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Theories and Practice of exploring China's e-CNY

Introduction

Technological change is permeating the financial system. Starting from a cryptographic experiment, Bitcoin and crypto-assets have gone too far, stealing the positive value of FinTech innovation while stablecoins entail promise and perils that we have to remain vigilant to and establish an appropriate supervision framework for accordingly. Sound money is a perpetual pursuit of central banks that always commit to providing public goods in the public interest. Meanwhile, the ongoing digitalization of our economy is leading to far-reaching changes in the mandates of central banks. Money and payment are no exception, and a digital form of central bank money for individuals and businesses to use in retail payments, the central bank digital currency (CBDC) is around the corner. There have never been more central banks who feel that: (i) unsupervised private networks could become a Wild West of financial fraud; and (ii) possible future payment solutions based on digitalization would most likely be CBDCs.

Motivations of CBDCs

CBDC as a new form of money and payment method could potentially facilitate enhancing resilience of the retail payment system, contribute to a better financial system, improving efficiency of the central bank payment system, and promoting financial inclusion of the society.

The first motivation is to improve the efficiency of the central bank payment system. Big Tech and fintech firms move into payment markets and digital payments via mobile phone provided by the private sector have gained ground. Concentrated yet fragmented market power may reduce the integration of different payment tools. As a trend in recent years, many central banks are improving their payment systems by building up fast payment systems, which widen the access to the payment system and incorporate more participants from different sectors. CBDC has a non-profit nature (Soderberg, 2022). By facilitating the integration among the payment markets, as well as adopting the latest technologies, CBDC with a low-fee structure could offer a digital form of payment that is cheaper to operate than legacy tools (Chen, 2022).

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To demonstrate, e-CNY is one of the People's Bank of China's (PBC's) latest efforts to improve the efficiency of the central bank payment system. E-CNY provides around the clock (24 x 7 x 365) services to the general public, which delivers the maximum level of accessibility to users. In addition, e-CNY realizes higher efficiency with the feature of settlement upon payment. Furthermore, e-CNY features in its high capability of 10,000 transactions per second, which enhance the concurrency performance of the central bank payment system. What's more, the PBC joins hands with participants from different sectors including not only commercial banks and financial market institutions, but also payment service providers (PSPs), fintech companies, telecommunication operators. This could fully tap the comparative advantages of different stakeholders in payment product design, system development, use cases exploration, marketing, business processing as well as operation and maintenance, and build a market-driven e-CNY eco-system in a more efficient way.

The second motivation is to provide a backup or redundancy for the retail payment system. Ensuring the ability to pay under severe circumstances is vital for all jurisdictions. For some countries frequently hit by natural disasters, resilience is considered a key policy goal. In addition, countries with a highly digitalized payment sector may be concerned with disruption to digital services and concentration risks where there are only a few large operators. The failure of any of these could have serious consequences to the payments system. Similarly, in some advanced economies, central banks advocate the continued existence of cash, and their CBDCs could potentially serve as additional backup to existing forms of digital payments Therefore, CBDC could function as a backup to the existing digital payment solutions. (Bank of Canada, 2020; BIS, 2020; Carstens, 2022).

China has witnessed a leapfrogging of mobile payment development in which the private sector has played a conspicuous role in digitalizing financial plumbing and providing retail mobile payment services to the public. Yet, any financial or technical malfunction of the payment system could bring dread consequences to financial stability. Central banks are born to facilitate the mandate to continuously provide public products and services in payment and settlement especially retail payment that directly serves the broad public, so this is the duty of the PBC. E-CNY as a new form of legal tender could build upon the latest innovations and technologies in the payment sector. Moreover, with a dual-offline payment function, it has sufficient motivation and capacity to better serve the public interest even in extreme scenarios during unexpectedly adverse times.

