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Digital RMB: Performance Expectations and Technology Support

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About this working paper

This is the second paper in a series of working papers that the authors have developed from their digital RMB project report on "China's e-CNY Journey: Design and Development". China began piloting its central bank digital currency in 2019. The trial programme now covers twenty-six cities and involves more than five million merchants. This working paper series examines the digital RMB's systems design and policy objectives, performance expectations and technology support, and hybrid delivery mode.

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Digital RMB: Performance Expectations and Technology Support

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Highlights

- The DC/EP will adopt a centralised governance and decentralised operation architecture to ensure payment innovation and help the e-CNY quickly “fly into commoners’ homes”.
- Digital RMB wallets’ “loose coupling” with bank accounts, “dual-offline” payment features, and “smart contract” functionality are expected to reduce barriers to financial services for disadvantaged groups, to guarantee “settlement upon payment”, to serve payment needs even in special environments, to improve capital turnover efficiency, and to prevent prepaid merchants from absconding with funds and/or infringing on consumer rights.
- A common Chinese understanding of the “controllable” or “semi-anonymity” adopted by the DC/EP is that “controllable” will focus mainly on macro-level security regulation issues, while “anonymity” means restraint being exercised on private and commercial transactions between individuals.
- Discussions on the boundary between information tracking and information security protection and on the prevention or resolution of the “double-spending” problem in “dual-offline” scenarios continue at the technical level.
- Digital RMB wallets are broadly divided into “software” and “hardware” types, and personal wallets are classified into four levels based on the strength of customer identification.
- It is widely believed in China that to enhance the competitiveness of the DC/EP in the market, it should not only be connected with various aspects of people’s daily lives, but also developed as an investment and wealth management platform to generate returns.
- The PBC does not preset or predefine technological paths for designated commercial banks and mobile payment platforms to follow in providing e-CNY exchange and payment services.
- Blockchain technology is not the core of the digital RMB, but a reference for its underlying technical concepts and designs.

Introduction

Chinese finance research and policy communities generally believe that central banks across the world are increasingly enthusiastic about developing digital currencies because CBDCs are regarded as being able to improve the monetary policy toolkit and enhance the security of the financial system.¹ The “White Paper on the Development of China’s Digital RMB” released by the People’s Bank of China (PBC) in July 2021 further specifies that the Digital Currency Electronic Payment (DC/EP) system aims to meet the public’s demand for cash in the situation of a digital economy. Coupled with a financial infrastructure that supports an open, efficient, robust, reliable, innovative, and competitive retail payment system, the new e-RMB should drive the development of the digital economy, advance financial inclusion, and improve the operational efficiency of monetary and payment systems.²

To ensure payment innovation, meet future payment needs in the digital economy, and enhance the accessibility and convenience of central bank currency, the digital RMB will adopt a centralised governance and decentralised operation architecture. Under this framework, the PBC formulates relevant rules and adopts a co-construction and sharing approach to work jointly with designated operating

institutions in developing a payment ecosystem for the wallet. The partnership allows the operating agencies to incorporate their respective visual systems and distinctive features into the new payment ecosystem, thereby enabling the full-scenario application of the digital RMB, both online and offline. These features cater to the goal of meeting users' many characteristics (multi-level, multi-category, and multi-form), ensuring the inclusiveness of the digital wallet, and avoiding usage barriers caused by the "digital divide".³

Nevertheless, the use of digital RMB is similar to physical cash in that it does not rely on a bank account or need to be bound to any bank or third-party payment card.⁴ The designed loose coupling between the digital RMB and bank accounts aims to allow people without bank accounts to enjoy basic financial services through the digital wallet. Additionally, short-term overseas visitors can open a digital RMB wallet without opening a local bank account to meet their daily payment needs in China.⁵ From the perspective of settlement finality, the loose coupling of the digital RMB and bank accounts allows digital wallets to directly transfer funds and thus guarantees settlement upon payment. This functionality is expected to optimise intermediate links of settlement, reduce costs, and improve capital turnover efficiency.⁶

