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The rise of digital rupee (e₹): Evaluating RBI's strategic approach to central bank digital currency (CBDC)

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Abstract
The introduction of Central Bank Digital Currencies (CBDCs) indicates the shift in the ideology of the world monetary systems based on the necessity to ensure a secure, efficient, and inclusive model of payment infrastructure. The present paper focuses on the Digital Rupee (e₹), one of the responsibilities of the Reserve Bank of India (RBI). The discussion is about how it has been conceptualised and its implementation into the digital economy in India in terms of its preparation and the steps involved. The research will reference international examples of case studies, including the e-CNY, Digital Euro, and mCBDC Bridge, and put the e₹ in the context of comparative schemes to evaluate technological decisions, tradeoffs involving privacy, and the possible macroeconomic effects. Among the main findings, it is possible to note the opportunities, including advanced monetary policy transmission, improved financial inclusion, and enhanced cross-border payments, and key risks associated with cybersecurity vulnerabilities, privacy, readiness, and disintermediation of the banking sector. The policy recommendations focus on phased deployments, privacy-by-design architectures, universal interoperability and engagement in partnership with citizens and businesses. The paper reaches the conclusion that it is reasonable to have a balanced, iterative, and collaborative effort that can ensure India takes the lead in influencing the norms of CBDCs globally, yet protects financial stability at home.

Keywords: Central bank digital currency, digital rupee, financial inclusion, monetary policy, interoperability

1. Introduction

1.1 Background of Digital Transformation in Finance

In the course of the last ten years, the sphere of finance has experienced a total reconstruction due to the influence of digital innovations. Advances in connectivity, computational power, and the availability of data have lowered transaction costs, blurred traditional boundaries between financial services, and enabled novel business models-including fintech startups and platform-based incumbents-to thrive alongside traditional banks (Feyen *et al*., 2021; Patelkhana *et al*., 2023) [15, 33]. This transformation has driven vast improvements in payment systems, credit access, and service delivery, embedding financial services into mobile and online environments and increasing overall financial inclusion and engagement (Gratton, 2024) [17].

1.2 Need for Innovation in Sovereign Currencies

This digital revolution has increased the expectations of the desired way money should operate- this makes governments and central banks consider the existence of a new currency that achieves monetary sovereignty but also welcomes the technological advancements. Central Bank Digital Currencies (CBDCs) have emerged as a leading response. CBDCs are digital liabilities issued by central banks, available for retail or wholesale use, potentially offering greater efficiency, privacy, and resilience when compared to private digital currencies or legacy systems (Auer *et al*., 2021) [5].

1.3 Global Interest in CBDCs: Motivations and Drivers

Globally, more than 130 jurisdictions-including major economies like China, India, the Bahamas, and the Eurozone-have explored or launched CBDC initiatives by March 2024 (Atlantic Council, 2025). Common motivations include improving payment efficiency (domestic and cross-border), strengthening financial inclusion, reducing reliance on cash,

and protecting public control over money amid the rise of private digital currencies (Sandhu *et al*., 2023; Rabouin, 2021) [41, 35].

1.4 RBI's Motivation for Launching the e₹

In line with these global trends, the Reserve Bank of India (RBI) launched piloting of the Digital Rupee (e₹) in late 2022. The Digital Rupee-classified into both wholesale (e₹-W) and retail (e₹-R) versions-is defined as a sovereign digital currency issued by RBI, exchangeable one-to-one with the fiat currency, and offering the same legal tender status (Ministry of Finance, 2022b). Key motivations for adopting e₹ include enhancing payment system resilience, reducing currency production costs, expanding financial inclusion, improving cross-border and domestic transaction efficiency, and maintaining technological relevance in the evolving financial ecosystem (Sandhu *et al*., 2023) [41].

1.5 Research Objectives and Scope

The purpose of this paper is to review the strategy of the RBI on the development and launch of the Digital Rupee, in the context of the development of CBDC in the world. It aims to examine the technological, policy and operational factors which inform India's design decisions, in addition to estimating their potential impacts on monetary policy, financial inclusion, and the digital economy. In particular, the aims are:

- To trace the evolution of the e₹, from concept to pilot deployment;
- To assess its key features and underlying technology;
- To compare the e₹ with other major CBDC initiatives (e-CNY, digital euro, etc.);
- To evaluate implications for India's monetary and financial stability; and
- To identify challenges and propose policy recommendations for broader adoption and scalability.

