



Opportunities and challenges associated with the development of FinTech and Central Bank Digital Currency

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ABSTRACT

Central banks around the world are exploring the possibility of Central Bank Digital Currencies (CBDCs) for retail and wholesale use. While no major economy is yet to fully introduced a CBDC, some countries have begun pilot programs. The purpose of this paper is to highlight the potential benefits and risks associated with CBDCs, including challenges and opportunities associated with proposed CBDC regulation in the United States and the European Union. The paper also discusses the CBDC landscape in Asia. It highlights some of the key findings of the research presented in this special issue on FinTech and CBDCs. Lastly, the paper offers thoughts for potential future research in areas such as the actual designs of CBDCs and their uses, 'DeFi' versus 'CeFi', their interoperability and stability, and concerns over cybercrime.

1. Introduction

Central Bank Digital Currencies (CBDCs) have emerged as a potential solution to a wide range of economic and financial problems. To many, CBDCs are a leapfrogging opportunity to close the gap in financial access, revolutionize payment systems for businesses and consumers, and more broadly for innovating financial products and services to allow for more efficient service provision. Numerous central banks around the world have started to explore the possibility of CBDCs for retail and wholesale uses. While no major economy has fully introduced a CBDC, some countries have begun pilot programs.

The Bank for International Settlements defines a CBDC as “a form of digital money, denominated in the national unit of account, which is a direct liability of the central bank” (Bank for International Settlements BIS, 2020).² A CBDC can be designed for *retail* (i.e., general purpose) use, which would function as a digital banknote for use throughout a population, or for *wholesale* use, which would be made available to eligible financial institutions only “for use in wholesale payment and settlement systems”.

CBDCs have now become a focus of global attention, with the Atlantic Council Report (2023) reporting that 130 countries—together representing 98 percent of global GDP—are investigating their own form of CBDC. While some countries, such as the United States, are still in the exploratory stage, others such as Australia are conducting or have completed pilots (Atlantic Council Report, 2023). Meanwhile, China has already conducted 1.8 trillion yuan (\$249.9 billion) worth of CBDC

transactions in its trial (Wee, 2023), and others including Nigeria and the Bahamas have officially launched CBDCs—so far with mixed results (Atlantic Council Report, 2023).

This paper discusses some opportunities and challenges associated with the development of CBDCs. First, it looks at some of the potential benefits and risks of CBDCs. Second, it briefly analyses some of the proposed regulations of CBDCs in the United States and the European Union. Third, it discusses the CBDC landscape in Asia. Then it provides an overview of the research findings of articles that are part of this special issue on FinTech and CBDCs. It then discusses potential research directions in the design of CBDCs and their uses, debate over the merits of decentralized or centralized finance ('DeFi' versus 'CeFi'), along with the interoperability and stability of CBDC, and cybercrime concerns, before concluding that there is no one-size-fits-all approach to its development.

2. Potential benefits and risks of CBDC

2.1. Benefits

While global interest in CBDCs is significant, central banks are exploring them for a range of different reasons (Boar et al., 2020). The Bank for International Settlements has identified a number of separate motivations (Bank for International Settlements BIS, 2023a), which include:

² Although this definition could be understood to include traditional central bank reserves or settlement accounts held by financial institutions with the central bank, it is important to note that CBDCs are a “new form of digital central bank money” (BIS 2022a).

- “Increasing financial inclusion, or more generally, broadening access to the financial system to serve the unbanked and under-banked population.
- Extending public access to safe central bank money (as opposed to private digital currencies).
- Safely meeting future needs and demands for payment services, including ensuring competition, data privacy and the integrity of the payment system.
- Reducing costs and improving access to domestic and cross-border payments.
- Contingency planning in case cash use suddenly declines or a private digital currency is widely adopted.
- Countering tax evasion and criminal uses of currency.
- Avoiding currency substitution and preparing for potential competition from other CBDCs.
- Creating a payment foundation to better support innovation (e.g., smart contracts, internet of things).³
- Facilitating the distribution of central bank money and government benefits, particularly in remote areas.”⁴

While each central bank has its own objectives, [Kosse and Mattei \(2023\)](#) note that the motives of advanced economies (AEs) and emerging market and developing economies (EMDEs) in considering retail CBDCs “are converging” over time. “Over the years, domestic payments efficiency and payments safety have become nearly equally important as motivations in both AEs and EMDEs. AE and EMDE central banks also attach about the same weight to the financial stability and cross-border payments efficiency reasons.”

In the case of wholesale CBDC, central banks are driven mainly “by the desire to enhance cross-border payments,” both in advanced economies and in emerging market and developing economies. In October 2020, the Group of Twenty (G20) declared the enhancement of cross-border payments a priority, given their high cost, slow speeds, poor transparency, and declining accessibility ([Financial Stability Board \(FSB\) \(FSB\), 2023](#)). Since then, several central banks have begun to work together on projects using CBDC to improve cross-border payments. As reported by the [Bank for International Settlements BIS \(2023a\)](#), an example is Project mBridge, a joint initiative of the BIS Innovation Hub, Hong Kong Monetary Authority, Central Bank of the United Arab Emirates, Digital Currency Institute of the People’s Bank of China, and Bank of Thailand. Project mBridge explored how the development of a common platform for multi-CBDCs could improve the speed, cost, and safety of cross-border payments ([Bank for International Settlements BIS, 2023a](#)).

A wholesale CBDC could provide several benefits for cross-border payments by increasing the operating hours of current payment systems (e.g., by making CBDC infrastructures available 24/7 to overcome mismatches in the operating hours across different jurisdictions), shortening the length of payment chains, and improving the efficiency of compliance checks. Studies on issues related to wholesale CBDC include [Bank for International Settlements BIS \(2021a, 2023b\)](#), [Richards and Furche \(2022\)](#), and [Kosse and Mattei \(2023\)](#). More generally, [Cong and Mayer \(2022\)](#) discusses countries’ strategic incentives to introduce

³ CBDC has the potential to facilitate “programmable payments” or “purpose-bound money” which, in the retail context, “enables senders to specify conditions, such as validity period and types of shops, when making transfers in [CBDC]” ([MAS, 2023](#)). Similarly, in the wholesale context, CBDCs can also enable the use of smart contracts that facilitate “conditional payments, to hold funds and to release payment upon the fulfilment of pre-defined conditions—for example, with payment-versus-payment (PvP) and delivery-versus-payment (DvP) transactions” ([BIS, 2022b: 10](#)).

