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CENTRAL BANK DIGITAL CURRENCY ENGAGEMENT RESEARCH BASED ON PROJECT INDEX AND USE OF DISTRIBUTED LEDGER TECHNOLOGY TO ENABLE DIGITAL CURRENCY

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ABSTRACT

The current payment system is rapid but has limits in terms of internet consumption, visibility, and usability. It is based on physical cash and online transactions. Central bank digital currencies strive to tackle the difficulties that afflict the current economic system by providing total transparency of the money supply. As opposed to completely decentralized cryptocurrencies, central bank-issued digital currencies are the most centralized. However, centralization will be advantageous in terms of money programmability, improved transparency, and financial crime monitoring. Before digital currencies can be widely used, a strong security framework, data protection, and effective governance will be required. Major central banks around the world are exploring technologies and methodologies to deploy their own version of digital currency that can coexist with the current physical cash and in near future replace the traditional form of value transfer. It can be promising for enhancing the economic outreach of a country and releasing a broad range of possibilities when it comes to financial inclusion and ease of transactions. CBDCs will not only help in easing payments but will help in government fund disbursements directly to eligible individuals without the interference of an intermediary bank, frictionless and faster value transfer, and exploring new financial mechanisms. These systems to support the CBDC architecture will require a robust security system that can be used for secure payments but the system design should also be simple and flexible enough to accommodate future design changes.

Keywords: *Central Bank Digital Currency, Project Index, Distributed Ledger Technology, Zero Trust, Digital Currency.*

1. INTRODUCTION

When it comes to the future of economies and how they will be governed with respect to the value provided, Central Bank Digital Currencies [CBDC] will be playing a major role in modernizing the process of value transfer. Human civilization has come a long way from exchanging goods via barter systems to digital payments in the 21st century. The mode of payments has expanded many folds, now we have multiple modes of value transfer mechanism but there's still room for improvement [1]. We need a faster and more efficient payment system that can not only satisfy users' demand for value transfer but also act as a tool for governments to distribute aid.

The usage of a project index and distributed ledger technology (DLT) to allow digital currency is explored in this research study along with the involvement of central bank digital currencies (CBDCs). This research project examines the creation and uptake of CBDCs with the intention of educating scholars, central banks, and policymakers. Readers may anticipate knowing the current level of CBDC involvement and the prospective role of DLT in allowing digital currency after reading this article. The results of this study can be used for future research in this

area as well as the creation and utilization of CBDCs.

This study adds a number of new insights to the field of CBDCs. First off, using a project index offers a thorough framework for assessing and contrasting various CBDC programs. Second, integrating DLT to enable digital money is a unique strategy that hasn't been fully examined in the literature to date. These contributions enrich the corpus of current research and offer fresh perspectives on the creation and uptake of CBDCs.

The study is based on the project index and the utilization of DLT. This approach differs from past research, which has mostly focused on CBDC design and execution. To assure the research's quality and dependability, a clear and complete description of the solution interpretation criteria is given.

1.1 Need For a CBDC

The need for a digital currency is increasing globally. With an increase in digital payments and the need for faster transactions is a prerequisite of a modern economy. While most of the CBDC projects have not reached the launch stage yet, 86% of the major central banks are working towards researching their own currency, nearly 60% are testing the type of technologies that can be deployed and 14% of central banks are in the stage of a pilot project launch. The need for a Central Bank Digital Currency is for the following reason:

- Physical currency is no longer a safer medium of money circulation. Banks are facing increased issues with regard to counterfeiting.
- Banks want to popularize digital payments as a widely accepted mode of value transfer.
- Digital currencies will make the issuance of currencies easy, as opposed to physical cash deployments using intermediate banks.
- Central banks and governments combined want users to avoid the use of private cryptocurrencies that pose an economic threat to the users. CBDC aims to reduce the damaging effect of private currencies and offer digital currencies that can be controlled and reliable.
- Reduce financial risks for senders and receivers along with offering accountable institutions for digital cash.

