

Central bank digital currencies and the transformation of monetary systems: Institutional design, financial stability, and digital payment efficiency: A systematic review

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Received: 02-Mar-2026, Manuscript No. JPAI-2026-0012; **Editor assigned:** 04-Mar-2026, PreQC No. JPAI-2026-0012 (PQ);

Reviewed: 16-Mar-2026, QC No. JPAI-2026-0012; **Revised:** 23-Mar-2026, Manuscript No. JPAI-2026-0012 (R); **Published:** 07-Apr-2026

Citation: Kumar K, Joshi D, Azhar A, Elamparuthi D, Elanthirayan D. (2026). Central bank digital currencies and the transformation of monetary systems: Institutional design, financial stability, and digital payment efficiency: A systematic review. J Prog Artif Intell.

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ABSTRACT

The accelerating digitization of global financial systems has elevated Central Bank Digital Currencies

(CBDCs) from theoretical constructs to active instruments of monetary reform. Defined as sovereign digital liabilities issued directly by central monetary

authorities, CBDCs occupy a structurally distinct position relative to decentralized cryptocurrencies and privately issued stable coins, principally by virtue of their legal tender status and the full faith of the issuing state. This systematic review synthesizes the extant empirical and theoretical literature on CBDC design architectures, payment infrastructure modernization, financial inclusion dynamics, and monetary policy transmission pathways. Drawing upon the institutional innovation framework and canonical monetary economics, the study constructs an analytical model linking CBDC adoption intensity with monetary system efficiency outcomes across a cross-national panel of economies at varying stages of digital currency experimentation, including China, Sweden, India, Nigeria, and the Bahamas. The review finds substantive evidence that well-designed CBDC frameworks can materially reduce transaction settlement latency, lower intermediation costs, and

1. INTRODUCTION

Contemporary monetary systems are undergoing a structural reconfiguration of historic significance. The convergence of digital payment innovation, disintermediated financial technology, and distributed ledger architectures has fundamentally challenged the institutional premises upon which twentieth-century central banking was constructed. Within this milieu, the emergence of Central Bank Digital Currencies represents both an adaptive response by monetary authorities and a potential catalyst for systemic transformation in how sovereign money is created, distributed, and utilised ^[1,2]. A CBDC may be operationally defined as a digital representation of a nation's fiat currency, issued and fully guaranteed by the sovereign central bank, possessing legal tender status equivalent to physical banknotes and coins. This

extend formal financial access to unbanked and underbanked populations. Concurrently, the analysis surfaces critical systemic risks, namely the potential for structural banking disintermediation, sovereign cybersecurity exposure, and erosion of transactional privacy. The study advances the CBDC literature by articulating the institutional preconditions regulatory coherence, technological redundancy, and international coordination architecture necessary for sustainable digital currency deployment. Policy implications for central bank governors, financial regulators, and multilateral institutions are discussed in detail.

KEYWORDS: Central Bank Digital Currency, Monetary Policy Transmission, Digital Payment Systems, Financial Inclusion, Institutional Innovation, Monetary Sovereignty

definition distinguishes CBDCs categorically from private cryptocurrencies such as Bitcoin or Ethereum which are generated through decentralized consensus mechanisms and derive no intrinsic monetary authority from any sovereign institution ^[3]. It equally distinguishes CBDCs from commercial bank money, which constitutes a liability of private financial intermediaries rather than the central bank itself ^[4]. The motivations driving central bank interest in CBDCs are pluralistic. First, the secular decline in cash usage across advanced economies has raised genuine concerns regarding the long-term viability of publicly accessible central bank money in retail transactions ^[5]. Second, the proliferation of global stable coins most notably the proposals associated with Meta's Libra/Diem project exposed potential challenges to monetary sovereignty in jurisdictions where private digital currencies might displace

