

Centralized use of decentralized technology: Tokenization of currencies and assets

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ABSTRACT

This paper presents a thorough examination of centralized use of a decentralized technology (blockchain) in monetary and financial systems at the national level. A comparative study is conducted to summarize the regulatory and legislative frameworks of currency/asset tokenization in seven major economies (US, EU, UK, Switzerland, Australia, Japan, and South Korea). China is then used as a case study to explore how blockchain technology is adopted to enable central bank digital currency, bond tokenization, and “currency bridge”. Based on various contexts analyzed, we extend the Technology Acceptance Model, highlighting the roles of perceived benefits, perceived risks, and collaborative leadership in building trust in and promoting adoption of tokenization. Policymakers and practitioners are recommended to follow a gradual, eclectic, and collaborative approach to tokenization.

1. Introduction

Blockchain technology has been adopted in various industries and contexts since Bitcoin was launched (Zhan et al., 2023; Piñeiro-Chousa et al., 2022). Inspired by the successes and failures of cryptocurrencies and other decentralized finance (DeFi) projects, many central banks have been experimenting with converting fiat currencies into Central Bank Digital Currencies (CBDCs), while commercial banks have been exploring the potential of tokenizing traditional assets on blockchains (Fig. 1). This ongoing trend is termed *tokenization*, which involves adoption of blockchain technology at organizational, industrial, and national levels. However, much literature on blockchain adoption focuses on the organizational perspective (e.g., Dehghani et al., 2022; Rico-Peña et al., 2023). Only a few papers take a national perspective in analysis of monetary and financial contexts. For example, Temperini et al. (2024) examine the effectiveness of helicopter money, a concept once theoretical but now viable with CBDCs, using a stock-flow model of an open economy. Wang et al. (2022) develop various CBDC-related indices and the negative relationship with the MSCI World Banks Index. A comprehensive comparison of current tokenization practices across countries is still lacking.

Early experiences of tokenization are mixed, with some countries

embracing it while others being more cautious (Auer and Boehme, 2020). Specifically, China has been at the forefront of blockchain-based finance, as one of the first countries to introduce CBDCs (also known as e-CNY). This has led to a growing interest among policymakers in combining tokenization with various finance and trade contexts (Allen et al., 2022). Proponents of this approach argue that using digital currencies could simplify cross-border transactions, reduce costs, and increase transparency and security (Chen and Siklos, 2022). Another proposal is to use e-CNY to finance the issuance of tokenized bonds (Hoang et al., 2023). This would provide an innovative way for companies and governments to raise capital and could help reduce the reliance on traditional financial intermediaries. In addition, this approach would also promote the internationalization of CNY, as it enables global investors to access China’s financial markets (Guo and Zhou, 2021).

In contrast, the US has been more skeptical about the development of tokenized currencies and assets. For example, the US congress has asked Facebook to pause development on its Libra cryptocurrency in 2019 (Financial Services Committee, 2019). This is because tokenized currencies represent a significant shift from traditional financial mechanisms and raise concerns about security, privacy, and monetary control. The cautious move was motivated by concerns over potential risks such

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as data privacy issues, the possibility of money laundering, the circumvention of regulations, and the overall impact on financial stability. Given Facebook’s vast user base, the potential for widespread adoption of Libra posed questions about regulatory oversight and the disruption of existing financial frameworks. In the middle ground, the EU is considering legislation that would regulate the use of tokenized currencies and assets, but there is still a debate over the best approach (Cullen, 2022). The debate in the EU demonstrates an open, proactive attitude towards new technology, which may lead to more finely tuned regulations that can adapt to technological progress and its challenges.

Admittedly, there are tremendous risks and challenges associated with tokenization of currencies and bonds (Gupta et al., 2023). One of the main risks is regulatory uncertainty as legislation always lags practices. This can lead to increased volatility in financial markets and undermine investor confidence (Yousaf and Goodell, 2023). Another notorious risk of tokenization is security concerns. Tokens are stored and traded digitally, making them vulnerable to cyberattacks and hacking. This can result in loss of assets and lack of trust in the technology, limiting its adoption and use in practice (Fantacci and Lorenzini, 2024; Tian et al., 2023). This paper aims to identify and address these challenges in tokenization based on a comprehensive review of existing experiences in major economies. To our knowledge, this paper is one of the earliest attempts in literature to discuss how blockchain technology can be used and should be used in tokenizing traditional currencies and assets from a national perspective.

Blockchain adoption from an organizational perspective is widely discussed (Tandon et al., 2021). Well-established models like Technology Acceptance Model (TAM) can still be applied to analyzing blockchain adoption at the national level, only that the decision-makers are now regulators and policymakers (Gupta et al., 2023). The TAM model assumes that the users’ decisions to adopt a technology are based on a rational evaluation of its expected benefits and usability (Davis, 1989). This means that users consciously assess how the technology will enhance their performance (perceived usefulness) and how easy it will be to use (perceived ease of use), which are the immediate antecedents to adoption. CBDCs are a special type of exchange technology, so TAM can help understand the key drivers and barriers behind the adoption decision.

Based on a comparative study and a case study, we propose three evidence-based policy implications for monetary and financial

authorities (e.g., central banks). First, *take a gradualism approach in tokenization*. We make an important distinction between “asset tokenization” and “tokenized asset”. The former is to tokenize existing traditional financial assets (e.g., fiat currencies and bonds) on blockchains, while the latter is to issue new tokenized assets on blockchain directly. It is suggested that asset tokenization (e.g., e-CNY and bond tokenization) is the main form of the initial stage. Once the technical and legal infrastructures are well established, tokenized assets (e.g., cryptocurrencies and tokenized bonds) can then be fully integrated. Second, *take an eclectic approach in tokenization*. It is argued that tokenized assets and centralized management are not substitutable but complementary to decentralized technologies like blockchain. There are conditions under which tokenization should be adopted, and there is an optimal degree of tokenization in terms of the benefit-cost analysis. Decentralized tokenization does not always dominate traditional centralized systems. A certain degree of centralization is essential for assuring financial stability, so the blockchain cannot be totally permissionless as in the DeFi ecosystem. Third, *collaborative leadership is needed to build trust in tokenization*. Blockchain technology provides a “trustless” solution to monetary and financial systems, but trust in the technology and participants is needed to join the blockchain in the first place (Kumar et al., 2022). To build trust and promote adoption, we highlight the role of “collaborative leadership” to deal with the barriers due to positive externalities and substantial costs of establishing blockchain infrastructures.