2. Theoretical Framework and Literature Review

2.1 Definitions and Types of CBDCs (Retail vs. Wholesale): Central Bank Digital Currencies (CBDCs) are digital liabilities issued directly by a country's central bank, representing a new form of official money available either broadly or within institutional networks. As detailed in foundational literature, CBDCs are categorised into retail and wholesale: retail CBDCs are accessible by the general public for day-to-day payments, whereas wholesale CBDCs are restricted to financial institutions for interbank settlement and large-value transactions (Bank for International Settlements, 2018). Auer *et al*. (2020) [4] highlight that retail CBDCs are direct claims on the central bank, akin to digital cash, while wholesale versions serve as settlement assets for institutions.

Source: (Lin, 2023) [28]

Fig 1: Types of CBDCs

2.2 Technology Behind CBDCs: DLT, Blockchain, Token-Based Systems

Technologically, CBDCs may be built on centralized ledgers, permissioned distributed ledger technology (DLT), hybrid systems, or token-based designs. A comprehensive survey notes that DLT-based CBDCs-leveraging blockchain or distributed ledgers-enable transparent and secure transactions across decentralized networks, whereas centralized models emulate traditional banking leverages (Tang & Si, 2018; Guo *et al*., 2024) [46, 18]. Additional analysis identifies public, permissioned, and private DLT structures, each bearing distinct implications for central bank control and financial system design (Guo *et al*., 2024) [18]. Token-based offline CBDC models also exist; these process locally without third-party validation and offer enhanced privacy and resilience during network outages (Richards *et al*., 2020) [39]. The BIS has further discussed key design considerations specific to retail implementations, emphasizing trade-offs among privacy, identity, and operational complexity (Bank for International Settlements, 2018).

2.3 Benefits and Risks of CBDCs in Global Literature

An emerging international literature highlights the possible advantages of CBDCs as far as efficient international and domestic transactions, their financial inclusion, enhanced monetary policy transmission, resilience, and dependency on cash are concerned (Seth, 2024) [43]. These benefits are, however, coupled with significant disadvantages. Among the major risks are cybersecurity risk, the risks to financial stability, and the substitution of bank deposits and the risk of bank runs, the risk to privacy, and operational inertia (Bank for International Settlements, 2021). The reports by the IMF and BIS also emphasise that some decisions about the design of CBDC may affect digital gaps and even exacerbate them, in case they do not focus on the needs of users (Bank for International Settlements, 2022).

2.4 Comparative Analysis of Other Countries' CBDC Projects

Some large economies in other parts of the world have made greater progress toward implementing CBDC, and thus provide useful comparisons:

- **e-CNY (China):** Developed by the People's Bank of China, this pilot includes both retail and wholesale functions and is designed for domestic retail use as well as domestic/cross-border payments (Bank for International Settlements, 2022).
- **Digital Euro (European Union):** The ECB is exploring hybrid models that combine account-based and DLT systems, aiming to balance functionality with privacy and interoperability (OECD, 2023).
- **Sand Dollar (Bahamas):** Launched in 2020, the Sand Dollar was one of the first operational retail CBDCs, intended primarily for financial inclusion and payment efficiency in underserved areas (Bank for International Settlements, 2022).
- **Project Jasper (Canada) and others:** Projects such as Jasper (Canada) and DCash (Eastern Caribbean) focus on wholesale settlement and interoperability, exploring CBDCs as new liquidity and payment rails (Soderberg *et al*., 2022) [45].

Such examples across the globe provide a broad range of design and policy options such as retail versus wholesale access, privacy versus auditability, DLT versus centralised, and domestic versus international interoperability, that guide the decisions of the RBI.

2.5 Literature on India's Fintech Growth and Financial Inclusion Needs

The payment systems in India have spectacularly grown to include the use of UPI, Aadhaar-based identity, as well as widespread connectivity via mobile over the internet, allowing the population to better access the digital financial system. UPI's rapid adoption has cemented India's position among global leaders in real-time digital payments (The Times of India, 2025a). Fintech investment soared to around USD 35 billion by 2022, and digital lending platforms reported record growth in FY 2024–25-sanctioning over 10.9 crore loans worth ₹1.06 lakh crore (Shukla, 2025) [44]. Financial inclusion improved notably, with India's RBI index rising from 43.4 in 2017 to 60.1 in 2023; pandemic-driven digital adoption accelerated merchant and consumer participation (FinTech, 2024).

