

The future of money

A comprehensive framework for analysing Central Bank Digital Currencies

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Abstract

This paper evaluates the development of Central Bank Digital Currencies (CBDCs) and introduces a new comprehensive framework to assess the design choices, implementation strategies, and their impact on financial systems. Drawing upon recent academic research and international implementation projects, the study outlines the opportunities and challenges of introducing state-backed digital currencies. The paper identifies four essential dimensions for CBDC development: (i) policy, regulatory and governance, (ii) design and technology, (iii) socio-economic and financial aspects, and (iv) sustainability and inclusion. The study highlights the critical trade-offs between innovation and resilience. CBDCs offer opportunities to enhance payment efficiency and improve financial inclusion, but they may introduce risks related to bank disintermediation, privacy concerns, and new cyber threats. By integrating operational, technological, and societal insights, our framework offers actionable guidance for policymakers, national monetary authorities, researchers and stakeholders to implement CBDCs that are resilient, scalable and inclusive.

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Executive summary

Central Bank Digital Currencies (CBDCs) are digital forms of money issued and managed by central banks. They represent the third form of base money, along with cash in circulation and bank reserves, and have the potential to transform the entire process of money creation, transfer, and use, leading to improved payment systems, enhanced monetary policy, and broader financial access.

However, CBDCs also bring significant challenges, including potential disruption to banking operations, reduced transaction revenues for financial institutions, privacy concerns, and the risk of low adoption and usage. In addition, CBDCs may introduce new privacy risks and cybersecurity threats and even affect financial stability and the evolving balance of responsibilities between central banks and commercial banks.

This White Paper establishes a framework for analysing CBDCs that combines evaluation criteria that are usually treated as separate components. The framework comprises the following dimensions:



Policy, Regulatory and Governance:

This section analyses the impact of CBDCs across monetary policy, financial stability, legal accountability, transition strategy, oversight and ethical considerations.



Design and Technology:

This section reviews the effects of CBDCs on payment infrastructure modernisation, security, cyber threat protection, scalability, user experience, interoperability, programmability, and the management of emerging technologies.



Socio-Economic and Financial Integration:

This section includes assessments of distribution models, adoption and use, accessibility, and international use for cross-border transactions.



Sustainability and Inclusivity:

This section evaluates the privacy and inclusivity aspects of CBDCs, their environmental impact and sustainability capabilities to support green finance initiatives.

The study explores the potential solutions, such as tiered remuneration, transaction and digital wallet holding caps, privacy thresholds and rollout through pilot programmes. The successful implementation of CBDCs will require sound legal and regulatory frameworks, resilient technology infrastructure, international collaboration, and active engagement from all stakeholders. It will also need a phased approach to enable central banks and financial institutions to manage risks appropriately and to build public trust gradually with well-defined communication strategies. This paper contributes to ongoing debates by providing a structured framework for assessing CBDC design choices, benchmarking international initiatives, and informing future policy and market decisions. By clarifying the operational, technological, and societal trade-offs, the study aims to guide central banks, regulators, researchers and stakeholders in shaping the future of money. This research provides readers with a detailed understanding of CBDCs, their design elements and economic functions, through the review of structured policies and industry discussions.

1. Introduction

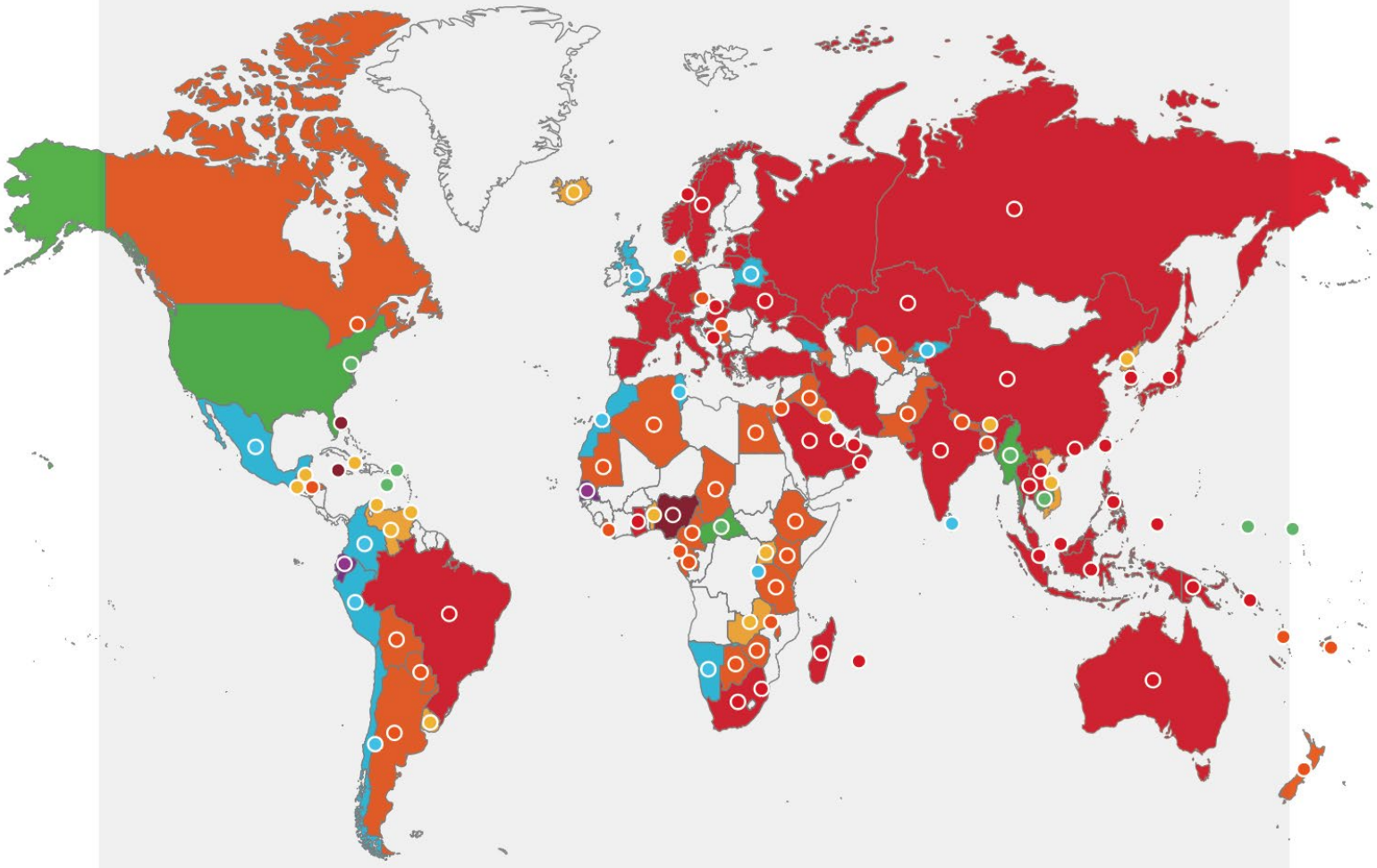
Money has always evolved, from its early forms of barter and metal commodities to coins to banknotes and legal tender. Today's monetary system is based on fiat money, a form of currency backed by the authority of governments. Where adopted, fiat currencies have replaced commodity-based standards and enabled central banks and governments to gain better control of economic operations through monetary policy tools. In recent years, private digital currencies have emerged, competing with traditional payment systems and challenging existing financial infrastructures.

Cryptocurrencies (such as Bitcoin, which emerged in 2009) were pioneers in digital currencies, providing new electronic payment methods, a way to store value, and a means to speculate, leading to their wide acceptance as an alternative to traditional state money. The crypto market experienced fast growth over the last decade and had a total capitalisation of 2.65 trillion USD on 2nd February 2026 (CoinMarketCap, 2026). Cryptocurrencies' broad acceptance has driven financial innovation; however, authorities have become concerned about their impact on monetary policy, sovereignty, and financial stability. In response, national monetary authorities are considering the implementation of central bank-issued digital currencies as a legal alternative to cryptocurrencies. Issued and operated by a country's monetary authority, CBDCs represent the third form of base money, along with cash in circulation and bank reserves, and could be adopted to modernise payment systems, to improve the efficiency of monetary policy transmission, and to support greater financial inclusion. Unlike cryptocurrencies, CBDCs combine the benefits of digital money with the trust, stability, and accountability of central bank electronic money.

CBDCs also present significant challenges. There are fears that they could disrupt banks' ability to collect deposits, leading to reduced access to credit and investment. Customers withdrawing deposits for transfer into CBDC digital wallets may trigger a requirement for banks to hold central bank reserves equivalent to the amounts converted into CBDC. Furthermore, a reduction in retail deposits may affect banks' funding costs. To offset deposit withdrawals, financial institutions may be required to draw down liquidity buffers, raise interest rates to attract retail depositors, or obtain funding through alternative sources. CBDCs may also have ramifications for privacy, cybersecurity, legal accountability, central banks' independence, and monetary sovereignty. Therefore, central banks must balance an assessment of systemic risks with the potential technological benefits of CBDCs. At the same time, financial institutions should analyse market developments arising from new technologies to formulate appropriate business strategies. Effective implementation requires resilient technical infrastructure, sound governance arrangements, and broad stakeholder engagement, supported by pilot programmes and informed by market feedback.

Central banks around the world are experimenting with the new technology or are engaging in deployment projects. Several national central banks are exploring or developing their own CBDCs; however, only a limited number have been launched to date. At the time of writing, 137 countries had CBDC projects underway (Atlantic Council, 2025). Of these projects, approximately 53% have progressed to either the development stage (20 countries) or the pilot phase (49 countries), and 3 have been launched in their respective domestic markets. It is also important to note that 22% of the projects are either inactive (21 countries), cancelled (2 countries), or on hold/other status (6 countries). A visual representation of the different projects, along with their status by country, is provided in Figure 1.

Figure 1: International CBDC projects by stage of development



Status of CBDC projects across the world (number of countries)

- Launched (3)
- Pilot (49)
- Development (20)
- Research (36)
- Inactive (21)
- Cancelled (2)
- Other status / On hold (6)

Source: Central bank digital currencies tracker (Atlantic Council, 2025).



Global interest in CBDCs is rooted in economic and institutional dynamics. The rationale for their introduction includes broader national digitisation agendas, efforts to reduce the informal economy, and the need to address inefficiencies in existing payment systems.

