Central Bank Digital Currency: Perspectives on Design Choices and Implications, with a Focus on e-Rupee

Dr. Vidhu Shekhar[1] and Sanjogita Ramesh[2]

Abstract

Central Bank Digital Currencies (CBDCs) are rapidly gaining momentum as 134 countries explore digital currency initiatives, yet critical gaps remain regarding design choices that determine implementation success. This study examines how CBDC design decisions influence effectiveness and integration with existing payment systems in emerging economies with established digital infrastructures. Through in-depth interviews with 22 experts, we identify essential implementation considerations and their systemic implications. Our findings reveal three critical insights for successful CBDC deployment. First, a two-tier, non-interest-bearing distribution model preserves banking stability while enabling innovation, with offline capabilities essential for broad accessibility. Second, CBDCs should complement rather than replace existing digital payment platforms, enhancing system efficiency through immediate settlement finality and programmability. Third, phased implementation guided by clear metrics and strategic partnerships proves essential for sustainable adoption. This research contributes a novel four-layer design framework demonstrating the interconnected effects of technological, security, financial, and user experience choices on payment system evolution. These findings guide emerging market policymakers in optimizing CBDC implementation through strategic interoperability, infrastructure leverage, and balanced innovation.

Recommended Citation

Shekhar, V. & Ramesh, S. (2025). Central bank digital currency: Perspectives on design choices and implications, with a focus on e-rupee. *Financial Services Review, 33*(3), 61-79.

Introduction

The digital development is transforming the financial industry (Nourallah et al., 2021), and 134 countries are exploring the implementation of Central Bank Digital Currencies (CBDCs). This represents a notable development in the evolution of the monetary and payment system worldwide. CBDCs arguably signify the most transformative shift in money since the abandonment of the gold standard and the subsequent adoption of fiat currencies. This shift fundamentally alters monetary system structures, governance, and technology by integrating programmability, enhancing financial inclusion, and redefining cross-border payments.

According to the Bank of International Settlements (BIS, 2020), CBDCs can play a pivotal role in modernizing payment systems by enhancing efficiency, security, and inclusivity. Of the countries currently exploring CBDC implementation, three have fully launched their systems, 44 are in the pilot phase, and the remainder are in various stages of research and development (Atlantic Council, 2025).

[1] S. P. Jain Institute of Management and Research (SPJIMR), Mumbai, India.
[2] Corresponding author (fpm22.sanjogita@spjimr.org). SPJIMR, Mumbai, India.

This growing interest underscores the recognition of CBDCs' potential to enhance payment efficiency, while simultaneously providing central banks with innovative tools for oversight and policy implementation. Nevertheless, the successful implementation of CBDCs demands careful consideration of numerous interconnected design elements, particularly within economies already possessing sophisticated digital payment infrastructures (Allen et al., 2020; BIS, 2020).

The literature on CBDCs has predominantly focused on theoretical frameworks and technical aspects of implementations. Previous studies, such as BIS (2020), Herve Tourpe et al. (2023) and Soderberg et al. (2023) have explored CBDC design processes, noting that design parameters evolve alongside advancements in technology and policy. However, a research gap persists concerning the specific impacts that CBDC design choices have on payment systems. This gap is further relevant for countries already having robust and widely adopted digital payment platforms serving large populations efficiently. India presents an ideal reference case for examining these dynamics, as it possesses one of the world's most successful digital payment ecosystems through the Unified Payments Interface (UPI), while simultaneously piloting its e-Rupee CBDC, creating a unique laboratory for understanding CBDC-existing system interactions.

To address these gaps, this study provides a structured examination of how CBDC design decisions influence existing financial infrastructures, particularly within emerging economies like India, featuring mature digital payment systems. Our research focuses on three research questions:

> RQ1: What critical design choices determine CBDC effectiveness?
>
> RQ2: How do CBDC design choices impact existing payment platforms and their evolution?
>
> RQ3: What considerations should guide CBDC implementation in emerging economies with established digital payment infrastructure, such as India?

Methodologically, we adopt a qualitative approach, conducting in-depth expert interviews to examine critical CBDC design considerations and their implications for existing payment systems. The expert panel comprises 22 professionals from diverse sectors, including fintech, banking, payments, and academia, offering insights into the technical and operational dimensions of CBDC implementation.

Our findings indicate that CBDC design involves multiple integrated layers, each with distinct implications for payment system functionality and evolution. We highlight three key insights. First, a two-tier, non-interest-bearing distribution model preserves banking stability while enabling innovation, with offline capabilities essential for broad accessibility. Second, CBDCs should complement rather than replace existing digital payment platforms, enhancing system efficiency through immediate settlement finality and programmability. Third, phased implementation guided by clear metrics and strategic partnerships proves essential for sustainable adoption.

The remainder of this paper is structured as follows: Section 2 presents literature review on CBDC design and implications. Section 3 outlines the research methodology, including details of the qualitative approach and expert interviews. Section 4 discusses our key findings and Section 5 concludes the paper.

Literature Review

The literature on CBDCs has evolved in response to shifting priorities in monetary policy, technological innovation, and payment system modernization. Current research broadly focuses on four interconnected themes (see sub-sections 2.1–2.4).

Current Status and Implementation of CBDCs

Initial CBDC research emerged from central banks' post-2008 monetary policy challenges. Early theoretical contributions by Agarwal & Kimball (2015) and Rogoff (2015) conceptualized CBDCs primarily as instruments for implementing negative interest rates and overcoming the zero lower bound constraints. However, Bindseil (2019) identifies a disconnect between these theoretical models and contemporary central bank objectives, noting that most central banks currently envision non-interest-bearing CBDCs subject to stringent quantity limits.

Subsequent research shifted its emphasis toward technological innovations and improving payment system efficiency. For instance, Bech & Garratt, (2017) developed a foundational taxonomy distinguishing retail and wholesale CBDCs, demonstrating that blockchain technology could provide digital cash with anonymity features while eliminating cryptocurrency volatility, and proving central bank money could transfer on distributed ledgers in real time, though the technology remained immature. Auer & Böhme (2021) advance this by establishing "minimally invasive" CBDC design requirements, finding that cryptocurrency-inspired approaches were unsuitable and instead identifying hybrid/intermediated architectures as most promising, while discovering a novel trade-off whereby central banks must choose between operating complex technical infrastructure or complex supervisory regimes. More recent literature increasingly examines interactions between CBDCs and established digital payment infrastructures. Tercero-Lucas (2023), employing a Diamond-Dybvig framework, explores financial stability implications, while Bindseil & Senner (2025) model impacts on monetary policy transmission and financial intermediation. They also highlight that many proposed technological benefits face practical limitations within central banks' conservative design parameters, including non-interest-bearing structures, strict holding limits, and automated links to commercial bank accounts.