Concerns about financial security compelled major central banks to investigate what the latest technologies, such as Blockchain, Distributed Ledger, and Decentralized Finance (Defi), had to offer. However, a significant increase in CBDC usage and the discovery of a solution for a central bank-based digital currency happened in June 2019. The release of the Meta-supported money (Diem) created a sense of urgency among central banks worldwide. The news came as a reminder that the present system still has huge payment gaps, and that customers want more easy payment choices. The national currency's continued use as the primary medium of exchange cannot be expected. At the same time, bitcoin adoption is expanding, diminishing monetary policy's power and reach.

Let’s understand what made CBDC emerge in the first place. CBDCs are based on the concept of blockchain and ledger systems [2]. Cryptocurrencies are based on a similar concept, in 2008 when Bitcoin emerged the concept behind this was blockchain. Blockchain is a system in which a record of transactions is kept across numerous computers linked in a peer-to-peer network. This is the fastest and most secure method of value transfer [3].

Rising innovations in payments and technology have enhanced interest in CBDCs. The major shift and quick adoption happened after digital currencies as a medium of exchange started growing. The idea of central banks releasing digital money for widespread circulation is a logical evolution from the printing of fiat money. Furthermore, for several decades, banks have had access to digital representations of central bank money via the wholesale payment system. Though the payments for individual users via CBDCs are substantially new and are being tested with a smaller audience before releasing it on a larger scale.

While we are witnessing a major cash usage decline with an increase in online and UPI payments provided by partner banks. CBDCs will play a vital role in increasing the monitoring and involvement of the central bank. This will further streamline the central bank's function of releasing money, stabilizing financial conditions, and tracking the flow of money in a purely digitalized economy.

The goal for faster payments accelerated digitization, and enhanced risk mitigation for payment clearance and account settlement drives global demand for CBDCs. Furthermore, there is a demand for more efficient domestic and cross-border value transfers, as well as financial inclusion for individuals and organizations at large. These advantages have compelled world economies to begin research into the release of digital fiat money [4].

In the past few years, central banks have started their pilot projects to better understand the use of Distributed Ledger Technology (DLT) for government-issued digital currencies [5]. Since 2016, central banks have been issuing currencies for wholesale purposes, which entail the settlement of high-value interbank transfers and cross-border payments utilizing wholesale CBDCs [6].

The chart attached here shows us the engagement rate of global economies regarding research, launching pilot projects, adopting CBDCs as a legal tender, and releasing them to the wider public [7]. Although global economies were quite skeptical about digital currencies at first due to their decentralized nature things changed after the widespread mass adoption of these currencies globally.

The April 2021 chart shows that there were only 1% of CBDC projects launched globally but by May 2022 this number improved to 14%. The number of countries that moved towards CBDC development also enhanced from just 74 countries in April 2021 to 109 countries in May 2022.

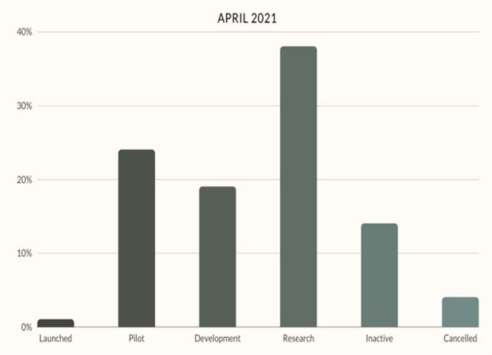

Fig 1. Engagements in CBDC April 2021

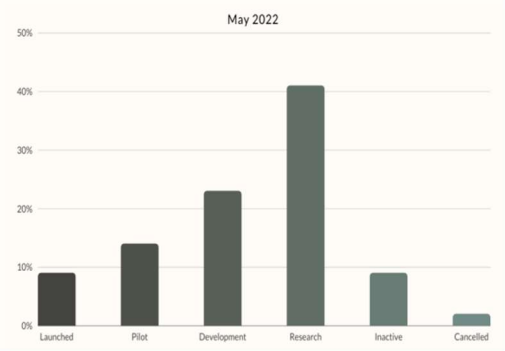

Fig 2. Engagements in CBDC May 2022

Key takeaways from the engagement:

