Reflections on the privacy protection of e-CNY

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Abstract: With the rapid development of fintech, digital economy, and blockchain technology, the problems of digital currency in privacy protection need to be paid attention to and solved urgently. We start with the characteristics and issuing mode of e-CNY. Then, the influence of e-CNY at home and abroad is investigated as an attempt, upon which the existing or potential threats and challenges in privacy security are analyzed. Finally, based on the above research, we put forward feasible suggestions and prospects for e-CNY.

1. Introduction

People's trading methods have also changed with the development, integration, and application of digital technology, blockchain, big data, and cloud computing technology. In recent years, with the emergence and expansion of crypto-digital currency such as Bitcoin, the sovereign status of legal tender in many countries has been directly shaken, and many pressures and challenges have been brought to the financial systems and regulatory systems of various countries. Since 2021, more and more countries have invested in the research of digital currency. In July of the same year, the European Central Bank officially launched the research and development of the digital euro project and plans to launch the digital euro before 2025. Sweden and South Korea have entered the pilot phase of CBDC, while Russia is making rapid progress and plans to carry out the digital currency test in 2022.

China has officially started the research of digital currency since 2014 and completed the construction of the first-generation digital RMB prototype system in 2016. With the successful pilot of digital currency, the central bank of China, in Shenzhen, Suzhou, Xiong 'an, and other places, as well as in the Beijing Winter Olympics, the attention to digital currency, the central bank, is increasing day by day, and some research has also been conducted on digital currency, the central bank. Compared with electronic money and virtual money, Zhu Ge (2015) [1] defined digital currency. Although digital currency belongs to virtual money in a broad sense, there are still essential differences between them. He believes that the development prospect of digital currency cannot be underestimated. However, it is difficult to guarantee the security of digital currency without government approval and legal protection. Li Jialin (2018) [2] expounded on the necessity of researching and developing the legal digital currency in China based on the analysis of the digital development trend of the world currency, the development of the central bank's monetary system, and China's national conditions. Yao (2018) [3] put forward the basic definition and future expectation of the central bank's digital RMB in digital currency's past lives. He mentioned that the central bank's digital currency should be based on cryptocurrency technology and can truly represent the direction of future technological development. Zhuang Lei et al. (2017) [4] summarized the essence, attribute, anchoring, and creation mechanism of digital currency, analyzed the design ideas, practical exploration, and prospects of digital currency's core mechanism, and discussed the adjustment of digital currency's credit model. Yao (2018) [5] analyzed the closed-loop process of issuing, transferring, and returning the legal digital currency under the dual mode, and proposed the optimization and improvement ideas for the application of distributed ledger technology in digital RMB system, the improvement opinions on the application of distributed bookkeeping technology in the future, and other aspects in the system. Qiu Xun (2017) [6] elaborated on the elements and specific functions of the digital currency core cloud system and mobile terminal application system in the digital RMB system. From the perspective of operation mode, digital RMB has two operation modes: the unitary mode of "central bank-public" and the dual mode of "central bank-commercial bank". Fan Yifei (2016) [7] performed a comparative analysis of the two, revealing that the digital people who follow the traditional dual issuance mode will coexist with the physical digital RMB for a long time

and mobilize the enthusiasm of banks. At the same time, he presented five positive influences of legal digital RMB on the financial system. Qi Aimin (2021)[8] conducted a comparative analysis of private digital currency and legal digital currency from the perspective of legal nature. He believed that compared with private digital currency, legal digital currency is the equivalent currency with legal compensation issued by authorized institutions, while private digital currency is essentially just a currency substitute.