The next section conducts a comparative study on international experiences of tokenization. Section 3 elaborates on China as a case study for its leading position in tokenization exercise. Section 4 develops a conceptual TAM based on the evidence reviewed. Section 5 discusses policy implications and Section 6 concludes.

2. A comparative study of seven economies

Some countries, such as China and Singapore, have been proactive in exploring and adopting blockchain in their monetary and financial systems, while others, such as the US, have been more cautious and skeptical. It is because decentralization undermines the old center and gives power to previously peripheral players. Both cryptocurrencies and CBDCs have the potential to undermine the old global center currency—the US dollar (Chen and Siklos, 2023). For example, China views blockchain as a strategic technology that can enhance its financial

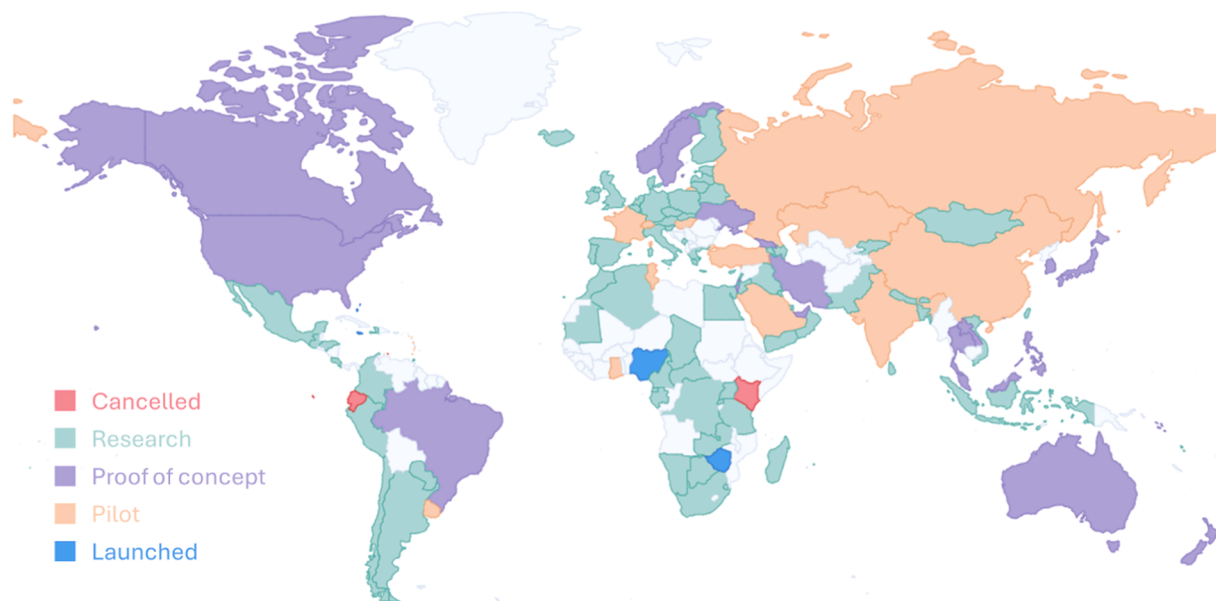


Fig. 1. The state of CBDCs in the world (as of April 2024)

Source: CBDC Tracker. Note: e-CNY is currently only used in Mainland China as Taiwan, Hong Kong, and Macau have their own currencies.

systems, increase efficiency, and boost the competitiveness in global finance. China's development of e-CNY aligns with its broader goals of increasing its technological sovereignty, reducing its dependence on the global dollar system, and facilitating internationalization of renminbi (Allen et al., 2022). By contrast, the US has a vested interest in maintaining the stability of its financial system, which underpins the global economy. As the issuer of the world's *de facto* primary reserve currency, the US has much to lose if new technologies disrupt the dollar's dominance (Fantacci and Gobbi, 2021, 2023). The decentralization inherent in blockchain and the use of CBDCs could dilute the dollar's influence in global trade and finance (Arauz, 2021). Beyond the international political economy, there are many economic benefits of tokenization of currencies and assets (BIS Innovation Hub, 2023a).

First, tokenization can increase liquidity of the financial markets. It allows for the fractionalization of assets, making it possible to own parts of high-value assets like real estate or artwork. This opens investment opportunities to a wider audience who may not have the financial capability to buy these assets outright. By converting physical assets into digital tokens, these assets can be traded on digital platforms, which can operate 24/7, potentially across global markets. This accessibility can significantly increase the liquidity of traditionally illiquid assets.

Second, tokenization can also enhance market efficiency. Blockchain technology can streamline processes that traditionally involve multiple intermediaries such as brokers, escrow services, and legal counsel. Tokenization can automate many of these steps through smart contracts, reducing costs and accelerating transaction times. Transactions recorded on a blockchain provide a clear, immutable history of asset ownership and transfers. This transparency helps in reducing fraud, enabling more secure transactions, and providing a reliable audit trail.

Third, tokenization can facilitate regulatory compliance and security. Tokens can be programmed with smart contracts that automatically enforce regulatory compliance across jurisdictions. This can include restrictions on who can buy tokens, how they are transferred, and ensuring that all transfers are reported to regulatory bodies as needed. The use of blockchain technology ensures that all transactions are encrypted and immutable. This reduces the risk of tampering and unauthorized access, enhancing the overall security of transactions.

To paint a snapshot of the status quo of central use of decentralized technology, this section compares existing practices of tokenization of currencies and assets in major developed economies, with a special focus on regulatory arrangements. The analysis summarizes “perceived usefulness”, “perceived ease of use”, and “perceived risks” of tokenization from the regulator's perspective following the TAM framework.

US. Tokenization is mainly developed for traditional financial assets rather than the fiat currency. The US dollar already plays a central role in the current international financial and monetary system. While its share as a reserve currency has declined recently, it remains to be the primary international reserve currency and the dominant choice for international debt, cross-border borrowing, global corporate borrowing, development finance, and international invoicing (Kuehnlenz et al., 2023). The US has no incentive to harm the dominant role of the dollar with a CBDC. Recent reports by the President's Working Group on Financial Markets describe stablecoins as a complex multifaceted product with a complex multifaceted set of risks (Allen et al., 2022). Consequently, it is proposed that only insured depository institutions should issue stablecoins convertible into US dollars, and legislation should be enacted to regulate these stablecoins as insured deposits, with oversight extending to both depository institution and holding company. In contrast, some traditional assets have been tokenized in the US such as real estate, art, fine wine, and other collectibles. In the case of real estate, for instance, tokenization enables fractional ownership of a property, enabling people to invest in high-value properties without having to buy them outright (Kreppmeier et al., 2023). Moreover, there has been growing interest in exploring the potential of tokenized bonds in the US (Xin et al., 2024). The goal of these initiatives is to develop a secure and reliable infrastructure for tokenized bonds that can provide

benefits such as greater transparency, improved accessibility, and reduced costs. The tokenization of traditional assets is still in its early stages. There are some challenges and uncertainties that need to be addressed, such as regulatory concerns for these tokenized assets, the lack of a clear legal framework, cybersecurity issues, and the potential for fraudulent activity on these platforms (Lambert et al., 2021). The Securities and Exchange Commission (SEC) has overall responsibility for the regulation of security tokens, while other regulatory bodies, such as the Commodity Futures Trading Commission (CFTC) and the Financial Industry Regulatory Authority (FINRA), have specific responsibilities for the regulation of other types of tokens and assets.