national currencies in everyday commerce^[6]. Third, in developing economies characterized by significant unbanked populations and underdeveloped payment infrastructure, CBDCs are increasingly perceived as a cost-efficient mechanism for extending formal financial access without requiring the expansion of physical branch networks^[7,8]. The empirical landscape of CBDC experimentation has expanded rapidly since 2020. The People's Bank of China has conducted extensive pilot programmes for its Digital Currency/Electronic Payment (DC/EP) system colloquially designated the digital yuan or e-CNY across multiple provincial economies, representing the most sophisticated large-scale CBDC deployment by a major central bank to date^[9]. The European Central Bank has advanced beyond conceptual investigation into a formal preparation phase for a prospective digital euro, targeting enhanced payment system resilience across euro zone member states^[10]. In the Caribbean, the Bahamas became the first jurisdiction globally to achieve full national-scale CBDC deployment with the Sand Dollar in 2020, offering instructive evidence regarding implementation dynamics in small open economies^[11]. Sweden's e-krona pilot, conducted by the Sveriges Riksbank since 2020, provides a complementary case study in the context of a high-income economy approaching near-cashless payment norms^[12]. Despite the breadth of policy experimentation, rigorous empirical analysis of CBDC macroeconomic implications remains nascent. Existing scholarship is disproportionately concentrated on technical architecture and legal design questions, with comparatively limited attention to the broader systemic consequences for monetary policy transmission, banking sector stability, and financial inclusion outcomes. This systematic review therefore aims to address three primary research objectives:

first, to synthesise and critically evaluate the existing theoretical and empirical literature on CBDC adoption and its implications for monetary system efficiency; second, to assess the conditions under which CBDCs may enhance or impair financial stability; and third, to derive actionable policy insights for central banks and international financial institutions engaged in CBDC design and governance.

2. LITERATURE REVIEW

2.1 Conceptual foundations of central bank digital currency

The theoretical origins of CBDC discourse can be traced to Tobin's proposal for 'deposited currency accounts' publicly accessible interest-bearing accounts held directly at the central bank as a mechanism for separating the monetary and credit functions of commercial banking^[13]. Contemporary CBDC scholarship has substantially extended this foundational framework, with Barrdear and Kumhof's seminal Bank of England working paper modelling the macroeconomic consequences of large-scale CBDC issuance and projecting potential GDP gains of 3% in the United Kingdom through reduced real interest rates and more efficient financial intermediation^[14]. Subsequent theoretical contributions by Brunnermeier and Niepelt established conditions under which private and public money may be welfare-equivalent in equilibrium, complicating earlier presumptions that CBDC would necessarily crowd out commercial bank deposits^[15]. The institutional design space for CBDCs encompasses two principal architectures. Retail CBDCs, also termed 'general purpose' or 'direct' models, are made directly accessible to households and non-financial firms, approximating a digital analogue of physical currency^[16]. Wholesale CBDCs,

by contrast, restrict access to licensed financial intermediaries and central bank counterparties, functioning as enhanced settlement assets within interbank payment systems ^[17]. Bindseil's tiered CBDC framework introduced a hybrid architecture

2.2 CBDC and payment system efficiency

Payment system efficiency constitutes the most consistently cited operational rationale for CBDC development. Auer, Böhme, and their collaborators at the Bank for International Settlements (BIS) have produced foundational empirical work documenting that contemporary retail payment architectures reliant upon multi-layer correspondent banking chains impose substantial dead-weight transaction costs, settlement delays, and systemic opacity that CBDC infrastructure could structurally eliminate ^[1,19]. Cross-border payment inefficiencies are particularly pronounced: The Financial Stability Board estimates that correspondent banking fees for international remittances average approximately 6.3% of transaction value, a cost burden disproportionately borne by migrant workers in low-income economies ^[20]. Empirical evidence from China's e-CNY pilot programmes indicates measurable reductions in retail settlement latency, with near-instantaneous transaction confirmation replacing the T+1 or T+2 settlement cycles characteristic of conventional digital payment rails ^[9,21]. Sweden's e-krona pilot similarly demonstrated enhanced operational resilience relative to commercial bank payment systems during simulated infrastructure disruption scenarios, suggesting that CBDC may provide systemic redundancy absent from privately operated payment networks ^[12]. The BIS's Project Jura and Project mBridge international experiments have further

incorporating remuneration rate differentials across holding tiers to calibrate deposit migration incentives, providing an institutionally sophisticated mechanism for managing disintermediation risk ^[18].

established technical feasibility for CBDC-enabled cross-border settlement at substantially reduced cost and settlement time relative to existing correspondent banking arrangements ^[22].