⁴ Note that a number of central banks are experimenting with the development of CBDC with offline functionality, which would ensure people could continue to make payments in CBDC even without internet connection ([BIS, 2023a, 2023b](#)).

CBDCs amidst global currency competitions.

2.2. Risks

Although CBDCs offer a number of benefits, as with any innovation, they also present risks—especially in the retail context. As [Bank for International Settlements BIS \(2023a\)](#) states, chief among them are risks of financial instability related to disintermediation and balancing privacy and financial crime concerns. And central banks are considering a range of design choices to mitigate the many risks emanating from the operation of a CBDC, such as operational, technology, third-party, and legal risks. Importantly, there is no standard design for a CBDC.

2.2.1. Financial stability risk

The risk of bank disintermediation (due to less deposit funding)—and the resultant reduction in the availability of bank credit, as pointed out by [Infante et al. \(2023\)](#)—is often raised in discussions about retail CBDC. However, this risk can be minimized through the CBDC architecture choice, opting for a *hybrid model*, which is a two-tiered retail CBDC model where intermediaries onboard clients, performing compliance checks and managing customer payments in real time, with the central bank’s role limited to recording retail balances periodically). The *hybrid model* contrasts with a *direct model*, which is “a single-tier retail CBDC in which the central bank directly handles all payments by the public and enterprises, and keeps all records of direct retail holdings by participants in real time” ([Bank for International Settlements BIS, 2023a](#)).

It can also be minimized through the design of the CBDC itself, for instance, by developing safeguards that support as the [Bank for International Settlements BIS \(2021b\)](#) highlights, the CBDC to function as “primarily as a means of payment rather than a store of value”. That paper also states: “Central banks might consider measures to influence or control CBDC adoption or use. This could include measures such as *access criteria for permitted users, limits on individuals’ CBDC holdings or transactions, and particular choices around CBDC remuneration*.”

Ultimately, the initial BIS judged that “the impacts [of CBDC] on bank disintermediation and lending could be manageable for the banking sector” ([Bank for International Settlements BIS, 2021b](#)). Although its analysis suggested that “a significant shift from bank deposits into CBDCs (or even into certain new forms of privately issued digital money) could have implications for lending and intermediation by the banking sector”, it also noted that “these impacts would likely be limited for many plausible levels of CBDC take-up, if the system had the time and flexibility to adjust” ([Bank for International Settlements BIS, 2021b](#)). As a study reported by [Canepa \(2023\)](#) highlights, a variety of options can be taken to support this; for example, the digital euro is likely to impose a cap of 3,000 euros (about \$3,250) as a store-of-value to minimize the risk of bank disintermediation.

[Lukonga \(2023\)](#) pointed out that another notable concern for emerging market and developing economies is the risk of dollarization or currency substitution through CBDCs. While this has potential to destabilize economies, the risk to monetary sovereignty can be managed—as discussed, for example, by [Auer et al. \(2021\)](#)—through cooperation between countries that leads to geographic controls on CBDC.

2.2.2. Privacy and financial crime: trade-off in risks

Central banks developing CBDCs are presented with a trade-off between managing user privacy and monitoring transactions to ensure compliance with laws on Anti-Money Laundering and Counter-Terrorism Financing (AML/CFT). An IMF report, authored by [Soderberg et al. \(2022\)](#), explains this tension: “Anonymity is one of the key traits of cash, and the rise of digital payments threatens the lawful or legitimate preference for anonymity by certain segments of the public or for certain purposes—such as buying a present for one’s spouse. Anonymity is also connected to financial inclusion: non-anonymous payment services often require forms of identifications that can be difficult

or costly to obtain. However, anonymity can also be used for illicit purposes and can undermine AML/CFT measures. Anonymity, therefore, poses a policy trade-off—the more anonymity, the larger the risk for illicit use.”

While this is ultimately a policy question for those developing CBDCs, several experiments have explored CBDC design choices that could balance these competing priorities (World Economic Forum, 2021). One solution explored by a number of CBDC projects has been “to provide a tiered selection of wallets with different levels of thresholds [of monetary value], according to Soderberg (2022). The report goes on to say that lower thresholds allow for greater anonymity, and that “[a]s a result, CBDC can more easily be rolled out into rural or disadvantaged areas where virtual identification can be difficult. The use of tiered CBDC wallets thus gives rise to ‘policy synergies’ between anonymity, risk-reduction (of bank runs), and financial inclusion.”

CBDCs also present an opportunity for authorities to develop innovative ways of monitoring illicit transactions while protecting user privacy, more so than current blockchain-based platforms. Crypto-enabled cybercrimes such as frauds and ransomware attacks are rampant (Cong et al., 2023). In comparison, for example, a World Economic Forum report (World Economic Forum, 2021) states: “Depending on the choices made, CBDC could enable appropriate regulatory entities to develop a topographical view of aggregated monetary flows and more effectively identify suspicious outlier transactions. This could be achieved in an aggregated way, by utilizing techniques (e.g., differential privacy) that would protect the privacy of individuals while providing the appropriate tools to regulators.”

2.2.3. Technology and operational risk

Central banks that issue a CBDC must prepare for the significant technology and operational risks that come with providing central bank money in digital form. A recent report by the Bank for International Settlements Consultative Group on Risk Management (2023) made the following finding: “For CBDCs to be a reliable means of payment, central banks should address the risks of interruptions or disruptions and ensure integrity and confidentiality. This requires the development of robust business continuity plans to ensure the reliability and continuity of services based on possible scenarios and threats, throughout the full (digital) currency cycle. CBDCs using novel technologies such as distributed ledger technology (DLT) will face unique cyber risks, as there is no widely accepted cyber security framework for DLT. Furthermore, real world data pertaining to threats to CBDCs, regardless of the type of technology they use. Accordingly, managing risks associated with CBDC issuance may require adapting existing cyber security assessment methodologies and frameworks to this unfamiliar landscape.”