A CBDC functions as a digital currency and as a payment system. This dual role can reinforce national sovereignty in payments by mitigating risks associated with reliance on international card processors (such as Visa, Mastercard, American Express, JCB, Discover, or UnionPay), traditional banks, and intermediaries (e.g. PayPal, Bizum). CBDCs offer a state-backed alternative to payment systems in case of service disruptions or outages. CBDCs may deliver benefits across all transaction types, including cross-border payments, which are highly inefficient due to complex procedures, high fees, and correspondent banking requirements. The implementation of CBDCs would simplify international transactions by enabling instant payment processing, removing the need for private networks, and reducing transaction costs. A review of existing research provides valuable insights into the technological developments of CBDCs. Recent studies focus on how design and implementation can optimise benefits, while limiting risks. Most papers analyse CBDC topics independently, focusing either on technology, monetary policy, or regulatory aspects, without studying their combined effects. This fragmented approach requires a comprehensive framework to provide a systematic understanding of CBDCs and their effects on financial systems. Such a framework will enable the evaluation of CBDC design elements systematically and provide policymakers, central banks, and industry stakeholders with tools to understand their economic and institutional effects. Furthermore, proper contextualisation and analysis of the long-term effects of CBDCs are absent due to the novelty of the topic and insufficient data on their impact over time across a wide range of socio-economic indicators. Few studies have attempted to integrate these dimensions, which strengthens the case for this paper's contribution, i.e. the development of a comprehensive framework to guide research, policy, and practice in the evolving field of CBDCs.This paper synthesises existing findings and highlights the strengths, weaknesses, and potential developments of CBDCs by critically assessing the assumptions and arguments in the current literature. It reviews recent research and policy work from academic sources, international institutions, and central banks actively engaged in CBDC design and experimentation. The paper makes two key contributions: it introduces a comprehensive theoretical framework to explore the implications of CBDCs for financial systems, and it addresses a gap in the literature, where research has often been fragmented or siloed. It provides a structured tool for benchmarking implementation models and for conducting comparative case study analysis. The framework integrates socio-economic, institutional, and technological perspectives to assess the implications of CBDCs across different design choices. The research provides recommendations for stakeholders at the national and international level, including national monetary authorities, policymakers, financial institutions and technology providers. The paper also identifies essential research areas for upcoming studies.

The analysis of CBDCs faces key limitations. First, the research field is subject to rapid change. The White House Executive Order (2025), which halted USA CBDC development, is one such example of an unforeseen change to the research environment. International organisations publish frequent research findings of interoperability projects that advance the knowledge in this field (BdF, BIS and SNB, 2021). Second, as only a small number of countries have implemented CBDCs, researchers lack access to extensive historical data, which creates challenges in analysing operational scenarios and understanding CBDC effects on financial systems.

2. Theoretical framework

A CBDC is fiat money in digital form, issued and controlled by a national central bank or other national monetary authority. It is an integral part of the country's monetary policy, with attributes similar to those of other forms of money (Bordo and Levin, 2017).

CBDCs represent a form of legal tender backed by the issuing state. Their expected core features generally include a centralised architecture and the capacity to be converted, via the banking system, into conventional money while remaining a separate monetary instrument (BIS et al., 2020). Cryptocurrencies, on the other hand, are decentralised and self-governing digital assets that do not represent legal tender, although they may be pegged to existing currencies (e.g., stablecoins). As a digital alternative to cash, CBDCs benefit from the speed, convenience, and security of electronic payments, mitigating counterparty default risk associated with banks, price volatility and the regulatory uncertainty of privately issued cryptocurrencies.

There is a broad international consensus among monetary authorities on the core features of CBDCs. With sovereign issuance, CBDCs retain the trust and value associated with traditional fiat currencies, thereby differentiating them from privately issued digital currencies. CBDCs serve as a store of value, a unit of account, and a medium of exchange (Ardic, Oya & Bossone, 2021). CBDCs are legal tender within the issuing country, meaning they must be accepted for settling debts and making payments. They exist in digital form and are recorded on a ledger managed by a designated authority. Their intangible nature distinguishes them from physical cash and coins. In addition, their programmability allows for embedded compliance with legal or regulatory requirements, behavioural restrictions, or novel applications in monetary policy. CBDCs therefore represent a unique category of money: they retain the security and legal tender status of cash while leveraging technology and the broader benefits of digital finance. Table 1 provides an overview of the key characteristics that distinguish different types of digital currencies.

Table 1: Characteristics of digital currencies

Currency	Issuer	Form	Legal status	Risk
Cash	Central banks	Physical currency	Legal tender	None (direct claim on central bank)
CBDCs	Central Banks / National Monetary Authorities	Digital Central Bank money	Legal tender	None (direct claim on central bank)
Commercial Bank Money (including tokenised deposits)	Licensed banks	Electronic money (Deposits) E-money tokens (Tokenised Deposits)	Issued following banking laws and crypto regulatory frameworks	Credit risk, liquidity risk, operational and interoperability risks
Stablecoins	Private companies	Digital assets backed by fiat currencies, commodities or cryptos	The applicable regulatory frameworks show significant material differences between these financial instruments mostly because they incorporate e-money principles or asset-referenced token features	Several risks including credit, market (loss of peg), liquidity, cyber, operational, systemic, and interoperability risks
Crypto	Decentralised digital assets, self-governing	Digital tokens not pegged to assets	No legal status (except for BitCoin in El Salvador, where it was legal tender between 2021 and 2024)	No lender of last resort, market risk, cyber risk, regulatory risk, liquidity risk, operational risks, systemic risks

Source: Authors' elaboration.

In this paper, we propose a theoretical framework that can support the classification of CBDCs by consolidating relevant factors into coherent thematic dimensions. Such a framework can serve as a comparative analytical tool for benchmarking CBDC implementations, drawing on insights and debates from current literature. It is informed by academic research, policy reports, and recent survey data from central banks and international financial institutions. We considered a range of factors for inclusion in the framework, including monetary policy, financial stability, legal accountability, transition strategies, regulatory oversight, and ethical implications.

We further examined payment system modernisation, security, scalability, user experience, technological requirements, interoperability, programmability, distribution models, adoption, accessibility, and cross-border functionality, as well as more complex dimensions such as privacy, inclusivity, and environmental sustainability. As illustrated in Figure 2, these factors can be categorised into four overarching dimensions: (A) policy, regulatory, and governance; (B) design and technology requirements; (C) socio-economic and financial integration; and (D) sustainability and inclusivity.

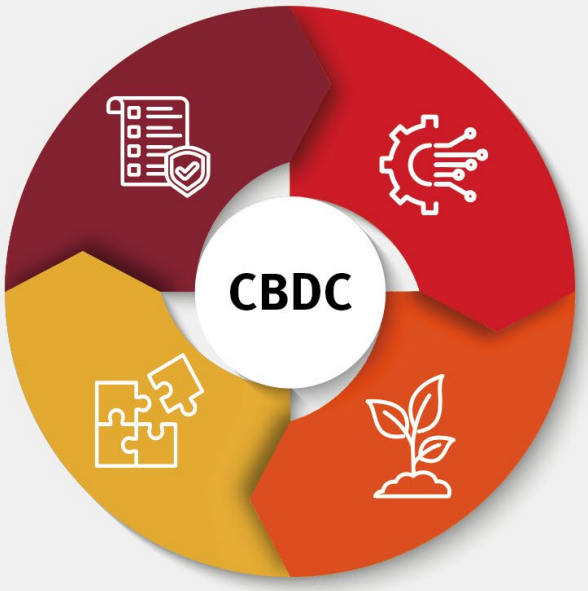
Figure 2: Theoretical framework for assessing CBDCs

A. Policy, Regulatory and Governance

1. Monetary policy
2. Financial stability
3. Legal accountability
4. Transition strategy
5. Regulatory oversights and ethical implications

C. Socio-economic and Financial Integration

13. Distribution model
14. Adoption and usage
15. Accessibility
16. International use for cross-border transactions



B. Design and Technology Requirements

6. Modernisation of payment systems
7. Security
8. Scalability
9. User experience
10. Technology requirements
11. Interoperability with existing payment systems
12. Programmability

D. Sustainability and Inclusivity

17. Privacy
18. Inclusivity
19. Environmental impact and sustainability

Source: Authors' elaboration.

Each dimension comprises interrelated variables, enabling a structured and comparable assessment of CBDCs across jurisdictions. The clustering reflects insights from recent academic and policy analyses that emphasise the multifaceted nature of CBDCs. The four dimensions encompass a wide range of equally important variables, detailed as follows:



A. Policy, Regulatory and Governance

This dimension covers monetary policy, financial stability, legal accountability, transition strategies, regulatory oversight, and ethical implications. Bindseil (2020) and Adrian and Mancini-Griffoli (2021a) argue that the CBDC design is not primarily a technological matter but, importantly, a financial and regulatory decision. CBDCs require the integration within an appropriate regulatory framework to support monetary policy objectives and to maintain financial system stability. The strategy for transitioning from existing fiat and electronic payment models to CBDCs would significantly influence user adoption and could help to mitigate systemic risks. The essential role of regulatory oversight is to ensure compliance, reduce illegal transactions, and protect consumer rights, as identified by BIS et al. (2024).



B. Design and Technology Requirements

This dimension includes variables such as modernisation of payment systems, security, scalability, user experience, technology requirements, interoperability with existing payment systems, and programmability. The rationale for grouping these aspects is that the technical architecture of a CBDC underpins its operational viability. Central banks' experimentation experiences demonstrate that selecting between Distributed Ledger Technology (DLT) or centralised ledgers substantially affects the scalability and interoperability aspects of CBDCs (Boar and Wehrli, 2021). The research into programmability connects directly with current studies about smart money capabilities, including conditional payments (Leucci, Attoresi and Lareo, 2023).



C. Socio-Economic, Financial Integration factors

This dimension integrates variables such as the distribution model, adoption and usage, accessibility, and international use for cross-border transactions. Research findings confirm that consumer trust and convenience, together with accessibility, may determine how widely CBDCs are used (BIS, CPMI and MC, 2018; IMF, 2023). The distribution method chosen for CBDCs affects accessibility, with direct and hybrid models (using financial intermediaries) delivering different levels of convenience to various population segments. The potential of CBDCs to lower cross-border transaction costs, alongside increased speed and transparency, and to establish new international arrangements has been evidenced in recent studies (Auer, Haene and Holden, 2021; Carstens, 2021).



D. Sustainability and Inclusivity

This dimension contains privacy, inclusivity, environmental impact, and sustainability. Initial literature about CBDCs concentrated on technical aspects, while current research emphasises privacy and data protection (Murphy et al., 2024). Consumers need assurance that transaction data will remain secure from misuse by central authorities and any third parties involved. Experts debate how to prevent discrimination and seek methods to enhance financial inclusion through CBDC, while examining principles of fairness in data ethics. The environmental footprint of CBDCs is a relatively new research field that emerged due to global commitments to sustainability and carbon neutrality.

These four dimensions offer a solid basis for comparative analysis across jurisdictions. In the next section, the variables are analysed in detail, with a critical review of the different perspectives advanced in the academic and policy literature.

3. CBDC's design choices and their implications for financial systems

Building on the proposed framework, this section examines possible design choices for CBDCs and their broader implications for financial systems. The analysis considers how different architectural, technological, and governance models influence monetary policy, financial stability, payment efficiency, and market structure.

Research indicates that public knowledge of CBDCs is growing, while consumer trust is mixed due to data privacy concerns and uncertain regulatory frameworks (BIS, 2019). To support the analysis, a multi-criteria evaluation framework is proposed to operationalise the variables within the four dimensions. The framework combines technical standards with policy objectives as well as social, regulatory, and environmental factors. It highlights the trade-offs inherent in CBDC design, reflecting the cross-disciplinary nature of CBDC research and practice, and enabling systematic cross-jurisdictional comparison of projects. For instance, privacy safeguards may limit regulatory compliance; however, greater accessibility may have impacts on financial stability. By identifying critical actions and key attention points, the framework provides policymakers with a structured tool to assess implementation options. The dimensions, factors, and practical considerations are reported in Table 2.



