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Overview of the Unique Regional Applications, Risks, and Regulatory Challenges of China's Digital RMB

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Abstract. Against the backdrop of rapid global advancement of central bank digital currencies (CBDCs), China, as the world's most populous developing economy, has pursued a distinctive development trajectory for its digital fiat currency, the e-CNY. Adopting a literature review and comparative analysis approach, this paper systematically introduces the two-tier operating system of e-CNY, its domestic pilot programs, and cross-border trial initiatives. It also compares e-CNY with retail CBDCs deployed in both developing and developed economies. The study finds that e-CNY demonstrates clear strengths in advancing financial inclusion, improving payment efficiency, and enhancing the precision of monetary policy transmission. However, it also faces notable risks, including privacy protection concerns, potential disintermediation of commercial banks, and technical security vulnerabilities in offline payment scenarios. This paper further discusses targeted regulatory solutions, including tiered anonymity rules, conversion limits, and central bank liquidity support mechanisms. This research deepens understanding of the opportunities and risks associated with large-scale retail CBDC deployment, and offers references for China and other economies to refine digital currency regulatory frameworks.

Keywords: e-CNY, function, risk, regulatory challenges

1. Introduction

In recent years, retail central bank digital currencies (CBDCs) have been officially launched in a number of developing economies and small high-income jurisdictions, such as Nigeria's eNaira, Jamaica's JAM-DEX, and the Bahamas' Sand Dollar. For these jurisdictions, digital currencies serve primarily as a tool to rapidly advance financial inclusion, extending accessible payment services to populations with limited access to traditional banking services. For small island economies such as the Bahamas, the Sand Dollar helps address the uneven financial access and high payment costs caused by geographic dispersion. In contrast, most advanced economies already have well-developed financial and payment systems, and therefore adopt a more cautious stance toward retail CBDC issuance, as CBDCs may introduce additional risks including privacy concerns and potential disruption to the existing banking system.

China, as the world's most populous developing country, occupies a distinct position that falls squarely into neither of the above categories, making it an important case for study. Research on China's central bank digital currency (e-CNY) began in 2014. After years of technical testing and

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regional pilots, large-scale trials officially launched in 2020. Today, e-CNY has become one of the largest and most widely adopted retail CBDCs globally. Unlike CBDCs in other economies, e-CNY pursues multiple policy objectives: beyond improving financial inclusion and payment efficiency, it also serves strategic functions including safeguarding monetary sovereignty, promoting RMB internationalization, and enabling more precise monetary policy implementation [1]. Nevertheless, its rollout also faces multiple risks, including personal privacy protection, commercial bank disintermediation, data security, and public acceptance. These challenges have led China to adopt a gradual, carefully regulated approach to e-CNY promotion.

2. The unique local functions and regional practice of e-CNY in China

2.1. Basic operational mechanism of digital RMB

Firstly, e-CNY is classified as M0, equivalent to cash and coins in legal tender status. e-CNY operates under a two-tier issuance system: the People's Bank of China (PBoC) issues e-CNY to commercial banks, which in turn provide exchange and circulation services to the public. Moreover, e-CNY allows loosely-coupled account linkage with bank accounts — users can open e-CNY wallet without relying on a bank account, and it also support offline payment.

In terms of the operation system, e-CNY managed by the People's Bank of China and adopts a two-tier operation system, which means the central bank issues e-CNY to commercial banks, and commercial banks provide e-CNY exchange service to the public. It also set up a certification centre, a registration centre and a data analysis centre, which are responsible for managing institutions,users and the money circulation. Wang argues in her research that WeChat and Alipay are wallet-type financial infrastructures, and their function is to store legal bank deposits. On the other hand, e-CNY is the currency itself so the two are not in a same dimension [2].

2.2. Core local functions of e-CNY in domestic economic operation

Beyond basic payment function, e-CNY have multiple advantages for China's financial market and economic system. Firstly, based on users do not need a bank account to use digital currency and e-CNY offline payment function, it can expand the users of modern financial services in China, especially in rural areas. Jiao argues that the growing number of mobile phone users among rural residents in China provides a large potential customer base for digital currency and mobile finance [3].