Furthermore, unlike third-party payment platforms, the digital RMB can facilitate transactions or transfers even when there is no internet connection or network signal. In such circumstances, the payer and payee can use the Near Field Communication (NFC) feature on their mobile phones to complete the transfer by simply having their digital wallets "touching" each other.⁷ This "double-offline" payment feature is expected to be primarily used in small-value payment scenarios. Nonetheless, it will provide convenience for the elderly and those who are not familiar with using smartphones. Equally important is that the "double-offline" function may also reduce the risks of "double spending" or "double payment".⁸

Another anticipated effect of using the digital *yuan*, which is loosely associated with bank accounts and can be independent of the existing payment system, is to strike a balance between protecting privacy and combating financial violations and crimes.⁹ To meet this expectation, the design of the DC/EP gives it the feature of "controllable anonymity". Thus, by following the principle of "anonymous for small transactions and traceable for large transactions", the digital RMB must be able to protect the security of transaction information and satisfy the public's privacy needs for normal economic life. At the same time, transaction records stored in the DC/EP system can be accessed to monitor and prevent telecom fraud, online gambling, tax evasion, money laundering, terrorism financing, and other illegal and criminal activities.¹⁰ The "loosely-coupled" account linkage, "double-offline" transaction and "settlement upon payment" features are also expected to help the digital RMB deliver "controllable anonymity" in practice.¹¹ Chinese finance researchers and professionals further point out that the 100 plus patents released by the Institute of Digital Currency under the PBC signify that these operational features and technological characteristics of the digital RMB are important pillars of the emerging DC/EP system.¹²

DC/EP: Digital Wallets and Offline Mobile Payments

According to information released by the PBC and pilot tests reports, the digital wallet serves as the medium of the e-CNY that reaches out to users. Depending on the carrier, digital RMB wallets can generally be divided into "software" or "hardware" types. A software wallet provides services to the user typically through mobile payment apps, software development kits (SDKs), and application programming interfaces (APIs). To enable the functions of the e-CNY, hardware wallets require the support of integrated circuit (IC) cards, secure digital (SD) cards, subscriber identity module (SIM) cards, mobile phones with built-in security chips, wearable objects, or internet-of-things (IoT) devices.¹³

Specifically, the software wallet refers to the digital RMB app, which is a platform that offers services of personal wallet opening and management as well as exchanging and circulating the e-CNY to the public. The hardware wallet, on the other hand, refers to diverse hardware carriers that do not rely on the internet.¹⁴ Furthermore, various devices such as cards, pendants, watches, wristbands, smart

canes/crutches, keychains, and wearable devices can all serve as hardware wallets, depending on the target user group, environment, and scenario.¹⁵ Also, due to the payment limit, misplacing or losing a hardware wallet will not result in excessive loss.¹⁶ More notably, some hardware wallets developed for golden agers who suffer from the digital divide not only enable payment functionality but also include a one-touch contact function for connecting with family members.¹⁷

Overall, personal digital RMB wallets are classified into four levels based on the strength of customer identification. Personal information required for the first level includes mobile phone number, valid identification (ID) documents, personal bank account and operating institution. When opening a wallet, the customer also needs to sign in person in front of an authorised handling agent. This type of “strong real-name” wallet account has no balance limit or single transaction limit. Opening a second-level wallet does not require any information about the operating institution or face-to-face verification of signature. However, the wallet has a balance limit of 500,000 RMB and each transaction cannot exceed 50,000 RMB. The third type is made up of “weak real-name” wallets that require only a mobile phone number and valid ID, but the balance limit is further reduced to 20,000 RMB, and the single transaction limit to 5,000 RMB. The fourth-level wallets are essentially “anonymous” or unnamed as they only require a mobile phone number. Their balance limit is 10,000 RMB, and per transaction limit is 2,000 RMB.¹⁸