Project Polaris is a BIS initiative developing a security and resilience framework to “guide central banks in designing, implementing and operating secure and resilient CBDC systems to mitigate the operational, legal and reputational risks facing central banks from cyber threats or operational failures” (Bank for International Settlements Innovation Hub, 2023). The project emphasizes the importance of doing this work early, given that: “A breach of a CBDC system due to cyber-attacks or technical failures could erode confidence and trust in the CBDC system, the central bank, and the financial system, in addition to generating a range of reputational, operational and legal impacts.” And it goes on to say that “Retail CBDC systems must be highly secure and resilient. Central banks are at various stages of their work on retail CBDC, and as this progresses it is important that security and resilience be considered at the earliest possible stage.”

3. Proposed regulation of CBDCs

While countries across the world are at different stages of CBDC development, there is consensus that CBDCs must be subject to regulation to manage their potential risks. This section provides an overview of literature on regulation in the United States and the European Union,

were these jurisdictions to decide to issue one.

3.1. The United States

The United States is still in the early stages of CBDC experimentation relative to other countries, according to Atlantic Council Report (2023). In September 2023, as reported by Schroeder (2023), the Federal Reserve’s Chair for Supervision, Michael Bar, confirmed that the Federal Reserve is investigating a CBDC but is “a long way” from any decision and will only proceed with issuing a digital dollar with “clear support” from Congress. This assessment is shared by some researchers: for example, Mack (2022) suggests that “[t]he current legislative framework does not allow the government to issue and create another form of currency.”

The United States is, however, exploring both retail and wholesale CBDCs. On the retail side, the Federal Reserve Bank of Boston has collaborated with the Massachusetts Institute of Technology on Project Hamilton, which demonstrated the potential for retail CBDC use at scale. Phase 2 of Project Hamilton is under way and, as reported by the Federal Reserve Bank of Boston (2022), will explore “cryptographic designs for privacy and auditability, programmability and smart contracts, offline payments, secure issuance and redemption, new use cases and access models, techniques for maintaining open access while protecting against denial of service attacks, and new tools for enacting policy.”

On the wholesale side, the Federal Reserve Bank of New York (NY Fed) is collaborating with the Monetary Authority of Singapore (MAS) on Project Cedar Phase II x Ubin+, to examine whether wholesale CBDC “developed using distributed ledger technology (DLT) could improve the efficiency and transparency of cross-border payments involving one or more vehicle currencies” (Monetary Authority of Singapore MAS, 2023).

In November 2022, Michelle Neal, the Executive Vice President and Head of Markets of the NY Fed, stated: “A US CBDC—a digital form of the US dollar that is a direct liability of the Federal Reserve—has the potential to offer significant benefits. A CBDC would need to protect against cyber and operational risks, safeguard the privacy of sensitive data, and minimize risks of illicit financial transactions. Additionally, as discussed by Neal (2022), one of the most important aspects in our deliberations is that any form of a CBDC in the future would need to be intermediated. This means that the private sector would need to act as intermediaries in that system, and a direct account approach would not be contemplated.”

Much literature has considered how regulation could help tackle these challenges. For instance, Schwarcz (2022) explains how Article 4 A of the Uniform Commercial Code (UCC), which addresses the risk of loss and counterfeiting, as well as other laws which focus on privacy, money laundering, and consumer protection could be applied to regulate retail and wholesale CBDCs in the United States. Given that US laws govern non-digital forms of money, Schwarcz (2022) provides examples of how regulations could be adapted to accommodate CBDCs, including AML laws.

This is reinforced by Executive Order (EO) 14067, which can be found in a Report from The White House (2022). This EO directs the Office of Science and Technology Policy to produce a technical evaluation to facilitate and support the introduction of a CBDC system in the United States if one is proposed. It states: “The CBDC system should promote compliance with AML/CFT requirements and mitigate illicit finance risks. The CBDC system should be designed to facilitate compliance with anti-money laundering (AML) and combating the financing of terrorism (CFT) requirements, as well as relevant sanctions obligations.”

3.2. The European Union

In October 2023, the European Union completed its two-year investigation phase, which considered the potential design and distribution of a digital euro, and has since progressed to the preparation

phase of the project. This will involve, as highlighted by (European Central Bank, 2023a): “finalising the digital euro rulebook and selecting providers that could develop a digital euro platform and infrastructure,” as well as “testing and experimentation to develop a digital euro that meets both the Eurosystem’s requirements and user needs, for example in terms of user experience, privacy, financial inclusion and environmental footprint.”

The European Central Bank expects this phase to last two years, after which the Governing Council will decide whether to proceed to the next stage for the possible issuance of a digital euro.

The European Commission (2023a) has released a ‘Single Currency Package’, which proposes taking the following steps to regulate a digital euro, were one to be issued.

- **Legal status and role of a digital euro:** As a part of the ‘Single Currency Package’, the *Proposal for a Regulation of the European Parliament and of the Council on the Establishment of a Digital Euro* has the stated objective of ensuring “that central bank money with the status of legal tender remains available to the general public, while offering a state-of-the-art and cost-efficient payment means, ensuring a high level of privacy in digital payments, maintaining financial stability and promoting accessibility and financial inclusion” (European Commission 2023b).

This means that a digital euro will be given the status of legal tender, “with an obligation for all payees to accept it, though with justified and proportional exceptions”, such as for microenterprises or not-for-profit enterprises (European Commission 2023b). However, the proposal further states that the digital euro is mainly intended as a means of payment rather than as a store of value, and provides that the ECB “should develop instruments to limit the use of the digital euro as a store of value, including holding limits” (European Commission 2023b). These limits will also assist in addressing possible risks posed to financial stability.

