

From Cash to Code: Exploring the Disruptive Architecture of Digital Currency in India's Financial Ecosystem

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ABSTRACT

In recent years, non-cash transactions worldwide have witnessed significant growth, leading to the rapid rise and global recognition of digital currencies in the business sector. The outbreak of COVID-19 in 2019 has further fueled the expansion of digital currencies, amplifying the impact of monetary policy and exposing vulnerabilities in the financial system. Consequently, this situation has raised concerns regarding the regulatory framework and cyber safety. Technological progress has played a pivotal role in offering diverse rapid and electronic payment mechanisms for routine transactions. This has led policymakers to contemplate the involvement of the public sector in furnishing a digital payment mechanism suitable for the contemporary economy. The focal point of this research is to augment our comprehension of central bank digital currencies (CBDCs) in a comprehensive manner, coupled with identifying the optimal attributes for the digital rupee. The article explores the historical and current challenges faced by Indian customers in adopting digital currencies, assesses the positive and negative aspects of their influence and development, and presents specific recommendations for improvement.

Keywords: Central Bank Digital Currency, Digital Currency, Non-Cash Transaction, Electronic Payment, E-Rupee

INTRODUCTION:

India has achieved significant strides in the realm of digital payment technology. With the enactment of the distinctive Payment and Settlement Systems Act, the nation's payment ecosystem has witnessed steady and remarkable growth. The country takes pride in its cutting-edge payment systems that embody qualities of affordability, accessibility, convenience, efficiency, security, and widespread availability. This substantial shift in payment preferences has been brought about by the establishment of robust round-the-clock electronic payment services such as Real Time Gross Settlement (RTGS) and National Electronic Funds Transfer (NEFT). These systems have paved the way for seamless real-time or near-real-time fund transfers.

Furthermore, the introduction of Immediate Payment Service (IMPS) and Unified Payments Interface (UPI), facilitating rapid payment settlements, along with the inception of mobile-centric payment solutions like Bharat Bill Payment System (BBPS) and National Electronic Toll Collection (NETC) for digital toll payments, marked a pivotal juncture that reshaped the nation's payments landscape and garnered global recognition.

The ease of these payment mechanisms led to swift adoption, as they presented consumers with an option other than relying on physical currency and checks for transactions. The integration of non-bank FinTech entities into the payment landscape, acting as PPI issuers, Bharat Bill Payment Operational Units (BBPOUs), and third-party technology firms on the UPI platform, has

significantly amplified the utilization of digital payments in the nation. Throughout this evolution, the Reserve Bank has played a pivotal role in catalyzing the realization of its public policy objective: to construct and advance a payment system that is not only secure, equitable, and efficient but also adaptable and all-encompassing.

The form and functions of money have undergone transformations over time, aligning with shifts in the economy and payment systems. These changes will continue to shape the trajectory of currency in the future. The progression of money's nature spans from its origins as a commodity, transitioning to metallic and paper currencies, and ultimately culminating in digital forms. These evolving attributes of money hold the key to reshaping the contemporary financial landscape.

Moreover, propelled by cutting-edge technologies, the next significant chapter in currency's history revolves around its digitization. Technological advancements have paved the way for the emergence of novel monetary constructs, prominently exemplified by Central Bank Digital Currencies (CBDCs).

In recent times, strides in technology-driven payment services have prompted central banks worldwide to explore the potential benefits and risks associated with introducing CBDCs. This exploration is driven by the imperative to stay abreast of the prevailing innovative trends. Notably, the Reserve Bank of India (RBI) is actively engaged in scrutinizing the merits and demerits of incorporating CBDCs into its monetary framework. The focus is presently channeled into a meticulously planned phased implementation strategy, encompassing a

series of stages that lead to the eventual launch. Simultaneously, the RBI is delving into diverse use cases