Table 2: Multi-criteria evaluation framework for CBDC implementation

Dimension	Factors	Critical Actions	Attention Points
(A) Policy, Regulatory and Governance	**1.** Monetary policy **2.** Financial stability **3.** Legal accountability **4.** Transition strategy **5.** Regulatory over-sight and ethics	▪ Integrate CBDCs within existing monetary frameworks ▪ Prioritise financial stability safeguards ▪ Strengthen and adapt legal frameworks ▪ Define interest and remuneration policies ▪ Identify transactional and digital wallet holding caps ▪ Plan gradual rollouts and pilot phases ▪ Gather public feedback during transition ▪ Clarify regulatory oversight responsibilities	▪ Balance strict regulation with space for innovation ▪ Address risks of bank disintermediation
(B) Design and Technology Requirements	**6.** Modernisation of payment systems **7.** Security **8.** Scalability **9.** User experience **10.** Technology requirements **11.** Interoperability **12.** Programmability	▪ Implement state-of-the-art security to build public trust ▪ Cooperate with international bodies on feasibility studies ▪ Launch consultations on user experience design ▪ Develop resilient solutions within local constraints ▪ Ensure interoperability through trial programs ▪ Embed programmability for future policy tools	▪ Evaluate trade-offs between scalability, cybersecurity, and user experience ▪ Assess execution speed and validation methods
(C) Socio-economic and Financial Integration	**13.** Distribution model **14.** Adoption and usage **15.** Accessibility **16.** Cross-border use	▪ Promote adoption via banks, merchants, and payment providers ▪ Conduct awareness and education campaigns ▪ Ensure usability and trust ▪ Collect feedback from stakeholders ▪ Support integration with international systems	▪ Balance accessibility with infrastructure costs ▪ Reconcile national priorities with geopolitical ambitions ▪ Manage interoperability across systems
(D) Sustainability and Inclusivity	**17.** Privacy **18.** Inclusivity **19.** Environmental impact	▪ Embed privacy safeguards ▪ Implement data governance ▪ Create a shared communication plan with all stakeholders ▪ Prevent misuse of data access ▪ Promote financial inclusion initiatives ▪ Adopt energy-efficient designs and technology	▪ Balance privacy rights with AML/CFT compliance ▪ Meet sustainability goals without compromising efficiency

Source: Authors' elaboration.

A. Policy, Regulatory and Governance

In this section, we review the policy, regulatory, and governance dimensions of CBDC design and assess how monetary policy objectives, financial stability, legal accountability, transition strategies, and regulatory oversight may shape implementation scenarios. Through the analysis of recent academic and policy debates, the research highlights both opportunities and potential risks associated with these factors.



3.1 Monetary policy

The implementation of CBDCs has significant implications for monetary policy operations. The main challenge arises when central bank liabilities with interest-bearing features compete with commercial bank deposits (BIS, 2021). The implementation of CBDCs can facilitate more systematic and transparent policy execution (Bordo and Levin, 2017) by improving the transmission mechanism (Meaning et al., 2021). Their legal tender status enables central banks to transmit policy changes directly to households and firms, thereby strengthening both interest rate adjustments and stimulus measures (Davoodalhosseini, Rivadeneyra and Zhu, 2020). However, the introduction of CBDCs may also generate new risks and potentially unintended consequences. Retail CBDCs could increase the risk of bank disintermediation, particularly during periods of financial stress (Das et al., 2023). They may also contribute to exchange rate volatility and the formation of liquidity traps, potentially resulting in substantial economic losses. These concerns underscore the importance of carefully designed CBDCs and strategically timed implementation to achieve optimal outcomes.

3.1.1 EXCHANGE RATE REGIMES

The existing exchange rate system affects how a CBDC functions. A free-floating exchange rate system allows markets to determine exchange rates and grants central banks full control over money supply and interest rates (Mishkin, 2009). The ability to adjust interest rates on digital CBDC balances enables central banks to implement policy more quickly (BIS, 2022). This system is effective at handling external shocks, as central banks may use expansionary or contractionary policies without currency peg constraints (Bordo and Levin, 2017). Despite the system's ability to manage external shocks, exchange rates become more volatile, demanding strong risk management systems that align with financial stability goals. The main goal of monetary policy in pegged or managed exchange rate systems is to maintain exchange rate stability. The implementation of CBDCs enhances transaction speed but does not change the requirement for sufficient anchor currency reserves to maintain exchange rate stability. Digital currencies enable fast capital movements, which could create reserve shortages and make countries more susceptible to international spillovers of shocks (Patel, Reshidi and Reuter, 2025). Implementing design elements such as transaction limits, multi-level wallet systems, digital wallet holding caps, and monitoring systems may reduce risks but at the cost of restricting the free movement of funds (Patel, Reshidi and Reuter, 2025). The Bahamas implemented the Sand Dollar under a pegged system while China tested its digital renminbi through a managed float system. The use of pegged exchange rates provides stability through currency anchoring but restricts monetary policy flexibility, and it reduces the operational range of CBDCs. The assessment of CBDC feasibility depends heavily on the selection of exchange rate regimes, which should be considered a primary design consideration.

3.1.2 INTEREST RATE POLICY

The academic debate on interest rate policy for CDBCs centres on two main points: the necessity of such policy and the appropriate methods for implementing positive and negative rates to enhance monetary policy effectiveness. Central banks can use interest rates on CBDC accounts to steer users toward saving or spending attitudes (Davoodalhosseini, 2022). The implementation of positive interest rates on CBDCs would drive users to replace cash with digital wallets, while negative interest rates would boost consumer spending during economic downturns, by overcoming the zero lower bound. The implementation of interest-bearing CBDCs would strengthen conventional monetary tools, as they create a faster path for central banks to reach businesses and individuals (Bindseil, Panetta and Terol, 2021). However, implementing interest-bearing CBDCs faces several operational challenges. Their adoption could allow users to shift funds from traditional bank deposits to digital currency accounts, thereby reducing banks' lending capacity and potentially constraining economic growth (Caccia, Tapking and Vlassopoulos, 2024). The combination of disintermediation risks and the uncertain public benefits of negative interest rates highlights the need for careful implementation strategies (Bindseil, 2020). Moreover, existing infrastructures may not yet support differentiated interest rates on digital accounts, creating additional risks for the financial system (Meaning et al., 2021).

The implementation of interest rates on CBDCs expands monetary policy tools, but experts remain uncertain about both its technical feasibility and its economic effects. The academic literature reflects diverse views on the desirability and implications of applying interest rates to CBDCs. The implementation of interest-bearing CBDCs may enhance monetary policy effectiveness by establishing a direct financial link between central banks and digital wallet holders (Bordo and Levin, 2017). The implementation of positive interest rates on CBDCs would draw cash users toward CBDC wallets, while negative interest rates would give central banks a new tool to boost spending during economic downturns.

The implementation of CBDCs offers three main advantages: greater precision in policy incentives, preservation of seigniorage revenues, and expanded financial access (Patel, Reshidi and Reuter, 2025). However, interest-bearing CBDCs face opposition due to potential disintermediation risks for the existing banking system. The migration of deposits from commercial banks to CBDCs could reduce banks' lending capacity and create challenges for economic growth. Managing these financial stability risks, alongside concerns about privacy and transparency, will require robust, effective governance frameworks (Das et al., 2023). Ultimately, the successful implementation of interest-bearing CBDCs will depend on targeted interventions and evidence from pilot programmes to validate theoretical models against practical outcomes.

3.2 Financial Stability

The implementation of CBDCs may lead to unforeseen consequences for financial stability. Central banks may issue CBDC to achieve several objectives, from financial inclusion to macroeconomic stability and enhanced monetary policy effectiveness (Fung and Halaburda, 2016). However, the combination of attractive interest rates and simple fund transfers into CBDCs may facilitate flight-to-safety behaviour during crisis situations (Bouis et al., 2024). The perception that CBDCs offer superior safety to bank deposits, and the absence of CBDC digital wallet caps, may lead users to move funds into their CBDC wallets during crises, depleting commercial bank deposits and resulting in credit shortages and banking system instability (BIS et al., 2021b).

In addition, the adoption of CBDCs could reduce traditional banking revenue from payment services, thereby decreasing banks' profitability and their ability to support real economic activity. Multiple design solutions exist to mitigate the risks posed by CBDCs. The implementation of tiered interest rates for CBDCs which pay no interest or minimal interest beyond specific balance limits may prevent large-scale bank deposit withdrawals (Bindseil, 2020). Implementing transaction and digital wallet holding limits can serve as a risk management tool to avoid disintermediation by restricting both balance limits and transfer amounts. The combination of these tools with appropriate CBDC design parameters enables financial stability protection while maintaining the efficiency of digital money (Meaning et al., 2021).

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3.3 Legal Accountability

An appropriate legal framework is essential for building public trust in CBDCs and supporting their widespread adoption. In particular, legal tender status, central bank independence, and user privacy regulations will shape both the opportunities and the risks associated with CBDC implementation.

3.3.1 LEGAL TENDER STATUS

The legal status of CBDCs is central to their public acceptance. The system requires legal recognition of central bank electronic money to function as a payment instrument that resolves financial obligations and executes payment operations. The legal tender status of CBDCs may enable citizens and businesses to use digital currencies as a payment tool, enhancing their status as a standard medium of exchange. CBDCs have the potential to enhance payment speed, reduce cash management expenses, and enable digital payment solutions for underbanked and unbanked groups of people (Bindseil, Panetta, and Terol, 2021).

Nonetheless, the use of CBDCs as legal tender may face significant operational challenges during implementation. Mandatory acceptance requirements could create additional burdens for vulnerable groups, including small businesses and elderly individuals, while gaps in digital infrastructure risk exacerbating existing social inequalities (Auer et al., 2022). The introduction of CBDCs will also necessitate extensive legal reforms affecting currency laws, payment systems, and financial regulations; these processes may prove lengthy and complex (Bossu et al., 2020). A phased legal strategy, implemented through sequential reforms, would help mitigate these risks by enabling a smoother and more manageable transition.

3.3.2 CENTRAL BANK INDEPENDENCE

Granting CBDCs legal tender status may affect central bank independence. The implementation of CBDCs would give central banks a more direct control over monetary policy; however, it would simultaneously increase their vulnerability to political interference. Governments might force central banks to implement CBDCs for quasi-fiscal operations, such as digital helicopter money transfers to households, thereby obfuscating the distinction between monetary and fiscal policy. Furthermore, the implementation of CBDCs by authoritarian governments may destabilise central banks' independence, posing a threat to monetary policy.