EU. The European Central Bank (ECB) has been preparing for the potential issuance of a digital euro following a two-year investigation from October 2021 to October 2023; for details, see the summary report “A Stocktake on the Digital Euro”). According to the report, the ECB's Governing Council will only consider issuing a digital euro after the necessary legislation is adopted. The regulation of tokenized assets varies from country to country in the Eurosystem, with some countries taking a more permissive approach and others implementing stricter regulations. Countries like Malta and Gibraltar (peripheral players) have established themselves as hubs for the blockchain and crypto industries, while others like Germany and France (the old regional center) have implemented more stringent regulations (Krasimir, 2021). Overall, the EU is working towards creating a unified approach to the regulation of tokenized assets through the European Securities and Markets Authority (ESMA). ESMA is responsible for supervising the implementation of EU securities laws and ensuring a level playing field for market participants across the EU. Specifically, the EU has developed the Markets in Financial Instruments Directive II (MiFID II), which sets out rules for firms providing investment services, such as trading and advising on securities. The EU has published the first final report under the Markets in Crypto-Assets (MiCA), which aims to establish a comprehensive framework for the regulation of crypto-assets in the EU (ESMA, 2024). In addition, the EU has been actively exploring the use of blockchain technology to tokenize bonds, with several initiatives underway to develop standards and regulations for this new asset class (Brunnermeier and Landau, 2023). The European Blockchain Services Infrastructure (EBSI) project is working to create a blockchain-based infrastructure that will support the issuance and trading of tokenized bonds.

UK. The regulation of tokenized assets falls under the purview of the Financial Conduct Authority (FCA), which is the country's main financial regulatory body. The FCA has taken a proactive approach to the regulation of tokenized assets and has issued guidance on the regulatory implications of various types of tokens, including security tokens, utility tokens, and stablecoins (G7 Working Group on Stablecoins, 2019). In terms of specific regulations, the FCA has stated that most tokens will be considered as securities and will fall under the regulatory framework set out in the Financial Services and Markets Act 2000 (FSMA). This means that companies offering tokenized assets will need to comply with a range of regulatory requirements, including disclosure, investor protection, and anti-money laundering rules. In addition to the regulations set out in FSMA, the FCA is also exploring the potential use of new technologies, such as blockchain and smart contracts, in the regulation of tokenized assets. For example, the FCA has established a Regulatory Sandbox, which allows firms to test innovative products, services, and business models in a controlled environment. In short, the tokenization of assets in the UK is an exciting and rapidly growing industry, with a supportive regulatory environment that is designed to promote innovation and protect investors (HM Treasury, 2022). However, companies offering tokenized assets will need to comply with a range of regulatory requirements to ensure that investors are protected.

Switzerland. It has been a pioneer in the development of the tokenization industry and has established itself as a hub for the issuance and trading of tokenized assets (Allen et al., 2022). This is largely due to the country's supportive regulatory environment, which has encouraged innovation and investment in the blockchain industry. In Switzerland,

the regulation of tokenized assets is primarily the responsibility of the Swiss Financial Market Supervisory Authority (FINMA). FINMA has issued guidance on the regulatory implications of various types of tokens, including security tokens, utility tokens, and stablecoins. In terms of specific regulations, FINMA has stated that most tokens will be considered as securities and will fall under the regulatory framework set out in Swiss financial market legislation, including the Swiss Federal Act on Collective Investment Schemes (CISA) and the Swiss Financial Services Act (FINSA). This means that companies offering tokenized assets will need to comply with a range of regulatory requirements, including disclosure, investor protection, and anti-money laundering rules. In addition to the regulations set out in CISA and FINSA, FINMA is also exploring the potential use of new technologies, such as blockchain and smart contracts, in the regulation of tokenized assets. For example, FINMA has established a regulatory framework for initial coin offerings (ICOs), which provides clarity and certainty for companies looking to raise capital through tokenized assets; for details see the annual report on digitalization (FINSA, 2023). Overall, companies offering tokenized assets are operating in a favorable regulatory environment that supports the growth of the industry. One famous successful story is Swiss bank Cité Gestion which becomes the first bank to tokenize its own shares in 2023.

Australia. The tokenization of assets is a growing industry, with many companies and organizations exploring the use of tokenized assets for various purposes, including raising capital, trading assets, and enabling new forms of investment (Ciriello, 2021). In Australia, the regulation of tokenized assets falls under the purview of the Australian Securities and Investments Commission (ASIC), which is the country’s main financial regulatory body. ASIC has issued guidance on the regulatory implications of various types of tokens, including security tokens, utility tokens, and stablecoins. In terms of specific regulations, ASIC has stated that most tokens will be considered as securities and will fall under the regulatory framework set out in the Corporations Act 2001 (INFO 225, 2021). This means that companies offering tokenized assets will need to comply with a range of regulatory requirements, including disclosure, investor protection, and anti-money laundering rules. In addition to the regulations set out in the Corporations Act, ASIC is also exploring the potential use of new technologies, such as blockchain and smart contracts, in the regulation of tokenized assets. For example, ASIC has established a regulatory sandbox, which allows firms to test innovative products, services, and business models in a controlled environment. The Australian Securities Exchange (ASX) is exploring the use of blockchain technology to tokenize bonds, with plans to launch a pilot program soon (Ledger Insights, 2022). This would make it easier for companies and governments to issue and trade bonds and could increase liquidity and transparency in the market.

Japan. The regulation of tokenized assets falls under the purview of the Financial Services Agency (FSA), which is the country’s main financial regulatory body. The FSA has taken a proactive approach to the regulation of tokenized assets and has issued guidance on the regulatory implications of various types of tokens, including security tokens, utility tokens, and stablecoins. Most tokens in Japan will be considered as financial instruments and will fall under the regulatory framework set out in the Financial Instruments and Exchange Act (CCI, 2023). This means that companies offering tokenized assets will need to comply with a range of regulatory requirements, including disclosure, investor protection, and anti-money laundering rules. The FSA has also established a regulatory sandbox, which allows firms to test innovative products, services, and business models in a controlled environment. This supports the growth of the tokenization industry by allowing companies to experiment with new ideas and technologies in a supportive regulatory environment.