| S. No | Payment System | Year Introduced | Key Features |
|-------|---|-----------------|---|
| 1 | ECS (Electronic Clearing Service) | 1990 | Facilitates bulk and repetitive transactions such as salaries and dividends |
| 2 | RTGS (Real Time Gross Settlement) | 2004 | Enables high-value, real-time fund transfers without netting |
| 3 | NEFT (National Electronic Funds Transfer) | 2005 | Allows electronic fund transfer in batches across banks |
| 4 | IMPS (Immediate Payment Service) | 2010 | Provides instant interbank fund transfer available 24x7 |
| 5 | CTS (Cheque Truncation System) | 2011 | Eliminates physical cheque movement through digital processing |
| 6 | NACH (National Automated Clearing House) | 2012 | Centralized system for bulk transactions and recurring payments |
| 7 | UPI (Unified Payments Interface) | 2016 | Real-time mobile-based payment system with interoperability |
| 8 | E-Rupee (Central Bank Digital Currency) | 2022 | Digital form of currency issued by the central bank |

for the issuance of its own CBDC, known as the Digital Rupee (e), with a steadfast commitment to ensuring minimal or negligible disruption to the existing financial system. The RBI's endeavors place it at the forefront of a pivotal juncture in the evolution of currency, a juncture that promises to fundamentally reshape the essence and functioning of money.

As an integral aspect of the current responsibilities held by Central Banks, the Bank for International Settlements has formulated the "foundational principles" and "fundamental elements" that delineate a Central Bank Digital Currency (CBDC). These guidelines serve as a

compass for exploration and the reinforcement of public policy objectives. The fundamental principles underscore the necessity for regulatory bodies to ensure that issuing a CBDC would not jeopardize the stability of monetary or financial systems. Moreover, they emphasize that a CBDC can coexist alongside and enhance the efficacy and innovation of existing currency forms.

The Reserve Bank broadly defines a CBDC as a digitally rendered legal tender sanctioned by a central bank. While akin to traditional national paper currency, it takes on a novel form. Its interchangeable nature with current currency remains intact, ensuring its parity in value. Furthermore, a CBDC is designed to function as a recognized instrument for transactions, a legitimate form of currency, and a secure repository of value.

In accordance with the established responsibilities of Central Banks, the Bank for International Settlements has introduced essential guidelines for the exploration and facilitation of Central Bank Digital Currencies (CBDCs). These guidelines encompass both "foundational principles" and "fundamental elements." The foundational principles underscore the necessity for regulatory authorities to ensure the stability of monetary and financial systems before CBDC issuance. Additionally, CBDCs are seen as a potential coexisting counterpart to traditional currencies,

aiming to enhance overall efficiency and foster innovation within the financial landscape.

Chronological Development of India's Payment Systems

Source RBI 2022

II REVIEW OF LITERATURE

Recent advancements in technology have led to an upsurge in rapid digital payment methods available to consumers for their day-to-day transactions. This trend has raised concerns among policymakers regarding the role of the public sector in establishing an electronic payment framework to support the country's economic growth. The introduction of a central bank digital currency (CBDC) presents complex theoretical challenges pertaining to the issuance of both public and private currency (as discussed by Gurley and Shaw in 1960). Additionally, it raises questions about the potential for the central bank to utilize CBDC as a direct channel for communicating monetary policy to the general public (as theorized by Tobin in 1985). Existing scholarly literature on CBDC has predominantly examined its implications from two main perspectives: (i) its effects on commercial banks, and (ii) its impact on monetary and financial policies, as well as overall stability and societal well-being. Policymakers, as highlighted by the Bank for International Settlements in 2018, are particularly interested in exploring these facets and other related concerns. Digital currency, in its electronic form, has emerged as a novel technological innovation that serves as a medium of exchange, a unit of measurement for value, and a store of wealth. It encompasses various payment methods that hold equivalent value to physical cash but exist exclusively in digital format.

In a globally interconnected world marked by the rapid international expansion of businesses and a predominant urban dwelling of the global population, digital currency has emerged as the cornerstone of commercial transactions involving goods and services. The proliferation of digital currency usage owes itself to the convergence of various technological advancements, including mobile devices, near-field communication technology, big data, storage solutions, cloud technology, and encryption methods. These innovations have been pivotal in catalyzing the growth of digital currency adoption (Dodgson et al., 2015).