The proposal further provides that a digital euro will be equipped with online and offline functionality and will not be “programmable money” (European Commission 2023b). Payments made in digital euros will benefit from instantaneous settlement, whether online (where final settlement shall occur at the moment of recording the transfer of the digital euros concerned from the payer to the payee in the digital euro infrastructure) or offline (where final settlement shall occur “at the moment when the records of the digital euro holdings concerned in the local storage devices of the payer and payee are updated”).

Similar to the United States, a CBDC will not be issued in the EU without legislative approval, though the legislative process is ongoing and could result in a vote being taken following the EU elections in June 2024 (European Commission 2023a).

- **Role of payment service providers (PSPs):** The proposal provides for PSPs to provide digital euro payment services, such as enabling access to and use of the digital euro, enabling digital euro payments to be made and received and managing digital euro payment accounts.
- **Interaction with the broader payments framework:** The proposal aligns with existing payment, AML, and data privacy regimes.
- **Data privacy and AML/CTF compliance:** The proposal sets out when and how PSPs, the ECB, and central banks may process different categories of personal data. It also seeks to balance user privacy with the need for transaction monitoring by distinguishing between data requirements for “online” digital euro transactions (i.e., where settlement takes place using the digital euro settlement infrastructure) and “offline” digital euro transactions (i.e., where payments take place using the payee and payers local devices).
- **Geographic limits on use:** The proposal establishes that the digital euro would primarily be available and have legal tender status within, and for obligations to payees living in, the euro area. It sets out how distributions of the digital euro could apply outside of the

euro area (in and out of the EU), which includes restrictions on PSPs distributing the digital euro outside the eurozone subject to arrangements that provide necessary cooperation and oversight.

4. The CBDC landscape in Asia

An IMF survey, Jahan et al. (2022), found that 83.4% of central banks in the Asia and Pacific region are working on CBDC projects in varying formats and stages of research, proofs of concept, or pilots. In addition, the IMF identifies countries in Asia and the Pacific as at the forefront of digital innovation, making CBDCs their natural next step of interest. One reason could be CBDCs ability to promote financial inclusion and financial stability for countries across the region, especially middle-income countries.

According to the Atlantic Council’s CBDC Tracker, out of 130 countries, 19 Asian economies have moved beyond the research stage for CBDCs, with 13 economies progressing further into the pilot stage. Most Asian economies that are seriously exploring CBDC consider both retail and wholesale uses. Application of CBDCs can span from retail payments to wholesale infrastructure for clearing and settlement, as well as to both retail and wholesale cross-border payments. Some country examples follow:

4.1. China

The People’s Bank of China (PBOC) was one of the first among major economy central banks to move on as CBDC, launching its project in 2016. China had successful private sector experiences of digitizing payments with FinTech wallets spurred by upgrade to the PBOC’s interbank payment system in 2010. Subsequent upgrades in financial infrastructure and better government oversight improved interoperability across different FinTech platforms as well as between banks and FinTech wallets. In this context, the PBOC has been one of the most active central banks exploring potential opportunities for CBDC.

While the eCNY digital currency is still in the pilot stage, its outstanding amount reached 13.6 billion yuan (\$2 billion) at the end of December 2023, according to PBOC data. The eCNY features a hybrid operational system intermediated in two layers. First, users can exchange traditional currency for the eCNY at designated banks. Second, they can use eCNY for transaction with digital wallets. This two-tier operational system is designed to avoid disintermediating banks. The eCNY deepens financial inclusion by enabling people without bank accounts to make payments and offering those living in areas without consistent internet access or mobile devices the means to pay offline.

The eCNY potentially enhances financial inclusion by enabling payments for people without bank accounts and offering offline payments for those living in areas without consistent internet access and mobile devices for payments. That said, adoption has been underwhelming partially due to the presence of well-developed e-wallet ecosystems (Bian, Cong, and Ji, 2023).

4.2. India

India started a pilot for wholesale CBDC in November 2022 and another for retail CBDC in December 2022. The Reserve Bank of India (RBI) noted that CBDC will help facilitate the transition to digital economy, reduce cash demand and its related costs, increase payment efficiency, and promote financial inclusion. RBI is also hoping to design CBDC to be interoperable to enable cross-border payment and transactions.

4.3. Indonesia

Bank Indonesia launched Project Garuda in December 2022 to develop the design and framework for the Indonesian CBDC, or Digital Rupiah. It expects that Digital Rupiah as a legal tender will complement

banknotes and coins. It also wants to use Digital Rupiah to support the country's digital transformation and to participate in the international development of CBDCs for cross-border payments. Finally, it anticipates that CBDC can accelerate integration of the digital economy and the financial system, expanding financial inclusion and innovation (Bank of Indonesia, 2022).

4.4. CBDC in Asia: Opportunities and challenges

Developing economies tend to be interested in CBDC's role in financial development and inclusion, whereas more middle-income economies have explored opportunities for efficiency and productivity gains by lowering business costs and facilitating digital transition and cross-border payments. CBDCs can also help address concerns about money laundering and terrorism financing often associated with private cryptocurrencies. A major push has taken place across Asia to build digital payments to support the real economy. In the earlier stage, some initiatives considered standardized QR codes for payments connected to central bank payment systems. A client links a digital wallet to her bank account and then scan a QR code to draw money out of her account.

Governments can be involved in different levels of service in the payments infrastructure that enables retail payments, from digital identify to running an interoperable digital payment platform. For example, D'Silva et al. (2019) report that in India the government spearheaded the creation and adoption of the Aadhaar digital ID card and launched the state-backed digital payments platform, the Unified Payments Interface (UPI) in 2016, which allows users to transfer money between bank accounts using a mobile app. Central Bank of Sri Lanka created LANKAQR, a national QR-code based payment system for users to pay merchants directly through their bank account using payment apps. The National Bank of Cambodia launched the blockchain-based nationwide Bakong payment system, which offers a peer-to-peer fund transfer service for financial service providers to serve individual users.