South Korea. It advances in formalizing asset tokenization – the Financial Service Commission (FSC) has authorized the Korea Exchange to establish a market for buying and selling security tokens through competitive trading methods (Lee, 2024). The regulation of tokenized

assets falls under the purview of the FSC, which is the country’s main financial regulatory body. The FSC has proactively addressed the regulation of tokenized assets by announcing the “Token Security Guideline”. This guideline governs the issuance and distribution of token securities and proposes amendments to existing laws and regulations to regulate these securities as electronic, distributed ledger-based assets (Seung et al., 2024). Regarding specific regulations, the FSC has stated that most tokens will be considered as securities and will fall under the regulatory framework set out in the Capital Markets Act. This implies that companies offering tokenized assets must adhere to various regulatory mandates, encompassing disclosure obligations, investor safeguards, and anti-money laundering rules. In addition to the regulations set out in the Capital Markets Act, the FSC is also exploring the potential use of new technologies, such as blockchain and smart contracts, in the regulation of tokenized assets. A regulatory sandbox has been established, allowing firms to test innovative products, services, and business models in a controlled environment.

Table 1 compares regulatory bodies, regulations, and attitudes towards tokenization of the major economies reviewed above. It is shown that the old centers (e.g., US, Germany, France) are more skeptical and cautious towards tokenization because the blockchain technology not only decentralizes the role of financial intermediaries, but also the power of financial hegemony. The role of the current international anchor currency (USD) and regional anchor currency (EUR) can face a great challenge when assets are tokenized. Nevertheless, most countries have developed and have been developing a wealth of regulations and legislations to protect the participants and ensure the stability of the financial system. Given the borderless and centerless features of blockchain, country-specific regulations and legislations seem to be difficult to match. This may be the greatest challenge to the development of tokenization of assets.

3. A case study of China

China is at the forefront of digital innovation in finance, which is worth an in-depth inspection. In this section, we conduct a case study of China’s tokenization in three contexts: (i) currency tokenization (CBDC), (ii) bond tokenization, and (iii) “currency bridge”.

3.1. Currency tokenization

The development of e-CNY, also known as digital RMB, started in 2014 as a research project by China’s central bank, the People’s Bank of China (PBoC). The goal of the project was to explore the potential benefits and challenges of using blockchain-based digital currencies and to develop a digital version of the country’s national currency, CNY. In 2019, the PBoC officially announced that it was launching a pilot program for the digital yuan, with several cities in China, including Shenzhen and Chengdu, participating in the program (CAICT, 2023). The pilot program was designed to test the technical capabilities of the digital currency, as well as its potential benefits and challenges. The pilot program was a success in terms of its technical performance

Table 1
Comparison of tokenization environments in major economies.

Economy	Regulatory Bodies	Legislative Framework	Attitude
US	SEC, CFTC, FINRA	The Securities Act	Skeptical
UK	FCA	FSMA, sandbox	Supportive
EU	ESMA	MiFID II, MiCA	Mixed
Switzerland	FINMA	CISA, FINSA	Supportive
Australia	ASIC	The Corporations Act, sandbox	Supportive
Japan	FSA	The Financial Instruments and Exchange Act, sandbox	Supportive
South Korea	FSC	The Capital Markets Act, sandbox	Supportive

(stability, scalability, and functionality) and usability (user engagement and ease of use). As a result, in 2020, the PBOC officially launched the digital yuan as part of its efforts to modernize the country's financial system and increase financial inclusion. A brief timeline of e-CNY is illustrated in Fig. 2.

The digital yuan operates as a digital version of the physical yuan, with users being able to use it for everyday transactions, such as buying goods and services and paying bills. Since its launch, the digital yuan has been rapidly adopted by the Chinese population, with millions of people using the digital currency for various purposes. The PBoC has also continued to develop the digital yuan, making improvements to its technology, and adding new features, such as QR code-based payments and support for offline transactions (Siu, 2023).

Overall, the development of e-CNY has been an important step in China's journey towards digitalization and has helped position the country as a leader in the digital currency space. The success of the digital yuan has also generated interest from other countries, which are exploring the potential benefits and challenges of using digital currencies for their own economies (Allen et al., 2022).

One of the main benefits of the digital yuan is that it could make it easier for Chinese businesses to participate in cross-border trade and investment (BIS Innovation Hub, 2023a; Siu, 2023). By using a digital currency, companies could reduce the costs and complexities associated with traditional currency exchange and could increase the efficiency and transparency of cross-border transactions. In addition, e-CNY could also help to promote the internationalization of the CNY by providing a new and innovative way for global investors to access Chinese debt markets. By issuing tokenized bonds denominated in digital yuan, the Chinese government and companies could raise capital from a wider range of investors, including those who are not currently able to participate in traditional bond markets.

3.2. Bond tokenization

Bond tokenization is a process by which a traditional bond is transformed into a digital asset that can be traded on a blockchain network.

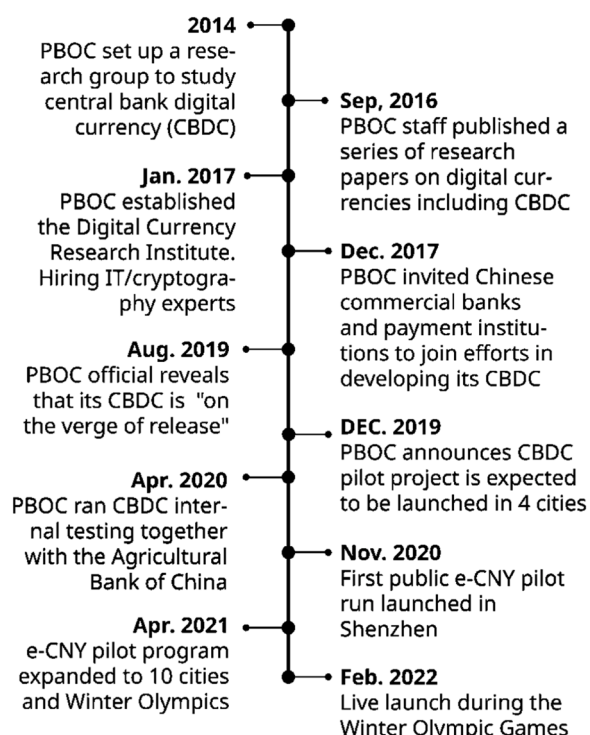


Fig. 2. The development of e-CNY.

