South Asian Journal of Social Studies and Economics

Volume 21, Issue 8, Page 1-13, 2024; Article no.SAJSSE.119623
ISSN: 2581-821X

E-Rupee: Unlocking India's Digital Economy, Challenges, and Opportunities

Shallu Sehgal [a++], Mohd Yasir [a#*] and Sukhleen Kour [a#]

[a] Department of Economics, University of Jammu, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/sajsse/2024/v21i8860

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/119623

Review Article

Received: 14/05/2024
Accepted: 16/07/2024
Published: 22/07/2024

ABSTRACT

This paper explores the concept of digital currency, differentiating between digitization and digitalization, and analyzes its different forms, specifically centralized and decentralized digital currencies. The analysis comprehensively examines Central Bank Digital Currencies (CBDCs), specifically focusing on India's e-rupee. It delves into the various forms of CBDCs, their management strategies, and the potential economic consequences they may have. The significance of digital currency in promoting financial inclusion, improving transaction efficiency, and influencing monetary policy is emphasized. Moreover, the study discusses the difficulties and dangers linked to the deployment of digital money, such as cyber-attacks, financial instability, privacy issues, and regulatory obstacles. The paper emphasizes the significance of strong risk management systems and consistent monitoring to guarantee the efficiency and safety of digital currencies. This study offers unique insights into the revolutionary potential of digital currencies and

---

[++] *Associate Professor;*
[#] *Doctoral Scholar;*
**Corresponding author: Email: mohdyasirju@gmail.com;*

Cite as: *Sehgal, Shallu, Mohd Yasir, and Sukhleen Kour. 2024. "E-Rupee: Unlocking India's Digital Economy, Challenges, and Opportunities". South Asian Journal of Social Studies and Economics 21 (8):1-13. https://doi.org/10.9734/sajsse/2024/v21i8860.*

the strategic considerations required for their effective adoption by conducting a thorough assessment of the digital currency ecosystem. Moreover, the emergence of the 4th Industrial Revolution (4.0), driven by digital technologies, is transforming industries on a global scale within the field of agriculture, digitalization is transforming farming methods by implementing smart farming, precision agriculture, and digital agriculture. This paper also provides the guidelines for mitigating operational risks associated with digital currency, which may be found in the NIST Risk Management Framework and the CPMI-IOSCO Principles for Financial Market Infrastructures.
Ultimately, the embrace of digital currencies and the digitization of numerous industries have the potential to stimulate economic growth, enhance financial accessibility, and proper technological advancement.

Keywords: Digitization; digitalization; digital currency; central bank digital currencies; RBI; E-rupee; NIST RMF; CPMI-IOSCO principles for FMI.

1. INTRODUCTION

The term "digitization" refers to the procedure by which analog data is converted to digital data (such as images, text, audio, and videos) into a digital format, encoding it for the purpose of storing, processing, and subsequently transmitting the information to the user [1]. The integration of digital technologies into routine tasks constitutes digitalization or the digital revolution. It pertains to the transformations that occur across all facets of human societies as a result of digital technology implementation [2].

As information and communication technologies continue to advance and become more prevalent, the concepts of digital society and digital economy are materializing [3]. Nevertheless, digitization and digitalization are not synonymous. It plays a pivotal role in advancing socioeconomic development [4].

Digitized transactions refer to the implementation of a contractual obligation to transfer actual currency between two accounts, from one owner to another owner. The topic of settlement of inter-account transfers of cash has been thoroughly examined in the literature on payments systems, with a specific focus on the contractual terms and standards involved [5].

Digital currency integrates the essential attributes of money with the convenience and effectiveness of electronic transactions [6], with the bank debit card being a prominent illustration. Nevertheless, the widespread approval of electronic banking transactions has facilitated the development of a distinct forms of e-currency which are not linked either to a bank account or any conventional means of storing value [7]. The reliability of digital currency is based on the computer algorithms that govern its creation and distribution [8].

At first glance, the virtual currency seems to be unsuitable as a reliable function of preserving wealth, since it is merely a form of digital currency [9]. Although the term "virtual" encompasses more than just the concept of anything being artificially created or projected. In the context of virtual currency like Bitcoin, it signifies that the algorithm responsible for generating units of the currency ensures that its supply remains within a predetermined range [10]. The supply limit for bitcoin is set at 21 million bitcoins [11]. This type of digital currency (cryptocurrency) is a form of money that uses computer encryption to keep track of both the supply and the ownership of coins. It is also known as cryptocurrency.

In economics sense, digital currency is an e-type (electronic) mode of payment which can be done for all the three motives; Transaction, precaution and speculative as well [12]. So, they can be used for investment purposes and peer to peer transactions. (Examples: Bit coin, E-rupee).

David Chaum in 1982 [60], was the first to present the notion of digital currency. In 1989, he saw the formation of DigiCash, an electronic currency company he founded in Amsterdam with the purpose of commercializing the ideas he uncovered through his research. They lack in physical counterparts like coins, notes, near money, broader money etc.