2.6 Gaps in Current Research and Relevance of Indian Context

Despite widespread global and national talk, there remain gaps. First, only a few studies incorporate Indian pilot data on e₹ conceptual design, usage pattern or interoperability with UPI and legacy payment systems. Second, research often treats inclusion in abstract terms without deeply assessing rural behavioural adoption or trust dynamics-areas critical for India's large non-metro population (Jhamb, 2025) [21]. Third, systemic risks-like deposit substitution in the Indian banking domain-call for more detailed modelling based on India's banking architecture and reserve requirements. Closing these gaps is vital for the development of any CBDC that will stand the test associated with India's particular fintech environment, inclusion targets and policy structure.

3. India's Digital Economy and Financial Inclusion Landscape

In India, the digital payments ecosystem has exploded over the last few years, led by the Unified Payments Interface (UPI), an instantaneous, interoperable, cross-bank and cross-application transfer protocol that operates through virtual payment addresses or QR code-based transfers. The use has reached skyrocketing levels as it went from only 93,000 transactions worth only 3 crore rupees in the month of August 2016 to over 18 billion taken per month, with a projection in the middle of the year 2025 (Sapovadia, 2018; The Times of India, 2025b) [42]. Since then, UPI processes about 80% of the entire digital payment in India (The Times of India, 2024b). Along with this, RuPay, the local card network of India, has further decreased its reliance on foreign card schemes by offering a localised alternative to their needs. Aadhaar-enabled Payment System (AEPS) can also be used to perform basic transactions by using biometrics to enhance their availability in underserved locations (Sapovadia, 2018) [42].

The synergy of several flagship initiatives-namely, Jan Dhan, Aadhaar, and India Stack (collectively known as the "JAM Trinity")-has underpinned India's financial inclusion drive. Jan Dhan Yojana alone opened over 318 million accounts by mid-2018, bringing formal banking access to

previously excluded populations (EPA Asia, n.d.). Aadhaar, the world's largest biometric ID system, links over 99.9% of India's adult population to digital identity services, enabling secure e-KYC-based access to services (Thales, 2023) [47]. India Stack, a unified open-API digital platform, comprises multiple layers-"presenceless", "paperless", "cashless", and "consent"-and integrates services like UPI, e-KYC, AEPS, and DigiLocker. Its adoption has accelerated inclusion, achieving near full population coverage in a fraction of the time previously projected (IndiaStack, 2015) [20].

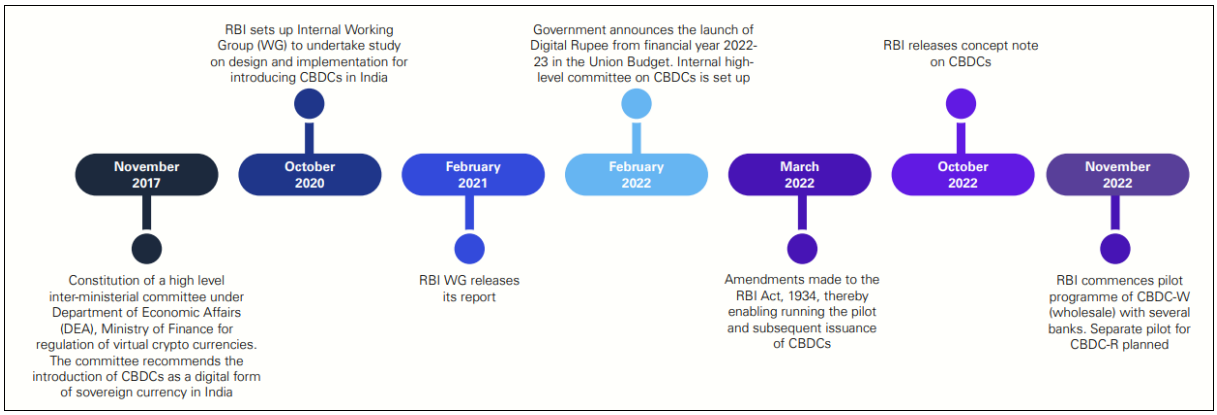
However, despite these developments, there are still large gaps: a sizeable part of the rural and low-income population continues to use informal or cash-based transactions because of the lack of digital literacy or poor internet connectivity, or because it is traditionally seen as cash. While digital systems have an extended reach, these populations often remain under-connected to digital financial tools, limiting the full realisation of inclusion benefits (Baker, 2021) [6].