Nevertheless, given that the DC/EP is defined as a replacement for banknotes, all digital RMB wallets are anticipated to support traditional cash payment methods, that is, without a need for internet connection.¹⁹ The “offline” function enables the wallets to serve payment needs even in special environments such as basements, parking lots, mountainous areas with weak or no signals, or when network paralysis caused by extreme weather or natural disasters occurs.²⁰ Currently, the “double-offline” payment capacity is supported by NFC technology, which requires the digital wallet devices of both payers and payees to have the functionality of a hardware wallet with built-in security chips.²¹ Combining this feature with mobile phones further enhances the convenience of the digital RMB wallet, as a simple touch between the two phones allows the transfer of digital currency from one wallet to another.²² This and other similar but still evolving “offline” and “no power” transaction functions are widely regarded as important supplements to the mobile payment methods of the digital RMB.²³

However, the discussion on how to prevent or resolve the “double-spending problem” in the “dual-offline” scenario seems still ongoing at the technical level. A generally accepted view among Chinese financial analysts is that the PBC’s decision to limit the DC/EP to small-scale retail scenarios can, to some extent, avoid substantial losses caused by the “double-spending problem”.²⁴ Also, the “double-offline” payment should be considered as an emergency measure and supplementary means in special environments and circumstances, rather than a universally applicable tool in normal situations. Therefore, at least in theory, it should not contribute to the “double-spending problem”.²⁵

“Controllable Anonymity”: Balancing Privacy Protection and Crime Prevention

According to a widely recognised definition in China’s finance research circles, the DC/EP is essentially an “encrypted string”. Although transactions are anonymous, the entire process of currency flow can, in theory, be recorded and reflected. This means that from issuance to return to the central bank’s treasury, the entire journey of the DC/EP can be recorded and traced.²⁶ The feature of “controllable” or “semi-anonymity” adopted by the DC/EP is reflected in the arrangement that only the central bank and authorised institutions can access and have control over the entire process of transfer transactions. The implementation of “controllable” is based on the unique coding of each fund movement that can link the inputs of the current transaction with the outputs of the previous transaction and ultimately record the flow of funds layer by layer or at each level.²⁷

Even though the DC/EP cannot be completely anonymous or untraceable, it enables free circulation independent of bank accounts and the internet, two key features of physical cash. As a result, commercial

banks and other payment service providers are unable to access information about individual users involved in the flow of the DC/EP, which ensures the privacy of transactions.²⁸ On the other hand, when necessary, the central bank and authorised institutions can carry out suspicious transaction screening through checking wallet types and resorting to other available and appropriate means, such as Know Your Customer (KYC), Anti-Money Laundering (AML), payment behavior analysis, and regulatory indicators.²⁹

Based on this, a general understanding is that “controllable” will focus more on macro-level security regulation issues such as anti-money laundering, anti-tax evasion, counter-terrorism financing, and anti-drug smuggling, while “anonymity” means restraint being exercised on private and commercial transactions between individuals.³⁰ Here, however, arises a crucial question: where is the boundary between information tracking and information security protection? There are loud voices in Chinese finance research and policy circles suggesting that the rules for accessing digital RMB transaction data should be improved to ensure that user anonymous data are monitored, recovered, and integrated only in extreme circumstances. And the rules should be made public to eliminate people’s concerns about using of the digital RMB.³¹

A survey on the Chinese public’s perception of the digital RMB published by the media also reveals that people’s main worry about using the e-CNY for daily payments is the protection of personal privacy in areas such as consumption habits. They do not want their legal and compliant payment activities to be easily recorded and disclosed by official big data records and their usage. Therefore, establishing a comprehensive and reliable internal control system and a “firewall” between “controllable” and “anonymity” is considered particularly important. For only by doing so can the public’s apprehensions about the digital RMB be alleviated, the attractiveness of DC/EP be enhanced, and its widespread adoption be secured.³²