Within this context, Beindseil and Ulrich conducted a comprehensive assessment of the progression of information technology and its integration into the financial sector. Their research report for the European Central Bank delves into not only the advancements in this realm but also explores the potential benefits inherent in the adoption of central bank digital currency (CBDC) that would be accessible to the general populace. The current research embarks on a comprehensive investigation into both the advantages and disadvantages associated with Central Bank Digital Currency (CBDC) as an initial stride. Subsequently, it delves into two primary rationales concerning CBDC: i) the potential threat of eroding the intermediary role of banks and the centralized credit approval mechanism within the central bank, and ii) the potential risk of exacerbating organized bank runs during times of financial crises. Dyson and Hodgson (2016) emphasize that CBDC "holds the potential to enhance the stability of the financial system: Enabling consumers, private-sector businesses, and non-bank financial institutions to directly engage with central bank money (in lieu of deposit accounts) significantly reduces the concentration of credit risk and liquidity within payment services. This reduction diminishes the systemic significance of major banks, consequently mitigating the adverse externalities that the financial instability of banks imposes on society. Furthermore, by offering a genuinely risk-free alternative to bank deposits, a shift from bank deposits to digital currency diminishes the necessity for government-backed deposit guarantees, thereby eliminating a source of systemic risk from the financial system. Currently, the realm of digital currency and electronic payment research is primarily centered around various aspects: the shift towards cashless transactions exemplified by platforms like SWIFT, Alipay, WeChat, and Apple Pay; the emergence of digital currencies like Bitcoin and Litecoin that operate on blockchain technology; the concept of stablecoins typified by Libra; and the development of central bank digital currencies. In the assessment of Arvind Narayanan and Joseph Bonneau (2016), Bitcoin holds remarkable technical importance, fostering innovation and intrigue while being firmly rooted in sound theory. Their conviction rests in the strong interrelation between Bitcoin and other fields within computer science, with the technology's potential to supplant established institutions. As underscored by Yao Qian (2020), blockchain technology enjoys a reputation as a trustworthy digital mechanism, substantiating its unquestionable significance. To label it the bedrock of the digital era would hardly be an overstatement.

III METHODOLOGY

The current study uses a descriptive and analytical research design to investigate the transformative influence of digital currency, specifically the Central Bank Digital Currency (CBDC) or e-Rupee, on India's financial ecosystem. The study primarily focuses on understanding the structural framework, benefits, and constraints associated with digital currency adoption, as well as its implications for financial inclusion, transparency, and monetary stability. (Kumhof & Noone, 2018; Reserve Bank of India, 2022).

The analysis relies heavily on secondary data sources, such as reports and publications from the Reserve Bank of India (RBI), Bank for International Settlements (BIS), World Bank reports, government papers, and peer-reviewed journal articles. Furthermore, pertinent information on digital payment systems and fintech advances was gathered from financial databases, policy papers, and published literature. This method gives a thorough and accurate foundation for assessing the emergence and operation of digital currency in India. (BIS, 2021; World Bank, 2021).

To augment the secondary investigation, a conceptual evaluation framework was used to compare the advantages and disadvantages of digital currency. The report categorizes essential criteria such as accessibility, cost-effectiveness, transparency, security, and financial inclusion. Comparative analysis is used to determine how digital currency compares to traditional cash systems and existing digital payment platforms. (Auer & Böhme, 2020).

The study also employs a qualitative analytical method, in which insights from current literature and policy documents are scrutinized to uncover new trends, hazards, and policy gaps. The results are evaluated using thematic analysis, which allows for the discovery of critical trends such as privacy concerns, cybersecurity threats, scaling issues, and regulatory challenges. (Fabris, 2019; Ozili, 2023). However, the study has drawbacks. Because it is based mostly on secondary data, the results may be limited by the availability and extent of current literature. Furthermore, because the implementation of CBDC in India is still in its early stages, the study does not involve substantial empirical or primary data analyses. Future study may use primary data collection methods, such as surveys and interviews, to acquire a better understanding of user perception and adoption behavior. (Reserve Bank of India, 2022). Overall, the methodology offers a formal framework for critically assessing the disruptive potential of digital currency and its ramifications for India's changing financial architecture.

IV DEVELOPING CASH 2.0 & ITS IMPACT

Creating 'cash 2.0' Central banks are now under obligation to provide a next-generation financial mechanism that incorporates several of the attributes that customers value in currency, including accessibility, general acceptance, and invisibility. Furthermore, in both emerging and developed economies, decreased cash usage and increased financial service digitization have aggravated financial inclusion difficulties.