3.4 Transition Strategy

The transition from cash to CBDCs demands detailed planning, followed by a step-by-step execution, and effective information sharing. The academic debate focuses on the optimal pace. Advocates of a gradual process emphasise risk reduction and inclusivity benefits, as digital literacy and access disparities can generate social inequalities (Boakye-Adjei et al., 2023). A controlled deployment, supported by coexistence with cash and tools such as tiered remuneration schemes, may mitigate risks of bank disintermediation and operational disruption (Bindseil, 2020). Others emphasise the urgency of rapid adoption to keep pace with technological change and counter the dominance of private cryptocurrencies (Berentsen and Schär, 2018). However, a faster transition may disregard the current state of infrastructure readiness and the need for public education programmes.

The decision between token- and account-based models in technological design will affect user adoption by shaping system accessibility and influencing user experience and security levels (BIS et al., 2021a). The development of trust and user adoption depends on effective communication strategies, which experts recognise as fundamental organisational elements. Research evidence indicates that central banks need to adopt clear communication strategies. Public education campaigns should focus on digital literacy, while businesses and stakeholders need direct engagement to understand goals and receive iterative feedback. The implementation process may receive additional support from private intermediary partnerships, which may also enhance system interoperability. Research shows that successful transition models require country-based methods, introduced in a phased approach, alongside public awareness programmes with inclusive messaging to ensure public acceptance and mitigate risks.

3.5 Oversight and Ethical Implications

The implementation of CBDCs may raise regulatory and ethical issues due to their potential impact on the traditional banking system, while simultaneously raising privacy concerns, governance challenges, and oversight control problems.

3.5.1 REGULATORY CHALLENGES

The implementation of CBDCs requires new regulatory oversight, as existing rules were developed for a pre-digital-currency system. The direct provision of services to people by CBDCs creates challenges for financial stability, monetary sovereignty and central bank identity, as, depending on the design choices, they might combine central banking operations with retail banking functions (Söderberg et al., 2022). BIS et al. (2021b) suggest that financial stability requires compliant regulatory systems to prevent criminal activity. Anti-Money Laundering (AML) and Know Your Customer (KYC) systems must be implemented to enable central banks to track risks while maintaining public trust (Wang and Gao, 2024). However, the imposition of excessive rules would undermine financial innovation and block the benefits that CBDCs for financial inclusion and productivity growth may provide (BIS et al., 2021b).

3.5.2 ETHICAL CONCERNS

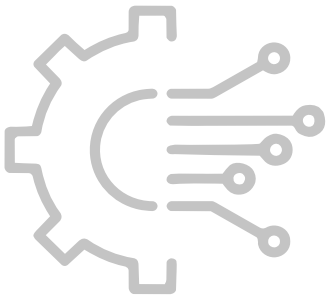
The implementation of CBDCs raises new ethical problems that go beyond the minimum requirements for compliance. The traceability and programmability of digital currencies could, under certain conditions, enable governments to steer consumer behaviour or restrict transactions, in pursuit of policy goals. The implemented features may enable fraud prevention and activity monitoring, but may also create privacy problems and surveillance issues in nations with limited democratic freedoms. Through tiered privacy systems, users can remain anonymous for small transactions, while being required to authenticate for larger transactions to fulfil regulatory requirements. Public acceptance of CBDCs depends on privacy protection being an essential requirement.

3.5.3 GOVERNANCE AND INTERNATIONAL COORDINATION

The implementation of CBDCs may generate new governance challenges. As mentioned, the application of interest rates by central banks to digital wallets could create negative perceptions about state control and blur distinctions between monetary and fiscal policy functions. International regulatory bodies should be tasked with identifying potential misuse cases to protect individual rights from unethical exploitation. The global financial system may benefit from the development of international CDBC standards that integrate regulatory frameworks, cybersecurity measures, and consumer protection protocols, thereby improving resilience and ensuring interoperability and trust across jurisdictions



B. Design and Technology Requirements



The design and architecture of CBDCs underpin their operational viability, resilience, and sustainability. Consideration should be given to several elements, including: the modernisation of payment systems (cybersecurity, scalability, interoperability, programmability, and user experience). The design choices may influence how CBDCs function, their ability to fulfil policy objectives, their interface with existing systems, and their ability to adapt to future technological developments. The following sections examine essential design elements, along with their implications for central banks, financial systems, and end users.

3.6 Modernisation of Payment Systems

CBDCs are widely viewed as a response to ongoing digital disruption in finance, with the potential to increase transaction speed, reduce costs, and simplify settlement processes. By removing intermediaries, CBDCs enable faster payment processing and immediate transaction settlement, thereby increasing the reliability of financial operations (BIS et al., 2020). Advocates of CBDCs point to their ability to transform cross-border payment systems through unified networks, which may eliminate correspondent banking chains for faster processing and lower costs (World Bank, 2021). The Chinese e-CNY program demonstrated that centralised CBDC systems can execute fast and secure transactions at scale (PBoC, 2021).

The implementation of CBDCs may increase efficiency and transparency of payment systems. CBDCs, through digital ledger technology, may process transactions in real time. This enables regulators to detect payment activities, reduce fraud and corruption risks, and prevent tax evasion. Improved monitoring could strengthen the integrity of the financial ecosystem while supporting public trust. Through partnerships with fintech companies, the creation of inclusive financial solutions, mobile payment systems, and alternative platforms may offer financial services to underbanked and unbanked populations (Auer et al., 2022).

However, risks remain. In retail direct distribution models, the implementation of CBDCs may allow people to store their money directly in central bank digital wallets, potentially reducing commercial bank deposits and banks' ability to provide credit to finance the economy (BIS et al., 2021b). Users' trust depends on the proper implementation of digital currencies, which is necessary to maintain a balance between privacy and cybersecurity requirements. Research shows that successful implementation depends on proper deployment, strong protective measures, and joint governance among central banks, policymakers, technology providers, and international organisations.

3.7 Security

The security of CBDCs must be based on sound design, as digital currencies face ongoing threats from cyberattacks, operational failures, and fraud. The combination of sensitive financial information with centralised infrastructure in CBDCs makes them vulnerable to potential breaches, which may damage trust and create widespread financial instability (BIS, 2023c). Digital asset protection depends on the three essential elements: (i) cryptographic security measures, (ii) authentication protocols, and (iii) sustained support for digital security systems (BIS et al., 2021a).

3.7.1 CYBERSECURITY AND OPERATIONAL RISKS

The digital nature of CBDCs makes them vulnerable to hacking, system failures, and unauthorised data breaches (Murphy et al., 2024). Multi-factor authentication, role-based access controls, back-up redundancy, and real-time monitoring systems may represent effective security measures. Programmable features of CBDCs, i.e. smart contracts, may introduce new vulnerabilities that necessitate rigorous code auditing and monitoring to avoid systemic disruptions. The implementation of appropriate legal frameworks for managing cyber threats is an essential requirement for successful cyber incident response. The implementation of standardised procedures for incident management, remediation and international co-operation may support public trust in CBDCs (BIS, 2023c).

3.7.2 DESIGN CHOICES: TOKEN VS. ACCOUNT MODELS

A central security concern in CBDC design is how ownership is verified. Token-based systems operate similarly to cash, allowing users to hold and transfer value anonymously, thereby enhancing financial accessibility (BIS, CPMI and MC, 2018). However, the adoption of digital currencies may also introduce security risks, including theft, loss, and the facilitation of criminal activities (BIS, 2023c).

Account-based systems, by contrast, verify ownership through identity checks, improving regulatory compliance and enabling asset recovery. However, these systems may create entry barriers for unbanked populations seeking access to financial services, while also increasing users' exposure to transaction monitoring (Auer et al., 2022).

3.7.3 TECHNOLOGICAL FRONTIERS

In this context, the development of new technologies brings several challenges. For example, quantum computing systems have the potential to break existing encryption methods (Aggarwal et al., 2017), but they may also enable faster transaction processing. To protect against these new types of threats, research teams are developing quantum-resistant algorithms and advanced cryptographic methods, including zero-knowledge proofs, to defend CBDC systems from future security risks (Azimi et al., 2025).

3.7.4 GOVERNANCE AND INTERNATIONAL COORDINATION

The operation of technology requires appropriate governance systems to achieve positive outcomes. Effective procedures require the development of response protocols for cyber breaches, while international organisations need to establish uniform security standards for the interoperability of CBDCs. The implementation of privacy protection systems requires policymakers to strike a balance among data confidentiality, oversight functions, and national security needs. The detection of future threats depends on ongoing collaboration between central banks, regulators and technology providers to protect public trust.





3.8 Scalability

The successful implementation of CBDCs depends heavily on their scalability, which represents the ability to handle increasing transaction volumes while maintaining both security standards and operational performance. The servicing of retail CBDCs will require systems capable of processing high transaction volumes.

A central debate in the literature concerns whether CBDCs should rely on centralised infrastructures or DLT technologies. Proponents of centralised systems (Auer, Cornelli and Frost, 2020) argue that they have a proven track record in current interbank settlement operations, their cost-efficient solutions and regulatory compliance capabilities. DLT systems may provide transparency, resilience and immutability; however, their scalability is uncertain. The current blockchain technology systems face challenges in scaling and efficiently processing transactions. Studies show that increases in block size can reduce decentralisation (Croman et al., 2016) and that, in its current form, blockchain may be unsuitable for national-scale payment systems (Casey et al., 2018; Peters and Panayi, 2016).

Recent studies identify three upcoming solutions, including permissioned blockchains, proof-of-stake protocols, and secure consensus algorithms, to boost system performance, though limitations in consensus mechanisms persist. A possible solution is the hybrid model, which combines core operations under centralised control with distributed verification systems and token-based methods to resolve these trade-offs. Systems may improve operational efficiency and scalability while maintaining regulatory control (Auer and Böhme, 2020). A risk-management approach to scalability, grounded in specific knowledge of technology choices, seems the most suitable way forward.

3.9 User Experience

The academic debate on CBDC focuses on technological and economic aspects, although user experience and interface design also play essential roles in adoption. Many researchers have not fully examined these aspects. A user interface (UI) that is easy to understand and secure functions as the primary entry point for people and organisations and determines how well users accept and adopt CBDC wallets (Auer and Böhme, 2021). Simplicity in systems reduces entry barriers and enables users to build trust, helping people with basic digital skills access new technology (Auer et al., 2022). CBDC user interface systems need to support underbanked people, elderly users and users with disabilities to achieve accessibility and inclusivity (Boakye-Adjei et al. 2023). The integration of CBDCs into current payment systems enables smoother adoption and decreases public opposition to new payment systems (BIS, 2021). The BIS (2019) surveys show that users consider simple interfaces to be vital for CBDC adoption. CBDCs need to achieve both usability and security standards. Easy-access systems that require minimal entry barriers lead to higher user adoption rates. However, these systems may pose security risks to users due to potential fraud and data breaches (BIS, 2023c). The trustworthiness of CBDCs depends on user-friendly interfaces and robust security measures. The design process needs strategic decisions about these trade-offs (BIS et al., 2021a). Auer, Cornelli, and Frost (2020) advocate working with private technology providers to drive innovation and reach diverse population segments. The academic literature suggests that user interfaces should be accessible, secure, and inclusive, but it does not provide effective methods to reach these objectives. Future research may examine social aspects of UI by analysing design elements that affect user trust, long-term adoption and financial inclusion. The implementation of CBDCs requires a multidisciplinary team comprising technologists, economists, and social scientists to meet the needs of diverse user populations.

