technology in exacerbating systemic financial risks is more pronounced [15]. In the long term, news related to Central Bank Digital Currencies (CBDC) exhibits a significant negative correlation with systemic risk [13].

The legal risk of digital currency refers to the potential legal liabilities and losses that digital currency-related entities may encounter during the processes of issuance, trading, and utilization. These risks stem from factors such as ambiguous legal provisions, insufficient supervision, or contradictions in the application of laws [16].

During the promotion of digital currency, a series of complex legal risks emerge. Firstly, the boundaries of compensation liability are ill-defined, and the ownership is unclear. This ambiguity makes it arduous to assign responsibility and divide rights and interests when relevant disputes arise. Simultaneously, the potential for privacy leakage cannot be overlooked. Digital currency operations involve a large amount of personal information of users. If not adequately protected, it is highly likely to lead to privacy breaches. Moreover, digital currency has posed challenges to the existing financial regulatory system. Its distinctive operating model struggles to fully conform to traditional financial regulatory approaches [17].

As digital currency continues to develop, risks related to the circulation environment also surface. As a novel form of currency, digital currency may bring about alterations in the traditional "central bank – commercial bank" financial structure. An unhealthy digital currency trading ecosystem can not only foster illegal speculation but also facilitate illegal activities such as tax evasion and money laundering [18].

Additionally, there is a risk of insufficient supporting laws. Before the legal system can keep

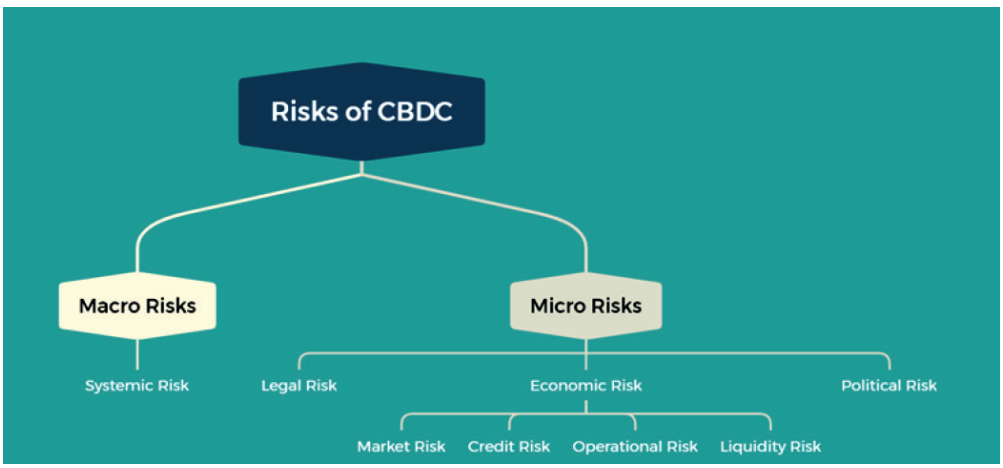

Figure 1. Risks of CBDC

pace with the development of digital currency, the challenges in information security management faced by digital currency are both intricate and severe, and a professional regulatory framework is lacking. The existing legal system is primarily established for traditional currencies and does not explicitly incorporate digital currency into its legal regulatory scope. This results in legal loopholes in the issuance, application, circulation, and supervision of digital currency [19].

The market risk of digital currencies refers to the risk arising from the fluctuations in the value of digital currencies. These fluctuations are a consequence of the market price of the underlying digital assets or the sharp swings in the value of digital currencies themselves. When there are significant fluctuations in the value of digital currencies, investors in digital currencies will be exposed to greater market risks [20]. Meanwhile, market risks induced by price fluctuations can directly impact the international financial environment beyond a country's borders and undermine the security and stability of a country's macro-financial system [21].