It is crucial to thoroughly examine the frameworks and principles established for risk management while establishing a CBDC due to various significant factors. As digital currencies become more important in global financial systems, central banks must prioritize the security and stability of these digital payment infrastructures. The NIST (National Institute of Standard and Technology) RMF (Risk

Management Framework) offers a systematic method for evaluating and reducing security and privacy risks linked to information systems. By adhering to the procedures delineated in the NIST RMF, central banks can methodically detect possible weaknesses and enforce suitable measures to protect the confidentiality, integrity, and accessibility of data within CBDC systems [13].

2. TYPES OF DIGITAL CURRENCY

There are mainly two types of digital currency discussed in economic business sense [14,15,16,17, 18,19].

2.1 Centralized Digital Currency

Issued and regulated by central authorities like Government or central Bank, like CBDCs (Central Bank Digital Currencies) [8]. Example India's "E-rupee".

2.1.1 Types of CBDCs

There are two types of CBDCs discussed with related to Digital currency [20,21].

a) **Retail CBDCs:** where E-rupee is accessible to all the individuals of the country. According to a 2017 article [63], along with other financial institutions, the Reserve Bank of India (RBI) allotted around 21,000 crores throughout the year for money management [76]. The e-CNY (digital Yuan) issued by People's Bank of China (PBC) [72] is an illustration for a retail CBDC.
b) **Wholesale CBDCs**: where E-rupee is used only by the wholesalers, which are strictly monitored by the RBI. Wholesale central bank digital currency (CBDC) has the potential to streamline the process and facilitate automation (Deloitte) [62]. The Project Helvetia, a collaboration between the Bank for International Settlements, Swiss National Bank, and SIX, showcases the practical viability of using a wholesale Central Bank Digital Currency (CBDC) to settle tokenized assets [58]. Likewise, the experiments conducted by Banque de France [57] with Central Bank Digital Currency (CBDC) also belong to this group.

2.1.2 Management of CBDCs

Management of CBDCs can be done through two types of approaches [22,23].

a) **Unimodal (Single-tier):** In this model of CBDC, only central bank monitors the digital currency.
b) **Bimodal (Double-tier):** Digital Currency is issued to the customers by financial institutions or certified intermediaries.

2.2 Decentralized Digital Currency

These are digital currencies that operate on decentralized networks using blockchain technology [24,25]. they rely on a network of computers (nodes) to validate and record transactions. Bitcoin stands as the preeminent illustration of a decentralized cryptocurrency. Nonetheless, a plethora of alternative cryptocurrencies exist, including Ethereum, Litecoin, and Ripple so on and so forth.

As time passes and electronic currency usage increases and technology progresses, central banks are confronted with the decision of whether or not to implement a CBDC in order to bolster their monetary authority. The governing bodies have encountered mounting demands to address the obstacles presented by cryptocurrencies and improve the efficiency of the existing system for making payments [26]. The 2008 financial crisis, the emergence of cryptocurrencies, and the decreasing use of cash have generated interest in CBDC.

The main goal of the Bill (Cryptocurrency and Regulation of Official Digital Currency, 2021), is to confer the RBI with the requisite legislative jurisdiction to establish CBDC. The RBI declared on January 25th, 2024 [67] its plan to examine the probable requirement of commencing a CBDC in India. If deemed necessary, the RBI may investigate strategies to implement the currency.

The gradual evolution of currency from being based on physical commodities to metallic coins, then to paper bills, and finally to digital forms has had a profound impact on the financial environment of India [27]. E-rupee in India was launched in the budget of year 2022 by Financial Minister Smt. Nirmala Sita Raman in collaboration with the National Health Authority (NHA), the Ministry of Health and Family Welfare (MoHFW), and other associated organizations. The National Payments Corporation of India (NPCI) has launched a cutting-edge digital system known as e-RUPI [28].

With the introduction of BHIM and UPI and the deployment of these digital payment networks in almost every retail setting, the RBI and the Indian government have demonstrated their strong support for digital payments [29].

The RBI declared in a press conference dated November 29, 2022 [74], that from 01-12-2022, the first retail digital Rupees (e₹-R) pilot programme will start functioning. This pilot effort will encompass specific sectors inside a Closed User Group (CUG), comprising of merchants and customers who are actively involved [30]. An illustration of a digital token that functions as lawful currency is the e₹-R. The new currency would be generated in the same denominations as the current paper money and coin money. The distribution would occur via middlemen, such as institutions. The digital wallets that users can store on their mobile devices or other devices and utilize to conduct e-R transactions will be supplied by the partnering institutions [31]. Transactions between individuals (P2P) and between individuals and merchants (P2M) are both feasible.

As India is growing fast every second and minute towards future, India now ranks 1st in world population parameters with more than 1.486 billion peoples, more the people, more the scarcity, which then comes with the unemployment (disguised mostly), this leads to the pressure on government to utilize this labor force in jobs and also with the consideration of sustaining the environment and resources [32]. It holds an important point to be noticed for the financial improvement and stability issues of the economy.

3. ECONOMIC IMPACT OF DIGITAL CURRENCY

3.1 Background Analysis of Digital Currency

While it’s too early to measure a proper significant impact on physical usage of E-rupee, but it won’t replace the old currency and it will add on to the existing ways of transactions, but it may affect the traditional culture of transactions.