CBDCs could enable central banks to take a direct role in enabling financial services accessibility for the unbanked, who are hesitant to link to commercial banks and may be overlooked in some circumstances due to a lack of revenue potential. Moreover, accounts might be held directly on the central bank ledger using CBDCs, allowing account holders to access and use their holdings through digital wallet technology connected to the central bank account via APIs.

Implication of Indirect model in CBDC:

The inadequacies linked with the Single-tier model underscore the necessity to develop Central Bank Digital Currencies (CBDCs) using a two-tier framework. This arrangement entails a cooperative effort between the central bank and diverse service providers. At present, this consortium comprises 13 financial institutions, namely SBI, ICICI, YES Bank, Bank of Baroda, Union Bank of India, HDFC, Kotak Mahindra, IDFC First Bank, Axis Bank, HSBC, Punjab National Bank, Canara Bank, Federal Bank, and IndusInd Bank. Within this study, our specific focus centers on the Indirect model, which is categorized under the intermediate architecture of CBDC implementation.

INDIRECT MODEL

In the concept of the "indirect CBDC" approach, individuals would place their CBDC holdings into a wallet offered by a bank or another service provider. This transfer of responsibility from the central bank to these intermediaries would handle the task of meeting CBDC requirements. Meanwhile, the central bank would primarily concentrate on overseeing wholesale CBDC amounts kept within these intermediaries. The central bank would assume the role of guaranteeing that the total wholesale CBDC balances align with the combined value of all retail balances accessible to customers. Unlike other models, such as the liability resting with the RBI, any issues concerning data or monetary theft in the digital wallet fall under the sole responsibility of the RBI. The distribution of e-rupi, issued by the RBI, is facilitated by intermediaries according to the framework established by the RBI, which mandates the maintenance of ledgers by these intermediaries. The indirect model does not accept the concept of finality of settlements, aligned with global standards, thereby mitigating payment-related risks and reducing systemic risk in the emerging digital securities market. The RBI asserts that the indirect model is suitable for a country like India, considering the advantages and disadvantages of the various models.

In the context of the two-tier model, the RBI is responsible for producing and allotting tokens to financial entities designated as Token Service Providers (TSPs). Subsequently, these TSPs are tasked with delivering these tokens to individuals engaging in retail transactions.

The intermediaries manage all aspects linked to transactions, encompassing the dissemination of CBDCs to the general public, services related to maintaining accounts, procedures for verifying customers such as KYC, and strict adherence to checks for Anti-Money Laundering and Combating the Financing of Terrorism (AML/CFT). Additionally, they handle transaction

authentication and various allied services [Avisha Gupta](#) and [Somya Yadav](#) (2022).

Embedded Finance: Transforming Traditional Boundaries

Embedded finance, in essence, refers to seamlessly integrating financial products within the realm of non-financial customer experiences, processes, or platforms. While it might sound innovative, the concept itself is far from novel. Consider how non-banking entities have long been offering financial services through avenues like private-label credit cards in retail chains, supermarkets, and airlines. Similarly, embedded finance finds expression in scenarios such as sales financing in appliance stores and vehicle loans facilitated by dealerships. These arrangements act as conduits, allowing supporting banks to directly connect with end clients.

The true potency of embedded finance lies in its ability to blend financial offerings into the very digital interfaces that customers engage with routinely. This convergence paves the way for the upcoming era of embedded finance, one characterized by unparalleled strength and transformative potential. Loyalty program application, digital wallets, accounting software, and shopping cart systems are just a few examples, obtaining financial services through these platforms it becomes easier for consumers and enterprises. With these interfaces, getting financial services has become a reasonable continuation of a nonfinancial experience, such as buying online, scheduling staff to shift work, or inventory control. This more deeply integrated form of embedded finance has risen dramatically in the United States in recent years. Fundamental shifts in business, merchant and consumer behavior, and technology have permitted the growth of embedded finance. The digitization of commerce and business management has greatly enlarged chances to infuse money in nonfinancial client experiences. Approximately 33% of worldwide expenditures on cards, and as much as 50% within the United States, are presently conducted over the internet. Notably, a significant segment of small and medium enterprises in the US are depending on software solutions to oversee their operations³. Additionally, with the maturing of digitally native generations, there has been an expansion in the group of consumers and businesses willing to embrace complete digital financial services.