On the other hand, the public does not want “anonymity” to compromise the security of digital RMB payments and transfers. The DC/EP’s transfer function is reportedly designed to allow designated operating institutions to categorise and manage digital wallets based on the strength of customer identity verification.³³ At the same time, they can also impose amount restrictions on various types of wallet transfers according to the user’s level of real-name authentication and completeness of personal information.³⁴ Reflecting the design principle of anonymity, least-privileged wallets do not require identity information to be provided. By default, users typically open an anonymous wallet with minimum levels of permission and can upgrade it to a high-privilege real-name wallet as needed.³⁵

Furthermore, individuals and individual businesses can open personal wallets. The categorised transaction and balance limits of the wallets can be managed according to the level of corresponding customer identity verification.³⁶ Even for offline payments, verifications of transfers can be done through fingerprints, facial recognition, and passwords to ensure security and reliability. Additionally, if and when misdirected or erroneous transfers happen, the principle of traceable use of digital RMB wallets supports appeals for recovering the funds.³⁷

DC/EP: Lowering Service Thresholds and Interconnecting Application Scenarios

It is widely acknowledged in China that digital RMB wallets’ “loose coupling” with real-name accounts and “offline” payment features have reduced the barriers to financial services for the general public, especially disadvantaged and vulnerable groups. Based on feedback from users in the pilot areas, the function of “settlement upon payment” has further improved the payment efficiency, providing tangible convenience and universal benefit for the public, small and micro businesses, and enterprises. As the DC/EP is positioned as Mo and follows the same management approach as the physical RMB, the PBC does not charge designated operating institutions for exchange and circulation services of the digital RMB. Accordingly, the designated operating institutions do not charge individual customers for services related to exchanging and converting the digital RMB. This significantly reduces payment costs.³⁸

User experience and reviews specifically indicate that the digital RMB wallet in the pilot phase has basic functions such as making payments, receiving payments, scanning QR codes, and transferring funds. Users can also choose to link their wallets up with their bank cards for making direct deposits to and withdraws from the wallets. Additionally, the wallet itself has functions like upgrading, canceling, and viewing transaction details. All of this helps to reduce the reliance on financial intermediaries in digital RMB transactions and make everyday payments simpler and more convenient.³⁹

Furthermore, Chinese finance academics and professionals widely believe that the development of the digital economy will push the financial industry towards a service model based on specific scenarios. Similarly, the promotion of the digital RMB will also revolve around various applications.⁴⁰ Indeed, in addition to lowering the threshold for public access to financial services in offline scenarios, the design of the digital RMB app's "sub-wallet" for online payments continuously enriches its market usage scenarios. In pilot areas of the digital RMB, users can now quickly complete payments with the digital RMB for shopping, dining, accommodation, transportation, utility payments, healthcare, tourism, entertainment, communication services, and more.⁴¹ Moreover, users can set daily maximum spending limits for their "sub-wallets" within these applications, allowing for restricted or conditional payments. They can also make small anonymous transfers between friends and family members.⁴²

Additionally, in response to the frequent occurrence of prepaid merchants absconding with funds and/or infringing on consumer rights in recent years, the digital RMB wallet has been equipped with "smart contract" functionality. Actualising payment "customisation" not only prevents merchants from arbitrarily transferring consumer prepaid funds, but also ensures that the funds remain owned by consumers until the actual consumption takes place. This safeguards consumer funds even in the event of merchant bankruptcy or liquidation. Smart contract templates developed for specific industries with unique professional attributes, in return, further expand the application scenarios of the digital RMB.⁴³