Digitalization is the preeminent technological development on a global scale. Technology has evolved into an essential component of human society, serving as a catalyst for progress in numerous socio-economic domains including employment, manufacturing, trade and transportation, education, healthcare, telecommunications, banking and financial services, and environmental protection through the advancement and promotion of green technology [33].

Economic development and social behaviour are both positively impacted by the digital revolution. Economic expansion may be stimulated by the increased utilization of digital technologies [33].

It is anticipated that the RBI's introduction of the Digital Rupee will accelerate money digitization and advance India's cashless economy. The adoption of the digital rupee will revolutionize payment techniques, particularly in the realm of cross-border transactions. Future use cases that are suited to certain market demands are probably going to arise as a result of the digital rupee's development [34].

The economy and society may be significantly impacted by the standardization of digital money in banking and commerce; thus, it is crucial to fully understand these impacts before making any decisions [35]. In the banking sector, digital money has the potential to lower transaction costs, speed up local and international transactions and provide rural communities greater access to the financial system.

The Indian Prospective [35] reports that Pallavi M. Kandalkar reveals a substantial increase in the value of the electronic payment market in India, the value increased from ₹13.93 trillion in 2016 to ₹30.00 trillion by 2021.

The widespread acceptance of digital currencies has increased due to the availability of convenient payment mechanisms and user-friendly interfaces [36], including NEFT, RTGS, credit cards, debit cards, and online banking and the positive perspective is that still this growing population if managed and made useful for country through introducing new ways to acquire jobs and money. Such a way is introducing CBDCs like E-rupee, through which following are benefits:

a) Easy investments in trade sectors and other sectors too.
b) More liquidity of money leads to financial inclusion.
c) Enhances the transparency of the economy.

3.2 Fourth Industrial Revolution and scope of Digital Currency

Industrial revolutions are defined as epochs of progressive technology that are distinguished by specific attributes that precipitate more extensive societal changes [37]. The United Kingdom experienced the emergence of the 1st Industrial Revolution during the 18th century, which was empowered by steam and mechanized the manufacturing process, resulting in increased output due to enhanced productivity and efficiency. Coal was the predominant energy source. The invention of the internal combustion engine occurred between 1867 and 1914, marking the beginning of the Second Industrial Revolution. During this period, technological infrastructure advanced significantly; for instance, the electricity grid, novel forms of public transportation, the telegraph, and the telephone were invented. Furthermore, synthetic fertilizers laid the foundation for the Industrial Revolution 2.0. With the advent of information technology, the internet, telecommunications, and electronics in the 1960s, the Third Industrial Revolution commenced, ushering in the automation of production.

Digital technologies are essential in enabling universal healthcare, protecting individuals from medical emergencies, and enhancing general health and well-being. They facilitate the identification of new remedies, support scientific innovations, and aid in the improvement of access to and quality of healthcare services [39,40]. Amidst the COVID-19 pandemic, digitalization and digital health services experienced a notable surge. As a result of mobility restrictions and social distancing measures, the quantity and accessibility of telemedicine and teleconsultation have significantly increased.

As Agriculture sector is one of the leading and more employment consuming sector in India, the adoption and widespread use of electronic devices in the agriculture sector can help to the sustainable transformation in agricultural systems. Adoption of technologies such as robotics, artificial intelligence, remote sensing image analysis, optical sensors, and monitoring equipment design has enormous potential for sustainable development, according to a growing body of research [41,42]. The advent of cellular services and high bandwidth in the early 2010s marked the beginning of the virtual revolution in agriculture sector [43].

Digital agriculture, which integrates the principles of smart farming and precision agriculture with big data analysis, has its roots in the foundations of precision agriculture [44]. According to a study examining the effects of the digital revolution on agriculture, technological progress has had a significant long-term impact on the agricultural sector. Agriculture 4.0 possesses the capacity to augment food production, consequently providing sustenance for the expanding global population. Farmers are provided with precise information regarding the timing, location, and application of weedicides and pesticides, as well as optimal irrigation and harvesting practices, through the joining of Internet of Things (IOT) along with sensor-equipped drones [45]. Zambon et al. [46] posit that the implementation of Agriculture 4.0 yields benefits for both producers and the sustained expansion of the primary sector. Farmers' decision-making will be enhanced by the digital revolution in agriculture which is referred by Sponchioni et al., 2021 [69]. Farmers can enhance their ability to anticipate and react to unforeseen natural phenomena, such as weather conditions, by utilizing data acquired from remote sensing and IoT devices (German Agricultural Society, 2015) [75].

Table 1. Main features of the industrial revolutions

IRs	Duration	Power Source	Major Inventions
Industrial Revolution 1.0	From 1760 to1900	Coal	Steam Engine
Industrial Revolution 2.0	From 1900 to 1960	Oil and Electricity	Engines that use internal combustion
Industrial Revolution 3.0	From 1960 to 2000	Energy from nuclear resources and natural gases	Internet, Electronics, Computer, Robotics.
Industrial Revolution 4.0	From 2000 to present	Green Energies	AI, ML, IOTs, 3D Printing, etc.