The advent of open-banking innovation has played a pivotal role in tapping into latent demand. This is achieved by granting third-party fintech enterprises access to customers' banking data and the ability to execute transactions on their behalf. This shift is observable in the European Union, while the United States has been experiencing a market-driven adoption of this trend.

Potential for radical redesign Finally, the success of CBDC launches will be determined by user adoption, which will be linked to the digital currency' acceptability as a form of payment with a value creation that outperforms existing alternatives. CBDC attempts may fall short of adoption targets if such advantages remain untested. The repercussions for traditional banking and payment players will be limited in this scenario. Nonetheless, if projects advance beyond the pilot level,

central banks and governments are likely to use every tool at their disposal to ensure success, given the essential policy objectives just mentioned, as well as the potential impact on central bank credibility. To be successful, CBDCs must obtain widespread adoption, displacing conventional forms of payment and value storage.

Central banks that apply eight best practices can improve the chances of CBDC adoption. Source: McKinsey analysis

Central banks that implement eight best practices can increase the likelihood of CBDC adoption. 1 Choose 1-2 use cases that provide a better user experience and more value to customers than existing alternatives. 2 Make consumer onboarding and usage as simple as possible, while making merchant integration as simple as possible. 3 Establish a strong presence in local marketplaces by utilizing brand awareness and loyalty. 4 Concentrate on niche markets; undertake a staggered rollout, beginning with use cases that are large volume and tackle immediate pain points. 5 provide Incentivize businesses and consumers to use digital currency. 6 Establish trust from the start by keeping promises; it is preferable to succeed at something easy than to fall short on something difficult by half deliver. 7 Develop collaborations to expedite scale-up while keeping a primary link with important stakeholders. 8 Utilize current payment infrastructure to minimize time to market. It is an encrypted data transmission that is entirely reliant on internet encryption technology. The knowledge is given economic significance and value.

Immediate payment volumes are expanding by 40 to 60 percent globally, and it is approaching a turning point. Immediate payments utilization tends to approximately double annually in nations such as **India**, Spain, and Thailand, among others, and it is expanding by around 50% per year in Australia and Singapore. Even in China and the United Kingdom, where the technology is already widely used, growth is still in the double digits.

Recent Trends driven the growth in digital payments.

The growth in digital payments has been shaped by four significant trends. Firstly, the Covid-19 pandemic accelerated the shift from cash to digital payments, a transition that was already in progress. Secondly, the landscape of e-commerce has undergone a transformative expansion, evidenced by a 25% global increase in volumes between 2019 and 2020. Projections suggest a consistent annual growth of 12 to 15% until 2025. The third trend involves governmental initiatives aimed at enhancing cashless transactions. These efforts, driven by objectives such as improving interoperability, plugging tax leakages, and facilitating efficient aid distribution, catalyzed the adoption of novel digital payment systems. Examples include Wave in Côte d'Ivoire, UPI in India, and Pix in Brazil. Remarkably, UPI in India alone has garnered the participation of over 300 registered banks, serving approximately 260 million users and facilitating nearly six billion monthly transactions.

BOON OF THE DIGITAL CURRENCY

A paradigm shift in the financial ecosystem, digital currency—especially the Reserve Bank of India's e-Rupee—improves accessibility, efficiency, and

transparency. Digital vouchers increase simplicity and usability for a variety of user groups by doing away with the requirement for physical instruments, in contrast to traditional cash-based systems (RBI, 2022). Customers can repeat transactions until the stored value is exhausted because to the addition of multi-use capabilities, which increases transactional flexibility (Kumar & Singh, 2023). Additionally, digital currency has shown itself to be very effective in the targeted distribution of government subsidies and social programs, guaranteeing that funds reach their intended recipients while reducing leakage.

Cost optimization is a major benefit. The government's administrative costs are lowered by digital currency since it eliminates the need to print, store, and move physical cash (RBI, 2022). The entire obligation of the central bank guarantees monetary stability and boosts public trust (BIS, 2021). It also lowers transaction costs for consumers and intermediaries and encourages a more effective currency management system (Auer & Böhme, 2020). Additionally, since digital transactions produce traceable records that increase accountability and lessen corruption, transparency is improved (Sharma, 2023).