Some governments have moved toward cross-border digital payment systems using a CBDC with interoperability. While the PBOC describes the eCNY as mainly a domestic project, it is one of the most active central banks in cross-border CBDC payment pilots. For example, the PBOC is a partner in Project mBridge, together with the BIS and central banks including the Bank of Thailand, Hong Kong Monetary Authority, (HKMA), and Central Bank of the United Arab Emirates. Project mBridge explores the potential of using blockchain to create a common platform for cross-border payments (Bank for International Settlements Innovation Hub, 2023). BIS also works in Project Dunbar with the central banks of Australia, Malaysia, Singapore, and South Africa to explore potential for using CBDCs in cross-border wholesale payments. Cambodia's Bakong system also added a cross-border service enabling Cambodians working in Malaysia to transfer money back home digitally. About half of Cambodia's population had used Bakong by November 2021 (Jahan et al., 2022).

Experiments of multi-CBDC projects involving central banks in Asia generally focus on cross-border payments. Project Stella is a joint research project of the Bank of Japan and ECB to explore ways of using distributed ledger technology to improve cross-border payments. Project mBridge also explores distributed ledger technology to facilitate cross-border payment and foreign exchange transactions (Bank for International Settlements Innovation Hub, 2022). Whereas Project Stella is research in nature, Project mBridge has the ambition to offer a new architecture for central banks and commercial banks to operate cross-border payments using CBDCs.

5. Overview of research papers in this special issue

The paper entitled "How do Private Digital Currencies Affect Government Policy?" by Raskin et al. (2024) develops a model of an economy in which the government maximizes personal welfare. The study establishes that a private digital currency can enhance local investment

and citizen welfare. It also establishes that a private digital currency can enhance government welfare and that the government may optimally set a permissive digital currency regulatory policy.

The paper entitled "A Simple Model of a Central Bank Digital Currency", by Mishra and Prasad (2024) develops a model highlighting key differences between cash and retail CBDC. It establishes the conditions under which cash and CBDC can co-exist. It analyses policies that affect relative holdings of CBDC, cash, and other assets. It shows how a CBDC can expand the monetary policy toolkit and improve welfare. It demonstrates that CBDCs enable negative nominal interest rates and helicopter drops of money.

The paper entitled "The Impact of Fintech Lending on Credit Access for U.S. Small Businesses" by Cornelli et al., (2024) discusses the fact that small businesses play an important role in fostering local economic growth and the overall GDP, but they often lack funding due to their lack of established financial records. This study argues that fintech lenders could potentially leverage alternative data and complex modelling to identify small businesses that are good borrowers although they may be opaque due to their short credit history. The empirical results of the paper show that fintech small business lending (SBL) platforms lend relatively more in areas that are more in need for SBL funding, such as in zip codes with higher unemployment rates and higher business bankruptcy filings. The paper finds that fintech lenders could potentially help close the credit gap, allowing small businesses that were less likely to receive credit through traditional lenders to access credit and potentially at a lower cost.

The paper entitled "How do machine learning and non-traditional data affect credit scoring?" by Gambacorta et al. (2024) provides new evidence from a Chinese fintech firm and compares the predictive power of machine learning and traditional credit models. It analyses data during normal and stress periods. The research shows that machine learning models outperform other models, especially during negative shocks. The paper concludes that such empirical findings demonstrate the machine learning's ability to detect non-linear patterns in stressful times.

The paper "Are ICOs the best? A comparison of different fundraising models in blockchain-based fundraising" by Sun and Yang (2024) shows that different fundraising models differ in fundraising success and token performance. The paper argues that factors affecting fundraising success and token performance vary across models. The empirical results show that Initial DEX Offerings have fast liquidity in the short term, Initial Exchange Offerings perform better in the long term and Initial Coin Offerings have no clear advantages compared to other models.

The paper entitled "Decentralization illusion in Decentralized Finance: Evidence from tokenized voting in MakerDAO polls" by Sun et al. (2024) shows that governance in Decentralized Finance (DeFi) is highly centralized. Governance centralization exerts complicated influences on DeFi protocols and DeFi investors face a trade-off between decentralization and protocol's performance.

The paper entitled "Digital Payments and Bank Competition" by Marianne Verdier (2024) examines how competition between banks and a digital PSP impacts the lending rate and the consumers' use of payment instruments. The digital PSP offers digital wallet and payment services but does not offer credit. In contrast, banks invest their deposits in lending activities, which implies that they may incur some costs of adjusting their liquidity needs when consumers make payments. The author shows that the adoption of the digital wallet for payments may sometimes increase the volume of payments by bank deposit transfers and the lending rate. This results from banks' trade-off between lowering their costs of liquidity when consumers pay from their digital wallet and reducing the revenues they receive from bank transfer fees.

The paper entitled "Volatile Safe-Haven Asset" by Yae and Tian (2024) highlights the fact that Bitcoin is known to offer diversification benefits through its relatively low correlation with stock markets. Unlike traditional safe-haven assets, Bitcoin is highly sensitive to time-varying correlations and diversification benefits. The authors find that a

decrease (an increase) in correlation between the price of Bitcoin and S&P500 index strongly predicts higher (lower) Bitcoin returns the next day. Under the classical mean-variance framework, the paper develops a stylized model of Bitcoin prices utilizing extreme disagreement among heterogeneous Bitcoin investors. When the model is calibrated to Bitcoin's predictability results, it simultaneously explains the lack of predictability in gold and long-term treasuries.

The paper entitled "The Impact of CBDC on a Deposit-dependent Banking System" by Steffen Vollmar and Wening (2024) examines implications of a CBDC for banks using business models particularly dependent on customer deposits. Employing unique customer data hand-collected from German savings and cooperative banks, the authors can generate conversion rates for deposits into a CBDC. The paper shows that even at moderate conversion rates, most banks would have experienced funding problems and lost profits if a CBDC had been introduced in most years from 2000 onward. The empirical results are relevant for commercial banks, contributing to better assessments of the impact of CBDCs on liquidity and profitability and help central banks to identify implementation costs for banks within historical and hypothetical interest rate environments.