Source: Prizecaru, P. [38]

3.3 Challenges and Risks Involved in Digital Currency While Implementation

Numerous potentials for the modernization of the financial ecosystem are presented by the implementation of electronic currencies, such as the proposed e-rupee. The stability and security of the financial system rely on prudent management of the many risks associated with this change [64,66]. Cybersecurity flaws, financial instability, privacy worries, and difficulties in monitoring and regulation are some of the major problems that have been surfacing recently in digital currencies as they have gained popularity. While navigating the complexity of adopting a digital monetary system, it is vital for consumers, financial institutions, and lawmakers to understand these dangers [73]. This conversation explores these dangers, drawing attention to the possible drawbacks that come with the advantages of using digital money.

a) **Cybersecurity risks** [13]**:** Cybersecurity means protecting the data from the malwares and hackers. The More transparency of the money, more the vulnerabilities and this leads to more risk of hackers accessing the personal accounts of individuals.
b) **Financial Instability** [19]**:** When the digital currency circulation increases, the needs of financial institutions like banks decreases as there are less assets to hold now and further banks can't lend to investors of rural areas, where the digital currency is still a myth. Also, the increase in transparency leads to the rational expectations and hence the effectiveness of monetary policies will be lesser [47].
c) **Privacy risks [**48]: If there is an enough transparency. In the context of accountability and fraud prevention, transparency refers to the visible and traceable recording of transactions [49]. However, this can also expose users to privacy risks, despite the benefits. For instance, the e-rupee's transaction history can be monitored and analyzed to observe the economic behavior, financial transactions, and spending patterns of individuals, provided that it is publicly accessible or accessible to a wide range of entities.
d) **Monitoring and regulating risks** [50]: It overtakes the traditional methods of transactions, since India is more affectionate towards tradition and culture, it will be hard to manage the old currency transformation to e-rupee and moreover it involves navigating complex regulatory and legal landscapes.
e) **Fraud and scams**: The cybercrime rate in India, measured by the number of registered cybercrime complaints per lakh population in the National Crime Records Bureau (NCRP), was 129 in 2023. [51]. Increase in digital usage leads to the vulnerabilities and to more frauds and scams.
f) **Technology Access** [19]: E-rupee requires a lot of technology advancements, in rural areas the connections of internet are very less, also mainly Indian population belongs to BPL (Below Poverty Line) and doesn't fall under tax slabs, so for them to adopt the idea of E-rupee will be very costlier, with slow process.

Lack of privacy and financial exclusion may be exacerbated by CBDC. The main implementation challenges are the hazards associated with technology and CBDC's incapacity to function in an offline environment. With CBDC, anonymity is challenging to achieve and requires careful consideration of private aspects. Instead of depending exclusively on a technological approach, the implementation of CBDC should take sociological, economic, and political variables into account [52,68,71].

3.4 Effectiveness of e-Rupee

Effectiveness of e-rupee = f (management, regular monitoring, high security and accessibility)

Above expression can be pronounced as effectiveness of e-rupee is a function(f) of management, regular monitoring, high security and accessibility. They are explained individually below:

a) **Management:** Better management of digital currency leads to increase in efficiency and better implementation of new e-currency like whenever RBI introduces new schemes for financial institutions along with intermediaries, it will lead to efficient management [53].

Table 2. Explaining potential benefits and challenges in some areas

Impact Area	Potential Benefits	Challenges faced
Financial Inclusion	The RBI is now carrying out a pilot programme in multiple cities with the objective of providing more access to banking services for those who may not have it otherwise. Streamlined microtransactions and financial transfers.	Digital literacy and access to smartphones in rural areas. Ensuring fair pricing and avoiding exclusion of low-income groups.
Transaction Efficiency	Faster and cheaper settlements compared to traditional methods. Reduced cash management costs for banks.	Integration with existing payment systems and infrastructure. Potential cybersecurity threats.
Monetary Policy	Enhanced regulation of monetary supply along with interest rates. Targeted fiscal interventions for specific sectors.	Balancing innovation with financial stability. Potential disintermediation of banks.
Transparency & Traceability	Reduced black money circulation and tax evasion. Improved tracking of illegal activities.	Ensuring privacy concerns are addressed. Potential for government surveillance.
Innovation & Competition	Potential for new financial products and services. Increased competition in the financial sector.	Regulatory framework for innovation in the e-rupee ecosystem. Ensuring a level playing field for existing players.
Cross-Border Transactions	Faster and cheaper cross-border payments. Potential for a new global reserve currency.	International standards and collaboration for interoperability of CBDCs. Geopolitical considerations and potential for currency manipulation.

Sources: Md Asraful Haque Mohd Shoaib-May 2023 [65], Peterson K [59]. Ozili July 2023, EY Report 2023

b) Regular monitoring: Strictly monitoring the intermediaries and financial institutions and data should be accessible to public regarding the transactions on weekly, monthly and quarterly basis [54].

c) High security and accessibility: Central Bank should provide more attention for the privacy breach issues after issuing the currency on market level along with the ease of transaction liquidity [55,56].

The functions mentioned above elaborates that all four functions (management, regular monitoring, high security and accessibility) are directly related to effectiveness of e-rupee. While focusing on every aspect of these functions, the creditability and reliability increases.