- It is attractive in terms of an advanced form of currency.
- A great value proposition for the under-served people.
- Increased financial inclusion and easy aid disbursement to the individuals who are eligible for government aid.
- A wide array of technological choices for the development and release of CBDC:
  - Underlying technology of CBDC
  - Privacy, security, and identity protection options
  - Interoperability options for seamless working across a wide spectrum of devices

- Digital currency regulatory choices:
  - Understanding policy and regulatory gaps
  - Policies for consumer protection
  - Understanding the role of public sector and work in conjunction of private sector technologies.

2. CBDC PROJECTS DRIVER AS PER DATA

The adoption of CBDCs is mapped using a machine learning data-driven system. Many economic and technological factors are used to predict the advancements in CBDC usage. To understand the advancements we will consider Project Index (PI) as a fixed variable and other factors like governments' progress in economy and technology as independent variables [8].

2.1 Project Index (PI)

The Central Bank Digital Currency Project Index was developed by Auer et al. to

measure its progress. This index identifies the nation's progress with regard to the research, development, and deployments when it comes to launching digital currencies. This a dynamic index and whenever a country decides to start research on digital currencies or makes some progress this index changes. The index value ranges from 0 to 3:

0 - No CBDC projects

1 - In the research phase

2 - Pilot runs and testing completed

3 - CBDC project is live

2.2 Research Methodology

Our main objective is to gain a better understanding of the CBDCs' growth primary motivators and factors influencing a nation's propensity to pursue this endeavor. CBDC project index is our objective variable and the influencing factors depend on the economic and technical progress of the nation.

2.3 Countries With PI Score (May 2022)

To extract the most crucial variables we decide to use the random forest. This being the main model learns intricate non-linear functions. To generate a comparison for our primary model we will deploy a multilayer perceptron (MLP).

The Project Index of CBDC is used to measure the country's approach toward digital currencies. It maps their stance, deployment status, and general public interest towards both types of CBDCs; Retail CBDC and Wholesale CBDC.
Traction in CBDC projects globally:

- 60+ central banks globally are working towards developing CBDCs since 2014.
- These projects are proving to be successful since most of these CBDC projects are in their testing phase and are about to go live.
- Economic institutions are getting involved in the digital currency ecosystem. CBDCs are gaining popularity among public stakeholders like the IMF, World Bank, WEF, Bank of International Settlements, etc.

Table 1. Countries and their PI scores

Country	PI Score	Wholesale	Retail
India	2	1	1
Switzerland	3	2	1
France	3	2	1
Bahamas	3	3	0
Japan	3	2	1
Canada	3	2	1

Central banks are considering two main CBDC designs:

1. **Retail CBDC:** In retail applications of digital currencies, it will be privately held by the corporates and people just like digital cash.
2. **Wholesale CBDC:** This is applicable for interbank and wholesale application purposes. This is applicable just for interbank transactions (national and international) and financial settlements among banks and nations.

Retail CBDCs are gaining more popularity among developed and developing economies due to their benefits of financial inclusions. Countries with highly developed capital markets and banking systems are focusing on the wholesale CBDC approach to ease and fasten interbank transactions.

2.4 Research outcome

The methodology mentioned above generates datasets with the help of trained models. Out of 145 countries, there are only 6 with a project index of more than 3. As per the feature extracted by random forest using May 2022 data, the financial development index is the most valued variable followed by GDP per capita and effectiveness of the government respectively.

The below chart illustrates the top 10 countries with their CBDC index.