6. Some research directions

This section provides some potential future research directions. At the same time, these suggestions come with caveats. For one, it should be noted that the relevant literature is evolving rapidly, spearheaded by significant efforts and research by the BIS and various central banks around the world, as they explore the potential benefits and risks of CBDCs. One also needs to be mindful that many interconnected economic, financial, social, and political factors could influence the pace and nature of the evolution of CBDCs.

6.1. Potential research into CBDC design

An aspect crucial to a CBDC is its design and how that design influences its use. But that does not mean that the degree of use is the best measure of success. As Ulrich Bindseil, head of payments at the ECB, has phrased it in the case for an ECB-issued CBDC: the digital euro should be "successful but not too successful" (Orchard, 2023). Typically, this means that on the one hand, the public should use the CBDC to such a degree that it serves a role as a general means of payment. Why else introduce a CBDC as, say, the digital alternative to cash which serves that role today?

Significant usage will also help justify the large implementation costs (e.g., the introduction of a CBDC would require building and maintaining a large-scale, resource-intensive central bank infrastructure). At the same time, one would not want the success of a CBDC to drive out all other payment instruments or result in households holding large portions of their money in the form of CBDC. A reduction of avenues for payment would reduce the valuable role of banks and other payment service providers when interfacing with customers and would put a large burden on the central bank in operating the CBDC infrastructure and system. And were households to hold most of their money as a CBDC this large transfer of bank deposits to CBDC holdings would result in a disintermediation of the banking system, which in turn would require the central bank to re-intermediate the CBDC into the financial system, giving it a large role in resource allocation. As such, like cash, a modest role with nevertheless a wide acceptance as the preferred way for a CBDC.

How to design the features of a CBDC so that it best balances this trade-off between too little and too much use and various other trade-offs is a complex undertaking. It requires insights into what factors drive the payments behavior of individuals (on the demand side), and the payment offerings of merchants (on the supply side). Why do individuals choose cash versus a bank deposit to pay at points of sale? When paying digital, how do they choose between using debit cards,

credit cards, or other means of payments such as Alipay, Apple Pay, Google Pay, and MasterPass)? What drives household payment choices in online and person to person (P2P) payments (e.g., using cash or bank transfers versus other means online and via related digital methods such as Venmo, PayPal PayU, 24 Transfers, DotPay)? When do households use fast payments systems (such as Twint, Swish, Pix, FedNow, and TIPS)?

Numerous factors likely matter in all these choices. Convenience is prominent, but also are factors like the interest rate on the balances used to pay with, points rewards or other benefits earned when using a specific payment method, legal or other requirements, as well as privacy desires and other social factors. And, since the payments market is two-sided, the availability of merchants and individuals accepting the specific payment means used, as well as the associated fees, are obviously key supply-side factors: Why do merchants choose to offer a particular tool, including checks? Is it largely about cost or do other factors play a role?

Answers to these questions are complex in theory and even more so in practice, since what drives the payments choices of payees and payors is not well-known. Note that we are not referring here to research on general savings or portfolio choice behavior, say in response to inflation or interest rates, is much more plentiful. But more work is needed specifically on the choice of payments modalities. By now many theoretical models that include a CBDC must often rely on many assumptions which still need to be empirically established.

On the demand side, most relevant research to date comes from surveys asking households about what affects their payment choices. This work generally shows that a complex and diverse set of factors influences consumer choices. The list of relevant variables is long.⁵ And while the factors driving the well-documented decline in the use of cash—which undoubtedly include digitalization—are relevant, the decline is not universal in its speed (Glowka, Kosse, and Szemere, 2023). This suggests that the significant roles for country and other (cultural) factors in the choice of payment methods are not all well known. Research so far shows that variations in consumers' choice about the means of payment exist for very good reasons, but few papers provide enough insight on what drives the specific preferences of households. (Banks and other payment providers have done much work on this, but little of it is in the public domain.)

On privacy, besides some theoretical work on its important role (e.g., Garratt and van Oordt, 2021), few papers assess quantitatively its importance in choice of payment. Furthermore, only some published studies control fully for all variables. Few studies use randomized controlled experiments, whether in a real world or laboratory setting, that can control for other factors. Such studies can also be used to assess general equilibrium effects. An example is a field experiment by Alvarez and Argente (2020) which reveals that the average cost of a ride for Uber customers in Mexico would rise by 50 percent if they were not permitted to use cash as a payment method.

What drives the range of available means of payments is important too. On the supply side, the circumstances behind the choice of various payments that merchants permit customers to use is not well known either. Merchant surveys are scarcer because it is more difficult to recruit merchants to participate in surveys. Costs nevertheless matter, which shows up in some merchants not taking payment by credit card or rejecting cards with high costs. There is of course a role for legal and

⁵ For example, Bagnall et al. (2016), based on a survey of consumer payments in seven advanced economies showed that the use of cash is strongly correlated with the amount of transactions, demographic data, and characteristics of the point of sale, such as acceptance of the buyer's card and the place of execution. Others have shown that payment instruments' characteristics, such as security, convenience, costs, and speed, are important choice criteria. Studies like Stavins (2018) and Coletti et al. (2022) document that consumer preferences correlate with demographic and income attributes, and vary by the value and type of transaction.

other regulatory requirements. These in some jurisdictions force merchants to always accept cash and/or to not differentiate in pricing between various payment means.⁶

It is also challenging to analyze the feedback effects between the two sides of a payment system. There is the obvious endogeneity in card acceptance in that consumers' choice of vendors may depend on the payments means they have on hand. Factors influencing the acceptance of various new payments means are even less known. Arifovic et al. (2023), in a laboratory experiment with a two-sided market, find evidence that learning provides a good characterization of dynamic adjustment in payments. However, what that means in practice to be defined, including as to the (legal) obligation of financial institutions to offer CBDC and of merchants to accept it.⁷

Not knowing the relative importance of these various factors makes CBDC design complicated and its use case less clear. These significant knowledge gaps leave a rich research agenda. More fundamentally, how CBDC systems compare and contrast with other electronic payment systems (e.g., Cong et al., 2024), also informs us why we need CBDCs and how to best design them.