2.3 Financial inclusion and equitable access

Approximately 1.4 billion adults globally remain unbanked, disproportionately concentrated in sub-Saharan Africa, South Asia, and parts of Latin America ^[23]. The World Bank's Global Findex Database consistently identifies the cost of account maintenance, physical distance from financial service providers, and documentation requirements as primary barriers to formal financial participation. CBDCs may circumvent these structural barriers through mobile-device-based digital wallet architectures that require neither a traditional bank account nor physical branch proximity ^[7]. Nigeria's eNaira, launched in October 2021, represents the largest emerging-economy CBDC deployment to date and provides a substantive empirical case study of financial inclusion dynamics. Initial adoption data were disappointing, with only approximately 0.5% of the population utilizing the eNaira within twelve months of launch, suggesting that supply-side availability is insufficient in isolation to drive financial inclusion without complementary demand-side interventions including digital literacy programmes, telecommunications infrastructure investment, and consumer incentive structures ^[24]. The Bahamian Sand Dollar experience, by contrast,

demonstrated more promising inclusion trajectories in a geographically dispersed island economy where physical banking services were structurally inaccessible to outer island populations ^[11]. The IMF's analytical work has underscored the importance of design choices particularly offline functionality, tiered

2.4 Monetary policy transmission and central bank capacity

CBDCs potentially augment central bank monetary policy capacity through multiple transmission channels. Most significantly, interest-bearing retail CBDC designs would enable the central bank to apply remuneration rates directly to broad money holdings, bypassing the commercial banking system's historically imperfect transmission of policy rate changes to deposit rates. Bordo and Levin argued that CBDC could facilitate a transition toward a price-level targeting monetary regime by enabling direct digital transfers so-called 'helicopter money' operations to household CBDC wallets, enhancing the potency of unconventional monetary policy at the zero lower bound ^[26]. Theoretical modelling by Fernández-Villaverde et al. suggests that CBDC introduction under competitive market conditions could compress commercial bank net interest margins, incentivizing banks to compete more aggressively for retail deposits through enhanced service quality and reduced intermediation costs, thereby improving allocative efficiency in credit markets ^[27]. Conversely, Williamson developed a model in which CBDC may crowd out private bank intermediation under certain parameter configurations, reducing aggregate lending and dampening investment, depending critically on the remuneration design and holding limits imposed by the central bank ^[28].

identity verification protocols, and low-denomination accessibility thresholds in determining whether CBDCs genuinely extend financial access or merely replicate existing digital payment systems under sovereign branding ^[25].

2.5 Financial stability: risks and systemic considerations

The financial stability implications of CBDC adoption represent the most contested dimension of the academic debate. The principal systemic risk identified in the literature is bank run amplification: In a crisis environment, households and firms may rapidly convert commercial bank deposits into CBDC perceived as the superior safe asset precipitating a liquidity crisis in the commercial banking sector that conventional central bank lender-of-last-resort operations may struggle to contain given the speed of digital transactions ^[4,29]. Mancini-Griffoli et al. at the IMF assessed this disintermediation risk as 'manageable but not trivial,' contingent upon the imposition of prudential holding limits and non-remunerative design features for retail CBDC ^[30]. Zhang and Wen conducted an empirical panel analysis of banking sector stability indicators across economies with advanced CBDC programmes and found that the magnitude of disintermediation risk was significantly moderated by the strength of pre-existing financial stability frameworks, prudential regulatory architecture, and the credibility of deposit insurance schemes ^[31]. Cybersecurity constitutes an additional dimension of systemic risk: CBDC infrastructure, as a centralized high-value target, presents concentrated attack surfaces for state-sponsored cyber actors and criminal organizations, necessitating enterprise-grade

cryptographic security, distributed resilience architecture, and continuous threat monitoring ^[32].

2.6 Research hypotheses

Grounded in the foregoing theoretical synthesis and the emergent empirical evidence from active CBDC programmes, the present review advances four principal research hypotheses:

H1: CBDC adoption at scale positively and significantly influences payment system efficiency, as measured by reductions in transaction settlement time, intermediation cost, and cross-border payment opacity.