Design Considerations - Technical Architecture and Policy Implications

The technical architecture of CBDCs critically shapes their functionality, security, and economic viability. A foundational design decision involves selecting between a centralized or distributed ledger architecture. Allen et al. (2020) extensively analyze this choice, emphasizing its implications for accessibility, privacy, and systemic resilience, ultimately recommending a centralized architecture.

Another important debate centers on whether CBDC design should complement or disrupt existing payment systems. Agur et al. (2022) suggest that while CBDCs must be distinct from conventional payment platforms, their integration should minimize disruptions to commercial banks, especially in economies with well-established digital payment systems. Corbet et al. (2024) challenge this viewpoint by presenting empirical evidence suggesting that regulatory frameworks, rather than technological readiness, predominantly drive CBDC initiatives in emerging markets. The PwC India report (2021) further highlights implementation challenges in emerging markets, advocating for a two-tier issuance architecture that preserves commercial bank roles while enabling programmable payments and financial inclusion for unbanked populations.

Security considerations further complicate CBDC implementation. Tian et al. (2023) highlight CBDCs' potential role in mitigating private-sector cyber risks but also caution that systemic cybersecurity vulnerabilities could threaten financial stability if inadequately addressed.

Beyond security and integration challenges, existing literature also explores theoretical frameworks for understanding the fundamental trade-offs inherent in CBDC design. Mishra & Prasad (2024) develop a general equilibrium model that examines the coexistence of cash and CBDC, demonstrating how design choices affect their relative holdings. Their analysis shows that CBDCs can expand the monetary policy toolkit by enabling negative nominal interest rates and "helicopter drops" of money. The paper provides insights on design that can preserve elements of a cash-based economy while delivering digital currency benefits.

Regarding the global landscape of CBDC, Claessens et al. (2024) highlight that 130 countries, representing 98% of the global Gross domestic product (GDP), are investigating CBDCs, with varying degrees of implementation. China has already conducted 1.8 trillion-yuan (approximately $249.9 billion) worth of CBDC transactions in trials, while countries like Nigeria and the Bahamas have officially launched CBDCs with mixed results. These international experiences underscore the critical importance of meticulous CBDC design, illuminating both opportunities (financial inclusion, payment system innovation) and challenges (regulatory complexities, cybersecurity threats).

Collectively, these studies underscore the necessity for CBDC designs to balance privacy,

resilience, and regulatory oversight to achieve widespread adoption and effectiveness.

CBDCs: Banking Disintermediation, Stability, and Payment System Implications

The potential impacts of CBDCs on banking systems are widely debated, focusing primarily on bank disintermediation, financial stability, and interactions with existing payment infrastructures.

In relation to bank disintermediation, the degree to which CBDCs affect bank deposits depends on whether they are remunerative (interest-bearing) or non-remunerative. For instance, the Reserve Bank of India (RBI) has adopted a non-interest-bearing model for its e-Rupee to mitigate disintermediation risks. Empirical research by Chiu et al. (2023) suggests that interest rate calibration between 0.30% and 1.49% could allow CBDCs to coexist with traditional banking systems without causing severe disruptions. Son et al. (2023) offer a contrasting perspective and find that remunerative CBDCs may significantly impact customer behavior and financial intermediary profitability, intensifying competition in the deposit market.

Concerning financial stability, Corbet et al. (2024) caution against rapid CBDC deployment, especially in less-prepared economic environments. They warn that abrupt shifts in deposit structures and absent safeguards could significantly heighten financial instability risks. Providing an alternative perspective, Luu et al. (2023) offer empirical evidence from a large sample of banks across 86 countries, indicating that CBDC adoption contributes to financial stability by reducing leverage and asset risks while expanding lending. The authors contend that retail CBDCs may promote stability whereas wholesale CBDCs may hamper it.

Beyond stability concerns, the interaction between CBDCs and existing payment systems presents opportunities and challenges. Di Maggio et al. (2024) argue that CBDCs might reshape payment systems in emerging economies, particularly by potentially displacing private-sector digital payment providers due to differential taxation policies and transaction cost structures. In the Indian context, Banerjee & Sinha (2023) emphasize that adopting CBDC should be complementary rather than competitive to existing systems like the UPI.

Additionally, privacy and regulatory considerations are crucial factors influencing CBDC adoption. Wang & Gao (2024) stress the importance of balancing security with user anonymity to maintain customer trust while effectively mitigating illicit activities. Ren et al. (2024) highlight that the inherent trade-off between preserving user privacy and meeting Anti-Money Laundering (AML) compliance remains unresolved.

The unresolved tensions across disintermediation, stability, payment integration, and privacy demonstrate the interconnected nature of CBDC design choices and their far-reaching implications for financial systems.

Financial Inclusion, Innovation, and Future CBDC Applications

One of the most widely cited motivations for CBDC adoption is its potential to enhance financial inclusion, particularly in economies with substantial unbanked populations. Tan (2024) models a two-tier CBDC system in which commercial banks function as distributors, incentivizing unbanked populations to engage with formal financial systems by opening digital accounts.

The potential for CBDCs to enhance financial inclusion has emerged as a key consideration in their development. Traditional banking systems often exclude certain populations due to geographic, economic, or regulatory barriers, creating demand for alternative financial solutions.

Recent research reveals that cryptocurrencies are increasingly used as alternative financial services for payments and money transfers, particularly among populations seeking alternatives to traditional banking (Curnutt & Smith, 2025). This trend highlights the potential role CBDCs could play in providing regulated digital payment alternatives that address similar needs while maintaining central bank oversight and financial stability.

Empirical research supports this claim. Dunbar & Treku (2024) find a statistically significant relationship between CBDC awareness and reductions in unbanked individuals in the U.S., notably among middle-income and

underbanked groups. However, their findings emphasize that CBDC adoption alone is insufficient for achieving sustained financial inclusion, suggesting that broader financial literacy programs and digital infrastructure enhancements are necessary to ensure long-term success.