6.2. Potential research into 'CeFi' versus 'DeFi'

There is a clear consensus that CBDCs fall within the realm of centralized finance (CeFi). At the same time, decentralized finance (DeFi) has gained increasing prevalence in recent years, given its promise by making products offered through traditional finance (TradFi) cheaper and easier to access through decentralized technologies that reduce (or potentially remove) the need for trusted intermediaries (Weingärtner et al., 2023). However, the term 'DeFi' lacks a clear definition (Schuler et al., 2024). As the International Organization of Securities Commissions IOSCO (2022) explains, "Currently, there is no generally accepted definition of 'DeFi', or what makes a product, service, arrangement or activity 'decentralized'." A helpful overview of its main features is provided in Xu and Xu (2022), which states that "DeFi's key features are generally recognized to be *open to anyone*, *transparent*, *non-custodial*, and *composable*, i.e., financial services can be arbitrarily composed to make new financial products."

Given confusion about what constitutes DeFi, it is often used as a synonym for blockchain-based financial services (Rossi, 2022). There is strong evidence that projects commonly categorized as DeFi are less decentralized than they appear (Schuler et al., 2024). This is because DeFi is confused with CeFi, which can also use blockchain-based financial protocols but offers centralized and custodial financial services rather than being built as "independent, neutral infrastructure."

In light of this, it is helpful to consider the purpose of DeFi in greater detail based on the definition of Auer et al. (2023): "DeFi is a new financial paradigm that leverages distributed ledger technologies to offer services such as lending, investing, or exchanging cryptoassets without relying on a traditional centralized intermediary. A range of DeFi protocols implements these services as a suite of smart contracts, i.e., software programs that encode the logic of conventional financial operations. Instead of transacting with a counterparty, DeFi users thus interact with software programs that pool the resources of other DeFi users to maintain control over their funds."

⁶ Some work (Agarwal et al., 2023) suggests that such requirements can be regressive in that those who pay in cash end up paying more as the cash price reflects the fee structure that applies to credit cards, and in that way leads to annual redistribution of some \$15 billion from less to more educated and poorer to richer.

⁷ Quoting again Bindseil as an example in the case of a euro CBDC: "It should be widely accessible. That's in line with the digital euro legislation. All euro area payment service providers should offer it—every bank should offer it, every non-bank payment service provider (PSP) in this business should offer it, and also all euro area merchants should accept it through an effective legal tender provision" (Atkins, 2023).

It is understood that in order to realize the full potential of DeFi, further research is needed across several areas. As Ozili (2022) highlights, examples include: "investigating how [CeFi] and [DeFi] can coexist together; understanding the implication of [DeFi] for financial system stability; developing a single one-size-fits-all regulatory framework for all types of digital financial innovations; finding innovative ways to eliminate the risks inherent in DeFi investing; and providing liquidity guarantees for smart contracts."

One especially interesting question is whether a CBDC can facilitate DeFi. Some argue that stablecoins—cryptocurrencies whose value is pegged to another currency, commodity, or financial instrument—are one of the main building blocks of DeFi, and have come under regulatory scrutiny for posing a significant risk to financial stability, among other risks. As Aramonte, Huang, and Schrimpf (2021) explain: "These risks are compounded by the fact that users treat stablecoins as a medium of exchange, although they are neither central bank money nor commercial bank money [...] as a better substitute for stablecoins, which are privately issued, central bank digital currencies (CBDCs) could support fund transfers with greater efficiency and safety."

It is still unclear whether CBDCs will be used successfully to support DeFi and so improve one of the main concerns around its safety and viability.

The perspective that a CBDC is a form of CeFi often puts it in opposition to the principles of DeFi, in the view of blockchain technology enthusiasts. It is crucial to understand that the pursuit of decentralization comes with its own costs and complexities. Advocating for decentralization without purpose serves only ideologists and hardline supporters. Economists are tasked with assessing the pros and cons of such approaches. To achieve meaningful expansion, blockchain and cryptocurrency must develop a reliable and scalable infrastructure like that of the Internet, to support a wide array of economic functions.

An anticipated result of the simultaneous evolution of CeFi, DeFi, and TradFi is the emergence of a network that effectively merges elements from each. Therefore, addressing the scalability challenges of blockchain technology, potentially through measures of localized centralization, remains a significant topic for discussion. Developers are diligently exploring solutions, such as Layer-2 technologies, and the need for more economic research in this area is clear. Furthermore, the development of Web3 reputation systems, moving past basic theoretical discussions, is an area ripe for economist intervention, especially considering the extensive body of academic work in ratings, reputation, and contract theory. Also, economic scrutiny is required for blockchain systems that support confidential Automated Market Makers on decentralized exchanges (AMM-based DEXes), particularly in addressing challenges like the 'sandwich attack'.

6.3. Potential research related to 'Interoperability and Stability'

Interoperability has a range of meanings depending on the context in which it is used. Considering CBDCs and payment systems, interoperability, as stated by Boar et al. (2021) refers to "technical, semantic and business system compatibility" between systems that enables "end users [to] seamlessly transact with each other across systems." According to Boar et al. (2021), payment system interoperability must be achieved at three levels: *business interoperability* ("systems agree on rights and obligations, such as who can access the platform, when and how to clear and settle obligations among payment systems, and how to address risks of payment failures"), *technical interoperability* ("systems speak and understand the same language so that data and information are interpreted uniformly and consistently across systems"), and finally *semantic interoperability* ("systems implement the same technical standards, such as message formats and data infrastructures, so that their hardware and software infrastructures can be connected directly").

According to the Bank for International Settlements (Bank for International Settlements Innovation Hub, 2022), interoperability is considered very important for CBDCs with cross-border

applications, in uses ranging from remittances to international trade, and central banks are collaborating on experiments to find solutions.

In the context of FinTech and digital assets, interoperability, as stated by the World Economic Forum, refers to “the ability for computer systems to exchange and make use of information” which enables the “transfer of an asset between two or more systems while keeping state and uniqueness consistent” (World Economic Forum, 2023). Standards are being developed to assist developers and policy makers work toward the objective of widespread interoperability (World Economic Forum, 2023).