On the other hand, many financial analysts in China have pointed out that the DC/EP, being designated as cash, does not yield interest payments to its wallet. Holding a large amount of the DC/EP is equivalent to waiting for devaluation, making it difficult to attract and retain users to use the digital RMB more extensively. Most people simply treat it as "pocket money".⁴⁴ Currently, the pilot programmes are primarily funded by pilot cities or operating institutions, using preferential policies such as issuing consumption vouchers and "red envelopes" to incentivise user adoption. The actual payment scale and wallet balances are also quite limited.⁴⁵

To enhance the competitiveness of the DC/EP in the market, it is widely believed that, in addition to connecting the digital RMB with various aspects of people's daily lives, it should also be developed as an investment and wealth management platform. For example, in addition to the digital money wallet, a wealth management wallet can be established. Users can choose to transfer funds from the digital money wallet to the wealth management account and invest in various financial products based on the annualised returns, thus earning investment profits. If they wish to withdraw funds from the wealth management wallet, they can choose to transfer them to a bank card or the digital RMB wallet. Furthermore, linking the digital RMB wallet with money market funds allows for the appreciation of the digital RMB and gives the wallet the potential to generate returns. Similarly, as its application ecosystem expands, the digital RMB should also be directly involved in loan services, particularly in consumer loans related to daily life and microloans for small and micro enterprises.⁴⁶

DC/EP: Incorporating Only Some Elements of Blockchain Technology

Many Chinese who are interested in digital currencies, while aware of the distinction between the digital RMB and Bitcoin, still wonder if they share similarities in technological approaches, especially the use of blockchain technology. When addressing this question, Chinese financial policy institutions and academic

and mobile technology communities acknowledge, without hesitation, that blockchain is an important technological foundation for digital currencies. On the one hand, this is because blockchain possesses financial attributes and genes. On the other hand, the financial industry currently requires reshaping and iterating its own “fintech” to better serve the digital economy.⁴⁷

Furthermore, the financial industry is one that is easily digitised and has strong credit and high-cost characteristics. Conveniently, digitalisation, elimination of manual credit, and reduction of costs are the “living soil” for blockchain and align perfectly with its utility. Blockchain eliminates the need for trust in counterparties or any third parties, making “trustless” the most important “value” of blockchain as the Internet of Value. In other words, blockchain can replace financial intermediaries and facilitate information transmission and value exchange through peer-to-peer interactions. In addition, consensus-based smart contracts enable blockchain to support a broader range of financial applications with greater programming power.⁴⁸ However, the continuous speculative trading of many blockchain concept stocks in the Chinese stock market has led decision-makers, researchers, and commentators in the digital RMB field to directly emphasise that the DC/EP is not a blockchain-based digital asset like Bitcoin or USDT. They also repeatedly clarify that blockchain is not the core of the digital RMB but rather a reference for its underlying technical concepts and designs.⁴⁹

Specifically, decentralisation is a natural attribute of Bitcoin’s success and the superiority of blockchain. Yet the digital RMB needs to adhere to a centralised management model. The main reason is that the central bank’s digital currency remains a liability of the central bank to the public. It is necessary to ensure the central position of the central bank in the issuance process, strengthen its macro-prudential and monetary control functions, and maintain the existing transmission methods and channels of monetary policy. At the same time, centralised management is necessary for designated operating institutions to conduct currency exchange to avoid excessive issuance by them.⁵⁰

Also, relying on blockchain technology, cryptocurrencies are transparent, that is, everyone in the community can see what transactions have been made and how much income has been received, because all money flows are recorded on a public ledger. However, the digital RMB is not transparent as users can only choose a digital wallet address from designated operating institutions, and they cannot see how others’ money is transferred. All information is strictly confidential and accessible only to the users themselves.⁵¹

Likewise, the traceability and immutability features of blockchain data are suitable for tracking, tracing, and ensuring the integrity of orders, payments, accounts, and other transactions. Yet in the case of payment transactions with the digital RMB, users need and should be able to make changes when errors occur. In addition, it is not sufficient to simply offset the original transaction with a negative transaction; rather, the original transaction record must be modified or erased as well. Otherwise, the information may be misused, including being incorporated into credit systems. This requirement conflicts with the immutability emphasised by blockchain.⁵²