3.10 Technology Requirements

The literature offers a range of views on technological solutions that could support the implementation of CBDCs. The creation of an appropriate technical infrastructure, ready to support the daily operations of CBDCs, would be the first step to ensure real-time transaction processing, seamless integration with existing financial applications, and data tracking for compliance purposes (Auer, Cornelli and Frost, 2020). However, this requires considerable investment and the setup and maintenance of sophisticated platforms to ensure transaction processing. For each technological component, the regular cycle of upgrades and security patching, as well as periodic infrastructure scaling, would also need to be ensured to support new technological demands (BIS, CPMI and MC, 2018). Auer and Böhme (2021) note that a reliable technological infrastructure and appropriate cybersecurity measures are significant factors in building trust in new digital currencies.

Additionally, international co-operation is needed to ensure interoperability and develop a set of standard protocols for cross-border payments. Whether CBDCs can provide continuity of service after launch depends solely on the robustness of the technological solutions implemented and the ability to adapt to the transaction volumes that must be processed. There are doubts about the technological readiness of CBDCs, as large-scale systems may not yet be ready, especially in the context of DLT. CBDCs may face significant technical and infrastructural challenges, which could jeopardise the achievement of the planned benefits. While the envisioned elements of the CBDC architecture are discussed in the literature, the specific solutions envisaged are diverse and depend on different technological setups (e.g., distributed or centralised), processing scalability, the legal framework, privacy considerations, and the requirement to interface with the banking system infrastructure. Technical details remain unresolved due to a lack of consensus, but working on these details through pilot projects and stakeholder collaboration could help resolve the ongoing debate. The development of optimal solutions that balance speed, efficiency and security with privacy demands requires continuous work across technological development as well as international coordination and partnerships between central banks, international organisations and fintech organisations.

3.11 Interoperability with payment Systems

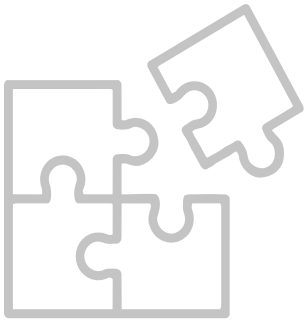
The ability of CBDCs to work with existing payment systems is critical for their successful implementation. The failure to integrate CBDCs with current financial systems makes them too impractical to gain broad acceptance and operational functionality. System interoperability depends on design choices and the adoption of standard protocols, as these elements determine the ability to prevent fragmentation and support borderless transactions (BIS, 2023b; Kiff et al., 2020). The regulatory framework for cross-border interoperability faces heterogeneous challenges due to diverse legal systems, data storage requirements, and privacy protection rules. The use of divergent rules allows financial actors to operate with less stringent KYC/AML systems and capital controls. It may create regulatory arbitrage opportunities that endanger CBDC policy goals and generate market instability (BIS et al., 2024). The FSB and G20 Roadmap on cross-border payments aims to standardise compliance procedures, reporting standards, and supervisory requirements for cross-border payments (FSB, 2024; BIS, 2023b). The OECD (2023) stated that organisations need to establish stable legal and governance systems to minimise their exposure to fraud, money laundering and terrorism financing risks. The technical implementation of interoperability poses challenges, as CBDC systems operate under separate architectural frameworks with diverse design choices. The validation and settlement processes for transactions operate differently across centralised, token-based, and hybrid systems (BIS et al., 2021a). The integration of these systems creates additional cybersecurity threats because weaknesses in one network can spread and affect other connected networks (BIS and SNB, 2023). The ISO worked to standardise financial messaging through ISO20022 protocols, with digital identity systems and security protocols to support international data exchange. The DLT progress, together with instant payment systems and RegTech solutions, may enable real-time compliance and scalable transaction monitoring, which improves security and operational efficiency. Although researchers broadly agree on the importance of interoperability, there is little consensus on the roadmap to achieve it. The key barriers to achieving a standardised functional architecture include technical differences across systems, operational challenges, and regulatory differences across countries. The implementation of successful CBDCs depends on extended co-operation between central banks, policymakers, industry players, and international organisations. Multiple actors must collaborate to integrate CBDCs into domestic and international payment systems successfully.

3.12 Programmability

A significant difference between digital currencies and cash is their programmability, i.e., the ability to embed code in a CBDC that automates transactions and/or enforces conditional rules based on predetermined conditions. Smart contracts can self-execute agreements when the conditions specified in the contract are met. Programmable CBDCs have the potential to strengthen inclusion in credit and financial markets significantly. The literature shows different views on this feature. Peters and Panayi (2016) emphasise the potential benefits of programmable CBDCs. Smart contracts can automatically execute rules for specific monetary policy transactions, such as stimulus payments, that may be subject to spending constraints on time, location, or categories of goods and services. Smart contracts could transform the application of monetary policy rules by enabling new monetary policy instruments. These new capabilities for monetary policy could be compelling for central banks. DLT could support programmability. However, central banks may need to address specific technological problems. Schär (2021) casts doubt on smart contracts, arguing that they may increase the complexity of security and privacy design. Consequently, if smart contracts are embedded in CBDCs, they might become more vulnerable to hacking than other transaction systems. Bulgakov et al. (2024) discuss issues of scalability and interoperability with different financial systems. With programmable CBDCs, it would be possible to design new functionalities to facilitate the implementation of monetary policy and enhance transaction efficiency. At the same time, programmability adds complexity to security, privacy, and the fundamental role of banks.



C. Socio-Economic and Financial Integration



The successful implementation of CBDCs depends on their ability to operate within both the financial sector and the broader social and economic context. The payment efficiency, financial inclusion, and public trust in CBDCs depend on their adoption models, accessibility, and distribution systems. Interoperability with cross-border payment systems brings operational advantages and transparency benefits; however, it may create difficulties in maintaining regulatory oversight, risk management, and international coordination. This section examines the socio-economic and financial dimensions of CBDC implementation, focusing on distribution models, adoption and usage, accessibility, and international use in cross-border transactions.

3.13 Distribution Model

The distribution model determines how CBDCs enter circulation and function within the financial system, affecting operational costs, system stability, and the organisational structure. Depending on the design choice, distribution models may require substantial administrative support to channel CDBCs correctly and may rely on appropriately trained personnel and dedicated technological infrastructure (Auer and Böhme, 2020). The literature divides CBDCs into three categories, which include retail, wholesale and hybrid models, based on the distribution methods.

Wholesale CBDCs restrict access to intermediaries and operate exclusively among selected institutions such as banks and financial intermediaries that manage wholesale payment and settlement systems (WEF, 2021). The distribution model operates in a closed-loop system in which central banks provide digital tokens or balances to authorised intermediaries, who then utilise those tokens in payment systems, for securities settlements, or for interbank transfers. These systems can execute Delivery vs. Payment (DvP) to improve clearing transactions in capital markets and Payment vs. Payment (PvP) for foreign exchange transactions (BDF, BIS, and SNB, 2021). Other areas include tokenisation of securities, which integrates tokenised assets such as stocks and bonds to make post-trade settlement more efficient (BIS and CPMI, 2019), and liquidity management, which enhances liquidity provision and minimises counterparty risk. Banque de France (2021) mentioned that wholesale CBDCs are likely to have a marginal direct impact on individuals. Wholesale CBDCs may ameliorate interbank processes but may not offer meaningful improvements for the public. Importantly, though, this new technology may introduce new features that may lead to the future development of payment systems.

Retail CDBC serves as a digital currency for public use by households and businesses in commercial functions that mimic physical cash transactions (WEF, 2021). The CBDC distribution involves either a direct model (one-tier), in which central banks handle end-user accounts and wallets and process transactions; or an indirect model (two-tier), in which authorised financial intermediaries maintain CBDC accounts, while central banks focus on issuance and settlement functions (Auer and Böhme, 2020). In the two-tier model, vetted financial institutions handle customer onboarding and compliance processes, including KYC. Auer and Böhme (2020) discuss a two-tiered CBDC model that combines intermediation principles with the traditional role of banks, limiting the possibility of disintermediating the banking system while still enjoying the public mandate and several other benefits of CBDCs. The operational complexities associated with a two-tiered solution require active oversight of authorised intermediaries. The implementation of retail CBDCs could enhance financial inclusion, according to Boakye-Adjei et al. (2023). Still, central banks risk losing their role as people begin to use central bank accounts for traditional banking services. Mitigating measures include caps on CDBC digital wallet holdings and transaction amounts, as well as tiered remuneration schemes (FSI, 2023).

Hybrid distribution models are also possible when direct claims can be made on central banks, which manage issuance and record retail balances, while intermediaries handle transaction operations. Hybrid models integrate retail functions with wholesale payment systems. This design option provides flexibility, but it may also create operational complexity and coordination difficulties. A variation of hybrid models might be represented by synthetic CBDCs, where private institutions issue stablecoins fully backed by central bank reserves (Marthinsen and Gordon, 2024).

In practice, the boundaries between CBDC models may blur, with central banks likely to adopt mixed frameworks that reflect national priorities. Retail models may enhance accessibility; however, one-tier models may disrupt financial stability and the principles of banking intermediation. Wholesale models improve settlement and cross-border system operations, yet their public reach remains limited only to specific market segments.

Hybrid models combine multiple approaches; however, they may present governance challenges. CDBCs demand that policymakers balance operational efficiency with service accessibility and develop protective measures for disintermediation and financial stability. The main distribution models, along with their key features, advantages, and risks, are shown in Table 3.

Table 3: CBDC Distribution Models

Model	Key Features	Advantages	Risks / Challenges
Wholesale	▪ Restricted to financial intermediaries ▪ Closed-loop settlement system ▪ DLT or centralised ledger technology	▪ Enhances interbank settlement efficiency ▪ Supports DvP and PvP transactions ▪ Reduces counterparty and settlement risk	▪ Limited direct impact for the public ▪ Requires harmonisation of industry standards ▪ Potential systemic risks, if poorly designed
Retail	▪ Direct access for households and firms ▪ One-tier or two-tier distribution models ▪ Often on permissioned ledger	▪ Broad accessibility and inclusion ▪ Supports everyday payments and remittances ▪ Enhance monetary policy transmission	▪ Bank disintermediation risks ▪ Complexity of the two-tier models ▪ Cybersecurity threats
Hybrid	▪ Combines retail access with wholesale settlement ▪ May include synthetic CBDCs (e.g. stablecoins backed by reserves) ▪ Shared roles between central banks and intermediaries	▪ Balances inclusion with efficiency ▪ Flexible design adaptable to national needs ▪ Encourages public-private cooperation	▪ Increased operational and governance complexity ▪ Coordination risks between central banks and intermediaries ▪ Potential inefficiencies, if responsibilities are unclear

Source: Authors' elaboration.