Under the advantages of digital currency and the assumption of legal digital RMB in China, He Ping (2019)[9] summarized the three development advantages of a legal digital currency compared with private digital currency: cash substitution, anonymity, and cost saving. Li Wanrong (2020)[10] suggested that the digitalization of RMB will profoundly affect the monetary base of China, accelerate the reconstruction of the financial model and economic system, and open a new era of the digital economy. Cai Hui et al. (2019)[11] proposed that China should build a new "center-periphery" RMB internationalization system under the "the belt and road initiative" strategic framework to promote the coordinated development of RMB digitalization and internationalization. At present, China is in the stage of overtaking in corners and thus should boldly try to use all kinds of breakthrough technologies. It is a rare historical opportunity for China to issue the central bank's statutory digital currency. Wu Zhennan (2021)[12] analyzed the international monetary and financial system and international forms, demonstrating that the research and distribution of digital RMB still need to be deepened and expanded. He believed that the multi-faceted influence of digital RMB on the economy and society would optimize the traditional payment function, promote the intelligent development of big data and financial technology, and reinforce other five potential far-reaching influences. With the gradual development of digital RMB, it will not only be integrated into all aspects of residents' life activities but also have a certain impact on our government governance. Liu Ying (2021)[13] expounded the new situation brought about by digital RMB from five perspectives: mobile payment, financial institutions, financial stability, monetary policy, and RMB internationalization. Ji Nan et al. (2021)[14] revealed that due to the characteristics of centralized distribution, decentralized technical structure, and controllable anonymity, China's legal digital RMB will significantly help the development process of RMB internationalization and face most challenges in the process of internationalization.

With the development of digital RMB, it inevitably meets various problems and challenges. Chen Hua et al. (2021)[15] elaborated on the challenges that digital RMB will face, such as the competition of private digital currency and the transformation of commercial banks, and provided some development suggestions. Through the analysis of various consensus mechanisms in the application of blockchain technology, Wang Hao et al. (2017)[16] pointed out that digital currency using blockchain technology is prone to privacy security problems such as the leakage of transaction addresses and the easy-to-see transaction amount. Qiu Xun (2017)[6] illuminated the problems faced by the issuance of digital RMB from the aspects of law, circulation, financial system, and technical realization. Currently, researchers focus on the theoretical study of the operation of digital RMB and its influence in the financial field. Although some researchers have investigated the challenges faced by digital RMB, there is little research on the risks faced by digital RMB in users' privacy data. Starting from the specific meaning, characteristics, operation mechanism, and influence of digital RMB, this paper will deeply analyze the potential or future privacy security problems of digital RMB. On this basis, feasible suggestions and measures will be proposed to provide theoretical support for the future application of digital RMB in China and the data privacy supervision and user privacy protection in the process of going to the international market.

2. Basic overview of RMB figures

2.1. Definition of RMB

Renminbi is the legal tender issued by the central bank for the public. Relying on digital technology, it has the same legal status as traditional physical Renminbi. The digital RMB system adopts the central bank-centered management mode, and the exchange and circulation services are provided by the designated operating institutions. The transaction process is based on the generalized account system, and the loose coupling of bank accounts is adopted[17].

Before the issue of digital RMB, WeChat and Alipay have remarkably changed the payment methods of people in the contemporary information technology era. In essence, digital RMB is legal tender, different from WeChat and Alipay as payment tools. After the implementation of digital RMB, the public can still use WeChat and Alipay to make payments under the new electronic payment

scenario. Nonetheless, they only act as wallets in the process of payment and settlement. Moreover, digital RMB can be used as the contents of wallets [18], and there is no competitive relationship between them.

2.2. Characteristics of RMB

2.2.1. Adopt a centralized management mode

As digital RMB is not a special currency outside the RMB system, it is necessary to implement a central bank-centered management model. It adopts the two-level delivery mode of centralized management by the People's Bank of China and distributed operation by designated operating institutions. In other words, the central bank located in the center of the digital RMB system is responsible for issuing and managing digital RMB to designated operating institutions, which will then pay it to the public.

2.2.2. Repayment: cannot be rejected

Renminbi is the sovereign currency of our country. It has the same unlimited legal compensation nature as the real RMB and is supported by national credit. No business or individual in China can refuse it for any reason at any time.