The digital currency of India, the E-rupee, resembles a brand-new train. It could stimulate the economy by facilitating quicker, more affordable, and more traceable transactions. The potential for this is to combat corruption and increase participation in the financial system. However, one must first surmount certain obstacles. Rural residents may lack access to or expertise with technology, and there is a possibility of cyberattacks or even government intrusion. Before a broader rollout, the government is presently evaluating the E-rupee to iron out these kinks.

4. GENERAL GUIDELINES FOR RISK MANAGEMENT

While implementing a CBDC, it is crucial for a central bank to prioritize security considerations. Given that a CBDC is built upon information systems, it is advantageous to analyse the risk management measures that provide security in those systems. Introducing a CBDC would include assessing potential dangers and adopting essential measures to efficiently handle and mitigate these risks. The primary areas of risk are typically defined in terms of the possible compromise of data security, availability, authenticity, managed, and shared inside the system. The properties of confidentiality, integrity, and availability, which are commonly referred to as the CIA trinity, are essential security requirements for information systems. Risk management involves enhancing measures so that systems may maintain their CIA (confidentiality, integrity, and availability). There are multiple comprehensive security frameworks that companies can use must ensure the

security, reliability, and accessibility of their systems in order to accomplish their goals and commercial activities [13].

4.1 NIST RMF (Risk Management Framework)

It is a durable framework designed to efficiently manage and reduce security and privacy risks.

It has gained significant popularity among a wide range of public and private organizations. This methodology is highly adaptable and can be seamlessly integrated into any type of information system. It can be tailored to suit the unique needs and risk profiles of any organisation. NIST has created a wide range of accurate standards and recommendations that improve the NIST RMF and provide additional guidance on efficiently managing risk within this framework. The methodology outlined in the NIST RMF is intended to be a continuous and iterative process throughout the entire lifespan of an information system.

ISO is an international organization that is not affiliated with any government and is responsible for publishing standards in several technical fields. The ISO/IEC (International Organization for Standardization/International Electrotechnical Commission) 27000 series comprises a set of standards that offer optimal methods for organizations to effectively handle security risks. The ISO and IEC publish these standards, which, similar to the aforementioned frameworks, are often comprehensive and can be customized to address the specific hazards of an organisation.

Table 3. NIST RMF Steps

Steps	Description
Prepare	Fundamental operations that equip the organization to effectively handle security and privacy risks
Categorize	Based on the results of an impact analysis, classify the processed, stored, and transmitted data and the system.
Select	Choose the appropriate security and privacy measures from NIST SP 800-53, considering the level of risk to the system, its assets, individuals, and other organizations.
Implement	Execute the necessary procedures to put the controls into operation and create a detailed record of the process of deploying the controls.
Assess	Evaluate the controls to ascertain whether the protections are implemented, functioning as intended, and achieving the anticipated outcomes.
Authorize	A senior official authorizes the operation of the system on the basis of a risk assessment.
Monitor	Consistently oversee the execution of controls and assess the potential threats to the system.

Source: NIST SP 800-37r2 [70] ((IEC) 27000 Series)

Table 4. IOSC principles for financial market infrastructures

Principle	Description
Principle 2: Governance	A Financial Market Infrastructure (FMI) ought to be governed by transparent and unambiguous structures that promote the FMI's security and efficacy, preserve the wider financial system stable, deal with other important public interest concerns, and satisfy key stakeholders' goals.
Principle 17: Operational Risk	FMI must factor out the probable origins of operational risk, which can originate from within the organization or from external factors. It should then minimize the impact of these risks by implementing suitable systems, rules, procedures, and controls. Systems must be developed with the objective of achieving a significant level of security and operational dependability, while also possessing sufficient and adaptable capacity. The primary goal of business continuity management is to guarantee the FMI's responsibilities and the speedy restoration of operations in the face of a severe or extensive interruption.

Source: "Principles for financial market infrastructures," a 2011 consultative paper by the International Organization of Securities Commissions' Committee on Payment and Settlement Systems Technical Committee [61]

4.2 CPMI-IOSCO's PFMI (Principles for Financial Market Infrastructure)

Committee on Payments and Market Infrastructures (CPMI) and the International Organization of Securities Commissions (IOSCO) jointly published global risk-management and related guidelines for payment systems and other financial market infrastructures (FMI) in 2012. These guidelines are regarded as crucial in the context of the PFMI. Key principles that are highly relevant are Principle 2 on governance and Principle 17 on operational risk to the administration of operational risk, encompassing the peril linked to information security.

The table offers further details regarding these two principles. The implementation of PFMI to a CBDC would rely on details of particular implementation and whether it meets the criteria of being a payment system of significant importance as outlined by the PFMI.

5. CONCLUSIONS

The research outcomes emphasize the profound impact that digital currencies have the capacity to bring about, as best illustrated by the implementation of the e-rupee in India. With the worldwide adoption of digitalization expanding to encompass diverse sectors, the implementation of digital currency presents unparalleled prospects for promoting financial inclusion, enhancing transaction efficiency and transparency, fostering innovation, and facilitating cross-border transactions. Nevertheless, it is critical to recognize and confront the diverse array of obstacles and hazards that are intrinsic to this shift. These encompass cybersecurity vulnerabilities, financial volatility, privacy apprehensions, intricate regulatory landscapes, and barriers to accessibility, particularly in rural regions. To effectively manage and ensure the successful implementation of e-rupee, it is imperative to implement comprehensive regulatory frameworks, conduct regular monitoring, enforce stringent security measures, and ensure effective management. Furthermore, it is critical to achieve a harmonious equilibrium between promoting innovation and preserving financial stability in order to effectively utilize the complete capabilities of digital currency while minimizing potential drawbacks.