3.14 Adoption and usage

In the proposed framework, examining the adoption and usage of CBDCs can provide valuable insights into end users' perspectives and the current stage of implementation. Such considerations can guide policy decisions in both advanced and developing countries, although the underlying motivations may differ. Adoption rates can affect the achievement of the initial goals for digital currencies. Improved payment performance and resilience, greater financial inclusion, and currency sovereignty might not be possible unless CBDCs attain sufficient transaction volume and user numbers in the issuing countries. Multiple usage considerations affect how quickly and effectively a CBDC may enter the public's consciousness and the mainstream economy. Adoption and usage are tightly related to many factors. For example, a clear regulatory framework establishes the scope and regulations of CBDC usage, including aspects such as data security, compliance with AML and Countering the Financing of Terrorism (CFT) regulations, and interoperability with other payment systems (BIS et al., 2024). Researchers contend that CBDCs might be undermined by the lack of rules and guidelines, leading to user mistrust (Bossu et al., 2020). Privacy-friendly models, including tiered CBDCs which maintain anonymity for low-value transactions, might ease public concerns, while preserving existing regulatory standards (Murphy et al., 2024). Sound technological platforms are critical to the use and adoption of CBDCs (BIS et al., 2021a).

Auer, Cornelli, and Frost (2020) maintain that successful CBDC deployment and high usage rates depend on technology and regulation, a conducive policy landscape, and early stakeholder engagement. Likewise, distrust in central bank policies might increase resistance in some countries. Through usage variables, Auer, Frost et al. (2021) found that CBDC adoption correlates with the level of digital payment infrastructure and with the proportion of contactless and mobile payments in a country. These results indicate that governments and central banks should consider developing their digital infrastructure to support the adoption of CDBCs. The academic literature suggests that CBDCs cannot serve as a universal remedy. As developed economies focus on improving payment system efficiency and resilience, emerging economies may wish to prioritise financial inclusion. Researchers generally recognise that a defined regulatory regime and privacy protections are essential for the viability of these systems, since public confidence is crucial for adoption (Carstens, 2023). CBDC adoption can also serve geopolitical purposes, for example, internationalising the currency (IMF, 2020). Digital currencies disrupt international capital flows and may need global coordination and international standards-setting. The adoption and use of CBDCs may depend on the interplay among technology, regulatory certainty, public trust, and socio-economic factors. The adoption of CBDCs across various jurisdictions may also be influenced by factors such as trust, usability, and socio-economic context, rather than technology alone, as summarised in Table 4.

Table 4: CBDC Adoption Factors

Adoption factors	Drivers	Barriers
Regulation and Governance	▪ Clear legal framework ▪ AML/CFT compliance ▪ Legal tender status	▪ Lack of regulation ▪ Inconsistent standards ▪ Risk of surveillance overreach
Technology	▪ Scalable platforms ▪ Fast transaction speed ▪ Strong cybersecurity	▪ Technical immaturity ▪ High infrastructure costs ▪ Stakeholders' support and collaboration required to interface CBDCs with existing payment systems.
Public Trust and Privacy	▪ Privacy-preserving design (e.g. tiered identification and anonymity for low-value transactions) ▪ Central bank credibility	▪ Low trust in institutions ▪ Privacy concerns ▪ Fear of state monitoring
Usability and Financial Inclusion	▪ Access for unbanked and underbanked ▪ Simple and inclusive user interfaces	▪ Digital divide across population ▪ Limited financial and digital literacy ▪ Exclusionary KYC requirements
Socio-Economic and Political Context	▪ Support for payment resilience ▪ Currency sovereignty ▪ Potential for internationalisation	▪ Risk of bank disintermediation ▪ Uneven digital infrastructure ▪ Geopolitical ambitions

Source: Authors' elaboration.



3.15 Accessibility

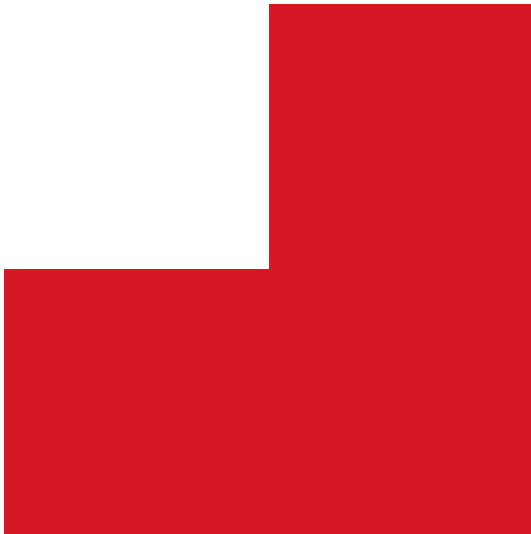
Accessibility shapes how widely and reliably a CBDC can be distributed and can function across a variety of devices, both online and offline. The success of CBDCs depends on their ability to deliver reliable financial services to all users for their daily needs. The BIS et al. (2020) study shows that CBDCs could become a valid alternative to cash only if they become widely available. The accessibility provision allows all population segments to use systems which operate regardless of infrastructure constraints (WEF, 2023).

Online-only CBDCs enable businesses and individuals to make instant, borderless payments, reducing payment obstacles. Advocates of online-only CBDCs highlight the possibility of utilising existing infrastructures as an additional point of emphasis. Online-only CBDCs may interoperate with current payment systems and enhance payment efficiency by processing transactions in near real-time, integrating with online services, and optimising transactional costs (Chu et al., 2022). Conversely, the lack of reliable connections can represent a significant limitation for those living in areas without adequate telecommunications infrastructure. The current payment systems work better with online-only CBDCs, but these applications pose challenges for people without digital access and in specific geographic areas. Online-only CBDCs face cyber threats that pose operational risks and

restrict privacy rights. The decision to prioritise online-only CBDCs, given their efficiency in development and implementation, is controversial when we consider the digital deprivation in many emerging economies.

Offline CBDCs are functional without internet connectivity and may enable transactional capability for larger shares of the population, including the people who are at the margins of the financial system, the unbanked and underbanked individuals (Minwalla et al., 2023). Advocates of offline CBDCs argue that the offline provision of central bank money at the point of sale could prevent transaction failures (Chu et al., 2022). Offline CBDCs have broader applicability during major disasters such as natural hazards, armed conflicts, or financial crises. Offline CBDCs may also be perceived as more resilient, especially in scenarios of widespread outages, operational breakdowns, or attacks perpetrated by hackers (Chu et al., 2022). An effective offline CBDC may require upgrading existing payment infrastructure and necessitate new settlement systems, with backup nodes to maintain safety even when the internet fails (Chu et al., 2022). However, there is currently insufficient evidence to suggest that offline technologies can be implemented widely or securely. It is worth noting that offline CBDCs are accommodative, expanding the range of options for users, but the risks of pursuing this pathway remain significant. To adequately replace cash's functions, including privacy, CBDCs must offer analogous capabilities, e.g., private, anonymous transactions with no tracking. The offline functionality provides anonymity and finality to cash payments. Researchers encourage technological innovations that enable private, anonymous, and irreversible transactions, both online and offline. Minwalla et al. (2023) highlight offline CBDCs as inclusive and resilient systems. Yet, experts continue to be concerned about the potential risks of fraud, double-spending, and permanent payment loss due to the absence of real-time verification. Moreover, the ability to use a CBDC offline might undermine transactions' compliance. Chu et al. (2022) highlight the technical difficulties of making payment systems more secure. Solutions proposed include ensuring the use of safe, dedicated hardware devices and the latest cryptography methods, although these may increase costs and complexity.

A combination of online and offline functionalities would provide offline capabilities for small-value payments, while large-value payments would still have to be performed online. Offline accessibility may deliver superior system reliability and inclusivity; however, it might create major technical and security obstacles that organisations struggle to overcome due to its complex nature and high implementation costs. The deployment of these systems would encounter significant challenges which may prevent their widespread use. Conversely, online-only CBDCs are more efficient but do not necessarily enable central banks to meet their goals of universal access and financial inclusion. A CBDC that is accessible only online may not find favour with the public. Striking the right balance between online and offline accessibility in CBDC design is therefore an essential and potentially delicate issue. The wide variation in positions within the literature illustrates the range of trade-offs that central banks must carefully consider when determining the design features of CBDCs. Future research into suitable technological solutions for offline CBDC problems may support the development of hybrid CBDC systems to maximise the benefits of both online and offline functionality.



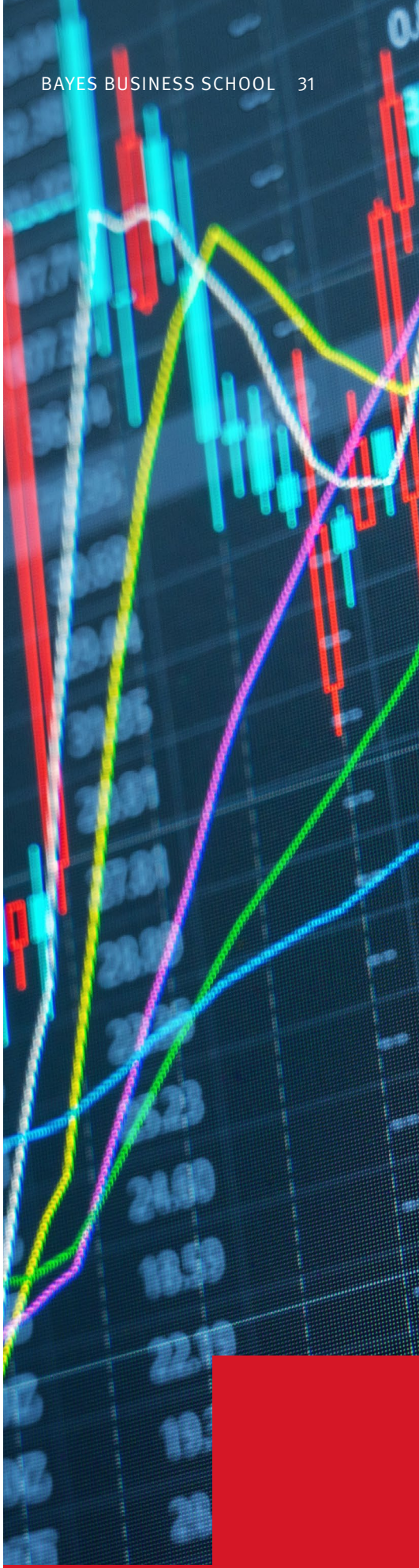
3.16 International use for cross-border transactions

To cater to the requirements of different user types, CBDCs need to interoperate with existing digital payment systems, both domestically (e.g., Real-Time Gross Settlement systems, or RTGS) and internationally (e.g., through the BIS mBridge platform). This is important for ensuring that CBDCs can be used alongside other banking services, payment systems, and cross-border financial networks (BIS, CPMI, and MC, 2018). The establishment of CBDC digital wallets may allow individuals and businesses to execute transactions. To implement interoperability, central banks, alongside private financial institutions and payment service providers, must work with international organisations to create common standards and technical protocols to bridge private and public digital payment systems. This issue is particularly significant in the context of international payments, where regulatory frameworks vary considerably across jurisdictions. For instance, many national payment systems adopted standards such as ISO 20022. Others, however, such as the Federal Reserve Bank's Fedwire Funds service (an RTGS system in the USA), transitioned to the ISO20022 message format only in July 2025 (Federal Reserve Banks, 2025). Differences in the standards adopted may lead to interoperability issues for cross-border payments. Resolving this challenge will involve significant technical coordination and standards setting, often with the support of international organisations. CBDCs could bring substantial changes to the global payment infrastructure and to the broader financial system (BIS et al., 2020). The debate in the academic literature reveals a complex and diverse range of positions on the trade-off between potential efficiency gains in cross-border transactions and financial stability, and the monetary sovereignty risks for jurisdictions.