The third motivation is to improve financial inclusion. Financial inclusion entails access to useful and affordable financial services that meet individual and business needs in a responsible and sustainable way, which is essential to the

common goal of poverty reduction worldwide. While digitalization has resulted in material progress in financial inclusion globally, 1.7 billion people remain outside the formal financial system (Auer at el., 2022). In addition, with network effects, a few payment service providers may obtain a substantial market share and build "walled gardens" with exclusive user data in the payment sector (Gowrisankaran, Stavins, 2004). This may lead to elevated cost of services and to long-tail users like the disabled, the elderly, as well as the non-residents, who might encounter difficulties accessing local payment tools. Therefore, it is the obligation and responsibility for the central bank to cover those long-tail users. By developing new services with greater added value, facilitating fiscal policy implementation, CBDC could make digital payments more accessible and widen the access to financial services for countries that demand improving access to financial service.

The PBC has, for nearly two decades, sought to promote digital payments and to promote financial inclusion in all aspects, and e-CNY is such an effort.

Firstly, e-CNY enhances the accessibility of payment services. E-CNY is loosely-coupled with bank accounts, so a digital wallet could be delivered to an enduser without opening a traditional bank account as a prerequisite. E-CNY also features hardware wallets and wearable products such as e-ink displayed cards andsmart watches. The elderly, foreign visitors and non-residents can thus easily access the formal financial services in China, which could extend financial services.Moreover, the dual-offline payment function of e-CNY could be a new problemsolver for the remote domiciled as well as for situations with poor telecom network coverage. Furthermore, the PBC collaborates with authorized operators onbarrier-free designs to meet the needs of the people with disabilities. People withvisual impairment can access the e-CNY wallet with user-friendly interface andtailor-made functions.

Secondly, e-CNY lifts unnecessary costs of payment services and helps improve their affordability. The PBC does not charge authorized operators for exchange and circulation services, the operators do not charge individual users for the e-CNY related services either, which reduces the burden of the retail payment and improves the business environment as a whole.

Thirdly, e-CNY improves the retail payment efficiency. With loosely-coupled account linkage and value-based feature, the e-CNY system achieves "settlement upon payment", which improves capital turnover efficiency for merchants andhelps relieve liquidity constraints imposed on small and medium-sized compa-nies.

Lastly, e-CNY could bolster market innovation and level the playing field which is vital to market structure and social welfare (Lovegrove, 2022). E-CNY is programmable in the sense that smart contracts can be loaded for complex payment functions such as conditional payments. Its programmability feature to-

gether with wallet matrix design, which will be explained below, can support innovations towards inclusive, green and sustainable finance. At the same time, with legal tender status, e-CNY is not constrained by the choice of service provider or payment tools, which could break institutional or tool-based barriers and harmonize fragmented payment markets.

Progress of e-CNY

With the visions and motivations above in mind, the PBC has promoted the development of e-CNY since 2014. For now, the PBC has partially realized three goals and motivations of e-CNY. From 2014 to 2016, the PBC established the digital fiat currency research group, and kicked off research in this field. In 2016, the concept prototype of China's first-generation digital fiat currency had been built. The PBC established the Digital Currency Institute, and proposed the top-level designs and fundamental features of e-CNY. At the end of 2017, the PBC started the e-CNY R&D project. The PBC has been piloting the e-CNY in Shenzhen, Suzhou, Xiong'an, Chengdu and 2022 Beijing Winter Olympics venues at the end of 2019. In November 2020, pilot areas were expanded to 6 more cities, including Shanghai, Hainan, Changsha, Xi' an, Qingdao and Dalian. More cities and areas have joined e-CNY pilot since 2022, now in total e-CNY pilot has covered 23 cities and areas in China.

In particular, e-CNY has reached several milestones since 2021. In July 2021, the PBC had released a white paper, namely Progress of Research & Development of e-CNY in China. In Jan 2022, the e-CNY App was launched for the public to download and for resident to sign up in for 11 pilot areas. From Feb to Mar 2022, e-CNY was piloted in the Beijing Winter Olympics venues. The non-residents used e-CNY App, e-ink card, or bracelets which imbed e-CNY hardware wallets to make quick payments at the Beijing Winter Olympic venues. Now e-CNY has been piloted in 23 cities, including Shenzhen, Suzhou, Xiong'an, Chengdu, Shanghai, Hainan, Changsha, Xi'an, Qingdao, Dalian, Beijing & Zhangjiakou, Tianjin, Chongqing, Guangzhou, Fuzhou, Xiamen and the 6 Asian Games host cities in Zhejiang Province. As of December 31, 2021, transaction volume of e-CNY had totaled 230 million and transaction value approximating RMB 88 billion. E-CNY had been accepted by over 3.6 million merchants, covering utility payment, catering service, transportation, shopping, and government services.