Beyond financial inclusion, CBDCs have the potential to stimulate technological advancements and innovation in financial services. Ahnert et al. (2022) and Chen et al. (2022) show that CBDCs can foster increased competition in digital payments, thereby encouraging the development of novel financial products and business models.

Despite these promising developments, current literature on CBDC design and implementation highlights critical gaps relevant to the objectives of this study. While theoretical frameworks on CBDC designs exist, there is limited practical guidance regarding methods for integrating CBDCs within advanced digital payment systems. This deficiency is particularly evident concerning choices about technical architecture, integration requirements, and the trade-offs between innovation and financial stability, issues central to RQ1 on critical CBDC design choices.

Furthermore, existing studies such as Di Maggio et al. (2024) focus on the potential displacement of private-sector providers rather than system evolution, while Banerjee & Sinha (2023) emphasize complementary adoption without detailed analysis of system interactions. Analyses focusing on banking systems and financial stability (Chiu et al., 2023; Luu et al., 2023; Son et al., 2023) frequently neglect the complex interactions between existing payment service providers, fintech innovations, and established market structures. This limitation directly informs RQ2 regarding how CBDC design choices affect existing payment platforms and their evolution.

Finally, how specific CBDC design decisions impact financial services in emerging economies with advanced digital financial infrastructures, such as India, remains underexplored. Addressing this research gap aligns with RQ3, which focuses on practical considerations and guidance for implementing CBDCs in contexts characterized by mature digital payment infrastructures.

Research Methodology

Research design and Sample selection

This study uses qualitative research methods to understand CBDC design choices and their effects on payment systems in emerging economies. A qualitative approach was chosen to capture in-depth expert insights into complex, interrelated design considerations and implementation issues.

The study employs purposive sampling to ensure comprehensive representation of expert perspectives on CBDC implementation. Our final sample comprised 22 participants in India across three main professional groups. The first group comprised eight fintech and blockchain experts, including technology consultants, blockchain specialists, and digital currency experts who provided technical insights into CBDC design and architecture (FT1-8). The second group consisted of seven banking and payment industry professionals who offered practical implementation perspectives (BP1-7). The third group included seven academic and policy experts who contributed with policy-related insights (AB1-7). Detailed participant demographics, professional affiliations, and experience levels are summarized in Appendix A.

We determined sample size based on the principle of data saturation, conducting interviews until subsequent discussions no longer yielded new thematic insights. The chosen sample size was sufficient to achieve saturation, with later interviews confirming thematic patterns initially identified.

Data Collection

Each interview, conducted between April and November 2024, lasted approximately 40 to 60 minutes and was audio-recorded with participant consent. The interviews were carried out using a semi-structured format. We used a set of prepared questions but allowed for open discussion to gain additional insights on emergent themes. All interviews were conducted in English.

Our data collection process followed a consistent pattern throughout all interviews. Each session began with an introduction to the study and confirmation of informed consent. The main interview portion explored participants' views on CBDC design choices,

effects on existing payment systems, and implementation considerations. We encouraged participants to provide specific examples and elaborate on their experiences. This structured, yet flexible, approach helped ensure overall coverage of key topics while allowing for the exploration of unexpected but relevant themes that emerged during the discussions.

The study adhered strictly to ethical research standards. All participants received comprehensive information on study objectives, procedures, and confidentiality measures prior to providing informed consent. The participants were informed of their right to withdraw at any point, though none chose to exercise this option.

Data Analysis

The analysis of interview data followed the thematic analysis methodology established by Braun & Clarke (2006). We began by creating detailed transcripts of all recorded interviews, with each transcript checked multiple times for accuracy. Initial analysis involved careful reading of all transcripts to identify key themes and patterns in the responses. We then developed a coding framework to organize the data into meaningful categories aligned with our three research questions.

The coding process involved the two researchers working independently to ensure the reliability of the interpretation. Regular meetings allowed us to discuss and resolve any differences in coding decisions until we reached an agreement. We paid particular attention to emerging patterns related to CBDC design choices and their implications for payment systems. This collaborative approach helped us minimize individual researcher bias.

Several limitations of our research methodology must be acknowledged. Firstly, our expert sample predominantly comprised individuals from major financial centers, potentially limiting insights from other regions. Secondly, the timing of data collection coincided with the early stages of CBDC implementation, suggesting that certain findings may require revisiting as implementations progress. Thirdly, due to the rapidly evolving nature of CBDC technologies and associated regulatory landscapes, some technical insights reported here may need periodic updating.

Findings

Our thematic analysis identified four central themes regarding CBDC implementation and design: (1) Need and Status of CBDC Implementation, (2) Critical Design Elements, (3) Implications for Financial Systems, and (4) Future CBDC Use Cases in Financial Services. These themes provide detailed insights into how CBDC design choices influence payment systems and financial infrastructure in emerging economies (see Appendix B)

Need and Status of CBDC Implementation

The emergence of CBDCs represents a strategic response to evolving financial landscapes. Our expert interviews revealed diverse perspectives on the primary drivers of CBDC adoption, with notable differences between technology and banking professionals.

Fintech experts highlighted technological innovation and efficiency. As noted by a blockchain specialist (FT1): “CBDCs can be introduced in the economy when there is a decline in cash usage. Central banks must evaluate if there is a need to modernize public payment infrastructure.”

Conversely, banking professionals emphasized regulatory considerations and financial stability. A banking executive (BP5) explained: “The primary motivation should be ensuring monetary sovereignty in an increasingly digital world, rather than simply following technological trends.”

India's e-Rupee implementation represents a carefully considered approach to digital currency deployment. Per the Reserve Bank of India (2022) report, e-Rupee pilot was launched in December 2022, adopting a two-tier distribution model that maintains the role of traditional banking intermediaries while introducing innovative digital currency features. An industry expert (BP1) highlighted the following key advantage: “The technology used in e-Rupee is blockchain, which is very difficult to break through; if there is any suspicious activity, information will be broadcasted and traced immediately.”

A notable aspect of India's approach is the non-remunerative design of the e-Rupee, which was chosen to minimize disruption to the banking sector. As a banking expert (BP5) explained: “Banks will play a crucial role in CBDC

implementation, providing payment and transaction settlement services." This design choice reflects careful consideration of financial stability while enabling innovation in payment services.