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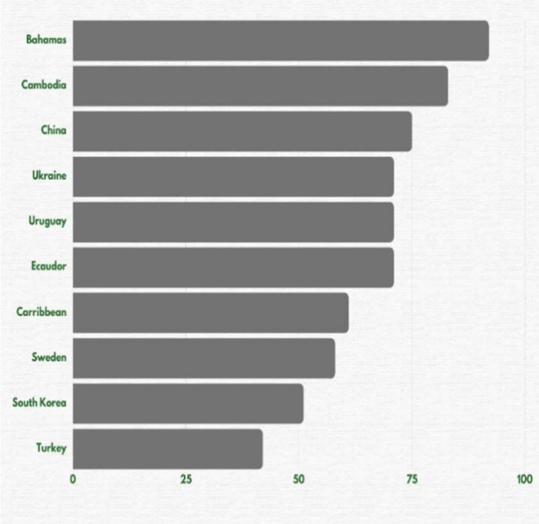

Fig 3. Top 10 Retail CBDC Projects

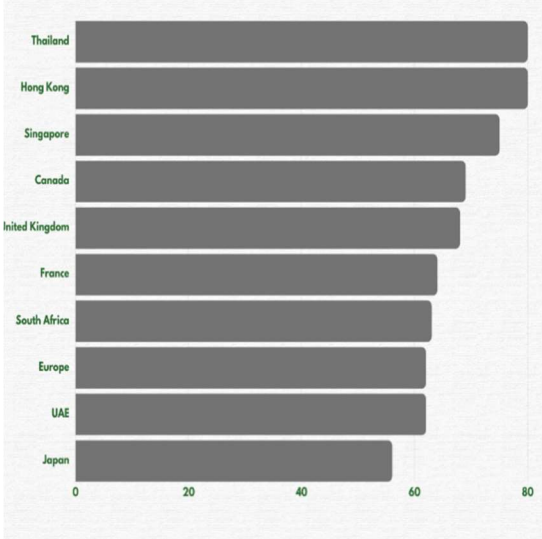

Fig 4. Top 10 Wholesale CBDC Projects

Key insights from the top 10 retail CBDC projects chart:

- Emerging economies where there's a higher demand for financial inclusions and there's increased digitalization have more retail CBDC projects and initiatives in for the digital currencies.
- Project Bakong from Cambodia and project Sand Dollar from the Bahamas are the two projects currently live.
- With more than 2 Billion Yuan currently in transactions, Mainland China's digital Yuan project has currently reached an advanced stage of the trial. It is mature enough for widespread usage by the common masses.

The research conducted using machine learning methodologies confirmed that countries with higher financial development index work developing more advanced CBDC projects. CBDC project index can be used as a fixed variable to get the status of countries' CBDC development at any time.

Key insights from the top 10 wholesale CBDC projects chart:

- Currently, there are no active wholesale CBDC projects but most of them are in the advanced testing stages (Pilot runs). Advanced wholesale CBDCs projects for interbank purposes have comparatively shorter research timelines when compared to retail CBDCs but their pilot runs and testing are longer.
- The major project driver for wholesale CBDC projects is the cross-border financial settlements. Most advanced economies are looking for reliable solutions for interoperability and cross-border connectivity.
- Whole CBDCs by central banks are being tested for interconnectivity between similar wholesale projects and retail CBDCs as well.

The study provides a thorough framework for interpreting the solutions suggested by CBDC initiatives in this context. The solution interpretation criteria, which are used to assess the possible advantages and disadvantages of CBDCs, are one of the framework's essential components. Accessibility, cost-effectiveness, safety, dependability, scalability, and creativity are among the characteristics listed in the article. Policymakers and practitioners can evaluate CBDC initiatives using these criteria as a useful foundation for their deliberations.

The study examines the framework's relationship to earlier works on CBDCs. The authors point out that their standards are consistent with those suggested in earlier research, such as the BIS's 2018 study on CBDCs. They do note certain distinctions, though, such as their emphasis on the value of innovation and their examination of the possible influence of CBDCs on monetary policy.

The research contributes significantly to the continuing debate over the advantages of CBDCs. In order to help policymakers and practitioners assess the potential of CBDCs, the paper gives a thorough methodology for assessing CBDC projects and contrasts it with prior research.