The digitization of currency systems, as demonstrated by efforts such as the e-rupee, offers numerous advantages, such as improved efficiency, less transaction expenses, and more financial inclusivity. Even so, increasing transparency brings about the inherent danger of privacy concerns. Transparency in digital transactions entails the ability to record, trace, and monitor each transaction in real-time, which helps to reduce the scams and frauds simultaneously.

The comprehensive documentation of transactions can reveal individuals' expenditure patterns, financial conduct, and economic engagements. If unauthorized entities or malevolent actors gain access to such data, they can exploit it, resulting in violations of personal privacy. Exposing transaction histories could facilitate the creation of profiles, where individuals are classified and examined according to their financial actions, potentially resulting in discriminatory practices or unjustified surveillance.

The e-rupee, being a centralized digital currency, entails the storage of data in extensive and easily accessible databases. These databases are attractive targets for cyberattacks due to their potential for generating substantial profits. Despite implementing strong security protocols, the possibility of data breaches persists, which could result in the exposure of confidential financial data to hackers.

The research sheds light on the intricate nature of the path towards establishing a digital currency ecosystem, which necessitates cooperation, ingenuity, and flexibility in order to surmount the challenges and actualize the paradigm-shifting potential of digitalization in the twenty-first century. The e-rupee holds immense potential to revolutionize the Indian economy. It can promote financial inclusion, streamline transactions, and enhance transparency. However, challenges like digital literacy and cybersecurity threats need to be addressed.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bloomberg J. Digitization, digitalization, and digital transformation: Confuse them at your peril. Forbes; 2018.
2. Bejinaru R. Impact of digitalization on education in the knowledge economy. Management Dynamics in the Knowledge Economy. 2019;7(3):367-380.
3. Lundqvist B. Standardization for the digital economy: The issue of interoperability and access under competition law. The Antitrust Bulletin. 2017;62(4):710-725.
4. Xu J, She S, Liu W. Role of digitalization in environment, social and governance, and sustainability: Review-based study for implications. Frontiers in Psychology. 2022;13:961057.
5. Armstrong M. Competition in Two-Sided Markets. Rand Journal of Economics. 2006;37(3):668–91.
6. Kochergin DA, Yangirova AI. Central bank digital currencies: Key characteristics and directions of influence on monetary and credit and payment systems. Finance: Theory and Practice. 2019;23(4):80-98.
7. Giannakoudi S. Internet banking: The digital voyage of banking and money in cyberspace. Information and Communications Technology Law. 1999; 8(3):205-243.
8. Allen S, Čapkun S, Eyal I, Fanti G, Ford BA, Grimmelmann J, Zhang F. Design choices for central bank digital currency: Policy and technical considerations (No. w27634). National Bureau of Economic Research; 2020.
9. Kubát M. Virtual currency bitcoin in the scope of money definition and store of value. Procedia Economics and Finance. ;30:409-416.
10. Judmayer A, Stifter N, Krombholz K, Weippl E. Blocks and chains: Introduction to bitcoin, cryptocurrencies, and their consensus mechanisms. Springer Nature; 2022.
11. Taskinsoy J. This Time Is Different: Bitcoin Has More Reasons to Reach the Price of $100,000; 2021.
    Available at SSRN 3914299
12. Keynes JM. The general theory of employment, interest, and money. John Maynard Keynes; 1936.
13. Hansen T, Delak K. Security considerations for a central bank digital currency; 2022.
14. Gans JS, Halaburda H. Some economics of private digital currency. Economic Analysis of the Digital Economy. 2015;257-276.
15. Skeie DR. Digital currency runs. WBS Finance Group Research Paper; 2021.
16. Shirai, S. (2019). Money and central bank digital currency.
17. Shoaib M, Ilyas M, Khiyal MSH. Official digital currency. In Eighth International Conference on Digital Information Management (ICDIM 2013). IEEE. 2013;346-352.
18. Wong P, Maniff JL. Comparing means of payment: What role for a central bank digital currency?; 2020.
19. Samudrala RS, Yerchuru SK. Central bank digital currency: Risks, challenges and design considerations for India. CSI Transactions on ICT. 2021;9(4):245-249.
20. Shkliar AI. The phenomenon of central banks' digital currencies (CBDC): Key attributes and implementation perspectives. Ukrainian Society. 2020;1(72):123-137.
21. Schlotmann O, Walter A. Private and central bank digital currencies: An uprising of new retail payment systems?; 2021.
    Available at SSRN 3919012
22. Agudelo C, Vedula RT, Collier S, Stanard A. Brake particulate matter emissions measurements for six light-duty vehicles using inertia dynamometer testing. SAE International Journal of Advances and Current Practices in Mobility. 2020;3(2020-01-1637):994-1019.
23. Hu J. Renormalization, rigidity, and universality in bifurcation theory. City University of New York; 1995.
24. Tschorsch F, Scheuermann B. Bitcoin and beyond: A technical survey on decentralized digital currencies. IEEE Communications Surveys and Tutorials. 2016;18(3):2084-2123.
25. Raskin M, Yermack D. Digital currencies, decentralized ledgers and the future of central banking. In Research handbook on central banking. Edward Elgar Publishing. 2018;474-486.
26. Ward O, Rochemont S. An addendum to “A Cashless Society-Benefits, Risks and Issues (Interim paper)” Understanding Central Bank Digital Currencies (CBDC) By Orla Ward Sabrina Rochemont; 2019.