Furthermore, digital currency may improve the efficiency of monetary policy of China. Zheng concludes that digital currency can significantly improve the efficiency of both expansionary and contractionary monetary policies [4]. Moreover, contractionary monetary policy due to the traceability and programmability of digital currency, the supply of digital currency can be controlled more easily [4]. Therefore, it can effectively solve bubble risks brought by overheated credit. On the other hand, government can inject e-CNY into enterprises more accurately and directly when they using e-CNY as a expansionary monetary policy.

Moreover, e-CNY can raise the competitiveness of RMB as an international medium of exchange by improving the cross border payment process. Zhang argues that traditional cross border payment process based on SWIFT and correspondent-banking model is more costly and slow compared with using digital currency [5]. Short of mBridge, it is a cross-border payment platform developed by the Bank for International Settlements in partnership with the central banks of mainland China, Hong Kong SAR, Thailand, and the UAE. The CBDC built on network systems like mBridge allows

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trading parties to settle more directly and shortens settlement time. If RMB payments become cheaper and faster, foreign firms may be more willing to use the RMB in trade settlement. However, e-CNY does not directly internationalise the RMB, it upgrades the payment system so that strengthen RMB's role as a transaction currency.

2.3. Typical regional pilot application cases of e-CNY

e-CNY has been piloted in many cities across China and supports various uses. In 2020, the People's Bank of China started tests of e-CNY in Shenzhen, Chengdu, Suzhou, Xiongan New Area and for the Beijing Winter Olympics. After five years of development, by July 2024, there were 180 million personal e-CNY wallets. The total transaction value reached 7.3 trillion yuan and covered 17 provincial-level regions in China [6].

In Shenzhen testing pilot, its e-CNY pilot by giving out several rounds of digital currency cash subsidy to citizens. There were three rounds in total. The first round took place in October 2020, with 10 million yuan in total and each subsidy worth 200 yuan. The second and third rounds were tested in different district of the city which each offering worth 20 million yuan subsidy [7]. The three rounds of e-CNY pilot activities in Shenzhen achieved satisfactory results with high public participation, building a positive public image for e-CNY. Nevertheless, security problems and fraud risks still exist. Besides, Shenzhen is a highly urbanized city. It raises a concern that the promotion effect of e-CNY may drop greatly in remote areas with low mobile-phone usage.

The use of e-CNY later moved from daily spending, such as consumption and transport to government payments like wages and tax. Hong Kong retail pilot is the notable example of e-CNY cross-border retail function. Users can top up their e-CNY wallets via the Faster Payment System, a local HKD payment system. Funds from HKD accounts are converted into RMB before being credited to the wallet. If the money comes from a Hong Kong-dollar account, the bank will exchange it into RMB before the wallet credited. Users can then pay RMB in the pilot areas without opening a mainland bank account. This reduces the need for a mainland account and for exchanging cash before each trip. However, this does not mean that the cost of exchange is always lower than that of money changers or card networks, because the exchange rate still depends on the bank.

3. Comparative analysis of regional application of foreign CBDCs

3.1. Retail CBDC practice in small developing countries and island nations

Some less developed countries and island nations have introduced retail CBDC due to inadequate financial infrastructure. Representative cases include the Bahamas' Sand Dollar, Nigeria's eNaira and Jamaica's JAM-DEX. Take Bahamas as an example. It spreads across 30 small islands and frequently hit by natural disasters, the country faces extremely high costs for cash transportation [8]. In the Bahamas, digital currency supports quick offline transactions after natural disasters and reduces the risk of common cash robber cases [8]. For a lower-middle-income developing economy like Nigeria, expected core users of eNaira are informal merchants and a large unbanked rural population.

Nigeria government divides eNaira accounts into five tiers. Higher daily transaction limits require more identity verification from users. Tier 0 needs no bank account or ID verification, it permits daily transfers of 20,000 naira with a balance cap of 120,000 naira. Tier 1 accounts do not require a bank account, but users need a phone number and verified NIN. They have a daily transfer limit of

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50,000 naira and a maximum balance of 300,000 naira [9]. Therefore, the daily use of eNaira greatly promotes financial inclusion for rural populations and reduces cash production costs [9].