3. PROPOSED SYSTEM DESIGN

3.1 No Network Payments

Offline CBDCs will enable payment settlements without the internet using SMS-based services, Near Field Communication (NFC) technology, or similar technology that can be used to complete payments.

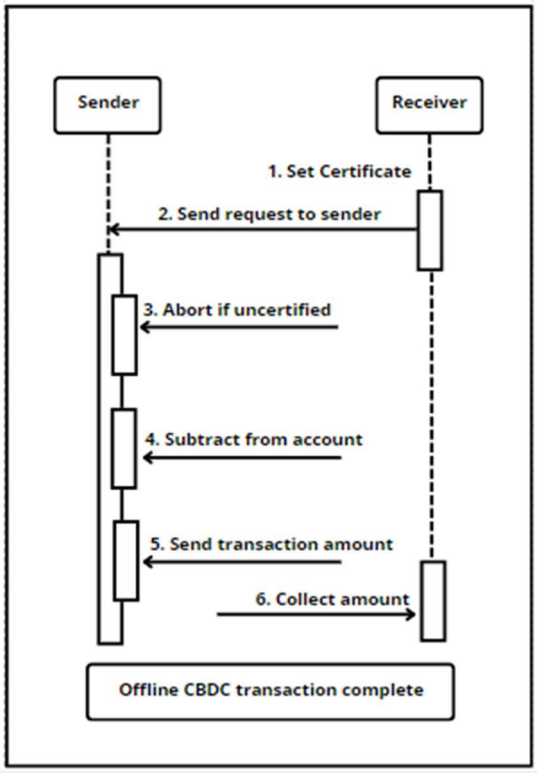

Fig 5. CBDC offline payments diagram depicting transaction protocol between sender and receiver

Offline CBDCs will enable payment completion using these mediums:

- Message (SMS)
- Bluetooth
- NFC Contactless
- QR Codes

Offline payment transfer is achieved by sharing 10-digit unique codes with the sender and receiver. This is shared over the phone or via a different medium of communication.

3.2 System Design

Most CBDCs work on Distributed Ledger Technology (DLT) which is a modern and more sophisticated method of storing transaction data in a decentralized environment, unlike centrally administered databases. Distributed ledger technology is a digital mechanism for recording asset transactions that store the transactions and their associated information in multiple locations simultaneously. Unlike traditional databases, distributed ledgers lack a centralized data repository and administrative capabilities [9] [10].

Adopting features like blockchain and DLT, on the other hand, comes with challenges and trade-offs that must be carefully considered. Centralized ledgers are the most often used data-storing solution in finance and can be stored on several physical nodes. Still, control is held by a trusted administrator who has access to these databases.

Decentralized Finance (Defi) and Web 3.0 is bringing in some of the most advanced developments in the financial sector [11]. By reducing the need for intermediaries and promoting inclusivity, Defi has the potential to provide economic and social benefits, perhaps destabilizing the financial industry. Similarly, Web 3.0 allows users to complete financial transactions with ease among users using smart contracts allowing transactions to be completed without intermediaries or a 3rd party service provider involved [12]. Now central banks across the globe working towards CBDC adoption has two choices in terms of issuing currency - the first token-based approach and the second account-based approach.

The transfer of cash in a token-based method is predicated on the transfer of an item of value from one wallet to another. Whereas in the account-based method, there's a value transfer

from one account to another [13]. The token-based approach contributes toward financial inclusion goals both users just require an internet connection to complete the transaction. Additionally, the token-based system provides customers with a high level of anonymity [14]. On the other hand, an account-based approach allows authorities to monitor transactions closely and participate in the entire payment process. Most central banks and regulators are considering the token-based approach to deploy CBDCs [15].

3.3 Zero trust for CBDC's

Existing security models is inefficient in safeguarding the financial assets of individuals and organizations. These legacy infrastructures are prone to breaches and data theft resulting in losses when it comes to financial technologies. Research shows that humans are the weakest link in any security framework. They fall prey to the socially engineered data breach system created by hackers.