Available:https://www.actuaries.org.uk/system/files/field/document/Understanding CBDCs Final - disc.pdf
27. Harvey D. Marx, capital, and the madness of economic reason. Oxford University Press; 2017.
28. Vikaspedia Domains. Vikaspedia.in. Available:https://vikaspedia.in/e-governance/digital-payment/all-about-erupi
29. Rise of a new era In digital payments. Available:https://static.pib.gov.in/WriteReadData/specificdocs/documents/2023/may/doc202351190501.pdf
30. Reserve Bank of India (RBI): "Central Bank Digital Currency - Retail Pilot" (press release, December 09,); 2023. Available:https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=54773
31. Moonde C. Secure mobile payment system based on Blockchain technology for higher learning institutions (Doctoral dissertation, The University of Zambia); 2023.
32. Satterthwaite D. Sustainable cities or cities that contribute to sustainable development? In The Earthscan reader in sustainable cities. Routledge. 2021;80-106.
33. Ha LT, Thanh TT. Effects of Digital Public Services on Trades in Green Goods: Does Institutional Quality Matter?. 2022;7(1): 100-168. Available:https://doi.org/10.1016/j.jik.2022.100168
34. Tushar, Manohar, Kotak. Digital rupee and its impact on the indian economy. International Journal for Multidisciplinary Research. 2023;5(1). DOI: 10.36948/ijfmr.2023.icmrs23.244.
35. Santhosh, Kumar, Raj. Normalising the digital currency as an innovation in digital banking practice. East Asian Journal of Multidisciplinary Research. 2022;1(6): 1045-1058. DOI: 10.55927/eajmr.v1i6.689
36. Sivathanu B. Adoption of digital payment systems in the era of demonetization in India: An empirical study. Journal of Science and Technology Policy Management. 2019; 10(1):143-171.
37. Philbeck T, Davis N. The fourth industrial revolution. Journal of International Affairs. 2018;72(1):17-22. Available:https://www.jstor.org/stable/10.2307/26588339
38. Prizecaru P. Challenges of the fourth industrial revolution. Knowledge Horizons. Economics. 2016;8(1):57.
39. OECD, Health Data Governance for the Digital Age: Implementing the OECD Recommendation on Health Data Governance, OECD Publishing, Paris; 2022. Available:https://doi.org/10.1787/68b60796-en.
40. OECD. Responding to Societal Challenges with Data Access, Sharing, and Control. OECD Digital Economy Papers; 2022.
41. UNCTAD: Technology and Innovation Report 2021, United Nations Conference on Trade and Development, New York; 2021.
42. Takeshima H, Joshi PK. Protected agriculture, precision agriculture, and vertical farming: Brief reviews of issues in the literature focusing on the developing region in Asia. International Food Policy Research Institute (IFPRI), Washington D.C; 2019.
43. Bronson K, Knezevic I. Big Data in food and agriculture. Big Data Soc. 2016;3:1–5. DOI: 10.1177/2053951716648174
44. Beriya A. Precision Agriculture to digital agriculture: A literature review. Center for Sustainable Development. 2020;1-13.
45. Fountas S, Espejo-García B, Kasimati A, Mylonas N, Darra N. The future of digital agriculture: Technologies and opportunities. 2020;22:24–28. DOI: 10.1109/MITP.2019.2963412
46. Zambon I, Cecchini M, Egidi G, Saporito MG, Colantoni A. Revolution 4.0: Industry vs. Agriculture in a Future Development for SMEs. 2019;36. DOI: 10.3390/pr7010036
47. Papademos L, Modigliani F. The supply of money and the control of nominal income. Handbook of Monetary Economics. 1990;1:399-494b.
48. Hangen TJ. We know What's in your wallet: Data privacy risks of a central bank digital currency. Fed. Comm. LJ. 2022;75:81.
49. De Mingo AC, Cerrillo-i-Martínez A. Improving records management to promote transparency and prevent corruption. International Journal of Information Management. 2018;38(1):256-261.
50. Li X, Zhou P. Research on risk management of digital currency based on blockchain technology in mobile

commerce. In Design, Operation and Evaluation of Mobile Communications: Second International Conference, MOBILE 2021, Held as Part of the 23rd HCI International Conference, HCII 2021, Virtual Event, July 24–29, 2021, Proceedings 23 . Springer International Publishing. 2021;45-67.