Further, it is important to note that these different forms of interoperability are *interlinked*. As Berg (2022) explains, research is being undertaken to understand how CBDCs “can interoperate with other CBDCs, private blockchains, and permissioned blockchains”. Infante et al. (2023), in a study similar to Azar et al. (2022), consider how interoperability to this level would affect financial stability. A successful launch would likely increase the interoperability between any new emergent digital payment systems and improve the soundness of DeFi networks by establishing and promulgating universal standards for interoperability.

For many FinTech applications to continue their growth, interoperability is crucial, and for CBDCs the involvement of both public and private sector participants is the ideal. Two questions that naturally arise are: how to best achieve interoperability while preserving security and privacy? And how does interoperability affect financial stability of the aggregate system? Much effort from computer science has been devoted to the first issue. Economists working on mechanism and information design can still contribute significantly.

The second issue of the aggregate effects of interoperability is understudied. One useful analogy is international economics: if we view digital networks and platforms as cyber countries, then the integration for value and information exchange becomes very similar to a country's integration into global organizations such as the World Trade Organization. Cong, Prasad, and Rabetti (2023) takes this perspective seriously and examines integration with oracle networks, which aggregate and feed information from and to a blockchain network. They find that interoperability seems to diversify risks and not increase systemic risks in the data. More comprehensive studies on other digital networks are needed to develop a more comprehensive understanding of the issues.

6.4. Potential research into ‘Cybercrimes and Stability’

Financial stability relies on the trust that individuals place in a financial system. The rise of FinTech introduces numerous regulatory challenges to this system. Confidence in investment and program participation is often weakened by a range of cybercrimes. As highlighted by Akartuna et al. (2022), criminals are exploiting the inadvertent security deficiencies in emerging technologies, such as cryptocurrencies, to launder funds or finance terrorism. Indeed, some consider that CBDCs will also risk increasing criminal activity.

However, work is being conducted to design a CBDC to ensure compliance with laws and regulations. According to the Bank for International Settlements BIS (2018): “Although a general purpose CBDC might be an alternative to cash in some situations, a central bank introducing such a CBDC would have to ensure the fulfilment of anti-money laundering and counter terrorism financing (AML/CFT) requirements, as well as satisfy the public policy requirements of other supervisory and tax regimes”. For example, Mu (2022) regards China's CBDC (the e-CNY) as “designed to maintain financial security by preventing money laundering and terrorist financing, tax evasion and other criminal acts” through its tiered wallet structure.

A pressing issue is how the approach of regulatory bodies toward blockchain-based entities (CeFi and DeFi) compares to traditional finance. While progress has been noted in some nations, the global landscape often exhibits vague or nonexistent crypto regulations. There is a debate where some advocate for activity-based rather than entity-

based regulation to ensure fair treatment across similar activities, while others suggest abolishing financial transactions on blockchain altogether.

Regardless, global regulators are involved in combating crypto market manipulations and cybercrimes, and are initiating other regulatory measures. Two research domains are becoming increasingly vital. The first involves developing tools for statistical analysis and blockchain forensics to address the sector's darker aspects and maintain market integrity. Studies in forensic accounting and finance, useful in traditional finance, are proving equally valuable in CeFi and DeFi, particularly for tackling crypto-related crimes and market manipulations. Some of these studies include works by Foley, Karlsen, and Putniņš (2019), Cong, Li, Tang, and Yang (2023), Cong et al. (2023), and Griffin and Kruger (2023).

The second research focus is on understanding economic incentives to predict outcomes and establish ‘intent’ in regulatory contexts, a topic addressed by many articles in this Special Issue. In a broader context, thorough economic research is essential to guide governments and help regulators create clear, protective frameworks against fraud and criminal activities, ensuring they do not overly inhibit innovation.

7. Conclusions

The issues discussed in this paper indicate that there is no one-size-fits-all approach to CBDC design. This variation also extends to outreach on and engagement of stakeholders for CBDCs. Different forms of engagement, such as bilateral exchanges, forums, and open consultations, should be utilized to engage stakeholder groups. Bilateral exchanges can help create awareness and understanding while gathering input and established forums can provide updates and practical insights, while open consultations can gather views from a broader range of industry professionals and the wider public. In addition, private sector innovation is crucial for the long-term success of any CBDC. Central banks may adopt different approaches in shaping and guiding private sector propositions for CBDC services and use cases. Some central banks may define a clear scope and practical use case, while others may allow the private sector to innovate within a set of principles and objectives. Moreover, legislators and authorities must remain engaged as work on developing CBDCs progresses.

A successful CBDC ecosystem should involve both the public and private sectors. National authorities can explore different CBDC business models to understand their potential benefits and risks to stakeholders and the public. Central banks also need to consider the optimal level of CBDC adoption required to achieve their public policy objectives. Some policy goals may be realized only if CBDC adoption reaches or exceeds a certain threshold. This consideration can influence the functionality, design, and use cases of the CBDC.

The issuance and design of CBDCs are ultimately sovereign decisions that rest with the relevant authorities based on their own assessments and the specific circumstances of their jurisdiction. Yet, there is value in working collectively on common issues. Some jurisdictions considering CBDCs aim to enable cross-border payments between them. Achieving this goal would require collaboration between central banks and substantial decision-making regarding the connection of CBDCs across jurisdictions and approaches to nonresident access. Finally, exploring governance frameworks and establishing common standards may be necessary to maximize the potential benefits of CBDCs for cross-border payments.

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Stijn Claessens^{a,b,c}, Lin William Cong^d, Fariborz Moshirian^{e,*}, Cyn-Young Park^f

^a Yale School of Management, United States

^b CEPR, United Kingdom

^c Bank for International Settlements, Switzerland

^d Cornell University SC Johnson College of Business, United States

^e Institute of Global Finance, UNSW Business School, Australia

^f Asian Development Bank, Philippines

* Corresponding author.

E-mail address: f.moshirian@unsw.edu.au (F. Moshirian).

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