Furthermore, the maximum payment speed reported for blockchain-based Bitcoin is 7 transactions per second (TPS), and Libra’s throughput is 1,000 TPS. During the Chinese Singles’ Day shopping festival, however, the TPS of China’s UnionPay network have reached 100,000 transactions/second.⁵³ The performance of the Mo-positioned digital RMB transaction system meanwhile needs to reach a level of at least 300,000 TPS. Clearly, if blockchain is used to implement the digital RMB, it may fall far short of the PBC’s requirements and market demands for retail-level payment throughput in China.⁵⁴

Nevertheless, Chinese financial policy research and technology development institutions also emphasise that although blockchain technology does not rely on centralised governance, that does not necessarily mean that it cannot be applied to the central bank’s digital currency system, or that centralised governance is completely contradictory to distributed operations. In other words, there is no inherent

conflict between the two. If designed properly, blockchain and distributed ledger technology can even effectively integrate distributed operations to better achieve centralised governance and control of the CBDC.⁵⁵ For example, to fully demonstrate its advantages of “settlement upon payment”, the digital RMB system combines blockchain consensus mechanisms and programmable smart contract features to achieve automatic reconciliation and automatic error handling. In the meantime, the Hash Function in the blockchain can achieve data isolation between different operating institutions, thereby ensuring personal data protection and privacy, and avoiding financial data security risks associated with distributed ledgers.⁵⁶

Regarding the operation of the digital RMB, China’s publicly available policy and guidelines indicate that the PBC does not preset or predefine the technological approach. Whether commercial banks and other operating institutions adopt blockchain or centralised ledger, the central bank can adapt to their decisions. Against this background, what is currently certain is that blockchain technology will be applied to the management of the DC/EP wallet addresses and transaction information supervision.⁵⁷ Meanwhile, there is a growing consensus among various stakeholders involved and interested in finance that, given the rapid development and application of financial technology and the multiple important aspects related to the DC/EP such as communication security, data security, and transaction security, the PBC should strengthen research on blockchain, digital encryption, and other technologies, improve the information processing capabilities of its digital systems, establish a stable and secure encryption algorithm system, and ensure the security of the DC/EP.⁵⁸

Conclusion

The e-CNY is a retail-oriented central bank digital currency primarily used to meet domestic retail payment demands in China. Its introduction is based on the modernisation of the domestic payment system. It aims to meet the daily payment needs of the public, improve the efficiency of the retail payment system, and reduce the retail payment cost of the whole society. To achieve these goals, the design of the e-CNY needs to balance the advantages of the physical RMB with the advantages of electronic payment tools. It should possess characteristics such as the “settlement upon payment” and anonymity of the physical RMB, as well as the low cost, portability, high efficiency, and resistance to counterfeiting associated with electronic payment tools.⁵⁹

Furthermore, it is publicly known in China that the operation of mobile payments relies on the support of electricity infrastructure, data processing centres, and telecommunication networks. The e-CNY’s double-offline settlement features thus relieve the public’s overtly expressed worries and guesswork about disruptive impacts of earthquakes, power outages, man-made disasters, and other unforeseen incidents.⁶⁰ By supporting loose coupling with bank accounts and a “round-the-clock” reliable digital payment network, the DC/EP should contribute to improving financial inclusion.⁶¹

Likewise, the decentralised operation design for the central bank issued digital RMB is intended to involve banks and financial technology companies, which are already a crucial support of China’s rapidly developing digital economy, in the expansion of the DC/EP’s application scenarios. Their participation may best help the digital RMB quickly “fly into commoners’ homes”.⁶² This operational approach also signifies that the DC/EP is not meant to squeeze or push out existing “third-party payment” platforms, nor is it “disguised nationalisation” of the payment industry.⁶³

Notes

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