The process of bond tokenization enables the creation of tokenized bonds, which are digital representations of traditional bonds that are recorded on a distributed ledger. The fintech foundation of bond tokenization is based on the use of blockchain technology and smart contracts (Xu and Guan, 2023). On the one hand, blockchain technology provides the infrastructure for bond tokenization, enabling the creation of a secure, transparent, and decentralized ledger of transactions. The decentralized nature of blockchain networks makes it possible to transfer ownership of tokenized bonds without the need for intermediaries, such as banks and financial institutions. This reduces transaction costs, improves efficiency, and increases the speed of transactions. On the other hand, smart contracts are self-executing contracts with the terms of the agreement between buyer and seller being directly written into lines of code. Smart contracts can automate the process of bond tokenization, making it possible to create, manage, and transfer tokenized bonds in a secure, transparent, and efficient manner. In what follows, we describe some famous cases of bond tokenization in practice.

ZhongAn, China's first online-only insurance company, has been exploring the use of blockchain technology for bond tokenization (Du, 2018). In 2019, the company completed a successful trial of a blockchain-based bond issuance platform, which demonstrated the potential for using blockchain technology to improve the efficiency and security of bond issuance and trading (ZhongAn Blockchain White Paper, 2020). Bank of China (BoC) has been actively exploring the use of blockchain technology for bond tokenization. In 2019, the bank completed the issuance of \$2.8 billion worth of bonds using its proprietary blockchain system (Ledger Insights, 2019; Sina Finance, 2019). The blockchain system developed by BoC includes functions such as bond creation, bookkeeping, underwriting, network management, bond purchase, order summary, pricing and placement.

The China Central Depository & Clearing (CCDC) has developed a blockchain digital bond issuance solution and was selected for a national blockchain innovation pilot in early 2022 (CCDC Specification, 2023). With regulatory guidance and market support, the blockchain digital bond issuance platform was launched and became operational in 2022. The Shanghai Stock Exchange has been exploring the use of blockchain technology for bond tokenization in recent years (PBC Shanghai Head Office, 2017; Stock Exchange, 2020). In 2023, The Securities and Futures Commission of Hong Kong (SFC) has published two highly anticipated circulars concerning the tokenization of SFC-authorized investment products and the activities of intermediaries engaging in tokenized securities (Mazzochi et al., 2023).

The evidence demonstrates the growing interest and activity in bond tokenization in China. By leveraging the benefits of blockchain technology, these initiatives have the potential to transform the traditional bond market and provide new opportunities for investment and capital formation. A common practice in these cases is the adoption of consortium blockchain. Consortium blockchains are maintained by a consortium of organizations, rather than a single organization (private blockchain) or network of users (public blockchain). For example, R3, a consortium of over 200 members, including banks, financial institutions, and technology companies, focuses on developing blockchain technology for the financial services industry. Hyperledger, an umbrella project of open source blockchains and related tools hosted by the Linux Foundation, includes various industry leaders in finance, banking, IoT, supply chain, manufacturing, and technology. Marco Polo Network, a trade and working capital finance network, seeks to streamline and automate the entire flow of trade transactions with blockchain technology. They offer a number of advantages for bond tokenization, making them an attractive option for companies and organizations looking to tokenize their bonds.

First, increased security. Consortium blockchains are more secure than public blockchains, as the consortium of organizations can enforce stricter security protocols and maintain better control over the network (Cui et al., 2021). This feature is especially important for financial assets

like bonds. Second, better scalability. Consortium blockchains are more scalable than public blockchains, as the consortium can decide on the number of nodes and the type of consensus mechanism to use, making it easier to manage the network and ensure its efficiency (Du et al., 2020). Third, enhanced privacy. Consortium blockchains offer enhanced privacy compared to public blockchains, as the consortium can control who has access to the network and what information is shared (Zhang and Lin, 2018). This can be especially important for sensitive financial information such as bond issuance details. Fourth, improved interoperability. Consortium blockchains can be designed to work with other blockchain networks, which can improve the interoperability of the bond tokenization process and make it easier to transfer and trade bonds on different blockchain platforms.

To build such a secure, scalable, private, and interoperable solution for bond tokenization, it requires a collaborative network in building the consortium blockchain. According to the cases reviewed above, we summarize the following difficulties:

- **Complex governance structure.** Consortium blockchains involve a consortium of organizations, each with its own goals, objectives, and interests. Establishing a governance structure that balances these interests and ensures that all participants have a voice in the decision-making process can be complex and challenging. Therefore, it requires one or several key players in the banking industry to lead the process and it inevitably causes some degree of centralization.
- **Interoperability issues.** Consortium blockchains may need to interoperate with other blockchain networks (e.g., e-CNY), which can be difficult due to technical and compatibility issues. Ensuring that the consortium blockchain can work seamlessly with other blockchain platforms can require significant effort and resources. Again, it requires leadership which implies power.
- **Regulatory compliance.** Consortium blockchains may need to comply with a range of regulatory requirements, depending on the jurisdiction and the type of applications that they support. Ensuring regulatory compliance can be challenging, especially in industries with complex regulations, such as bond issuance.
- **Security risks.** Consortium blockchains are maintained by a consortium of organizations (banks), which means that there is a greater risk of security breaches and data theft. Ensuring the security of the consortium blockchain requires implementing robust security measures and protocols, as well as ongoing monitoring and management of the network.
- **Technical difficulties.** Building a consortium blockchain requires a deep understanding of blockchain technology, cryptography, and distributed systems. Overcoming technical difficulties such as scalability, performance, and interoperability can require significant expertise and resources.
- **Subjective resistance.** Consortium blockchains may face resistance from organizations that are skeptical of blockchain technology or are reluctant to change their existing processes and systems. Overcoming this resistance may require education and outreach, as well as a clear demonstration of the benefits of the consortium blockchain.

Despite these difficulties, consortium blockchains offer several advantages over other types of blockchain networks, such as increased security, scalability, and privacy, making them an attractive option for banks and bond issuers. However, building a successful consortium blockchain for bond tokenization requires careful planning, design, and execution, as well as a deep understanding of the challenges and limitations of the technology. This is why we propose a gradualism approach—first tokenize existing bonds (bond tokenization) which already have mature regulations, and then issue tokenized bonds when the market is ready.