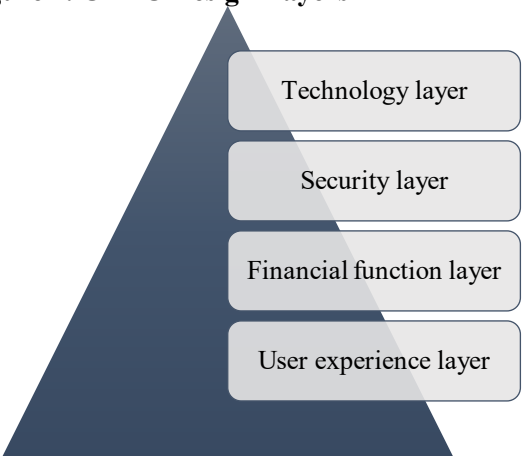
The pilot phase has revealed several promising developments. In the retail segment, the e-Rupee demonstrates capabilities for instant settlement, offline transactions, and enhanced privacy features. The wholesale segment shows potential for improving interbank settlement efficiency and reducing operational costs. A fintech research expert (BP6) noted: "CBDC settlements are instantaneous and final, reducing operational risks and settlement time significantly."

Critical Design Elements of CBDC

Figure 1 illustrates the layered conceptual framework of CBDC design, as derived from expert interviews and thematic analysis. This structure comprises four interconnected layers: technology, security, financial functions, and user experience, each representing critical areas of decision-making in CBDC implementation. These design layers collectively influence the effectiveness, adoption, and integration of CBDCs within existing financial infrastructures, highlighting the multifaceted considerations central banks and stakeholders must navigate. The interconnected nature of these layers directly impacts how CBDCs integrate with existing payment systems (RQ2) and shapes implementation strategies for emerging economies (RQ3).

Expert interviews revealed differences between different stakeholder groups regarding optimal CBDC design choices. While banking experts emphasized the importance of financial layer and a two-tier distribution model to maintain financial stability, technical experts highlighted the need for robust security frameworks and offline functionality in the technology layer.

Figure 1. CBDC Design Layers



Source: Authors' illustrations

Technology Layer

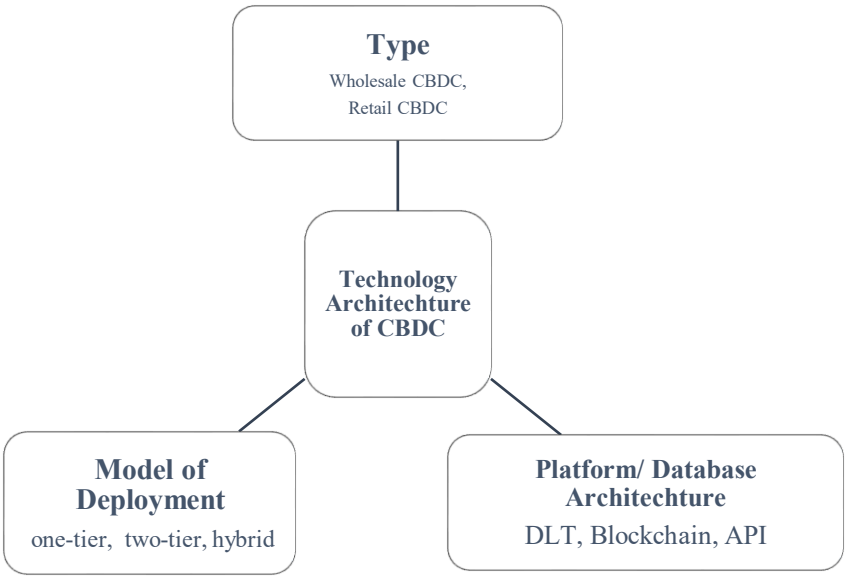
The technological framework has strong implications for financial markets and services. The success of CBDC implementation depends on aligning technological choices with policy objectives while addressing practical requirements.

Interviews revealed divergent priorities: fintech experts emphasized innovation, with a consultant (FT4) noting: "The choice of architecture must balance innovation potential with practical implementation constraints." On the other hand, banking professionals prioritized integration with existing financial systems.

As shown in Figure 2, CBDC is of two types: Wholesale CBDC for interbank settlements and retail CBDC for customer usage. CBDC can be deployed using a one-tier (central bank direct), two-tier (with intermediaries), or a hybrid model.

India's two-tier approach contrasts with China's digital yuan implementation, which employs a centralized management model within a two-tier operational model, with direct central bank oversight. While China prioritizes monetary control and surveillance capabilities, India's model preserves banking sector roles. Nigeria's eNaira represents a third approach, utilizing a hybrid model that faced adoption challenges due to limited integration with existing mobile money systems. As one academic expert (AP3) noted: "Each country's existing payment infrastructure shapes viable CBDC architectures."

Figure 2. Technology Architecture of CBDC



Source: Authors' illustrations

As shown in Figure 2, CBDC platforms can be Digital Ledger Technology (DLT)-based, blockchain-based, or Application Programming Interface (API)-based, each with distinct characteristics. DLT refers to a digital system for recording transactions where records are maintained simultaneously across multiple locations, providing greater security and transparency than traditional databases. Blockchain is a type of DLT designed to be cryptographically connected in a sequential order (Bureau of Engraving and Printing, 2025). APIs are sets of protocols and tools that allow different software applications to communicate with each other, enabling seamless integration between systems.

DLT platforms offer flexibility and privacy controls, suitable for both wholesale and retail applications. Blockchain platforms provide enhanced security but may face scalability issues. API-based platforms allow integration with existing banking systems and high scalability.

Financial experts (BP5, BP6) favored approaches that maintain compatibility with existing infrastructure, while technology specialists (FT1, FT3) emphasized the distributed ledger technologies' transformative potential.

Platform selection creates critical trade-offs that directly impact payment system integration (RQ2). Wholesale CBDCs prioritizing security and settlement finality favor DLT or blockchain architectures, but this choice may limit interoperability with existing banking APIs. Retail CBDCs requiring high transaction throughput often employ API-based approaches for seamless integration with current payment rails yet sacrifice some of the programmability benefits that DLT platforms offer. Cross-border applications demand strong interoperability, typically requiring DLT or hybrid solutions that can bridge different national payment systems while maintaining regulatory compliance.

A centralized architecture prioritizes efficiency and oversight but introduces potential vulnerabilities. Decentralized architectures enhance resilience and market participation, while hybrid approaches balance innovation with regulatory control. As one banking professional (BP1) noted: “Settlement efficiency gains in wholesale applications could transform liquidity management for financial institutions.”