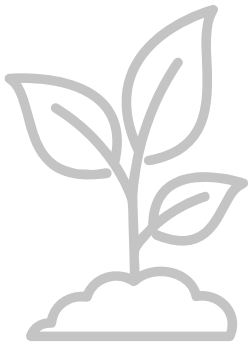
Advocates of CBDCs, such as Cœuré (2018) and IMF (2024), emphasise potential operational efficiency gains and improved payment infrastructures, while more cautious researchers,



such as Brunnermeier, James and Landau (2019) and the WEF (2023), point to geopolitical and economic risks associated with the international adoption of CBDCs. The BIS et al. (2020) note that cross-border payment systems are notoriously slow and costly, while using a direct central bank payment channel may improve efficiency by reducing reliance on extensive multi-tiered correspondent banking networks. Mu (2024) analyses China's CBDC pilot, which involved processing millions of transactions and encouraging domestic merchants to adopt the technology, thereby seemingly providing strong support for a highly usable, large-scale CBDC. While modern technology can enable innovation, its proper deployment depends on several economic, legal, and geopolitical elements. Adrian, Mancini-Griffoli, and Zettelmeyer (2021) examine how CBDCs may influence global payments and currency substitution. They argue that their broad adoption might lead to considerable exchange rate volatility and disruption of capital flows, particularly in emerging economies. The points raised about the international implications of the CBDC ecosystem highlight the need to ensure a collaborative approach to development and roll-out. Independent actions by major economies could have global consequences for financial stability and may prevent the full realisation of expected benefits. Interoperability can play a crucial role; a CBDC system in a specific country could interact with other national CBDC systems and execute international payments. The digital nature of CBDCs calls for international coordination and cohesion in guiding principles. Bossu et al. (2020) attempt to understand the challenges of developing a common regulatory regime and focus on differences in legal frameworks. The authors point out that international organisations could lead the way in creating common standards. Carstens (2021) argues that international co-operation is required to develop common technical standards and legal frameworks. Even the design of CBDCs may depend on broader coordination issues. Auer, Haene and Holder (2021) favour the implementation of multi-CBDC agreements for the execution of global payment transactions.



D. Sustainability and Inclusivity



Aside from fulfilling their payment function, CBDCs are expected to achieve other objectives, such as financial inclusion, environmental sustainability and social equality. Central banks and policymakers may assess their capacity to reduce digital inequality and support disadvantaged populations while maintaining economic fairness and environmental protection. The literature shows that CBDCs may improve inclusivity and resilience, but there are concerns about unequal access, surveillance, and environmental costs that may result from poor design choices.

3.17 Privacy

The protection of individual privacy rights while upholding the legal requirements to monitor and prevent criminal activity is one of the most delicate trade-offs. Digital currencies necessitate simple interfaces and privacy protection, in compliance with AML and CFT regulations. The public acceptance of the system depends on the privacy features design, as users tend to avoid systems with tracking capabilities that are too invasive. However, complete anonymity would lead to legal and compliance issues. A central line of academic debate contrasts anonymity as a right with traceability as a safeguard. The protection of personal financial data and the prevention of unauthorised monitoring represent the key reasons for anonymity. Ballaschk and Paulick (2021) explain that users need anonymity to protect against excessive government surveillance. Privacy-preserving CBDCs that offer transaction secrecy, like traditional cash, may experience high adoption rates. From this perspective, anonymity could also foster financial inclusion and reproduce the role of cash in retail payments. The use of anonymity has raised concerns among opponents, who fear it will enable illegal activities. State-backed CBDCs must follow AML and CFT regulations, according to Murphy et al. (2024).

Niroula et al. (2024) warn that anonymous capital flows may facilitate unregulated capital movements. In this scenario, enabling anonymity for some payments and identity controls for large transactions could offer a more balanced approach. A tiered privacy model, which requires identification for large transactions but allows anonymity for small ones, has been proposed by Darbha and Arora (2020) as a possible solution. DLT may improve transparency and compliance by enabling the creation of permanent records and the embedding of programmable smart contracts (Peters and Panayi, 2016), though scalability and interoperability challenges remain (Houben and Snyers, 2018). There are examples of potential middle-ground approaches, between fully anonymous token-based systems, which might favour the users (Chaum, Grothoff and Moser, 2021), and fully known account-based systems, which may disappoint individuals, merchants, and payment providers, but may offer regulators ease of monitoring and compliance (Ballaschk et al., 2021). The debate about privacy symbolises the conflict between personal freedoms and regulatory control. The implementation of excessive transparency creates risks for surveillance, public distrust, and resistance to adoption (Murphy et al., 2024). Financial operations that lack identification methods pose significant risks to both legal and financial monitoring systems. The ECB (2020) recognised this challenge when it stated that the digital euro would protect user privacy while preventing illegal activities. Research shows that public trust in privacy features may determine the success of CBDCs. User privacy protection systems need to strike the right balance between privacy measures and regulatory compliance to gain lasting user acceptance.

3.18 Inclusivity

People need access to financial services to meet their fundamental requirements and participate in economic activities. The literature presents CBDCs as tools for financial inclusion, providing secure, efficient, and accessible services to unbanked and underbanked populations (Bossone, 2022). The financial sector has made progress toward expanding access to financial services, yet significant disparities persist, particularly in developing nations and disadvantaged social groups. The implementation of CBDCs could reduce inequalities in access to financial services, but requires proper design to eliminate structural barriers that may prevent financial inclusion. Researchers maintain a neutral stance on CBDCs, as they could promote financial inclusion but also create barriers to access. The implementation of CBDCs offers several advantages, including lower transaction costs,

direct access to digital wallet funds, and financial services for unbanked populations. The offline functionality and device-agnostic access features provide broader access, enhancing inclusion (Auer et al., 2022). Evidence from mobile money adoption suggests that digital payment innovations can meaningfully improve access when combined with enabling regulation and supporting infrastructure (Ozili and Náñez, 2024). The Sand Dollar in the Bahamas is a real case that demonstrates how CBDCs enhance financial services delivery to residents in remote locations (CBOB, 2019). Technological gaps, limited smartphone availability, scarce digital and financial skills, and restricted internet access may represent important barriers for specific groups of people (Niroula et al., 2024). In specific cases, CBDCs might exacerbate financial exclusion, as those unable to meet requirements or impacted by low financial and digital literacy could remain excluded (WEF, 2023).

The combination of insufficient security measures, inadequate privacy protection, and weak governance systems might exacerbate current social gaps (Mancini-Griffoli et al., 2018). The adoption of CBDCs does not ensure that all population groups will automatically receive access to them. Financial inclusion success depends on three essential elements: improving digital and financial literacy, building institutional trust, and creating regulatory frameworks that simplify operations and protect consumers.

According to Auer et al. (2022) and Boakye-Adjei et al. (2023), user-friendly interfaces, offline access and interoperability with current payment systems may increase accessibility. CBDCs should not be viewed as a single technological panacea. The implementation of CBDCs in developed countries may help reduce existing financial barriers that prevent disadvantaged populations from accessing banking services. In emerging economies, people may use CBDCs to replace expensive or unreliable services. Central Banks should avoid widening the digital divide, protecting users from new system vulnerabilities.

3.19 Environmental impact and sustainability

The environmental implications of CBDCs are receiving increasing attention from central banks and policymakers. Although these solutions may consume less power than cryptocurrency networks, deploying CBDCs requires powerful computing resources and secure systems. The implementation of energy-efficient systems has become a priority to achieve sustainability goals. CBDCs have the potential to reduce the environmental and financial costs of physical cash. The process of managing cash requires significant resources, as it involves producing and distributing currency, maintaining storage facilities, implementing security measures, and periodically replacing worn-out banknotes and coins. The production of banknotes and coins, along with the implementation of anti-counterfeiting technology, money transportation security, and cash stock management, generates considerable expenses (Khiaonarong and Humphrey, 2019). Additional costs include staffing for protection against theft and counterfeiting, and frequent replacement cycles (Bergman et al., 2007; Chakravorti et al., 2013). These costs scale with the reliance on physical cash. The transition of economies toward digital payment systems has made CBDCs more attractive as a digital payment solution, potentially reducing transaction costs while providing a secure public payment system. Researchers highlight that CBDCs could deliver environmental and efficiency gains. Bordo and Levin (2017) believe that CBDCs may function as a superior payment system, eventually eliminating the need for physical money. Khiaonarong and Humphrey (2019) suggest that CBDCs may decrease banking service fees, lower cash management costs and reduce its environmental impact. Similarly, Mancini-Griffoli et al. (2018) and Khiaonarong and Humphrey (2019) support the idea that CBDCs may lessen the need for physical money production, distribution, and storage, thereby reducing energy consumption. Higher adoption rates would amplify these effects by reducing the residual costs of cash still in circulation, whereas low adoption would limit the benefits.

Researchers warn that CBDC systems require significant technological and operational resources, potentially eroding some of the advantages of

digital currency. Auer and Böhme (2020) indicate that the necessary infrastructure development for system maintenance, cybersecurity protection, back-up systems and volume capacity expansion requires significant investment. These expenses may decrease some of the environmental advantages that result from producing and circulating fewer physical banknotes. The sustainability equilibrium depends on effective digital infrastructure maintenance and on development plans. The implementation of CBDCs allows payment systems to incorporate sustainability goals into their operations. Through programmability, central banks can establish green incentives by lowering fees for sustainable transactions and rules to encourage environmentally beneficial consumption and investment. The system enables financial transactions to fund climate and sustainability goals, potentially allowing CBDCs to serve as active green finance facilitators rather than merely neutral payment instruments. The benefits of these technologies depend on their adoption rates, on effective system design, and on proper oversight. Table 5 compares the environmental and cost impacts of cash use and CBDCs.

Table 5: Environment and cost impacts of physical cash versus CBDCs

Aspect	Physical Cash	CBDCs
Production and circulation	▪ High expenses for materials and energy needed for printing, minting and implementing anti-counterfeiting measures.	▪ The digital nature of cryptocurrency allows for minimal production expenses thanks to digital infrastructure.
Distribution and storage	▪ Transportation services, protection measures, and periodic replacement with high-cost impact.	▪ Cloud or on-premises infrastructure, licencing and maintenance services, security patching, and periodical upgrades represent most costs
Operational risks	▪ Subject to theft, forgery, wear and tear, and expensive logistics and security measures.	▪ Introduce new operational risks such as cyber threats; requires constant monitoring and compliance to several regulations
Environmental carbon footprint	▪ Production of banknotes, minting of coins, periodical inspection and replacement, waste management of destroyed banknotes and coins.	▪ Energy usage of datacentre, merchant, and end user devices. The overall environmental effects of digital currencies remain uncertain as they depend on the efficiency of the infrastructure.
Scalability of costs	▪ Costs increase with cash demand and circulation.	▪ Costs linked to transaction volume, scaling, and system resilience.
Potential for green incentives	▪ None.	▪ Programmability can embed sustainability goals (e.g. fee reductions for green transactions).