Importantly, digital currency promotes financial inclusion by enabling rural populations and differently-abled individuals to participate in digital payments independently (World Bank, 2021). It also facilitates cross-border transactions and can function in offline modes, addressing connectivity challenges in remote areas (RBI, 2023). Moreover, digital currency reduces payment-related risks and enhances security by minimizing fraud and unauthorized transactions through advanced technological safeguards (Kosse & Mattei, 2022).

BANE OF DIGITAL CURRENCY

Despite its benefits, digital currency has a number of operational and structural issues. One significant drawback is the wallet holding limit, which might limit high-value transactions and make it less appealing for widespread use (RBI, 2022). Due to procedural complexity, the voucher-based redemption process may also be inconvenient for users, which could deter adoption (Gupta, 2023). Concerns regarding privacy and surveillance are also raised by transaction traceability, since consumers may be worried about government monitoring of their financial transactions (Auer & Böhme, 2020).

The reliance on digital and banking infrastructure presents another difficulty. It could be challenging for those without bank accounts or digital payment methods to use digital currency, which would restrict inclusivity (World Bank, 2021). Users used to cash-based systems may be discouraged by the lack of convertibility into actual cash, which further restricts liquidity flexibility (RBI, 2023). In digital financial systems, cybersecurity threats including hacking and data breaches continue to be a major worry (Kosse & Mattei, 2022).

Furthermore, to guarantee dependability, problems like duplicate spending and system vulnerabilities call for strong technological frameworks (BIS, 2021). Additionally, digital currency lacks interest, which makes it less appealing than conventional savings options

(Narayana, 2022). As transaction volumes expand, scalability issues could surface, especially in a big, varied economy like India (Sharma, 2023). Widespread adoption is still hampered by digital illiteracy, particularly in rural areas (Gupta, 2023). Lastly, its expansion and policy efficacy may be further hampered by fierce competition from already-existing digital payment systems and restricted access to transaction data for institutional analysis (Kumar & Singh, 2023).

V DISCUSSIONS

As far as digital currency is concerned, implication of the own digital currency i.e., E-Rupee (CBDC), libra for China has different motives where both the countries use the same CBDC block-chain has a different view on the privacy factor of the public. The major finding related to negative impact of E-Rupee on the general public:

1. **No Interest rate** - Which has a great impact on the economy as a whole. In the point of view as a customer the benefit which is acquired from the service matters, a great example is the success of UPI in India, now many countries around India have adopted the UPI payment method. The only benefit of CBDC is that the liability of the beneficiary is on the heads of the RBI but still now the extent to which the RBI is responsible is not yet define.
2. **More the power more the desire is:** RBI is making every part of transaction centralized, the main concept of the CBDC is to eliminate the intermediaries so the financial institutions, payment app problems are gone. Where here comes the problem, the elimination of financial institutions can further have a greater impact on the monetary policy, money supply even the institution can be vanished. which may further have an impact on the public in change
3. **Increase in the deposits:** No interest rate can be a major reason for the increase in money deposits where around 3.6% interest is being put forward by banking institutions for the money in the bank accounts.
4. **Redeeming the voucher:** The major issue of the E-Rupee is the voucher issued can be used only once if the the amount in the voucher is used, the beneficiary is required to meet the institution to redeem it and it should be pre-booked, pre-booking is the major disadvantage of this digital currency especially in this technical world.
5. **Double sending:** Double spending, which is likely using the same coupon for multiple times where the coupon is issued only once. CBDC has the higher possibilities of double sending which has a greater impact on the users of the E-Rupee. The cyber securities should have a greater wall built towards the threat and hackers.
6. **Centralized ledger:** As RBI uses the centralized ledger every data related to every transaction and every personal details are under one database which is under the control of RBI. If the cyber security is weaker all the customer data will be transparent and the money can be looted. It can be used for some positive purposes like, the data would be highly useful for

enforcing money laundering regulations. Where if they are hacked it has visa versa impact.