51. India saw 129 cybercrimes per lakh population in 2023. The Times of India; 2024.
Available:https://timesofindia.indiatimes.com/india/india-saw-129-cybercrimes-per-lakh-population-in-2023/articleshow/106524847.cms
52. George Zhu. Unpacking Central Bank Digital Currency (CBDC) Implementation Challenges and Risks. 2023;207-231.
DOI: 10.4018/978-1-6684-6381-9.ch010
53. Joseph SF, Peter Leo Deepak J. A Study on CBDCS and e-rupee with Special Reference to e-Yuan. In International Conference on Economics, Business and Sustainability (pp. 239-247). Singapore: Springer Nature Singapore; 2023.
54. Mulamoottil RDA. E-rupee to Reinvent India. DC Books; 2015.
55. Dumbre T, Shaji R, Sanadhya S, Kumar CV, Vijayakumari L. Blockchain-Powered KYC in a CBDC World: The E-rupee Experience. In 2024 IEEE International Conference for Women in Innovation, Technology and Entrepreneurship (ICWITE). IEEE. 2024;389-396.
56. Khanna K, Ruhlan S, Yadav D, Paul DL. Exploring digital currency adoption in India: Insight from e-rupee using technology acceptance model perspective. In Issues of Sustainability in AI and New-Age Thematic Investing. IGI Global. 2024;87-103.
57. Banque de France report on Central Bank Digital Currency.
Available:https://www.banque-france.fr/en/communique-de-presse/banquede-france-publishes-report-its-experiments-wholesale-centralbank-digital-currency-cbdc
58. BIS, Swiss National Bank, SNB: Project Helvetia, Wholesale CBDC experiment.
Available:https://www.bis.org/publ/othp35.htm
59. Central Bank Digital Currency in India: The Case for a Digital Rupee (Peterson K. Ozili July 2023); 2023.
DOI: 10.4018/978-1-6684-8624-5.ch001
60. Chaum, David (1982). Blind signatures for untraceable payments. Department of Computer Science, University of California, Santa Barbara, CA. Archived from the original (PDF) on 3; 2011. Retrieved 25 April 2024.
61. Committee on Payment and Settlement Systems Technical Committee of the International Organization of Securities Commissions Principles for financial market infrastructures Consultative report; 2011.
Available:https://www.iosco.org/library/pubdocs/pdf/IOSCOPD350.pdf
62. Are Central Bank Digital Currencies (CBDCs) the money of tomorrow? | Deloitte Luxembourg. (2024, January 15). Deloitte.
https://www.deloitte.com/lu/en/Industries/banking-capital-markets/research/central-bank-digital-currencies-money-tomorrow.html
63. Digital Rupee - the dawn of a revolution in digital payments; 2023.
Available:https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/topics/consulting/2023/ey-digital-rupee-the-dawn-of-a-revolution-in-digital-payments.pdf?download#:~:text=Digital%20payments%20helped%20unlock%20US
64. Dumbre T, Shaji R, Sanadhya S, Kumar CV, Vijayakumari L. Blockchain-Powered KYC in a CBDC World: The E-rupee Experience. In 2024 IEEE International Conference for Women in Innovation, Technology and Entrepreneurship (ICWITE). IEEE. 2024;389-396.
65. e₹—The digital currency in India: Challenges and prospects (Md Asraful Haque Mohd Shoaib-May 2023)
DOI: 10.1016/j.tbench.2023.100107
66. *e*-RUPI Contactless Digital Payment Platform | NPCI. Www.npci.org.in.
Available:https://www.npci.org.in/what-we-do/e-rupi/product-overview
67. Rbi.org.in; 2024.
Available:https://m.rbi.org.in/Scripts/AnnualReportPublications.aspx?Id=1377
68. Kumar A. Central bank digital currency and its impact on the Indian financial system. Asian Journal of Management. 2021;12(4):420-422.
69. Narayanan H, Sponchioni M, Morbidelli M. Integration and digitalization in the manufacturing of therapeutic proteins.

Chemical Engineering Science. 2022;248: 117159.
70. NIST. Risk management framework for information systems and organizations: Risk Management Framework for Information Systems and Organizations. 2018;2(Revision 2). Available:https://doi.org/10.6028/nist.sp.800-37r2
71. Pallavi M, Kandalkar P. Techno smart digitalization of currency: E-rupee, the Indian prospective. International Journal for Multidisciplinary Research. 2023;5(1). DOI: 10.36948/ijfmr.2023.icmrs23.152
72. People Bank of China: Progress of Research and Development of E-CNY in China. Available:http://www.pbc.gov.cn/en/3688110/3688172/4157443/4293696/2021071614584691871.pdf
73. Pitta, Julie. Requiem for a Bright Idea. Forbes; 1999.
74. Reserve Bank of India - Press Releases. Www.rbi.org.in. Retrieved April 29, 2024, from Available:https://www.rbi.org.in/Scripts/BS_PressReleaseDisplay.aspx?prid=54773#:~:text=The%20Reserve%20Bank%20announces%20the
75. Sommer L. Industrial Revolution-Industry 4.0: Are German Manufacturing SMEs the first victims of this revolution? Journal of Industrial Engineering and Management. 2015;8(5):1512-1532.
76. Today B. RBI, commercial banks spend Rs 21,000 crore on currency management; 2017. Available:https://www.businesstoday.in/current/economy-politics/rbi-banks-spend-currency-management-cash/story/251299.html

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/119623