Multi-dimensions of e-CNY

Beyond those achievements, the multi-dimensional characteristic design is the foundation for the e-CNY system. Based on a holistic consideration of monetary

functions, market demand, supply model, technological support, and the cost-benefit analysis, the PBC introduced the e-CNY system. Among them, there are four major dimensions.

The first dimension is the operation architecture of e-CNY. In line with the central bank's mandates, there are two options to operate a digital fiat currency. One is a single-tier system under which the central bank directly provides issuance, circulation, and maintenance services. The other is two-tier operation under which central bank issues digital fiat currency to authorized operators and then these operators take charge of exchange and circulation. Before the pilots of e-CNY, the PBC had feared that the former could lead to a digital stampede of bank assets to the central bank and financial disintermediation and now this view is becoming industry consensus that a one-tier system is not minimally invasive (Working Group on E-CNY R&D of the PBC, 2021; Auer& Boehme, 2021; Board of federal reserve system, 2022).

E-CNY adopts a two-tier design whereby the PBC is responsible for issuance and redemption, interoperability and wallet ecosystem management. Additionally, it prudently selects commercial banks which meet criteria of capital and technology as authorized operators. The authorized operators are responsible for taking the lead in providing e-CNY exchange services, opening different types of digital wallets for customers based on the strength of KYC. Other commercial banks and institutions emancipate their capacities of creation, and collectively provide services for e-CNY circulation and retail payment, including payment product design, system development, use cases exploration, marketing, business processing as well as operation and maintenance.

With the adoption of the two-tier operational system, the e-CNY system can minimize its impact on the financial system while keeping a level playing field. It would not change the current currency circulation system and not disrupt the proven two-tier architecture of the monetary system, thus be neutral to competition in the savings market. In other words, a two-tier CBDC would not increase banks' reliance on interbank borrowing or affect their lending capacities, thus disintermediation could be avoided. Neither would it change the current creditor-debtor relationships in currency circulation. The commercial banks would need to reduce their reserves with the central bank to exchange for the equivalent amount of CBDC issued, thus the e-CNY issued to the public would remain as the central bank's direct liability. Since it would not affect the monetary policy transmission mechanism, it would not strengthen macroeconomic procyclicality. Accordingly, e-CNY would not impact economy negatively.

The second dimension is that e-CNY could be a compound of a value-based, quasi-account-based, and account-based payment system, which takes the initiative worldwide. With a loosely-coupled account linkage design, the general pub-

lic could apply for digital wallets without opening bank accounts in advance. The least privileged e-CNY wallet could be opened with any users' unique ID such as a phone number, thus users' real identity is not required. Moreover, this dimension of e-CNY helps foster financial inclusion and achieve managed anonymity, which will be demonstrated as the fourth dimension below.

The third dimension is the wallet matrix design of e-CNY. E-CNY wallets could be classified by KYC level, by the type of holder, by the carrier type, or by the management authority. More elements shall be added to the wallet matrix in the future.

By KYC level, e-CNY wallets can be classified in four categories with different balances and transaction caps. Users can open the least privileged category wallet with a mobile phone number only. Under the Personal Information Protection Law in effect, telecommunication operators are prohibited from providing any identity information to authorized operators or the PBC, thus the wallet is anonymous to banks, merchants and the PBC. Users can upgrade wallets by providing more information like ID and banking account information if they wish to make large amount payment or keep higher balances.

By the type of holder, e-CNY can be classified as individual wallets and corporate wallets. Individuals and self-employed business owners can open individual wallets. Corporates, whether legal persons or non-legal persons, could open corporate wallets. The functions of wallets can be customized to suit the diversified needs of users.

By the carrier type, e-CNY can be classified as software wallets and hardware wallets. Software wallets could provide payments services via apps or software development kits. Hardware wallets are supported by IC card, mobile phones chips, wearable objects such as badges, bracelets, smart watches, gloves, and Internet of Things devices with payment functions.