7. **Privacy:** The usage of E-Rupee has completely eroded privacy compared to other payment apps, as government intervention enables tracking and surveillance of users. China also faces privacy issues with certain payment services like WeChat, where the government collaborated for digital currency distribution. However, the success of such apps compromises transaction privacy. To strike a balance, authorities must consider maintaining transaction confidentiality while pursuing anti-money laundering objectives.
8. **Interoperability:** While digital transactions allow easy conversion of money between bank accounts and wallets, the RBI does not currently allow CBDC to be converted to cash or accessed via payment systems like UPI or cards. This limitation restricts the potential use cases of CBDC. The success of CBDC depends on integrating and modifying existing payment infrastructure for efficient CBDC payments, leading to lower costs and wider adoption across the country.
9. **Legal stability:** Stable and sustainable growth of digital currency necessitates clear rules and regulations. The government must frame acceptable laws and policies that meet the specific requirements of the legal framework. Implementing the best legal framework is crucial for leveraging CBDC to enhance the economy.
10. **The technological aspect:** When designing CBDC, it is essential to consider the resource intensiveness of the system. The technical choices made in the initial stages should remain flexible, as technology, policy considerations, and security requirements evolve. Avoiding vendor lock-in and enabling complete ownership by the Central Bank when engaging technology service providers is important. Algorithm-driven processes, focusing on energy efficiency and environmental friendliness, should replace energy-intensive mining associated with private cryptocurrencies.
11. **Enhancing competitiveness of E-Rupi:** The RBI's main objective is to counter the influence of cryptocurrencies and offer a superior option to citizens that aligns with current trends. CBDC provides numerous benefits that extend beyond the existing digital payment apps, particularly for rural development and facilitating payments for disabled individuals. The 2-tier model adopted by the RBI ensures customer liability is directly controlled, reducing the risk of theft or hacking. The RBI maintains full control over transactions and data, addressing grievances and even enabling offline payments for users with basic phones. Overcoming drawbacks such as privacy protection, addressing interest rates, and fulfilling legal requirements can contribute to the success of e-rupee.

VI STRATEGIC MEASURES FOR MITIGATING TECHNOLOGICAL RISKS IN CBDC IMPLEMENTATION

The foundational focus during the design of CBDCs must be on ensuring top-notch security. Individuals holding privileged positions within the CBDC network ought to be subjected to a comprehensive risk management framework. Beyond ensuring a robust back-end infrastructure, equal emphasis should be placed on subjecting the user interface to thorough testing to preempt the exploitation of vulnerabilities. **Employing Vertical Segmentation & Eliminating Single Points of Failure:** The entirety of the CBDC ecosystem will be categorized into distinct segments, such as wholesale or retail, adopting various formats like account-based or token-based. This approach ensures that a breach in one segment will not cascade into the compromise of other segments automatically.

Cryptography & Quantum Resilience: The security of CBDCs will be fortified through advanced cryptographic techniques, surpassing the safety of current payment systems. Nevertheless, the prospective challenge posed by quantum computing must also be taken into account during the CBDC design phase. Quantum computers exhibit unparalleled processing power, outshining even the mightiest supercomputers of today. To counter this, the CBDCs need to incorporate quantum-resistant algorithms, also referred to as post-quantum, quantum-secure, or quantum-safe algorithms. These cryptographic measures stand as barriers against potential quantum computer attacks. The imperative for each CBDC lies in its capability to withstand the power of quantum computing. Thus, ensuring the robustness of cryptographic methods alongside other encryption approaches and establishing quantum resilience becomes pivotal in constructing a secure and dependable CBDC technical framework. **Recall Capability:** Should any specific sequence of tokens face a breach, there exists a technical avenue for immediate recall or the implementation of novel digital security features. **Recoverability:** In designing Central Bank Digital Currencies (CBDCs), the concept of recoverability holds paramount importance. This concept emphasizes that even in the event of a breach, the system must possess the resilience to promptly bounce back. Additionally, the aim is to curtail any detrimental effects on production systems and business processes to the greatest degree feasible. The incorporation of Application Program Interfaces (APIs) plays a pivotal role in facilitating seamless interaction with essential currency management systems at central banks and token service providers.