Overall, the market risks of digital currencies can be mainly categorized into the following four aspects: Firstly, when a risk event occurs, digital currency exchanges are prone to bank-like runs. This phenomenon can have a detrimental impact on financial stability and potentially trigger systemic financial risks. Secondly, the low threshold for Initial Coin Offering (ICO) investment and financing means that entrepreneurs face extremely low costs, and there is a lack of proper supervision. As a result, a large number of ordinary investors with low risk-bearing capacities are lured into the ICO wave, thus triggering risks associated with ICO financing. Thirdly, in cases of fraud, theft, counterfeiting, and other similar incidents, it is often impossible to clearly identify the party responsible for the incident. Consequently, it becomes extremely difficult to safeguard consumers' rights and interests, leading to risks in consumer rights protection. Lastly, service providers and users within the digital currency market system operate under anonymity, and the unclear transaction chains make it convenient for criminals to conceal the source and investment direction of their funds. This situation facilitates money laundering, terrorist financing, and sanctions evasion, thereby triggering the risks of money laundering and terrorist financing [22].

The credit risk of digital currency refers to the performance risk that occurs during the transaction and circulation of digital currency. It encompasses the credit support provided by digital currency in the settlement process. If one party is either unwilling or unable to fulfill its obligations, it constitutes a breach of contract, which will cause losses to the other party [23].

The credit risk of digital currency is manifested in three aspects. Firstly, due to the decentralized nature of digital currency, it lacks the credit endorsement from the state and relevant institutions. Its price is entirely reliant on market expectations, making the market price of the currency highly susceptible to significant fluctuations. Secondly, the utilization of digital currency hinges on people's trust in intermediaries such as specialized currency exchanges. These digital currency trading intermediaries need to build and maintain their own reputations. Simultaneously, they face challenges such as the loss of customer funds, restricted fund transfers, and a lack of market integrity. Thirdly, factors like the highly centralized characteristics, inadequate management, and information asymmetry between the two parties in digital currency transactions can easily give rise to frequent credit risks.

In the current banking system, the issuance of Central Bank Digital Currency (CBDC) could lead to a substantial transfer of credit risk from commercial banks to the central bank. When depositors shift their risky deposits to CBDC, the central bank, in order to keep money market rates and the monetary policy stance unchanged, has to assume the banks' credit risk on its balance sheet. To limit this transfer of credit risk, it is advisable for the central bank to impose limits and exercise control over the quantity of CBDC. However, restricting the demand or supply of CBDC may dissuade its use as a medium of exchange and instead encourage holding it as a store of value [24]. Empirical results also indicate that loan loss provisions (a proxy for ex-ante credit risk) are negatively correlated with financial stability [25-27].

The operational risk of digital currency refers to the possible losses caused by human errors, system failures, external events and other factors during the issuance, trading, storage and other operations of digital currency. The sources of operational risk are mainly divided into processes, personnel, systems and external events. The level of operational (process-related) risk varies depending on the CBDC model, design features, and technology to be implemented. The adoption of information technology (IT) and related security standards may increase operational risks and costs. Operational risks of CBDC are often related to IT risks, and unaddressed IT risks can lead to system disruptions or failures, which could pose

significant risks to the credibility of the CBDC and the central bank itself [28].

The liquidity risk of digital currency refers to the possibility that a financial institution will be unable to borrow sufficient funds or convert sufficient assets into cash quickly and without sustaining a significant loss in value to meet its short-term spending obligations [29]. Technical malfunctions, market participants' behavior and market structure, as well as uncertainties in monetary and regulatory policies, all lead to liquidity risks for central bank digital currencies.

Empirical research indicates that excessive confidence in CBDC among economic entities can lead to a significant reduction in bank reserves. This reduction, in turn, restricts banks' lending capabilities and causes liquidity issues [30]. Further analysis reveals that the broader adoption of CBDC exposes banks to heightened liquidity risk, as evidenced by an increase in the banks' funding gap ratio. The adverse impact of CBDC adoption on bank liquidity stems from a decline in banks' core deposits [31].