Source: Authors' elaboration.

4. Implementation timeline for CBDCs

The development of a CBDC requires a strategic approach that includes design and planning phases followed by regulatory changes, technological deployments, and public involvement. The potential duration of implementation timelines for CBDCs depends on the unique combinations of regulatory frameworks, technological readiness, and policy objectives across different countries. Four critical stages govern the implementation timeline.

12-24 months

Preliminary research

The first step for central banks involves conducting feasibility studies to determine the reasons for adopting CBDCs, evaluate their effects, and select basic design elements (Auer, Cornelli and Frost, 2020). The objectives could focus on improving financial inclusion, enhancing payment efficiency, and ensuring monetary sovereignty. The evaluation of design choices occurs during this stage, and it may assess alternatives such as DLT token-based or centralised account-based systems, as well as different solutions for retail, wholesale, and hybrid systems. It may require broad participation from central banks, policymakers, and academic experts. This phase may be completed in 12-24 months.

24-36 months

Regulatory frameworks

The updates to the legislation should focus on privacy, data protection standards, and compliance with AML/CFT regulations (Murphy et al. 2024). In addition to appropriate laws, consumer protection and privacy require suitable governance systems (Ballaschk and Paulick, 2021). The process requires authorities to work together during this stage, which extends for two or more years.

36 months

System architecture and pilot testing

The process of establishing legal and regulatory frameworks may direct the selection of the system architecture (BIS et al., 2021a). The development process may last three or more years, with continuous feedback loops and design adjustments. The testing phase should start with pilot projects to evaluate the system's functionalities, security, and user acceptance with small groups of participants (WEF, 2021).

up to 24 months

National rollout

The last stage of implementation occurs after the completion of pilot projects to enhance user adoption, connect CBDCs with existing payment systems, and launch public awareness campaigns (IMF, 2024). National monetary authorities should monitor system performance, including adoption rates and macroeconomic effects, to determine appropriate policy changes to maintain financial stability. This phase may take up to two years.

Overall timeframe

The entire process from research to widespread implementation may take 4 to 10 years, depending on legal preparedness, technological readiness, and policy targets. The BIS (2023b) states that jurisdictional regulations, design choices, and project complexity are the key drivers of implementation. Wholesale CBDCs may have a faster implementation process than retail CBDCs, considering the time required for retail CBDCs to evaluate and approve adequate legal frameworks, implement new technological solutions and, most importantly, gain public trust (BIS, CPMI and MC, 2018). National specificities may influence the implementation journey.

5. Conclusions, policy recommendations and future research agenda

CBDCs represent an important innovation for monetary and financial systems. They support financial transactions through multiple channels, enhancing payment efficiency, monetary policy effectiveness and financial inclusion. CBDCs operate as an alternative to private digital currencies, interfacing with existing payment systems for both domestic and international use, enabling instant payment processing and reducing transactional costs. The digital transformation brings new security threats, operational and privacy risks, that may disrupt traditional banking operations and threaten the independence of central banks.

CBDCs may be targeted by fraud and may also stimulate regulatory arbitrage and exacerbate geopolitical tensions. Therefore, they require international coordination and appropriate design choices. The success of CBDCs depends on the level of attention central banks and policymakers give to design, regulatory frameworks, and implementation strategies. Their successful outcome may depend on a combination of factors, including design choices, regulatory oversight models, and operational processes. Central banks and policymakers may direct that. CBDCs require adequate governance mechanisms, resilient technology, stable operational procedures, and public trust to reach their full potential. Central banks and policymakers should identify the balance between financial innovation, privacy protection, oversight capabilities, and financial inclusion to ensure the successful implementation of CDBCs.

5.1 Policy recommendations

The following recommendations can assist national monetary authorities, policymakers, technology providers, and international stakeholders in assessing CBDCs and improving their implementation:

1 STRENGTHEN THE REGULATORY FRAMEWORKS.

- The establishment of clear rules should outline key areas, including the distribution methods for CBDCs, data protection measures, AML/CFT compliance requirements, and consumer protection standards.
- The achievement of legal certainty and the alignment of domestic law with international standards to prevent regulatory arbitrage opportunities should be important concerns for policymakers.

2 PRIORITISE FINANCIAL STABILITY.

- The design of CBDCs should function as an addition to existing commercial banking operations, rather than seeking to replace them.
- The following measures may help prevent bank disintermediation: limits on digital wallet holdings, no-interest or tiered remuneration, and transaction caps.

3 BALANCE PRIVACY WITH COMPLIANCE.

- CBDC systems should protect users' personal information while still enabling the tracking of high-risk transactions.
- Researchers should investigate advanced privacy solutions, including tiered anonymity systems and privacy-preserving cryptography methods.

4 PROMOTE FINANCIAL INCLUSION.

- Implementing accessible systems with user-friendly digital wallets that integrate with low-tech devices and function offline without internet access may support adoption rates.
- Promoting awareness initiatives, such as digital and financial literacy campaigns, may strengthen the impact of investments in technical solutions and digital infrastructure.

5 IMPLEMENT RESILIENT TECHNOLOGY.

- Central Banks need to develop or invest in infrastructure systems capable of scaling capacity to meet transactional demands, while enhancing security and protecting against cyber threats.
- The implementation of hybrid technological systems may unite centralised resilience capabilities, with specific decentralised elements to accelerate execution at the user level.

6 PROMOTE SUSTAINABILITY.

- The deployment of energy-efficient technologies may reduce carbon footprints and mitigate the environmental impacts of CBDCs.
- The development of programmable features may be adopted to motivate users to adopt green finance and carbon-neutral solutions.

7 FOSTER INTEROPERABILITY AND INTERNATIONAL CO-OPERATION.

- CBDCs should be integrated with existing systems and the broader payment services ecosystem to prevent the creation of silos and the fragmentation of liquidity pools.
- The BIS, IMF, FSB, World Bank and other international bodies may support global co-ordination efforts to establish common standards for international interoperability.

8 ADOPT A PHASED AND ADAPTIVE IMPLEMENTATION APPROACH.

- Soft-launch services through dedicated pilot projects and phased rollouts, to test adoption, scalability, and public trust.
- Implement iterative feedback loops from users and stakeholders to enable design structure adjustments and to preserve financial stability.

5.2 Future research agenda

The development of CBDCs has made substantial progress over the last few years. However, key areas need additional focus. Future research can help close current knowledge gaps by examining CBDCs across the four dimensions of the proposed framework.

A. POLICY, REGULATORY, AND GOVERNANCE

The evaluation of CBDCs requires examining their long-term effects on financial stability, economic growth, and disintermediation. The focus should be on analysing how CBDCs may impact geopolitical ambitions, the potential risks of digital dollarisation, and their implications for monetary sovereignty.

B. DESIGN AND TECHNOLOGY

The evaluation of various CBDC architectures requires comparative studies to assess hybrid models, which combine centralised features with innovative decentralised elements. Researchers may study the creation of interoperability standards and support cross-border pilot projects to achieve technical integration and to secure international payment settlements.

C. SOCIO-ECONOMIC AND FINANCIAL INTEGRATION

The combination of CBDCs with other digital finance systems and their integration should be further investigated, especially in developing countries, where mobile money is a key instrument for financial inclusion. CBDCs might complement or compete with existing solutions, especially those designed by private firms. Understanding these dynamics may be crucial to increasing adoption rates and transactional use.

D. SUSTAINABILITY AND INCLUSIVITY

Research groups should evaluate the environmental impacts of digital currencies while exploring their programmable features and design elements to achieve sustainability objectives. The evaluation process should assess energy efficiency while examining the potential of CBDCs to support green financial programs.

Research evidence shows that CBDCs may bring more than just technological progress. They represent a structural transformation in the nature of money.



Glossary

Access Controls: Security mechanisms that oversee user-system interactions and their connections with other systems and resources.

Base Money: The aggregate amount of currency in circulation, including commercial bank deposits and reserves held by banks at the central bank.

Blockchain: A blockchain system maintains a transaction record across multiple computers, in a network structure that prevents retroactive alterations of this information.

Central Bank Digital Currencies (CBDCs): National monetary authorities distribute electronic currencies that function as state-backed digital money to implement modern payment solutions and expand access to financial services.

Conditional Spending: The ability to establish rules for digital currency spending, based on predefined conditions.

Cross-Border Transactions: Financial trades between a sender and recipients located in different countries.

Cryptocurrencies: A form of digital currency secured by cryptography and operated in a decentralised way, without a lender of last resort.

Disintermediation: The decrease in the number of intermediaries in a productive process. In the context of CBDCs, banks and financial institutions act as intermediaries in financial services.

Distributed Ledger Technology (DLT): Different typologies of systems which log transactions at multiple locations and prevent modifications and deletions of recorded data.

Double-Spending: A scenario where funds could be used multiple times from the same CBDC wallet.

Environmental Impact: The consumption of energy, waste generation and carbon emissions generated by a specific activity and/or system.

Fiat Money: Currency acting as legal tender as per government rules but lacking physical asset backing.

Interbank Settlements: The mechanism of settling transactions and concluding transactions among financial institutions.

Interoperability: The capability for various systems and applications to operate together within and across organisational limits.

KYC (Know Your Customer): The procedure by which a business confirms client identities and evaluates their risk potential for illegal activities in business transactions.

Legal Tender: The lawful money that must be accepted for settling debts according to rules.

Monetary Sovereignty: The control by a country of its own currency and monetary policy.

Multi-Factor Authentication: The requirement to authenticate to specific systems through multiple forms with separate categories of credentials.

Pilot Phase/Project: Before full market release, organisations perform initial testing of their new systems or products in controlled environments to identify and resolve issues.

Programmability: Digital currencies offer functionality that allows automated rules and conditions to be programmed into the currency.

Quantum Computing: This computing method performs complex calculations by exploiting quantum-mechanical phenomena, such as superposition and entanglement.

Regulatory Arbitrage: The action of exploiting regulatory variations between nations to evade adverse legal requirements.

Regulatory Frameworks: A set of rules and regulations that provide the structure and guidance for financial institutions to operate.

Scalability: The capability of a system to manage increasing amounts of work as well as its potential for expansion to handle further growth.

Smart Contracts: Contracts which operate through code-based terms and trigger automatic execution on the network.

Throughput: The amount of data processed through a system during a defined period.

Tiered Remuneration Schemes: A system in which different interest rates, or other incentives, are applied to varying sums of money or transactions.

Time-Limited Currency: Digital money that becomes invalid once its predetermined expiry period passes.

Transaction Fees: Charges imposed by a financial institution for processing a transaction.

User Interfaces (UI): A User Interface (UI) serves as the interactive bridge between a user and computer software or applications.

Zero-Knowledge Proofs: A technique that lets one entity demonstrate knowledge of a value to another party without transmitting any additional information beyond proof of possessing that value.

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