H2: CBDC adoption positively influences financial inclusion outcomes, as measured by increases in formal digital account access among previously unbanked or underbanked population segments. H3: CBDC adoption strengthens monetary policy transmission mechanisms by reducing the dependence of policy rate changes on commercial bank deposit pricing behaviour.

H4: The strength and quality of existing financial stability frameworks moderate the relationship between CBDC adoption intensity and aggregate monetary system efficiency outcomes, with robust stability frameworks amplifying positive effects and attenuating disintermediation risks.

3. RESEARCH METHODOLOGY

3.1 Review design and scope

This study employs a systematic comparative literature review methodology, supplemented by secondary macro-financial data analysis, examining

CBDC developments across a purposively selected cross-national panel of five jurisdictions: China, Sweden, India, Nigeria, and the Bahamas. These cases were selected to provide theoretical and empirical diversity across dimensions of economic development status, financial system depth, CBDC design architecture, and implementation maturity. The case selection strategy intentionally spans retail and wholesale CBDC models, account-based and token-based access mechanisms, and high-income and emerging market contexts, thereby enabling structured comparative analysis across institutionally varied settings ^[33].

3.2 Data sources and institutional provenance

Secondary data were drawn from a systematic review of peer-reviewed publications indexed in Scopus and Web of Science databases (2015–2025), supplemented by grey literature comprising central bank technical reports, BIS working papers, IMF staff discussion notes, World Bank financial development reports, and regulatory consultation documents. Data pertaining to payment system performance metrics, financial inclusion indicators, and banking sector stability variables were sourced from the World Bank's Global Financial Development Database, the BIS Payment, Clearing and Settlement Statistics, and individual central bank annual reports ^[34,35].

3.3 Variables and operationalization

Table 1. Conceptual dimensions and operationalization of variables in the CBDC Adoption Model

Variables	Conceptual dimension	Operationalization
CBDC Adoption	Policy implementation	Ordinal score: pilot / limited / national deployment; transaction volume as % of M1
Payment System Efficiency (PSE)	Infrastructure performance	Average settlement time (hours); domestic/cross-border transaction cost (% of value)
Financial Inclusion (FI)	Access equity	% adults with formal digital account; unbanked population change (percentage points)
Monetary Policy Transmission (MPT)	Policy effectiveness	Pass-through coefficient of policy rate to retail deposit rate (basis points)
Financial Stability (FS)	Systemic resilience	Banking sector liquidity coverage ratio; non-performing loan ratio; deposit volatility index
Monetary System Efficiency (MSE)	Aggregate outcome	Composite index: PSE + FI + MPT weighted equally

3.4 Analytical framework

The central econometric specification estimating the determinants of monetary system efficiency is expressed as:

$$MSE_i = \beta_0 + \beta_1 CBDC_i + \beta_2 PSE_i + \beta_3 FI_i + \beta_4 MPT_i + \beta_5 FS_i + \beta_6 (CBDC_i \times FS_i) + \varepsilon_i$$

where MSE denotes the composite monetary system efficiency index for country i ; CBDC represents the CBDC adoption intensity score; PSE, FI, MPT, and FS denote payment system efficiency, financial inclusion, monetary policy transmission, and financial stability respectively; the interaction term $(CBDC \times FS)$ operationalizes the moderating hypothesis (H4); and ε represents the stochastic error term. Given the limited cross-sectional sample size, the primary analytical contribution of this study resides in the systematic

qualitative synthesis and comparative case analysis rather than the econometric estimation, which is presented as a preliminary structural framework for subsequent large-N empirical research.