Systemic liquidity risk has long been a critical challenge in the financial system. When liquidity problems at one or more large financial institutions escalate, a contagion effect occurs. This leads to a decline in market asset prices and an increase in volatility, ultimately resulting in systemic (national or global) difficulties. These difficulties manifest as reduced lending, lower real GDP, increased unemployment, and financial failures [29].

The policy risk of digital currency refers to the probability that policy objectives may not be achieved or negative consequences may arise due to various uncertainties during the processes of research and development, issuance, circulation, and supervision of central bank digital currency. It encompasses multiple domains, including monetary policy, financial regulatory policy, and legal policy [32].

CBDCs are anticipated to enable a wide array of new functions, such as direct government payments to citizens, seamless consumer payment and remittance systems, and a variety of novel financial instruments and monetary policy tools. However, CBDCs must also address the inherent conflict between privacy and transparency. It is essential to protect user data from misuse while selectively permitting data mining for end user services, policymakers, and law enforcement investigations and interventions [33].

It is expected that interest rates will soon be incorporated into the monetary policy toolkit. A reduction in the CBDC interest rate will have both direct and indirect effects. Directly, it will not only impact the interest rate of the CBDC itself but also prompt non-competitive deposit providers to adjust their spreads as new substitutes for their products become relatively less appealing. Indirectly, in a highly concentrated deposit market, the overall impact of the CBDC policy rate will be significantly amplified [34].

Specifically, if retail central bank digital currencies alter the amount of commercial bank deposits held by customers, this can affect the implementation of monetary policy, as it subsequently influences central bank reserves in the system. Moreover, uncertainties regarding the timing and scale of the conversion of deposits into CBDCs may prompt banks to increase their demand for central bank reserves to maintain larger precautionary buffers. Consequently, central banks may need to adjust their reserve supply and other aspects of monetary policy implementation [35]. Additionally, the volatility of CBDC can have significant implications for the effectiveness of monetary policy, potentially affecting inflation control, interest rates, and economic stability [9].

Preventing and resolving risks holds great significance for maintaining financial stability. As a result, the development of financial risk management theory and technology has become a necessity. Financial risk management involves the utilization of financial instruments to mitigate financial risks and prevent substantial losses for relevant countries, regions, institutions, and individuals [36].

To adapt to the economic and financial environment and risk management requirements of different periods, various theories and methods of financial risk management have emerged successively. Table 1 presents the main achievements in the field of financial risk management in recent years, ranging from the theory and method of gap management for interest rate risk to the comprehensive risk management of enterprises.

The concept of duration was proposed by Frederick Macaulay in 1938 and has become a popular tool for measuring financial instruments today [37]. From the mid-1940s to the 1970s, market risk management theories and methods underwent major development changes, laying the foundation for the subsequent formation of comprehensive risk management concepts.

In 1952, Harry Markowitz created the core and cornerstone of modern financial theory – modern portfolio theory (MPT). The theory includes Markowitz's mean-variance Model and William Sharp's capital asset pricing model (CAPM). The

Table 1

Changes in risk management theory and technology

Period	Theory and technology
Before the 1970s	Theory and method of gap management of interest rate risk (1938 Frederick Macaulay's duration gap model)
	Modern portfolio theory (1952 Markowitz's mean-variance model; 1963 William Sharpe's capital asset pricing model)
The 1970s-1990s	1973 Black Scholes option pricing model
	Ross's arbitrage pricing theory in 1976
	Capital adequacy ratio management
The 1990s	VAR (value at risk) system
	Credit derivative
Latest developments	Comprehensive risk management

mean-variance model is used to solve the proportion of optimal asset allocation, and it is also the first time that mathematical statistical methods are introduced into portfolio theory [38]. This model became one of the most important studies in modern finance. The capital asset pricing model mainly studies the relationship between the expected rate of return of assets and risk assets in the securities market, and how equilibrium prices are formed, which is the pillar of price theory in modern financial markets [39].