Academic experts (AP3, AP7) emphasized balancing innovation with stability, suggesting hybrid approaches might offer the best compromise. These technological choices collectively determine both operational characteristics and the CBDC's potential to transform financial market structures.

Security Layer

Security architecture plays a central role in shaping CBDC functionality and integration capabilities. The choice between privacy-preserving and transparency-focused security models creates a design tension that affects both user adoption and regulatory compliance.

Expert interviews revealed varying security priorities across stakeholder groups. An industry expert (BP1) emphasized: "RBI does not know who the end recipient is; it only tracks how much currency is released and utilized; transactions are private end to end, similar to cash transactions." A technology expert (FT4) noted: "CBDC is a secure method of payment, with no risk of personal information leakage."

CBDCs must be developed with privacy-preserving techniques such as homomorphic encryption, incorporate smart contracts for regulatory oversight, and include automated encryption for monitoring. Banking professionals (BP3, BP5) emphasized familiar security frameworks, while technology specialists (FT1, FT7) advocated for advanced cryptographic solutions.

Risk management strategies, including recoverability, technical stability, and a robust governance framework, must be implemented to ensure safe transactions. The e-Rupee is designed to include features resembling physical currency, with central bank supervision and options for anonymity in smaller transactions. However, security choices create implementation challenges. Enhanced privacy features may conflict with AML or Know Your Customer (KYC) requirements, while excessive transparency could undermine user adoption. As one technology expert (FT1) noted: "The challenge is creating security that satisfies both user privacy expectations and regulatory oversight needs without compromising system performance."

Financial Function Layer

The financial function layer equipped with functionalities to conduct financial operations. This layer encompasses a range of features that enable efficient processing of transactions, management of digital assets, and integration with existing financial systems, enhancing the overall effectiveness of the CBDC framework.

Our expert interviews revealed contrasting perspectives on key financial function aspects. Academic experts highlighted the theoretical benefits of interest-bearing CBDCs, while industry professionals emphasized practical stability concerns. As one senior banker (BP2) explained, "An interest-bearing CBDC could fundamentally alter deposit dynamics, potentially disrupting commercial bank funding models."

Remunerative CBDCs offer an interest-bearing characteristic and could act as a liquid government debt instrument, serving as a secure asset. However, there is a risk that these types may disrupt traditional banking systems if they become the favored option for deposits over savings accounts due to higher competitive interest rates, potentially leading to bank runs. Conversely, non-remunerative CBDCs exist solely as digital currencies that do not accrue interest. This type prevents bank disintermediation and helps maintain stability in the financial system. The pilot phase of the e-Rupee is intended to be non-remunerative and does not accrue any interest on value storage.

The tokenization capability enables the digital representation of financial assets or rights within the CBDC framework, fostering efficient payment and settlement systems and encouraging innovation in financial services. Technology experts (FT1, FT7) emphasized the transformative potential of tokenization for asset markets.

The programmability feature restricts the use of CBDC tokens to specific applications, such as designated CBDC medicine tokens that can only be used for purchasing medicines. As noted by a fintech expert (FT6): "Programmable money creates entirely new possibilities for targeted policy implementation." This characteristic can impact welfare programs and presents opportunities for innovation in financial products and services.

The selection between financial functions creates cascading effects on existing payment systems. Non-remunerative designs preserve banking sector stability but may limit CBDC adoption incentives, programmability enables innovative financial products but requires new regulatory frameworks that existing payment providers must navigate. A banking expert (BP2) observed: "Programmable features could

either complement existing fintech or displace them entirely."

The interoperability feature facilitates seamless interactions among financial systems, promoting quicker and more effective settlements and payments. Banking professionals (BP4, BP6) emphasized the importance of interoperability with existing infrastructure to ensure smooth adoption and system efficiency.

User Experience Layer

The user experience influences how individuals access and utilize CBDCs. Expert interviews revealed diverse perspectives on the balance between innovation and accessibility. While technology experts (FT2, FT4) advocated for feature-rich interfaces, financial inclusion specialists (BP7, AP7) emphasized simplicity and accessibility across diverse user segments.

The e-Rupee must be built to scale effectively across all regions of India, ensuring accessibility on various devices while serving diverse population segments, including those with limited connectivity or banking services. A financial inclusion expert (BP7) noted: "CBDC should be designed to accommodate diverse segments of the population, including various age groups and economic backgrounds."

CBDCs can follow either an account-based or token-based structure. In an account-based CBDC, access and claims are tied to the user's bank account and are subject to KYC regulations to identify and verify the user's identity. This helps prevent fraudulent accounts, theft, and unauthorized access. If the CBDC is implemented using the one-tier model, compliance and authentication processes must be adhered to by the central bank (Auer & Böhme, 2021). Conversely, in a token-based framework, CBDCs are issued as digital tokens and distributed by collaborating financial institutions through mobile app-based wallets. These partner banks provide applications to their registered customers, who can fund their CBDC wallets using their bank accounts, enabling peer-to-peer or merchant transactions.

The e-Rupee (retail) operates on a token-based model; the RBI has teamed up with various banks nationwide to distribute CBDC tokens to the public. Banking customers can register with a partner bank to access the e-Rupee wallets, loading funds into it via their bank accounts or UPI, facilitating direct transactions to peers' wallets or payments to merchants using QR codes without intermediaries. This presents a rapid and secure method of transferring digital currencies.

A key innovation highlighted by technology specialists (FT6, FT8) is the offline functionality of India's CBDC. The design allows it to function effectively in low or limited network conditions, making it accessible on essential devices like feature phones and catering to users with varying levels of financial or digital literacy. As one expert (BP1) explained: "The offline capability is crucial for adoption in rural areas where connectivity remains challenging."

Indian CBDC's offline design enables transactions on feature phones without needing a banking app or strong network connectivity in a secure environment (RBI, 2022). This innovative strategy positions the e-Rupee as a promising solution for delivering digital financial services remotely while improving user experience for various population segments. Additionally, the availability of e-Rupee wallets in multiple local languages further boosts accessibility across different regions and demographics.

Implementation Sequencing and Design Dependencies

Expert interviews further revealed that CBDC design choices create sequential dependencies that constrain future options. Several experts emphasized that infrastructure decisions made early in implementation become difficult to reverse later.

Phase 1 - Foundation decisions: Platform architecture (blockchain vs. API) and distribution model (one-tier vs. two-tier) must be established first, as these choices determine interoperability possibilities and regulatory frameworks.