3.3. Currency bridge

The history of tokenization is also a history of internationalization of CNY (Guo and Zhou, 2023). The biggest five commercial banks in China initiated the m-CBDC-Bridge project in 2022 to enable cross-border transactions among trading partners using different currencies (Lee and Shen, 2022). It is designed to facilitate trade and investment among countries by allowing for the exchange of currencies in a convenient, efficient, and cost-effective manner. The “currency bridge” allows for the exchange of e-CNY and other currencies, such as USD, EUR, or JPY. It helps promote cross-border trade and investment between China and its trading partners, especially in the RCEP region. It could also support the internationalization of CNY.

A currency bridge like m-CBDC-Bridge that utilizes blockchain technology can assist in international and regional trade in several ways (BIS Innovation Hub, 2023b). First, it can reduce transaction costs and increase efficiency. By using blockchain technology to facilitate cross-border transactions, the need for intermediaries such as banks and other financial institutions is reduced. This results in lower costs for cross-border transactions, as well as faster and more reliable transactions. Second, it can increase transparency and security. Blockchain technology is a secure and transparent ledger that can provide a clear record of all transactions. This can help to prevent fraud and other types of financial crime and can increase confidence in cross-border transactions. Third, it can improve access to financial services. By using blockchain technology to facilitate cross-border transactions, financial services can be made available to a wider range of people and businesses. This is particularly important in developing countries, where access to financial services is often limited. Fourth, it can support the internationalization of the currency. For example, if e-CNY is used in a currency bridge using blockchain technology, this can help to promote the use of e-CNY in international trade and investment. This can help to increase the demand for e-CNY, which can in turn support its internationalization. In conclusion, a currency bridge utilizing blockchain technology can provide a range of benefits for international and regional trade, including lower costs, increased efficiency, greater transparency and security, improved access to financial services, and support for the internationalization of the currency. These benefits can help to promote more open and inclusive trade and investment and can help to foster economic growth and development in the region.

Specifically, the first step of internationalization of CNY is to claim the anchor currency of regional trade (Guo and Zhou, 2021; Fritz et al., 2023). The RCEP is one of the most important regional trade agreements in the world between the ten countries of the Association of Southeast Asian Nations (ASEAN) and five other Asia-Pacific countries, including China, Japan, South Korea, Australia, and New Zealand. The RCEP aims to promote trade and investment in the region by reducing barriers to trade, such as tariffs and non-tariff measures, and by promoting greater economic integration. The combination of e-CNY and the RCEP in a consortium blockchain could have a significant impact on trade and investment in the Asia-Pacific region. By using e-CNY for cross-border transactions, Chinese businesses could reduce the costs and complexities associated with traditional currency exchange and could increase the efficiency and transparency of cross-border transactions. In addition, the RCEP could help to create a more open and inclusive trade and investment environment in the region, which could further support the use of e-CNY. And again, as with building a consortium blockchain for bond tokenization, building a consortium blockchain for currency bridges also requires leadership. In this case, China needs to take responsibility as it was the first country to develop CBDC (e-CNY) and has a head start in bond tokenization. With greater power comes greater responsibility.

4. A conceptual framework based on the TAM model

Building on the comparative study and the case study, we extend the TAM model, as shown in Fig. 3, to summarize the analyses in preceding

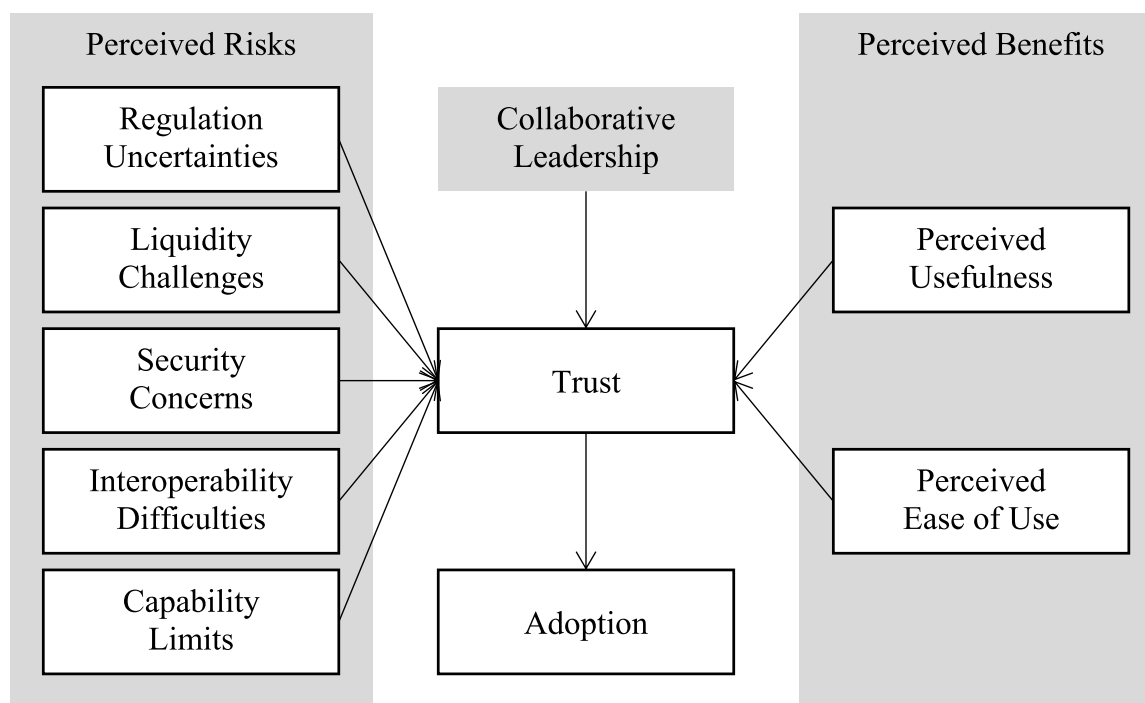


Fig. 3. The conceptual framework of tokenization adoption.

sections. This conceptual framework leverages trust as an antecedent for adoption (cf. Benbasat and Wang, 2005 and Gupta et al., 2023). Our novelty is to highlight collaborative leadership as an antecedent for trust formation.

4.1. Perceived usefulness

Perceived usefulness of tokenization includes swift payment systems, heightened financial inclusivity, and enhanced implementation of monetary policy (Bordo and Levin, 2017; Kuehnlenz et al., 2023). These technical benefits can lead to greater trust in the financial system, as individuals can verify the authenticity of transactions themselves. As CBDCs and bond tokenization are usually led by the government, trust in the technology and trust in participants can be built more easily than cryptocurrencies and DeFi tokens.