2.2.3. Alternative currency: no different from cash

Renminbi is positioned as the current currency M0 and cannot replace narrow money M1 and broad money M2. Its validity is the same as that of real RMB. As the legal tender, RMB does not need to rely on the third-party payment platform for the settlement of transactions. Hence, the corresponding interest and handling fee will not be paid.

2.2.4. Controllable anonymity

The characteristics of digital RMB "front-end anonymity and back-end real name" are to meet the needs of anonymous payment and privacy protection of individuals. No one can disclose the transaction information collected in the digital RMB system to a third party or other government departments without permission, contributing to effectively preventing the leakage or illegal abuse of user identity and transaction information [18] and better assisting the government in combating illegal activities such as money laundering. Technically, digital RMB can be anonymous to a certain extent, and digital wallets can only be registered with mobile phone numbers. However, this function is still controversial, and how to strike a balance between protecting consumers' personal information and illegal behavior still needs further research and discussion.

2.3. Digital architecture and operation mode of RMB

2.3.1. Digital architecture system of RMB

As the legal tender issued by the central bank, RMB has the characteristics of a national sovereign currency, and it adopts the architecture mode of "one currency, two warehouses, and three centers" and the "two-level operation". One currency refers to the digital RMB guaranteed and issued by the central bank. Because of the controllable anonymity of digital RMB, it is required to be a cryptocurrency with some financial information [19], different from the account balance displayed by electronic money. "Two repositories" include the central bank issuing repository and the commercial bank repository. The issuing bank is mainly used to store the transaction information of sovereign digital currency, while the bank provides more personalized services for digital RMB. They cooperate to guarantee the creation and issuance of digital RMB. "Three centers" are the data analysis center, registration center, and certification center. The authentication center is the security foundation of the digital RMB system, used to centrally manage the institutions and users in the digital currency system and distinguish the user levels to realize controllable anonymity. The registration center mainly records the information of digital RMB and user identity in the process of circulation and carries out ownership registration, which is considerably improved compared with the traditional paper money that only records the information of the issuer. The data center will analyze financial behavior, which is the key to ensuring the security of sovereign currency transactions, preventing illegal financial transactions, and enhancing the effectiveness of monetary policy [20].

2.3.2. The digital operation mode of RMB

The issuance and operation of digital RMB adopt the "two-level operation" mode. Specifically, in

the first level, the People's Bank of China is responsible for the issuance and cancellation of digital RMB, inter-agency interconnection, and ecological management of wallets; commercial banks can only participate in the operation when certain conditions are met. The second level is that the designated commercial banks, under the quota management of the central bank, open different types of digital wallets for customers according to their identification strength and provide digital RMB exchange services to the public. This delivery path is consistent with the physical RMB. Additionally, the designated operating institutions and commercial banks will provide digital RMB circulation services and be responsible for the management of retail links to ensure the safe and efficient operation of digital RMB.

The single-tier operation mode, which is different from the two-tier operation mode, indicates that commercial banks do not participate in the issuance of digital RMB, while the central bank directly issues digital RMB to the public. If the single-tier operation mode is adopted, there will be direct competition between commercial banks and the People's Bank of China. Considering the high level of protection of digital RMB for information and privacy security, it is bound to have a certain impact on the expansion of commercial banks' assets [21].

3. The influence of digital currency's central bank

3.1. Improve the stability of monetary policy and optimize the transmission mechanism of monetary policy

The RMB contributes to expanding the scope of the central bank's monetary policy. Paying the interest on digital currency by the central bank will create a new monetary pricing policy tool. By analyzing the digital information, the central bank can summarize the relevant laws and formulate a more reasonable monetary policy according to the characteristics of digital RMB operation data. This will further strengthen the effectiveness of the central bank's monetary policy, reduce serious risks, and improve economic stability. Renminbi may become a new monetary policy tool to optimize the transmission mechanism of monetary policy during the economic downturn. The central bank can implement the negative interest rate policy to avoid the negative interest rate trap. During the period of economic overheating, the central bank can accelerate the appreciation of RMB by introducing the positive interest rate of digital RMB. Besides, the central bank can use the incomplete replacement of digital RMB and deposits as a control tool to improve and strengthen the transmission channels of monetary policy and enhance the efficiency of monetary policy.