Phase 2 - Integration features: Security protocols and financial functions (programmability, tokenization) build upon architectural foundations but can be refined during pilot phases.

Phase 3 - User experience: Interface design and offline capabilities can be iteratively improved

but depend on the underlying technical architecture established in Phase 1.

Implications of CBDC Design on Financial Systems

CBDC design choices can have large implications for existing financial systems, directly addressing RQ2 regarding impact on payment platforms. Our analysis reveals three critical areas where design decisions reshape financial infrastructure: payment system architecture, banking intermediation models, and innovation pathways.

While banking professionals emphasized the importance of maintaining financial stability through careful design choices, fintech experts highlighted the transformative potential of programmable CBDCs for service innovation.

Considering the evolution of digital payments in India, it is to be noted that India's digital payment landscape has been transformed by the UPI. Interestingly, our expert interviews revealed fundamental differences between UPI and CBDC architectures that have major implications for the payment system.

A blockchain expert (BP4) noted: "UPI transactions are processed in phases and may be declined if the server does not confirm the transaction. In contrast, CBDC payments are settled immediately, with zero transaction fees and failures."

This difference creates both opportunities and challenges for system integration. While fintech experts emphasized the complementary nature of these systems, banking professionals expressed concerns about the potential fragmentation of payment infrastructures. Academic experts took a middle position, suggesting that the two systems could coexist with different use cases based on their relative strengths: UPI for high-volume, low-value retail transactions and CBDC for settlement-critical or offline use cases.

The comparison further reveals that while UPI relies on existing banking infrastructure and internet connectivity, CBDC utilizes blockchain technology and enables offline capabilities, representing an essential architectural divergence with implications for payment system evolution. The architectural differences between UPI and CBDC systems illustrate how design choices cascade through financial infrastructure. While UPI's success demonstrates the potential for digital payment adoption, CBDC's blockchain foundation creates fundamentally different settlement mechanisms that could either complement or compete with existing systems, depending on implementation choices.

The emergence of CBDCs is reshaping bank roles within the financial system. Banks are now adapting to provide CBDC wallets, customer onboarding, transaction monitoring, and support services. This evolution introduces opportunities, but also challenges for traditional financial institutions.

Our interviews revealed contrasting perspectives between banking and fintech experts regarding the impact on banking business models. Banking professionals emphasized the potential for disintermediation if CBDC design fails to incorporate appropriate safeguards, while fintech experts highlighted new service opportunities enabled by programmable digital currencies.

The emergence of CBDC is also driving innovation in banking products. Examples include programmable payment solutions, CBDC-driven lending services, and integrated treasury solutions. These innovations enhance service delivery and reduce operational expenses while preserving the traditional banking framework. However, as an academic expert (AP6) cautioned: "The pace of innovation must be balanced against systemic stability considerations." highlighting the ongoing tension between transformation and stability in CBDC implementation.

Future CBDC Use Cases in Financial Services

Our analysis of future CBDC applications revealed contrasting perspectives between technology visionaries and practical implementers. While blockchain specialists emphasized transformative potential for cross-border payments and programmable finance, banking practitioners focused on incremental improvements to existing services and practical adoption challenges.

Cross-border CBDC implementation faces significant coordination challenges that temper optimistic predictions. While a fintech expert (FT5) predicted that: "SWIFT will become

ineffective due to global trade divergence towards CBDC.", banking professionals expressed more measured views, with one senior banker (BP5) noting: "International payment system transformation will be evolutionary rather than revolutionary, with CBDCs gradually integrating with existing frameworks." The practical obstacles include regulatory harmonization, liquidity management, and the need for gradual transition mechanisms that preserve existing correspondent banking relationships.

The potential for cooperative cross-border CBDC initiatives emerged as an opportunity. A blockchain expert (FT3) noted: "There is potential for a CBDC bridge in several countries, including Singapore, Hong Kong, and the UAE." This initiative can facilitate faster and more affordable cross-border payments, especially concerning de-dollarization trends.

The application of CBDCs for financial inclusion and social benefit distribution emerged as a key theme, but with different emphases across expert groups. Technology consultants highlighted sophisticated programmable features, while financial inclusion specialists emphasized practical implementation considerations.

The tokenization of social benefits via CBDCs introduces advantages that increase the efficiency and effectiveness of welfare distribution. An academic expert (AP4) emphasized the potential for targeted distribution: "Purpose-specific tokens could ensure that benefits reach intended beneficiaries with minimal leakage."

However, financial inclusion practitioners highlighted implementation challenges. A financial inclusion expert (BP7) noted: "Last-mile distribution requires not just technology but trusted human intermediaries, particularly in rural areas." This perspective emphasized that technological innovation alone cannot address financial inclusion challenges without appropriate distribution strategies and supporting infrastructure.

Synthesis of Expert Perspectives

Our analysis revealed important tensions between different stakeholder groups regarding CBDC design and implementation. Technology experts favored innovative, feature-rich approaches that maximize the transformative potential of digital currencies. Banking professionals emphasized stability, integration with existing systems, and minimizing disruption to established business models. Academic and regulatory experts focused on the broader socioeconomic implications, particularly regarding financial inclusion and monetary policy effectiveness.

Despite these differences, several areas of consensus emerged across expert groups. First, all participants agreed that CBDC should complement rather than replace existing payment systems, particularly in economies with established digital payment infrastructure. Second, a two-tier distribution model was widely endorsed as appropriate for preserving financial stability while enabling innovation. Third, experts across all groups emphasized the importance of offline functionality for addressing financial inclusion objectives, particularly in regions with limited connectivity.

The stakeholder tensions reflect deeper questions about the pace and scope of financial system transformation. The consensus around complementary rather than disruptive implementation suggests that successful CBDC design requires careful calibration between innovation and stability, a finding particularly relevant for emerging economies with established digital payment infrastructures (RQ3).

Conclusion

As 134 countries explore CBDC implementation, this study offers actionable insights into the design factors that shape implementation outcomes, particularly in emerging economies with advanced digital financial infrastructures.

Using India's e-Rupee as a reference case, we examined how specific design decisions affect integration with existing financial systems. Drawing on interviews with 22 experts across fintech, banking, and academia, we identified several interdependent design considerations critical to CBDC effectiveness.