The Digital Rupee (e₹), as India's Central Bank Digital Currency (CBDC), is designed to further strengthen this digital trajectory. It complements existing tools by offering RBI-backed digital legal tender that mirrors cash in usability and settlement finality, but with digital convenience-making it configurable for offline use, instantaneous transfers, and broader interoperability with platforms like UPI and existing banking systems (PwC, 2024). e₹ holds promise for reaching populations still tethered to informal channels by providing low-cost, resilient, and regulated digital access, thereby advancing inclusion, reducing cash dependency, and reinforcing the digital public infrastructure India has built.

4. RBI's Vision and Implementation of the Digital Rupee (e₹)

4.1 Timeline of RBI's CBDC Development Phases

The Digital Rupee roadmap started in November 2017 when a high-level inter-ministerial committee was constituted and recommended that a sovereign digital currency in India should be developed. An Internal Working Group and successive amendments of the RBI Act followed at the RBI. On 7 October 2022, the RBI published its CBDC concept note. Subsequently, pilot projects began in phases: the wholesale version (e₹-W) launched on November 1, 2022, and the retail version (e₹-R) commenced just a month later on December 1, 2022 (Coin World, 2025; KPMG, 2022).



Source: (KPMG, 2022)

Fig 2: Timeline of RBI's Central Bank Digital Currency (CBDC) Development and Implementation Phases (2017–2022)

4.2 Objectives Articulated in the RBI Concept Note

The principles of the digital rupee are outlined in the Concept Note of October 2022. RBI wants to develop a digital currency that is as similar to physical cash as possible, with all the facilities of speed, cost-effectiveness, and familiarity. The digital rupee is meant to be an additional payment option, fully backed by the central bank without replacing existing systems (Reserve Bank of India, 2022).

4.3 Key Features of the Digital Rupee

Table 1: Key Features of the Digital Rupee

Feature	Description
Legal Tender Status	Recognised as legal tender equivalent to physical currency, fully backed by the Reserve Bank of India.
Technological Infrastructure	Uses token-based architecture for retail CBDC (e₹-R) and account-based architecture for wholesale CBDC (e₹-W).
Offline Capabilities	Supports offline transactions via proximity and non-proximity methods for low-connectivity regions.
Interoperability with Existing Systems	Integrated with UPI and compatible with QR code payments to ensure seamless adoption across platforms.
Programmability	Allows setting conditions such as location-specific validity or restricted usage for certain payments.
Types (Retail vs Wholesale)	Retail CBDC targets the general public for everyday transactions; Wholesale CBDC is for financial institutions to settle interbank transactions.

4.4 Pilot Projects: Retail and Wholesale Trials

e₹-W (Wholesale): It was launched on November 1 2022, with an aim of settling a liability in secondary government securities markets. It has the purpose of streamlining inter-bank payments without making settlement guarantees or collateral, consequently lowering charges (Ministry of Finance, 2022a).

e₹-R (Retail): It debuted on December 1, 2022 and was initially limited to closed-user groups of merchants and banks. The first phase consisted of SBI, ICICI Bank, Yes Bank, and IDFC First Bank; the second phase added Bank

of Baroda, Union Bank, HDFC Bank, and Kotak Mahindra Bank (Ministry of Finance, 2022a). The payments can be done as P2P and P2M fees by using digital wallets, resembling the capabilities of cash, but with a more limited anonymity of the small-value transactions (The Times of India, 2024a).

4.5 Regulatory and Legal Frameworks

The development of e₹ is proceeding within the existing legal frameworks, involving legal authorisations which were realised by amendments of the RBI Act and various other supportive legislations. Implications on the monetary policy, financial stability and data privacy frameworks are also analysed in the Concept Note of 2022. Notably, it advises against interest-bearing models to preserve similarity with cash (KPMG, 2022).

By the middle of 2025, the retail pilot would be scaled up very substantially with a 600,000-user base, 17 banks, and access to a wallet to be provided through non-banking entities of choice. The RBI is testing advanced features like programmability and offline functionality, while exploring cross-border use cases to enhance global interoperability (DeepFlowTech, 2025).