By management authority, e-CNY can be classified as main wallets and sub-wallets. Users could set major wallets as the main wallets and open several sub-wallets under the umbrella of the main wallets. E-CNY pushes sub-wallets to online merchants including e-commerce platforms, O2O (online-to-offline) platforms, using encryption and tokenization, which could insulate personal information against tech companies and protects user privacy.

The fourth dimension is that e-CNY supports managed anonymity. E-CNY system follows the rule of "anonymous for small-value and traceable for high-value transaction", and adopts a way to strike a balance between combating criminal activities and privacy protection.

In terms of combating illegal and criminal activities, such as tele-fraud, Internet gambling, money laundering etc., authorized operators are responsible for applying AML/CFT regulations to the transactions, and required to report large-va-

lue and suspicious transactions to the Financial Intelligence Units. If any suspicious or illicit transaction is identified, FIUs or law enforcement agencies can present authority to execute or authority of law to the telecommunication operators and retrieve the real identity information, which keeps the capacity to combat the illicit activities.

In terms of privacy protection, the PBC aims to be the vanguard in protecting people's privacy and personal information in the digital era.

Firstly, users could open the least privileged e-CNY wallets without revealing their real identities, which could facilitate user privacy protection.

Secondly, users could make payments under the protection of the encrypted and tokenized e-CNY sub-wallet, or choose to pay with no-real-identity-attached hardware wallets, which provide users varied options of securing personal information.

Thirdly, based on the Personal Information Protection Law, the e-CNY system does not provide information to third parties or other government agencies. Commercial banks are usually required to collect and process nine categories of personal data from individuals during the onboarding process, or before engaging in certain business transactions with the traditional banking sector. Compared to traditional electronic payment method or instruments, e-CNY has a higher degree of privacy and personal information protection. To begin with, telecommunication operators can't release or provide user identity information to any third party, including PBC and authorized operators. What's more, the e-CNY App gives a notice to the user to get a permission for personal information collection. E-CNY still provides basic services to the user without user permission for information collection, which took the lead in the App market Furthermore, e-CNY provides services to a user under age 14 with parental or guardian consent. Provisions similar to GDPR such as the right to forget, to make correction, and to delete, the protection of transfer of personal data, are also adopted in the e-CNY App.

Fourthly, the PBC sets up a firewall for e-CNY-related information, and strictly implements information security and privacy protocols, such as designating special personnel to manage information, separating e-CNY from other businesses, applying a tiered authorization system, putting in place checks and balances, and conducting internal audits. Any arbitrary information requests or use are prohibited.

Together, the four dimensions of e-CNY follow the principles of safe and inclusive, innovative and user-friendly, and time-evolving, which facilitate delivering an open, inclusive, sound, and reliable e-CNY system that best realizes its three motivations and serves the retail payment market in China.

Challenges of CBDCs

With the progress of e-CNY, CBDC explorations in other jurisdictions have also reached their milestones and manifested much progress in achieving the common visions, whether retail or wholesale. However, there still remain some common challenges, where e-CNY also pioneers the way to solutions.

The first challenge lies in the insufficiency of incentives and acceptance of CBDCs. For end-users getting used to retail payment provided by the private sector, switching cost may prevent consumers from using new instruments like CBDCs. For the adoption environment, merchants might be concerned with the pecuniary and non-pecuniary costs of accepting CBDC payments, which includes up-front cost, on-going update and maintenance costs, as well as learning costs. Given that it is a two-sided market, if there was no collaboration with market participants to build up the adoption system for all merchants, user experience would be below market expectation and switching cost would be daunting.

To tackle these challenges, the e-CNY system has been continually evolving its design and building its ecosystem. E-CNY preserves the dynamism of the market by enhancing the efficiency of market mechanisms and restoring fair competition in the market. The two-tier system adoption of e-CNY fully taps authorized operators' advantage in resources, talent, and technology to build a market-driven ecosystem that promotes innovation and fair competition. In terms of user adoption, the two-tier system of e-CNY respects customer behavioral inertia in accessing formal financial services and products via commercial banks and their distribution networks, and leverages the partnership with commercial banks to boost mass adoption of e-CNY. In terms of user experience, the PBC seeks to provide diversified choices of smart and tailor-made functions, as well as a wide variety of use cases. In particular, e-CNY is ready-to-hand and easy to master for the elderly, the disabled and foreign visitors, which serves the long-tail users and fills the gaps among other payment tools. To decrease adoption environment frictions, e-CNY system is exploring how to integrate with the existing payment instruments, which could ease the burden of the merchants.