While these developing-country CBDC projects are mainly driven by financial inclusion and practical cash-circulation problems, e-CNY carries multiple policy goals. Different from such purely inclusion-oriented economies, e-CNY not only improves payment efficiency and optimizes monetary-policy transmission, but also aims to safeguard monetary sovereignty and support RMB internationalisation.

3.2. Attitude and trial layout of developed economies toward retail CBDC

While CBDC has gained support in many countries, a number of nations, including several advanced economies still remain unwilling to launch it. According to Alonso et al. , low public demand, failed trials and no extra advantages compared with existing electronic payments are the main factors discouraging CBDC adoption [10].

After classifying public statements released by different central banks, the authors conclude that advanced economies have different reasons for holding back on CBDC. Denmark, Israel and Hong Kong SAR fall into the group of "no advantages over existing electronic payments". This suggests that cards and bank transfers already satisfy everyday payment needs, leaving retail CBDC with few additional benefits. The United States is marked by both "insufficient demand or operational capacity" and "no advantages over electronic payments". The United Kingdom has two concerns: further security-related research is required, and CBDC offers no extra value compared with current electronic payment tools. Japan and Singapore face limited demand or operational constraints. Australia, Finland, New Zealand and South Korea mainly focus on unfinished trials or the need for further security assessments [10].

Therefore, advanced economies do not share one single technical barrier. Instead, their common position is that current payment systems already work well, and retail CBDC has not yet proven itself to be better than existing electronic payment services. To sum up, these advanced-economy central banks share a common consensus. Under well-established electronic payment infrastructure, CBDC brings limited positive value. Meanwhile, potential unknown risks such as banking-system disintermediation and security vulnerabilities have not been fully ruled out. For these reasons, most advanced economies take a cautious and wait-and-see attitude toward launching retail CBDC.

4. Negative risks derived from the popularization of e-CNY

4.1. Personal information and privacy protection risks

Some studies suggest that the anonymity mechanism of e-CNY carries potential risks of customers' information disclosure. Firstly, although e-CNY follows the principle of controllable anonymity and some low-level wallets can be registered with a mobile phone number only. However, some operating agencies still collect excessive personal data in practice. For instance, the YiPay App requires users to provide their highly-sensitive Chinese ID numbers even when creating low-level wallets [11]. Besides, Gao also points out that the People's Bank of China has become the largest personal-information processor. Its registration centre, certification centre and data-analysis centre centrally store users' identity details, transaction records and ownership data. This centralised data management may raise risks of information leakage and hacker attacks, even though the central bank has adopted strict technical measures for information security [11].

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4.2. Disintermediation risk of commercial banking system

The e-CNY also carries certain risks for Commercial Banking System. Its issuance may theoretically encourage people to transfer bank deposits from commercial banks to e-CNY wallets. This could hurt the profits of commercial banks, and some small-scale commercial banks may struggle to survive [12]. This is because the e-CNY is issued by the central bank, so it is safer than deposits in commercial banks. Moreover, if the e-CNY bears interest, it will cause greater harm to commercial banks. According to Cui and Sun [13], e-CNY wallets will become more attractive if its provide interest fand may trigger several specific crises for commercial banks. First, after the e-CNY starts to bear interest, commercial banks will be forced to raise interest rates to attract deposits. This reduce their profits. Second, large-scale deposit outflows directly reduce the amount of loanable funds for commercial banks. With the narrowing of interest spreads between deposits and loans together with falling loan volumes, the traditional profit model of commercial banks will be affected. Under pressure, commercial banks may turn to riskier loans to make up for lost income. This will eventually push up the overall level of risk-taking [13]. Under extreme conditions, if the public transfers all their deposits from commercial banks to the central bank via digital currency, this will lead to a "narrow banking" system at the macro level. It means commercial banks must keep 100% reserves at the central bank. They can no longer expand credit through lending, and the money multiplier will disappear [13].