Hence, apart from technological solutions, addressing security risks also entails the implementation of policy measures. These could involve setting limits, bolstered risk management and governance frameworks, and rigorous testing of functionalities through pilot programs before the CBDCs are introduced for public use.

Examining the architecture and technological aspects of Central Bank Digital Currencies (CBDCs), we can outline the primary risks that consumers might encounter:

Privacy Concerns: The widespread adoption of CBDCs introduces a heightened privacy risk across the ecosystem. CBDCs offer a degree of anonymity and privacy, but the level of risk to consumers hinges on how CBDCs are designed. The principles governing CBDC design will determine both the extent of privacy risk for consumers and potential strategies to alleviate this concern.

Security and Technological Hazards: The security of CBDCs directly links to their technological blueprint. Critical issues encompass the design of security protocols and their technical implementation, which significantly impact the safety and reliability of CBDC-related products and services. Recognizing that the intricacies of CBDC system mechanisms might surpass the comprehension of the average consumer, it could be imperative to establish suitable technical and audit standards. These standards would counteract potential technical roadblocks that indirectly amplify consumer risk.

Accountability Concern: It is of utmost importance to identify the responsible party for addressing consumer losses, making it a pivotal and central aspect related to managing risks associated with consumer protection.

VIII SUGESSTIONS

The implication of CBDC is in the crawling stage in India, in most of the developing countries CBDC is implemented to nurture all the financial inclusion i.e., to include all class of peoples to avail the service. Review on the study of CBDC has reflected many benefits but some studies indicate that the limiting factor of CBDC indicates that every kind of process cannot be achieved. In India the centralised ledger technology is being used where it is more functional and efficient for the Indian government, they adopted it to secure the customers, investors and people rely on the service but limit is being fixed for the adoption for new innovation in the payment methodology. As India is creating their own CBDC imposition of some useful set of technology for the distributed ledger technology kind of immutable distributed technology like cryptography, programmability and smart contract here the data can't be change and it remain constant even if there is any change occur it is immediately altered who is making change to the data where the distributed technology is more secured and eliminates the cyber threats. Implication of useful technology from distributed technology to the centralized technology can be a solution for the feebleness of the security system of centralized system.

- Implication of both retail and whole E-Rupee should at least have a similar range in their usage to have a stable and ethical economical growth.
- Widespread usage of E-Rupee is essential to competitive with other payment apps.
- Highly suggested for the use of policy related transactions where the voucher is being tracked by the government even if any fraud occurs the RBI is wholly liable.

- Basically, in India paper currency is a King where it is anonymous and cannot be tracked by the government and has a wide range of usage where mobile usage in India is enormous but the digital literacy is down to the core, improvisation in this part is highly required.
- Implementing a two-step verification process, along with the integration of Aadhaar cards and biometrics, presents a potential solution to address privacy concerns.

VIII CONCLUSION

India is presently engaged in a major initiative involving the introduction and testing of its own Central Bank Digital Currency (CBDC) named the E-Rupee. This initiative is currently in its initial implementation phase and is undergoing rigorous testing. According to reports from the finance minister, the E-Rupee is designed not to replace conventional paper currency, but instead, it presents a range of supplementary advantages as a viable alternative. The effective utilization of centralized ledger technology, prioritizing cyber security measures, is crucial for providing substantial advantages to the general public. The RBI has made assurances regarding the

heightened security of the E-Rupee under their control, emphasizing the importance of avoiding any biases in their management of the centralized currency system. The implementation of CBDC holds significant potential for India's economic and technological growth, potentially propelling the country from a developing nation to a developed one, provided that the implementation is well-structured and maintained by the RBI. CBDCs present clear benefits, encompassing reduced costs, improved risk monitoring, broader financial inclusion, and heightened digitization of the economy. India's rapid embrace of UPI, Fastag, and Rupay cards in recent periods underscores the nation's preparedness for digital progress. However, there exist certain considerations that demand attention, specifically the delicate balance between traceability, anonymity, and privacy. In this context, the Reserve Bank of India (RBI) shoulders the monumental responsibility of establishing a seamless, interoperable system for integrating CBDC into the Indian economy. Consequently, the choices undertaken by the RBI throughout the introduction and execution phases will wield significant influence over the destiny of CBDC, determining whether it achieves resounding success or falls short of envisioned outcomes

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