3.2. Contribute to the accurate release of credit funds and crack down on illegal and criminal acts involving money

Renminbi can accurately track the flow of funds, noticeably reduce the probability of default, weaken the probability of financial risks, and strengthen the flexibility of the financial system. From the perspective of commercial banks, digital RMB has not changed its main business form. Concurrently, the digital payment of RMB is easy to manage, which promotes the accurate investment of funds, reduces the credit risk of customers, and improves service quality. Renminbi is a digital cryptocurrency based on blockchain technology, providing a wide range of opportunities for commercial banks to expand new businesses. Its uniqueness, traceability, and limited anonymity reinforce the transparency of transactions, making it a natural asset to combat fraud and helping to combat crimes such as money laundering and fraud.

3.3. Reduce the management cost of paper money and improve transaction security

Compared with third-party payment, the digital payment process of RMB is much simpler and faster, and fewer participants determine the lower transaction cost. According to the requirements of the People's Bank of China, commercial banks, as operating institutions, exchange digital RMB for customers free of charge, enabling customers to convert their digital RMB into bank deposits free of charge. All the privacy-sensitive information related to customers of RMB is kept by the central bank only, and other institutions cannot master it. When necessary, the People's Bank of China can backtrack and trace the transactions to improve security of transactions. When customers use the third-party payment to conduct transactions, their security is provided by the corresponding payment institutions, while some payment institutions, especially small and medium-sized payment institutions, are limited by the pressure of management, technical level, and operating costs. Consequently, it is difficult to

provide a high-quality transaction security guarantee for customers, and even illegal behaviors such as the disclosure of sensitive information of customers occur.

3.4. Improve payment convenience and settlement efficiency

When RMB is paid, it does not need the intervention of a third party, realizing the goal that "payment is settlement". By contrast, the business process of third-party payment requires the participation of third-party payment institutions, receiving and paying banks, and clearing institutions such as UnionPay or Netlink. The whole payment process is complicated, and the timeliness of fund settlement and liquidation is poor. A business dispute requires coordination among multiple institutions, and the handling process is cumbersome, resulting in poor customer experience. In the storage and payment of RMB, there is no need to bind three-party software such as WeChat and Alipay. As long as it is on the storage medium, transaction payment can be completed without networking.

3.5. Help the digital RMB to go international and enhance the international discourse power of RMB

Some countries such as the European Union, Russia, Japan, and Iran are studying and launching their own digital currency. Renminbi is issued first and is the only central bank digital currency in the world, occupying the first-Mover advantage. Currency issuance involves currency sovereignty, and super-sovereign currencies such as Facebook Libra will be issued and listed soon, which will directly erode the sovereignty of currencies of many countries except the US dollar. At present, the application test of digital RMB in China is still in its infancy. In the process of promoting the internationalization of RMB, digital RMB can continuously improve the convenience of cross-border payment, settlement, and liquidation, which is a noticeable promotion for RMB internationalization payment. Additionally, the digital currency will be the key development field of the financial industry in various countries in the future, and China should actively promote its development, so as to gain a dominant position in global finance and competition.

4. Privacy security challenges faced by digital currency's central bank

Compared with the traditional fiat currency, digital RMB using emerging Internet technologies such as big data, cloud computing, and blockchain has many advantages that physical RMB cannot have. However, digital currency, the central bank, is still in the initial stage of development and will inevitably face many challenges when applying these new technologies due to their technical characteristics and development. In the process of using digital RMB, the protection of users' privacy data is undoubtedly one of the most concerning aspects for users. If the user's transaction data information is leaked or maliciously stolen, it will considerably dampen the enthusiasm of users to use digital RMB and bring a big challenge to the development of China's legal digital currency. Besides, there are some gaps in the legal definition and system construction of digital currency, the central bank of China, which will be a big challenge to the regulation and system protection of data privacy in the future.