The Digital Rupee of RBI depicts a strategic picture of gradual implementation steps, with the initial stage being policy creation, next being conceptualisation, and finally, pilot implementations in wholesale and retail realms in a controlled way. Through a semi-token, semi-account system with the capability to make offline and programmable payments and expand on top of existing infrastructure (such as UPI), RBI is trying to strike a careful balance between innovation, security and inclusion.

5. Comparative Analysis: Digital Rupee vs Other CBDCs

Table 2: Comparative Analysis: Digital Rupee vs Other CBDCs

Parameter	Digital Rupee (India)	e-CNY (China)	Digital Dollar (USA – proposed)	Digital Euro (EU)
Design Approach	Two-tier model: token-based for retail (e₹-R), account-based for wholesale (e₹-W); phased rollout via pilots.	Two-tier distribution via commercial banks; designed for domestic use and select cross-border pilots.	Under research; likely account-based retail CBDC managed by the Federal Reserve through intermediaries.	Hybrid model: intermediaries distribute CBDC; offline functionality emphasized.
Technology Choice	Hybrid: permissioned DLT for wholesale; token-based architecture for retail with UPI integration.	Centralized core with selective DLT elements; strong control by PBoC.	Exploring centralized ledger vs. hybrid DLT; strong emphasis on resilience and scalability.	Centralized ledger for core operations; exploring offline token-based modules for resilience.
Privacy Approach	Limited anonymity for small transactions; traceable for larger values to comply with AML/KYC.	"Managed anonymity" – masked IDs for small payments, traceable for law enforcement.	Privacy protections aligned with U.S. constitutional principles; likely pseudonymous with safeguards.	High privacy for small-value offline payments; regulatory traceability for online transactions.
Impact on Monetary Policy	Could improve monetary transmission; non-interest-bearing to avoid deposit substitution.	Allows granular policy tools (e.g., expiry dates, targeted stimulus).	Could enhance stimulus delivery in crises; policy reach increased.	Limited monetary policy role; focus on payment efficiency and sovereignty.
Impact on Banking Disintermediation	Designed to minimise disruption; coexists with deposits and UPI.	Potential disintermediation if PBoC wallets bypass banks.	Risks acknowledged; possible caps or tiered remuneration as safeguards.	Minimal risk via caps and non-interest-bearing design.
Lessons for RBI	Ensure interoperability with existing rails; scale gradually with pilot feedback.	Programmability and cross-border potential can enhance CBDC utility.	Public trust, legal clarity, and technical robustness are key.	Privacy protection and integration with current payment systems build adoption trust.

6. Implications for Monetary Policy and Financial Stability

CBDCs add an additional form of central bank liability, which may change the demand of cash and reserves. Evidence suggests that CBDCs, if properly designed, do not inherently create higher inflation risks but may influence money velocity and the transmission of monetary policy through changes in liquidity preferences (Rehman *et al*., 2023) [36]. The capacity to implement programmable money could also enhance precision in targeting specific sectors for stimulus, making inflation control more responsive and granular (Kosanović, 2025) [23].

By cutting off intermediaries and directing information flows to the central bank to the populace, CBDCs will also enhance the monetary transmission mechanism by eliminating lags in policy execution. This "precision monetary policy" could be especially relevant during crises or liquidity traps, improving the reach of stimulus measures (Haque *et al*., 2023) [19]. Furthermore, cross-border CBDC arrangements could improve the transmission of exchange-rate-linked policies by lowering settlement times and costs (Sampaio & Centeno, 2022) [40].

Bank disintermediation, or the transfer of money out of retail banks into CBDC wallets, is one of the risks discussed in the CBDC literature that could have a destabilising effect on funding networks. This is especially severe in jurisdictions that have rather small retail deposit bases and high demand deposits. Design features like caps on holdings and non-interest-bearing CBDCs are proposed to moderate this risk (Lukonga, 2023) [29].

CBDCs may aggravate the threat of bank runs under stress, as people would immediately and instantaneously withdraw funds from banks in favour of so-called safer central bank-issued money. This "digital bank run" risk can be mitigated through phased access limits, transaction friction mechanisms, or tiered remuneration structures (Buzuriu,

2024) [11]. Liquidity management would require robust intraday funding arrangements to offset sudden large flows (Kosanović, 2025) [23].