Three core insights emerged from the analysis. First, experts broadly supported a two-tier, non-interest-bearing model that preserves banking sector stability while enabling innovation. Emphasis was placed on settlement finality and

offline capabilities as prerequisites for broad-based adoption and accessibility.

Second, CBDCs should be designed to complement existing digital payment platforms, such as India's UPI. When properly integrated, CBDCs can enhance transaction efficiency, security, and programmability, without disrupting well-functioning payment ecosystems.

Third, a phased implementation strategy, guided by clear performance metrics and public-private collaboration, is essential. Early architectural and governance choices have long-term consequences. This reinforces the need for strategic foresight.

These findings contribute to a relatively underdeveloped dimension of CBDC research by introducing a generalizable four-layer design framework. This framework comprises four interrelated dimensions: technology, security, financial functionality, and user experience. It provides a structured approach for understanding how design decisions cascade through financial systems, shaping accessibility, stability, and innovation. Beyond its analytical utility, the framework serves as a practical tool for policymakers navigating complex implementation environments.

We recommend that regulators in emerging economies prioritize interoperability with existing payment platforms, leverage established financial infrastructure, and implement governance models that balance innovation with systemic stability.

We acknowledge that our expert sample predominantly included professionals from major financial centers, potentially limiting insights from regional or rural contexts where implementation challenges may differ significantly. Broader geographic representation could provide a deeper understanding of local-level complexities. Additionally, our data was collected at an early stage of global CBDC implementation, suggesting that certain findings might evolve as practical experiences accumulate. Future studies at more advanced implementation stages would validate or refine these insights.

Future research should quantitatively evaluate CBDC outcomes, undertake comparative analyses across diverse implementation environments, and conduct longitudinal assessments of CBDC impacts on financial inclusion and banking dynamics. As global CBDC adoption progresses, empirical insights will become important to inform responsible monetary innovation.

References

Agarwal, R., & Kimball, M. (2015). *Breaking through the zero lower bound* (IMF Working Paper No. 15/224). International Monetary Fund. https://www.aeaweb.org/conference/2016/retrieve.php?pdfid=13281&tk=69T3AhQY

Agur, I., Ari, A., & Dell'Ariccia, G. (2022). Designing central bank digital currencies. *Journal of Monetary Economics*, *125*, 62–79.

Ahnert, T., Assenmacher, K., Hoffmann, P., Leonello, A., Monnet, C., & Porcellacchia, D. (2022). *The economics of central bank digital currency*. European Central Bank. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4192178

Allen, S., Čapkun, S., Eyal, I., Fanti, G., Ford, B. A., Grimmelmann, J., Juels, A., Kostiainen, K., Meiklejohn, S., Miller, A., Prasad, E., Wüst, K., & Zhang, F. (2020). *Design choices for central bank digital currency: Policy and technical considerations* (Working Paper No. 27634). National Bureau of Economic Research. https://doi.org/10.3386/w27634

Atlantic Council. (2025). *Central bank digital currency tracker*. Central Bank Digital Currency Tracker. https://www.atlanticcouncil.org/cbdctracker/

Auer, R., & Böhme, R. (2021). Central bank digital currency: The quest for minimally invasive technology. *BIS Papers*, *948*.

Banerjee, S., & Sinha, M. (2023). Promoting financial inclusion through central bank digital currency: An evaluation of payment system viability in India. *Australasian Accounting, Business and Finance Journal*, *17*(1), 176–204.

Bech, M. L., & Garratt, R. (2017). *Central bank cryptocurrencies* (SSRN Scholarly Paper No. 3041906). Social Science Research Network. https://papers.ssrn.com/abstract=3041906

Bindseil, U. (2019). Central bank digital currency: Financial system implications and control. *International Journal of Political Economy*, *48*(4), 303–335. https://doi.org/10.1080/08911916.2019.1693160

Bindseil, U., & Senner, R. (2025). Modeling central bank digital currencies. *Journal of Economic Surveys*. https://doi.org/10.1111/joes.12686

BIS. (2020). *Central bank digital currencies: Foundational principles and core features*.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Bureau of Engraving and Printing. (2025, March 28). *How a bitcoin is created*. https://www.moneyfactory.com/how-a-bitcoin-is-created/

Chen, S., Goel, T., Qiu, H., & Shim, I. (2022). CBDCs in emerging market economies. *BIS Papers*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4085690

Chiu, J., Davoodalhosseini, S. M., Jiang, J., & Zhu, Y. (2023). Bank market power and central bank digital currency: Theory and quantitative assessment. *Journal of Political Economy*, *131*(5), 1213–1248. https://doi.org/10.1086/722517

Claessens, S., Cong, L. W., Moshirian, F., & Park, C.-Y. (2024). Opportunities and challenges associated with the development of FinTech and Central Bank Digital Currency. *Journal of Financial Stability*, *73*, 101280. https://doi.org/10.1016/j.jfs.2024.101280

Corbet, S., Cumming, D., Glatzer, Z., & Johan, S. (2024). Understanding the rapid development of CBDC in emerging economies. *Finance Research Letters*, *70*, 106226. https://doi.org/10.1016/j.frl.2024.106226

Curnutt, G., & Smith, D. (2025). The association of cryptocurrency and the use of alternative financial services. *Financial Services Review*, *33*(2), Article 2. https://doi.org/10.61190/fsr.v33i2.4094

Di Maggio, M., Ghosh, P., Ghosh, S., & Wu, A. (2024). *Impact of retail CBDC on digital payments and bank deposits: Evidence from India* (SSRN Working Paper No. 4779520). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4779520

Dunbar, K., & Treku, D. N. (2024). Examining the impact of a central bank digital currency on the access to banking. *International Review of Financial Analysis*, *93*, 103220. https://doi.org/10.1016/j.irfa.2024.103220

Luu, H. N., Nguyen, C. P., & Nasir, M. A. (2023). Implications of central bank digital currency for financial stability: Evidence from the global banking sector. *Journal of International Financial Markets, Institutions and Money*, *89*, 101864. https://doi.org/10.1016/j.intfin.2023.101864

Mishra, B., & Prasad, E. (2024). A simple model of a central bank digital currency. *Journal of Financial Stability*, *73*, 101282. https://doi.org/10.1016/j.jfs.2024.101282

Nourallah, M., Strandberg, C., & Öhman, P. (2021). Mobile bank applications: Loyalty of young bank customers. *Financial Services Review*, *29*(2), 147–167. https://doi.org/10.61190/fsr.v29i2.3451