4.1. Blockchain technology defects and potential privacy problems caused by technical characteristics

The realization of some functions of digital RMB depends on blockchain technology, and many parties need to take part in the record when conducting transactions. Specifically, in the process of using digital RMB, different users conduct transactions, and the transaction data (regarded as blocks in the blockchain) generated by this transaction user (regarded as nodes) is sent to the chain according to the order of transaction time. Since this transaction information is not fully published to the public, it has certain security. However, the core content of the blockchain technology used in digital RMB is distributed ledger, suggesting that the transaction data of users will be recorded in the duplicate ledger of each node. As a result, many participants in the blockchain will have access to the data of users' consumption information, transaction habits, and user preferences. Once targeted by unscrupulous criminals, this will greatly increase the probability that users' privacy and security will be violated from outside, while the difficulty of preventing and protecting privacy data leakage will also be significantly increased. In the era of the digital economy, the development of major enterprises is inseparable from the huge productivity of data. Nevertheless, this demand has also caused many bad social phenomena

such as selling users' privacy data and maliciously competing for business data. Unscrupulous businesses will surely seek opportunities to steal user data and information in the process of implementing and using digital RMB. Simultaneously, this will bring more uncontrollable factors to cyberspace governance and increase the difficulty of cyberspace security.

Blockchain's security depends on its decentralized and unchangeable characteristics, indicating that all users' transaction information is scattered on each node of the blockchain for account keeping. When you want to tamper with the data in the blockchain, you can only regenerate all the blocks and then tamper with the information in the chain if you have more than 51% computing power, that is, you have the absolute advantage of bookkeeping in the blockchain. With the help of cryptography and other encryption technologies, the account book information in the blockchain will remain accurate and authentic and thus has relatively strong protection for the digital currency of the central bank. If more than 51% of the account books in the blockchain are hacked, the original account book information is maliciously tampered with, and it is difficult to recover the data the first time because of its non-tampering, it will inevitably bring irreparable losses to users and capital systems. With the continuous development and improvement of computer computing level, as well as the computing power of advanced quantum computers, there is a high probability that 51% of the node passwords in the blockchain can be cracked, which will be a great challenge for the digital RMB system, according to the characteristics that different nodes in the blockchain have different security levels.

4.2. Challenges based on the characterization of relevant laws and the vacancy of the legal system

The existing laws restrict digital currency, and the privacy protection system is not comprehensive. From one perspective, the basic legal information of digital RMB is blank. The status of digital RMB and physical RMB is equal to that of national legal tender, while the current legal framework of RMB lacks the content of digital RMB. The current legal rules and regulations on legal tender are aimed at physical RMB, and there is a big gap in the legal status of digital RMB and the relevant legal provisions on the issuance and circulation of digital RMB. Digital RMB uses a lot of advanced computer technology, though it is more difficult and less likely to be destroyed by technology. However, it is possible to use computer technology to fake digital RMB, destroy digital RMB systems, or attempt malicious destruction. Meanwhile, there are still no corresponding laws and regulations on this aspect in the current law. Although it is less likely that digital RMB will be counterfeited by criminals, it is still necessary to guard against this kind of illegal act of using digital RMB for profit and formulate relevant laws and regulations. Digital RMB also involves cryptography and related technologies of network information security, while the contents of Cyber Security Law and Cryptography Law have not supplemented the related issues involved in digital RMB. From another perspective, regardless of relevant laws and regulations to protect the data privacy policies in all kinds of networks or communications in China, their legal nature is vague and their functions are unclear, and many aspects of laws and regulations still need to be improved. Therefore, the actual situation of protecting personal privacy data rights is not optimistic, and it is difficult to comprehensively protect personal privacy information. China's digital RMB adopts a dual operation mode. Besides the central bank and ordinary users, many third-party operators are involved in the issuance and circulation of digital RMB. Nonetheless, there is no detailed division of responsibilities at present. If there is a financial dispute in the future, it will be difficult to make an authoritative judgment, causing the lag of the law to some extent.