The second challenge arises from cyberattacks. The CBDC system, as an important payment system, could become the center of cyberattacks. So concerns over on security and data protection of CBDC are also paramount for ensuring trust (ECB, 2021). Therefore, ensuring cyber security is the common challenge for CBDC projects. The PBC, in this case, collaborates with the national security team and is carrying out security training and tests. In addition, the e-CNY system improves its security management throughout the entire lifecycle, covering encryption algorithms, financial information security, data security and business continuity, thus defending cyberattacks from multiple dimensions.

The third challenge lies in CBDCs for cross-border payments. There are three main challenges in cross-border payments: high cost, low speed, and low transparency. Cross-border payments suffer from long transaction chains in which regulatory cost is the major cost. In addition, cross-border payments suffer from low traceability and lack of transparency, causing frictions regarding AML/CFT checks. Rules and regulations including capital flow management measures, data and privacy treatment differ among jurisdictions, which exacerbates the burden on compliance. In addition, central banks have to balance universality and autonomy with appropriate governance arrangements (BIS, 2021).

The PBC follows the initiatives of the Committee on Payments and Infrastructures (CPMI) and the Financial Stability Board (FSB) to explore the potential of CBDC arrangements in enhancing cross border payment. Under this area, the PBC introduced the principles of "no disruption, compliance, and interoperability" in cross border cooperation, which shall be observed before conducting any CBDC cross-border experiments.

First is no disruption. CBDCs supplied by one central bank should continue to support the healthy evolution of the international monetary system, and should not disrupt other central banks' currency sovereignty and their ability to fulfill their mandate for monetary and financial stability.

Second is compliance. Cross-border payment arrangements with CBDCs should comply with the regulations and laws of the jurisdictions concerned, such as capital management and foreign exchange mechanisms and also the regulatory requirements for anti-money laundering and countering terrorist financing.

Third is interoperability. The development of CBDCs should fully tap the role of the existing infrastructures and leverage Fintech so as to enable interoperability between CBDC systems of different jurisdictions as well as between CBDC systems and incumbent payment systems. Currency conversion will be processed on the virtual border between wallets. In that way, there is no financial risk such as currency substitution, since domestic CBDCs should be converted to other currencies as payments cross borders to avoid potential adverse macroeconomic implications.

Under these principles and approaches, the PBC has raised the Lego Bricks approach in the Multiple CBDC Bridge (mBridge) project. The Lego Bricks approach allows for disparate modules, including payment, foreign exchange, capital management, AML/CFT, etc. Modules can be assembled as needed as building Lego bricks to accommodate evolving needs from different jurisdictions and parties. In addition, technical tools such as smart contracts can help accommodate the enormous clauses and make them machine readable. Compared to a "Silo Architecture", where information is sequestered in different parts, the Lego bricks approach is better as it allows further interaction and synergy among modules,

which could significantly reduce compliance and regulatory cost. On the mBridge platform, transaction costs are halved and transaction time has been reduced from a few days to few seconds.

While tackling these challenges, the development of e-CNY will still base on previous pilot tests, further improving user experience, functions such as programmability, security and robustness of systems, efficiency of business model, and exploring more functions and scenarios in the future.

Conclusion

"The train has left the station". Central banks should be pioneers in exploring the endless frontier of financial technology to better capture the zeitgeist of the age of digital transformation. In concert with the initiative of CPMI and FSB, the PBC welcomes broad forums of relevant stakeholders to share ideas and experience in CBDCs, and encourage open discussion and cooperation of CBDCs worldwide. The PBC believes that CBDCs will be the answer for the digital era, and there is no doubt that central banks shall offer the real economy a better future with continuous efforts on unleashing the potential of CBDCs.

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