Beyond these technical benefits, we have seen political benefits for tokenization, i.e., to decentralize the old centers. Nevertheless, tokenization is a double-sided blade. It not only decentralizes the old center, but also decentralizes all centers. Policymakers and regulators in peripheral countries (e.g., China) support the decentralized technology in the international financial market on the one hand, while strengthening centralized control of the technology within the country on the other hand. It is essentially a trade-off between cross-border trust and within-border trust. This dilemma can eventually limit the full potential of tokenization.

4.2. Perceived ease of use

Perceived usefulness determines whether tokenization is favorable, while perceived ease of use determines its feasibility. To adopt blockchain technology, perceived ease of use can help build calculative-based trust in the technology and in the participants (Hernandez-Ortega and Jimenez-Martinez, 2013; Senyo and Osabutey, 2020).

In the context of currency tokenization, the China case study has shown positive evidence for ease of use and mass adoption. Centralized digital payment systems like Alipay and Wechat Pay have already established the non-physical transaction habit of the population since

2010s. It lays a social foundation for trust in CBDC. China is also well known for its centralized government, which enjoys strong public trust from (and power over) its citizens and businesses (Zhao et al., 2017). It enables the government to lead blockchain projects like CBDC and bond tokenization, facilitating more secure and efficient financial transactions.

In the context of asset tokenization, businesses are the trustors. They need successful application cases to build trust in blockchain applications and participants. Industry leaders are usually the pioneers to launch blockchain projects in environments legitimized by national leadership. There are no precedents for them, but they possess greater technical and financial capabilities to withstand potential losses. As the first bank to tokenize its own shares, Swiss bank Cité Gestion is one of such examples. We emphasize the role of collaborative leadership, as blockchain projects often require participation from other stakeholders at the industry or international levels.

4.3. Perceived risks

Based on the evidence from the comparative study and the case study, we summarize the following challenges of tokenization of currencies, bonds, and other financial assets.

Regulation uncertainties. Tokenization (especially bond tokenization) operates in a regulatory gray area, with limited guidance from regulators on how it should be treated and managed. Even for developed economies like the US and the EU, the regulation infrastructure is far from being established (see EU's summary report "A Stocktake on the Digital Euro"). Lack of clarity can create distrust for market participants and limit the growth and development of tokenization.

Liquidity challenges. Liquidity is a key challenge in asset tokenization, as it is difficult to determine the value of tokens, which can lead to lack of demand and low trading volumes (Ciriello, 2021). This can create difficulties for investors who want to sell their bond tokens and make it more difficult for issuers to raise capital. These challenges are trust barriers to adoption and diffusion of tokenized currencies and assets.

Security concerns. Tokens are stored and traded digitally, making

them vulnerable to cyberattacks and hacking. Around \$10 billion was lost due to hacks and scams in 2021 alone.¹ This can lead to a loss of assets and a lack of trust in the technology, which could limit its adoption and use. It is technically and legally difficult to deal with digital crime or “cybercrime” because criminals may well be in another country.

Interoperability difficulties. Tokens can only be traded on specific platforms, which can limit their use and create barriers to entry for new market participants. This can lead to a distrusted fragmented market and low efficiency of the overall tokenization process. In the case of currency bridge, different countries must collaborate to connect disparate monetary systems in one unified blockchain, which requires collaborative leadership and mutual trust. The BIS has proposed three models for cross-border CBDC interoperability: Helvetia Phase II project, swift CBDC experiments, and project Dunbar (Themistocleous et al., 2023). While technical interoperability is feasible, significant work remains in developing standards, interfaces, and addressing legal and governance concerns.

Capability limits. Tokenization is a complex process and requires a high level of technical expertise and knowledge to implement and manage (Heines et al., 2021). Moreover, the token sponsors lack the expertise to carry out the acquisitions and management of assets post fundraising (Chow and Tan, 2022). This can limit its adoption and make it difficult for issuers and investors to fully utilize the technology.

4.4. Trust

The perceived usefulness, ease of use, and risks form the basis of the conceptual framework. They all point to trust, which is a key antecedent for adoption. Trust can be defined as a gradual, self-reinforcing phenomenon that evolves as one party, called the trustor, places themselves in vulnerable situations, while the other party, called the trustee, is the one in whom trust is placed and can take advantage of the trustor’s vulnerability. The comparative study and the case study has shown that trust is essential for participants to have confidence in the security, reliability, and transparency of tokenized currencies and assets as well as the underlying blockchain technology.

In the context of CBDCs, users need to trust that the central bank will maintain the value and stability of the CBDC, protect their privacy and security, and ensure the efficient functioning of the payment system. In the context of asset tokenization, it involves representing real-world assets, such as real estate, stocks, or commodities, as digital tokens on a blockchain. Trust in asset tokenization is essential for investors and participants in the market. They need to trust that the tokens represent real assets, that the ownership and transfer of these tokens are secure and transparent, and that the underlying blockchain technology is reliable.

Contrary to the notion of blockchain’s trustless disintermediation, new intermediaries may be introduced in the context of CBDCs and asset tokenization, and these intermediaries need to be trusted. For example, in the case of asset tokenization, there may be intermediaries responsible for verifying the authenticity and ownership of the underlying assets, managing the tokenization process, or providing liquidity in the market. Participants in these digital asset ecosystems need to trust these intermediaries to ensure the integrity and efficiency of the system (Lumineau et al., 2023). In sum, blockchain technology is trustless, but blockchain adoption needs trust.

4.5. Collaborative leadership

Much literature has discussed how blockchain technology can

enhance trust among participants (Werbach, 2018), but less has been done on how to build trust in blockchain technology itself. The evidence has shown that leadership is a necessary but not sufficient condition to build trust in tokenization. Strong leadership implies a strong center, which contradicts the philosophy of blockchain technology in the first place. To build trust in blockchain-based tokenization, leaders cannot act in isolation.

Collaborative leadership is a unique style of leadership that promotes an ongoing integration of ideas and interdependency among multiple stakeholders (VanVactor, 2012). It is a transformational style of leadership that emphasizes the development of alliances for better business practices and processes. In a collaborative environment, leaders and followers raise each other’s levels of motivation and morality, nurturing interdependencies among multiple parties. Tokenization is supposed to benefit both leaders and followers almost equally, so the incentive for leaders to initiate and maintain the blockchain is low. The economic theory of externality suggests that, if the “private benefit” is lower than the “social benefit”, then the market-based equilibrium falls short of the social optimum. Adoption of an innovation entails positive externalities, such as shared setup costs and learning costs, benefiting other adopters (Dybvig and Spatt, 1983). In a centralized system, a strong leader such as the government or industry leader can act as the trusted provider of public goods. The costs incurred by the central leader can be compensated for by the consequent benefits guaranteed by its central power, e. g., taxation, monopoly profit. However, in a decentralized system, collaborative leadership is needed to share the costs and power among multiple, if not all, participants.