5. Suggestions for the future development of privacy protection based on a digital RMB system

5.1. Increase research efforts in relevant fields of blockchain technology

According to the potential demand of China's central bank's digital RMB, the key elements, the technical framework of the overall system framework, and the corresponding top-level design of information technology are formulated. China needs to strengthen the exploration and research on blockchain technology, distributed accounting technology, and digital encryption technology, attach importance to the research and development of related technical fields, and increase investment.

Further strengthening and research on the security of the digital RMB system will be a long and continuous improvement process. First, the distributed account book technology and signature encryption technology in the prototype system are improved, the distributed account book technology is further studied to obtain more advanced encryption technology, and a stronger encryption algorithm

is used as soon as possible, so as to remove the threat of the current quantum computing power to the current digital RMB system and prevent the system from being maliciously attacked by the outside world. Second, research and development should be conducted to strengthen the management of network security by using existing technologies, and high-level password protection should be set up to strengthen the construction of prevention mechanisms in the system. In this way, criminals who attack the system or maliciously obtain other users' privacy data can be tracked and recorded.

5.2. Complete the existing legal system

Perfecting the existing legal system of legal tender and the complete legal system of digital RMB is the necessary prerequisite for digital currency supervision. First, it is urgent to clarify the legal status of digital RMB, incorporate it into China's RMB legal system as soon as possible, promote the legal construction of digital RMB issuance, circulation, and trading, and issue relevant management measures, rules, regulations, and normative documents. Secondly, based on the difference between digital RMB and traditional physical RMB, it is necessary to supplement relevant technical laws, such as the laws and regulations related to network security and information technology. Additionally, the detailed responsibilities of regulatory authorities at all levels and many third-party operators should be clarified to standardize the operation of the digital RMB system.

5.3. Establish a strict privacy protection model under the pluralistic supervision system

Compared with the traditional physical RMB, digital RMB has the characteristics of digitalization and electronization, and its development is inseparable from information technologies such as blockchain and cloud computing. The issuance and circulation of digital RMB involve many third-party operators. Therefore, the establishment of a diversified supervision system is more conducive to the development of digital RMB. Its diversification is embodied in the daily supervision of digital RMB by the central bank supervision departments, government supervision departments at all levels, financial institutions supervision departments, and network security supervision departments. Secondly, a supervision mode focusing on privacy protection should be established. On the premise that the data in the digital RMB system flows to the central bank, a special system data supervision department should be set up to supervise the third-party operators and users to prevent malicious theft of system user data. Finally, the regulatory authorities are transformed into science and technology. In daily supervision, information technologies such as big data are employed to supervise the currency operation and circulation, and artificial intelligence is adopted to establish a regulatory decision-making model to improve the regulatory efficiency of digital currency, especially private data.

6. Prospects

China has vigorously promoted the development of digital RMB and is improving all the work for digital RMB to land in the whole country. At present, with the vigorous development of information technologies such as blockchain technology and cloud computing technology, digital RMB has a considerable development prospect, and its application scenarios are gradually enriched and secure. Digital RMB based on blockchain technology will further break through the technical problems of its security while making up for the shortcomings in the current pilot process. In the future, the content of the legal system of digital RMB will be gradually optimized. Based on this, the regulatory system will be more scientific, diverse, and rigorous, standardize market financial activities and circulation means, and prevent illegal activities from taking advantage of it.

The circulation and application of RMB will be a long-term process. China's digital RMB is currently in the pilot stage in some areas. Nonetheless, in the long run, digital RMB will gradually gain the recognition and trust of the public because of its controllable and traceable performance and then become the mainstream trend around the world, finally bringing new changes to international trade payment. Simultaneously, the digital RMB will also face a more changeable and severe international situation. As a new payment method, digital currency is responding to the fluctuation caused by global economic uncertainty, while its advantages that meet the requirements of the development of the digital economy are constantly emerging. More and more countries will intensify the research and construction of their central bank, digital currency, to form more intense international competition.

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