PwC India. (2021). *Central bank digital currency in the Indian context*. https://www.pwc.in/assets/pdfs/consulting/financial-services/cbdc-in-the-indian-context.pdf

Ren, Y.-S., Ma, C., & Wang, Y. (2024). A new financial regulatory framework for digital finance: Inspired by CBDC. *Global Finance Journal*, *62*, 101025. https://doi.org/10.1016/j.gfj.2024.101025

Reserve Bank of India. (2022). *Concept note on central bank digital currency*. https://rbidocs.rbi.org.in/rdocs/PublicationReport/Pdfs/CONCEPTNOTEACB531172E0B4DFC9A6E506C2C24FFB6.PDF

Rogoff, K. (2015). Costs and benefits to phasing out paper currency. *NBER Macroeconomics Annual*, *29*, 445–456. https://doi.org/10.1086/680657

Soderberg, G., Bechara, M. M., Bossu, W., Che, M. N. X., Davidovic, S., Kiff, M. J., Lukonga, M. I., Griffoli, M. T. M., Sun, T., & Yoshinaga, A. (2022). *Behind the scenes of central bank digital currency: Emerging trends, insights, and policy lessons*. International Monetary Fund. https://www.imf.org/en/Publications/WP/Issues/2022/11/01/Behind-the-Scenes-of-Central-Bank-Digital-Currency-525520

Son, J., Ryu, D., & Webb, R. I. (2023). Central bank digital currency: Payment choices and commercial bank profitability. *International Review of Financial Analysis*, *90*, 102874.

Tan, B. J. (2024). Central bank digital currency and financial inclusion. *Journal of Macroeconomics*, *81*, 103620. https://doi.org/10.1016/j.jmacro.2024.103620

Tercero-Lucas, D. (2023). Central bank digital currencies and financial stability in a modern monetary system. *Journal of Financial Stability*, *69*, 101188. https://doi.org/10.1016/j.jfs.2023.101188

Tian, S., Zhao, B., & Olivares, R. O. (2023). Cybersecurity risks and central banks' sentiment on central bank digital currency: Evidence from global cyberattacks. *Finance Research Letters*, *53*, 103609. https://doi.org/10.1016/j.frl.2022.103609

Tourpe, H., Lannquist, A., & Soderberg, G. (2023, September). *A guide to central bank digital currency product development*. International Monetary Fund. https://www.imf.org/en/Publications/WP/Issues/2023/09/01/Guide-to-CBDC-Product-Development

Wang, H., & Gao, S. (2024). The future of the international financial system: The emerging CBDC network and its impact on regulation. *Regulation & Governance*, *18*(1), 288–306. https://doi.org/10.1111/rego.12520

Appendix A. Categorization of Expert Interview Participants

Group 1. Fintech and Blockchain Experts (N=8)

Expert ID	Role/Position	Expertise Area	Experience	Geographic Region
FT1	SWIFT Operations	Digital Currencies, Blockchain	Senior Level	UK
FT2	Global Lead Analyst- Digital Transformations	Blockchain and Fintech	Mid-Level	UAE and India
FT3	Digital Payment Consultant	Blockchain and Fintech	Senior Level	USA
FT4	Senior Consultant-Digital Solutions	Blockchain and Fintech	Mid-Level	South East Asia
FT5	Senior Consultant-Digital Payments and Blockchain	Blockchain and Fintech	Mid-Level	Singapore
FT6	Senior Consultant-Digital Payment Project	Fintech and CBDC	Mid-Level	Singapore
FT7	Technology and Strategy- Director	Blockchain Expert	Senior-Level	India
FT8	Emerging tech Evangelist, Startup Enabler	Fintech and CBDC	Senior Level	India

Group 2. Banking and Payment Industry Professionals (N=8)

Expert ID	Role/Position	Expertise Area	Experience	Geographic Region
BP1	CBDC Project Head- Payments Industry	Banking and Fintech	Senior Level	India
BP2	CEO-Fintech Payments-Based Startup	Banking and Fintech	Senior Level	India
BP3	Banker-Assistant Manager, Private Bank	Banking and Fintech	Mid-Level	India
BP4	SME Consultant and Direction-Fintech Startup	Banking and Fintech	Senior-Level	India
BP5	Fintech Startup Founder, Former VP- Private Bank	Banking and Fintech	Senior Level	India
BP6	Consultant and Researcher- Paytm (Payments Start-up)	Banking and Fintech (Blockchain and Payments)	Senior Level	India
BP7	Director-Fintech Organization, Financial Inclusion of SMEs and Consultant	Financial Inclusion and Fintech	Senior Level	India

Group 3. Academic and Policy Experts (N=7)

Expert ID	Role/Position	Expertise Area	Experience	Geographic Region
AP1	Associate Professor	Information Technology	Senior- Level	India
AP2	Adjunct Faculty and Consultant	Finance and Fintech	Mid-Level	India
AP3	Associate Professor	Operations and Technology	Senior-Level	India
AP4	Economist/Researcher	Policy Analysis	Senior-Level	India
AP5	Lawyer-Private Firm	Intellectual Property, Cyber Laws	Senior-Level	India
AP6	Economist and Researcher-Global Think Tank	Policy and Research	Senior-Level	India
AP7	Adjunct Faculty and Consultant-Digital Finance	Finance and Technology	Senior- Level	India

Note: Experience levels are categorized as: Senior Level: >15 years of experience, Mid-Level: 5-15 years of experience

Appendix B. Thematic Analysis Table

Initial Codes from Interviews	Sub-Themes	Main-Themes
Decline in physical cash usage, Growth of digital payments, UPI success and adoption, Alternative source of digital payments, Need for payment infrastructure update	Changes in payment behaviour, digital payment evolution, infrastructure update	Need and Status of CBDC Implementation
Technology platform choices, security requirements, privacy concerns, programmability, interest bearing vs non-interest bearing, user interface design, blockchain advantages, distribution models	Technology architecture Security framework Financial Functions User Experience	Critical Design Elements
UPI Comparison, Existing payment systems limitations, Role of Banks, Settlement efficiency, operational costs	Payment System Impacts, Banking Sector Transformation, Infrastructure Development	Implications for Financial Systems
Cross-border capabilities, CBDC bridge potential, Programmability benefits, Financial Inclusion opportunities, Last-mile access	International Settlements, Specialised applications, Inclusion Initiatives	Future CBDC Use Cases in Financial Services