4.3. Technical operation and data security risks

The offline payment system of the e-CNY may bring certain potential risks. First, since the it removes third-party information processors, stolen funds are harder to recover. Ke divides the risks of offline terminals into two sides. On the payer's side, if the encrypted string in a hardware wallet is tampered with, the same record can be used to change balances or spent repeatedly [14]. Also, when offline deductions have no limits on times or amounts, the same payment may be sent many times during the offline period. Although encrypted chips can reduce double-spending, protection may fail after device damage or technical updates.

On the payee's side, if both parties complete the transaction but do not go online, the transaction record cannot reach commercial banks or the central bank. It is uncertain until the payee can truly obtain the funds. To prevent repeated payments, some banks plan to freeze e-CNY received offline. In this way, users can only use it after reconnecting to the network. Therefore, tampered, damaged or long-offline terminals may trap small-value payments outside the normal circulation system, rather than causing a breach of the central bank's system [14].

5. Feasible regulatory countermeasures to address e-CNY risks

5.1. Multi-level supervision system for personal privacy protection

Faced with the privacy problems of e-CNY, the government should strictly set up hierarchical anonymous transaction rules. Small value transactions can have controllable anonymity, while large value transactions can be traced according to laws. Also, special laws for personal information protection of e-CNY need to be improved. When protecting users' transaction privacy, the government should set limits on information collected by intermediaries. It balances privacy protection and regulatory goals such as anti-money laundering.

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5.2. Regulatory tools to mitigate commercial bank disintermediation

Sun believes that the central bank and the government should take some measures to prevent risks for commercial banks [15]. He gives two suggestions. First, set up a special organization to supervise the circulation of digital currency. Second, when local commercial banks face the risk of bank runs, the central bank should provide them with financial support [15]. Also, in some areas where a lot of deposits are changed into digital currency and cause bank runs, the authorities can temporarily raise the threshold for exchanging digital currency. This can reduce the pressure of bank runs and give commercial banks more time to deal with the problem.

5.3. Regulatory responses for technical operation and data-security risks

Strict security standards should be set for offline wallets and payment devices. Relevant equipment is required to install tamper-resistant security chips to reduce the risks of encrypted-string tampering and double-spending. At the same time, offline-payment permissions need to be restricted, and an offline-fund "freeze-unfreeze upon reconnection" mechanism should be put in place. After both sides finish an offline transaction, the e-CNY received by the payee will be temporarily frozen. Only after the device reconnects to the network and transaction records pass verification by regulators can these funds circulate normally. This prevents unchecked abnormal funds from entering the currency-circulation system. In addition, the state should build a big-data risk-monitoring platform. All offline devices are required to report full offline-transaction records immediately after regaining network access. Regulators collect and analyse transaction data so that security risks can be detected at an early stage.

6. Conclusion

While e-CNY delivers notable benefits in payment efficiency, financial inclusion, and monetary policy transmission, its large-scale popularization also brings multifaceted risks. In terms of privacy, the principle of controllable anonymity cannot fully prevent excessive data collection by operating agencies or the risks associated with centralized storage of personal information by the central bank. For the banking sector, large-scale conversion of deposits into e-CNY wallets may erode the funding base of commercial banks and increase their overall risk-taking. On the technical front, offline payment is subject to vulnerabilities such as double-spending, delayed settlement, and difficulties in fund recovery. To address these risks, this paper discusses feasible regulatory countermeasures, including tiered anonymity rules and clearer data protection regulations for privacy governance, as well as temporary conversion limits and central bank liquidity support to mitigate bank disintermediation risks.

This study has several limitations. First, it relies primarily on existing literature and official reports, lacking first-hand empirical data. Second, the discussion of technical risks focuses predominantly on offline payment scenarios, without fully covering other system-level vulnerabilities. Third, the proposed regulatory approaches remain at a general conceptual level and have not been validated against specific real-world cases. Future research could examine the actual impacts of e-CNY on bank deposits and monetary policy transmission using empirical data. It could also conduct more systematic cross-country comparisons of privacy and security designs across different CBDC projects, or evaluate the performance of technical supervision mechanisms in large-scale real-world operations. Such studies will help form a more comprehensive understanding of both the benefits and risks of e-CNY as it continues to evolve.

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