In the context of CBDCs, the central government is the main leader, but trust and mass adoption cannot be achieved without collaborations from commercial banks, online businesses, and payment technology providers. In the context of asset tokenization, issuers are the main leader, but collaborations are needed from security exchanges and regulatory bodies due to complexity of the market and fragmentation across platforms. Collaborative leadership is applicable in both interorganizational and international contexts for initiating blockchain projects.

5. Discussion

Based on the comparative study and the case study, we have shown that tokenization is still in its early stages of development, and various risks and challenges must be addressed to ensure its success and growth. According to the neoclassical economic theory, positive externalities and substantial costs can result in the “free rider problem” and under- or even no provision of technical and legal infrastructure of tokenization (Cong et al., 2022). Therefore, policymakers, regulators, and industry leaders need to work together in the form of collaborative leadership (Vangen and Huxham, 2003; VanVactor, 2012) to create robust regulatory frameworks, develop secure platforms, provide education and training, and build trust in tokenization and among market participants. We discuss five measures against the five perceived risks identified in the extended TAM conceptual framework.

First, it is fundamental to ensure that asset tokenization complies with the regulations and laws of the jurisdiction in which the bonds are being issued and traded. This will help to avoid any legal and financial consequences. This requires leadership and supervision from regulatory bodies to build trust in tokenization.

Second, the liquidity challenges can be addressed by implementing mechanisms for the trading and transfer of the bond tokens and ensuring that the market for the tokens is deep and active. It also supports the gradualism approach, i.e., starting with bond tokenization and then moving to tokenized bonds. A mature traditional, widely-acknowledge traditional bond market can provide good support for liquidity.

Third, tokenization involves the use of digital assets, which can be vulnerable to hacking, cyberattacks, and other security breaches. It is important to ensure that the platform and infrastructure used for bond tokenization are secure and that proper security measures are in place.

¹ Elliptic. (2022). \$76 Million Stolen from Beanstalk Farms DeFi Stablecoin Protocol. Retrieved 10/10/2023 from <https://www.elliptic.co/blog/76-million-stolen-from-beanstalk-farms-defi-stablecoin-protocol>

This measure can build trust among market participants.

Fourth, to ensure the smooth functioning of the tokenization ecosystem, it is important to have interoperable systems and standards in place. This will help to avoid any issues related to compatibility and ensure that tokens can be easily transferred and traded on multiple platforms. This requires leadership and collaborations between central banks, commercial banks, bond issuers, as well as international counterparts.

Fifth, governments and financial regulatory bodies should consider investing in educational programs and initiatives to enhance technical expertise in the field of bond tokenization. For example, in 2021, the Chinese Ministry of Human Resources and Social Security, along with the Ministry of Industry and Information Technology, officially issued the “National Occupational Skill Standards for Blockchain Application Operators (2021 Edition)” (China Daily, 2023). These Standards categorize the profession into four levels: Fourth Level/Junior Worker, Third Level/Senior Worker, Second Level/Technician, and First Level/Senior Technician. Policymakers can also collaborate with industry experts and technology providers to develop best practices and standards for bond tokenization. This collaborative leadership can help bridge the capability gap and ensure that tokenization is implemented effectively and securely.

In summary, to mitigate and manage the risks and challenges of asset tokenization, it is important to have collaborative leadership between the central government and industry leaders to build trust in blockchain technology and among participants.

6. Conclusion

Blockchain technology provides a disruptive innovation to the finance industry. Originally, it challenged the role of banks and fiat currencies, but soon the development of smart contracts revolutionized the markets of other financial assets like bonds and stocks. Inspired by these DeFi projects, traditional financial institutes like central banks and commercial banks started to adopt blockchain technology. This paper reviews the early evidence on tokenization of currencies, bonds, and other assets all over the world. We identify five challenges and corresponding strategies to mitigate them.

Our research has the following implications for policymakers and practitioners in the financial market. First, when approaching tokenization, it is important to adopt a *gradual approach*. There is a distinction between “asset tokenization” and “tokenized asset”. Asset tokenization involves converting traditional financial assets, such as fiat currency and bonds, into tokens on the blockchain, while the latter involves issuing new tokenized assets directly on the blockchain. It is recommended to begin with asset tokenization, such as e-CNY and bond tokenization, and then gradually move to developing tokenized assets once the technical and legal infrastructure is in place.

Second, an *eclectic approach* to tokenization should be taken. Tokenized assets and centralized management are not mutually exclusive, but instead complement each other. The adoption of tokenization should be based on a benefit-cost analysis that considers the optimal degree of tokenization for each specific scenario. Tokenization does not always replace traditional centralized systems and a certain level of centralization is necessary to ensure financial stability. This means that the blockchain cannot be entirely permissionless, as seen in the DeFi ecosystem. Effective leadership is crucial in constructing consortium blockchains for tokenization, as demonstrated by the successful bond tokenization and currency bridge efforts. The success of e-CNY as the first CBDC is a result of strong leadership from the PBOC. In theory, a purely decentralized system would promote fairness, but in practice, a moderate level of centralization is necessary for achieving a balance between fairness and efficiency. The DeFi ecosystem represents pure decentralization, while traditional finance embodies pure centralization. Currently, the financial industry is trending towards a middle ground, incorporating centralized and decentralized aspects of

permissioned consortium blockchains for optimal results.

Finally, *collaborative leadership* is essential for successful tokenization. Developing a consortium blockchain to support tokenized assets requires the cooperation of leading financial institutions, regulators from various countries, and a supportive ecosystem. For instance, leading banks and regulators must work together to establish clear regulations for digital currencies and tokenized bonds, invest in education and outreach, and promote understanding and adoption of these new technologies. Great power comes with great responsibility, and shared power comes with collaborative leadership.

As we conclude our study on the tokenization of currencies and assets, we acknowledge the complexities and transformative potential this decentralized technology holds for the global financial ecosystem. Our research has laid a foundation, but the pathway forward requires further exploration and robust engagement from both academia and industry. Future research can explore the identified challenges, such as interoperability of tokenized systems, scalability solutions, regulatory frameworks and compliance, tokenization of illiquid assets, and privacy concerns in the historical process of tokenization.

CRedit authorship contribution statement

Ying Zhang: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing – review & editing, Writing – original draft. **Bing Gong:** Data curation, Funding acquisition, Investigation, Methodology, Validation, Visualization, Writing – review & editing. **Peng Zhou:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Ethic Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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