4. RESULTS AND DISCUSSION

4.1 Payment system efficiency: Evidence from advanced pilots

The comparative evidence drawn from advanced CBDC programmes provides substantial support for Hypothesis 1. China's e-CNY system processed over 100 billion yuan (approximately USD 14 billion) in transactions across pilot regions as of early 2023, demonstrating real-time retail settlement capability at scale without the inter-bank clearing delays inherent to conventional payment systems ^[9,21]. Critically, the programmable smart contract functionality embedded

in the e-CNY design enables conditional payment automation including government subsidy disbursements with embedded temporal or categorical spending constraints a feature without precedent in existing payment infrastructure. The BIS Innovation Hub's multi-CBDC cross-border settlement experiments Project Jura (France, Switzerland) and Project mBridge (Hong Kong, Thailand, UAE, China) demonstrated foreign exchange transaction settlement

4.2 Financial inclusion: heterogeneous outcomes across implementation contexts

The evidence regarding financial inclusion effects is more heterogeneous, providing qualified support for Hypothesis 2 contingent upon critical design and contextual factors. The Bahamian Sand Dollar achieved measurable financial service penetration in outer island communities previously reliant on infrequent branch visits or informal financial arrangements, leveraging the existing mobile telecommunications infrastructure and simplified onboarding procedures ^[11]. India's digital rupee (e-Rupee) pilot, launched by the Reserve Bank of India in late 2022 across selected cities, has demonstrated promising adoption dynamics among small-merchant vendor populations in the retail pilot stream, though national-scale inclusion data remain limited given the controlled pilot parameters ^[36]. Nigeria's eNaira, however, illustrates the limitations of supply-side CBDC deployment in the absence of complementary enabling conditions. The initial 12-month adoption rate of approximately 0.5% of the population reflected structural impediments including inadequate smartphone penetration in rural areas, limited digital literacy, absence of merchant acceptance infrastructure, and insufficient consumer education

in seconds rather than the two-to-five business days typical of correspondent banking, with transaction costs reduced by an estimated 50% ^[22]. These results strongly indicate that CBDC-enabled payment infrastructure can materially displace existing inefficiencies in cross-border payment architecture, with particular relevance for remittance-dependent developing economies.

regarding CBDC functionality ^[24]. These findings corroborate the IMF's contention that CBDC is a necessary but insufficient condition for financial inclusion, requiring coordinated investment in telecommunications infrastructure, digital identity systems, and financial literacy programming ^[25].

4.3 Monetary policy transmission: theoretical promise and empirical constraints

Hypothesis 3 receives strong theoretical support but limited direct empirical validation at the current stage of CBDC experimentation, given that no major economy has yet deployed a fully interest-bearing retail CBDC of sufficient scale to generate observable monetary policy transmission data. The theoretical mechanism identified by Bordo and Levin and elaborated by Fernández-Villaverde et al. direct central bank-to-household monetary policy transmission bypassing commercial bank intermediation remains compelling as a long-run institutional possibility rather than a demonstrable near-term outcome ^[26,27]. The European Central Bank's preparation-phase analysis for the digital euro has explicitly incorporated monetary policy transmission considerations into its design deliberations, particularly regarding the question of whether a digital

euro should be remunerated and at what rate differential relative to overnight deposit facilities ^[10]. An important theoretical caveat identified by Williamson merits emphasis: under plausible parameter configurations, interest-bearing CBDC may compress commercial bank net interest margins to a degree that reduces aggregate credit provision, partially offsetting macroeconomic welfare gains from improved policy transmission through adverse effects on financial intermediation efficiency ^[28]. This welfare trade-off underscores the need for careful calibration of CBDC remuneration design and holding limit policies.

4.4 Financial stability: the disintermediation constraint

Hypothesis 4, positing a moderating role for financial stability frameworks, is supported by the available comparative evidence. Zhang and Wen found that the magnitude of deposit migration from commercial banks to CBDC during pilot programmes was inversely related to the robustness of pre-existing deposit insurance schemes and the credibility of central bank lender-of-last-resort commitments ^[31]. Jurisdictions with strong prudential regulatory frameworks such as Sweden and China exhibited significantly less evidence of bank run amplification risk during CBDC pilot operations than theoretical models absent institutional context had projected. The cybersecurity dimension of financial stability risk deserves particular analytical attention. CBDC infrastructure, by virtue of its centralization and systemic importance, constitutes a high-value target for advanced persistent threat actors. The concentration of national payment infrastructure in a single sovereign digital currency platform creates single-point-of-failure vulnerabilities that distributed

commercial banking architectures do not exhibit to the same degree ^[32]. Central banks designing CBDC systems must therefore incorporate distributed architecture design, cryptographic resilience standards exceeding those applied to conventional financial market infrastructure, and robust business continuity provisions.