In line with global best practices to prevent disintermediation, the Reserve Bank of India has indicated preference towards non-interest-bearing retail CBDCs, those that will not provide a store of value investment function. This stance aligns with recommendations in international research, which caution that interest-bearing CBDCs could amplify monetary policy effects but at the expense of bank stability (Kurian, 2023) [25].

CBDCs can be used to improve inflation management and efficiency of monetary transmission with the addition of new vectors of risks, especially the stability of bank funding and liquidity. With a wise set of design elements (like non-interest-earning structures, limits of holdings, and limits on transactions), RBI can enjoy the potential of the monetary policy of e₹ and protect the financial stability simultaneously.

7. Risks, Challenges, and Concerns

CBDCs need a good, solid digital foundation. Any cyberattacks on the key systems might destroy the trust levels, cause payment disruptions, lead to systemic setbacks. Among the risks there is hacking, malware injection, and taking advantage of smart contract vulnerabilities (Kuznetsova & Larina, 2023) [26]. The experience of e-CNY and eNaira emphasises multi-level protection and monitoring in real-time (Lee, 2025) [27].

CBDCs cast a preliminary doubt on the privacy of transactions. The face value of the architectures is based on poor designs and provides an entry point to state surveillance in practice, crippling trust from the user side (Jiang, 2023) [22]. About finding the balance between compliance and protection of privacy, the so-called models of managed anonymity have been suggested as a protection of the small-value transactions but a provision of surveillance of the large ones (Rennie & Steele, 2021) [37].

Incorporations of CBDCs would need good infrastructure, composability with current payment rails and inclusion into fintech ecosystems. Such areas as telecom, cloud security, and rural connectivity are the weakest and may hamper adaptation (Appalonova *et al*., 2024) [2].

Despite good technology adoption is based on the trust and familiarity of the user. Studies on public perception in India note a strong interest in increasing the speed and security of transactions and online payments, but in actuality, concerns about cyber risk and the potential of abuse by the government (Yashwanth & Suresh, 2024) [52].

CBDCs should correspond to the rights proclaimed in the Constitution, primarily those related to privacy and property. The presence of clear legal frameworks related to issuance, liability, and dispute resolution is very important prior to widespread deployment (Kurian, 2023) [25].

8. Future Outlook and Policy Recommendations

The e₹ needs to be phased accordingly, and every stage should deal with technical gaps, regulatory issues and market preparedness. The RBI's pilot-led approach reflects global best practice in managing systemic risk.

Participation in initiatives like the mCBDC Bridge can ensure cross-border compatibility, lower settlement costs, and prevent digital currency fragmentation (Lee, 2025) [27].

Private sector collaboration can accelerate innovation and expand service reach, especially in underserved regions (Adesomoye *et al*., 2024) [1].

Sandbox environments enable iterative testing of features like offline payments, programmability, and cross-ledger interoperability while minimising public risk (Kuznetsova & Larina, 2023) [26].

Recommendations include:

- Use privacy-by-design measures to gain user confidence.
- Ensure that retail non-interest CBDCs do not cause disintermediation of banks.
- Empower rural accessibility.
- Participate in international CBDC standard-setting organisations in order to make it interoperable.

9. Conclusion

The Digital Rupee is the crucial step in the evolution of digital finance in India as it provides the chance to participate in payment efficiency, financial inclusion, and more elaborate tools of the monetary policy. Nonetheless, its advantages are possible to achieve only under the condition that the factors of cybersecurity, privacy, and operability are taken into consideration initially.

It is international experience that design can achieve this balance between innovation and systemic stability, and some examples are hybrid architectures, managed anonymity, and non-interest-bearing accounts. This balanced approach fits well with the way the RBI has been rolling out the initiative, using a pilot based route that may prove to be a springboard to further iterations, prior to large-scale use.

In the international CBDC ecosystem, India has a strong chance of influencing the standards, particularly by incorporating CBDCs into interconnectivity in the cross-border environment. With a robust mixture of technological innovation, effective legal protection, and cooperation between government and the private sector, the e₹ could become a method of domestic financial empowerment not only in its own country, but also an example to other developing economies to follow.

An ambitious yet cautious approach will be needed to ensure that a vision of the future where the Digital Rupee supplements the current payment systems and protects the user rights, and that promotes financial robustness is achieved. When successfully implemented, the e₹ may make India a leader in the industry of digital currencies.

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