The main limitation of the CAPM theory is that it relies on market asset portfolios (including all securities, real estate, foreign exchange, etc.) that are difficult for investors to actually obtain, and the model has many strict assumptions, which makes the CAPM model lack certain reality and is difficult to verify. In 1976, American economists Stephen Ross and Richard Roll proposed the Arbitrage Pricing Theory (APT) in response to the limitations of the CAPM model, further improving the pricing theory of the financial market [40].

Since the 1970s, the increasingly urgent need for market risk management has prompted the continuous emergence of new financial risk management tools. In 1973, the Black-Schulz option pricing model was born. This model laid the theoretical and technical foundation for financial risk management and provided important methods and tools for pricing and risk management of financial derivatives [41]. By 1986, regulators were concerned that the main capital ratios failed to distinguish between risks and accurately measure the risk exposures associated with innovation and the expanding banking business (most notably the off-balance sheet activities of large institutions). Regulators began to study risk-based capital frameworks in other countries: France, the United Kingdom, and West Germany implemented risk-based capital standards in 1979, 1980, and 1985, respectively [42], which provided important reference for the development of global financial regulation.

From the 1990s to the present, in order to adapt to the market risk management model and comprehensively measure market risks, Morgan Company developed the value-at-risk (VAR) method for the first time. The VAR method is a cutting-edge achievement in financial risk management technology, and it can even be said to have led a revolution in the field of financial risk management. Its emergence marks the transition of financial risk management from traditional single risk measurement to comprehensive risk management. Initially, the VAR method was mainly used to measure and manage market risks, helping financial institutions and investors to quantify potential losses caused by market fluctuations. With the further development of the financial market and the increasing demand for risk management, the application scope of the VAR method has gradually expanded to the measurement and management of credit risk, liquidity risk and operational risk. By incorporating different types of risks into a unified assessment framework, the VAR method has promoted the formation and practice of the concept of comprehensive risk management [43].

Comprehensive risk management emphasizes the comprehensive and systematic management of all risks faced by financial institutions, realizes the integration and sharing of risk information, helps financial institutions formulate more scientific and effective risk management strategies, and improves their overall risk resistance capabilities. By 1992, credit derivatives were introduced into the financial market to manage and hedge risks, further enriching the means and tools of comprehensive risk management and making the financial risk management system more complete and mature [44].

Throughout the development process of financial risk management theory and technology, the aspects of financial risk management are becoming more and more comprehensive. From the traditional market risk to the coexistence of market risk and credit risk, and then to the current management of various risk management forms such as market risk, credit risk, operational risk and liquidity risk, the financial risk management system is increasingly systematic and perfect. For countries that are looking for answers to all national financial problems, they should find a financial risk management system suitable for their own countries from the global successful experience and establish an independent and complete financial system.

CONCLUSION

This study has systematically explored the risks associated with central bank digital currencies (CBDCs) and the evolution of financial risk management theories and methods. By integrating research findings from the Basel Accord and other scholars, the author has comprehensively classified the risks faced by CBDCs into macro-risks (systemic risks) and micro-risks (legal, economic, and policy risks), with economic risks further subdivided into market, credit, operational, and liquidity risks. This risk classification approach offers a more detailed and comprehensive perspective for understanding and addressing CBDC-related risks, facilitating better risk identification, evaluation, and management for relevant departments and market participants, and promoting the healthy development of national digital currencies in a stable environment.

Preventing and resolving financial risks is crucial for maintaining financial stability. In response to the changing economic and financial environments and risk management requirements over different periods, a series of financial risk management theories and methods have emerged. From the early gap management theory for interest-rate risk before the 1970s to the modern portfolio theory, and then to the Black-Scholes option pricing model, VAR system, and the latest comprehensive risk management, these achievements reflect the continuous development and adaptation of risk management in the financial field.

In conclusion, as the financial landscape continues to evolve, especially with the rise of CBDCs, continuous research and improvement in risk management theories and methods are essential. Future studies should focus on how to better integrate these existing risk management approaches to address the unique risks of CBDCs, ensuring the long-term stability and healthy development of the global financial system.

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