4.5 Policy Implications

4.5.1 Phased and calibrated implementation architecture

The comparative evidence strongly favors graduated CBDC deployment over 'big bang' national launches. Pilot programmes confined to defined geographic regions, user segments, or transaction categories enable central banks to generate empirical evidence on adoption dynamics, system resilience, and unintended consequences before scaling reducing both operational and reputational risk ^[1,33]. The Reserve Bank of India's structured bifurcation of retail and wholesale e-Rupee pilots into distinct experimental streams provides a methodologically sound template for evidence-based CBDC rollout.

4.5.2 Banking sector integration and disintermediation mitigation

Central bank authorities should design CBDC holding limits and remuneration structures with explicit attention to deposit migration incentives. Non-remunerated or negatively remunerated CBDC holdings above defined thresholds analogous to Bindseil's tiered architecture effectively cap the substitution of commercial bank deposits with CBDC, preserving the commercial banking system's capacity for financial intermediation and credit creation ^[18]. The maintenance of a two-tier distribution model in

which commercial banks serve as CBDC distributors and custodians further preserves existing financial intermediation relationships while enabling central bank direct issuance ^[4]. Cybersecurity and operational resilience investment. The systemic importance of CBDC infrastructure necessitates cybersecurity investment commensurate with critical national infrastructure designation. Central banks should establish dedicated CBDC cyber threat intelligence functions, mandate penetration testing and red team exercises against CBDC platforms, implement zero-trust network architectures, and develop offline transaction capability to ensure payment system continuity during network disruption events ^[32]. International information-sharing frameworks for CBDC-specific cyber threats potentially coordinated through the BIS Cyber Resilience Coordination Centre would further strengthen collective security.

4.5.3 International coordination and monetary sovereignty preservation

The proliferation of CBDC programmes across jurisdictions creates both cooperative opportunities and coordination challenges. Without harmonized technical interoperability standards, the global financial system risks fragmentation into incompatible digital currency ecosystems with adverse consequences for cross-border trade and investment. The BIS Innovation Hub, the IMF, and the Financial Stability Board should collectively advance international standards for CBDC interoperability, anti-money laundering compliance, data governance, and cross-border settlement protocols ^[22,34]. Simultaneously, digital currency governance frameworks must actively safeguard national monetary sovereignty against the risk of digital

currency substitution in dollarised or heavily remittance-dependent economies.

5. CONCLUSION

This systematic review has synthesised a substantial body of theoretical and emerging empirical evidence bearing on the capacity of Central Bank Digital Currencies to transform the efficiency, inclusivity, and policy effectiveness of modern monetary systems. The weight of evidence supports the view that well-designed CBDC frameworks characterised by prudential holding constraints, distributed technical architecture, complementary financial infrastructure investment, and robust international coordination can materially enhance payment system efficiency, expand formal financial access, and strengthen monetary policy transmission relative to existing arrangements. However, the review equally establishes that CBDC is not a panacea. The risks of commercial banking disintermediation, cybersecurity vulnerability, and transactional privacy erosion are neither theoretical artefacts nor marginal concerns; they represent substantive systemic challenges that require deliberate institutional mitigation through design choices, regulatory safeguards, and governance architecture. The heterogeneous adoption outcomes observed across the eNaira, Sand Dollar, e-CNY, and e-krona programmes further demonstrate that CBDC design must be contextualised to the specific institutional, infrastructural, and socioeconomic characteristics of the issuing jurisdiction. Future research should prioritise longitudinal empirical analysis of mature CBDC programmes to generate causal evidence on monetary policy transmission effects, banking sector stability impacts, and financial inclusion outcomes. Comparative institutional analysis of CBDC

governance models across common law and civil law legal systems would enrich understanding of how regulatory architecture shapes adoption trajectories. Finally, the welfare distributional implications of CBDC including differential impacts across income quintiles, geographic locations, and demographic groups merit systematic investigation to ensure that digital monetary innovation serves broad societal objectives rather than amplifying existing financial inequalities.

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