To mitigate the biggest risk, Zero Trust Architecture (ZTA) works towards the lowest resource accessibility. ZTA considers every user as a malicious hacker and asks for access credentials at every step. ZTA in CBDCs will be a multi-layered security framework working on an identity-centric model. It will continuously monitor users accessing the data and verify risk factors in real-time covering all aspects of digital security.

3.4 Why Zero Trust Architecture?

- ZTA Always assumes that the system is under attack and that a hostile attacker is using it until the system confirms the user's identity and determines whether the user has the necessary permissions to get access.
- ZTA reduces the time it takes the system to discover and detect data breaches. This may be accomplished by gaining detailed visibility into CBDC network users, devices, and network traffic and finding irregularities.

3.5 Securing CBDC and Digital Currencies

CBDC architecture should satisfy six digital currency security requirements to safeguard user cash and bank transactions.

3.5.1 Currency cannot be forged

Just like our physical currency that contains holograms to identify its reliability and if it is real or not. Similarly, digital currency should have a mechanism in place to differentiate real from forged ones. A continuous audit trail is a method of keeping a check on the counterfeiting of e-cash.

Countries with fewer administrative resources are looking forward to CBDC as a solution to cash forgeability issues. Encryption keys attached to each CBDC token can be a solution to avoid fake serial numbers causing counterfeiting problems.

3.5.2 Avoid double spending

In the case of digital currencies and e-cash, double spending is defined as a phenomenon through which the same cryptocurrency can be spent twice for two different transactions. This is a major potential flaw when it comes to propagating digital currencies. When it comes to digital currencies users (Buyers and sellers) can be given a common identification number that can be used to settle transactions and eliminate the possibility of double spending.

3.5.3 Transaction verifiability

The transactions need to be verified to avoid falsified information about completing transactions. Verifiability is important to detect malicious activities in identifying the transactions and avoid bad actors from evading the security protocols. Just like cryptocurrency information is stored on a block in a blockchain system, CBDC's transaction information is stored on a decentralized ledger.

4. CBDC USE CASES

4.1 P2P rapid transactions

Similar to online payment services provided by fintech service providers, CBDCs will facilitate instant peer-to-peer payments much faster than the current conventional method.

4.2 Money programmability

CBDCs have the ability to be programmed and use for the specific purpose for which they have been issued. This feature enables easy value transfer by the government for public welfare, scholarships, and schemes. This will improve direct benefit transfer and subsidy

deployment. This feature of digital currency is used as a 'fit-for-purpose' type of payment. This makes the government disbursal of payments for the social welfare schemes and the targeted value transfer for specific entities.

For example, programmable money can be used for the direct transfer of subsidies for various schemes such as; Farmer subsidies as the direct benefit transfer to eligible individuals. These subsidies can be easily availed at the authorized farm product distribution center and agencies or farmer banks. The payments will be declined for other areas if failed to verify the authenticity of the individual. Government agencies will be allowed to convert physical cash and general CBDCs into a token-based digital currency. These conversions will happen at any banking institution that will have complete authorization to convert currencies.

These tokens can be used for other public sector value distribution as well. Like, LPG subsidies that can be collected at the authorized LPG distribution centers and agencies. This will ensure maximum error-free value transfer and minimal leakage.

When it comes to the private sector and handling employees as a whole, programmable money can be deployed to cover extra charges such as fuel, mobile recharges, bills, etc. This will also ease the industrial supply chain woes of manufacturers by providing dedicated tokens for fuels, charges, and taxes.

RBI, banking institutions, industrial merchants and manufacturers, software and hardware services providers, data center service providers, and the general public will play a major role in making the programmability seamless.

4.3 Cross-Border settlements

Commercial payments involving huge transactions or individual payments can be done easily in the case of cross-border payments with CBDCs. It will also facilitate securities settlement and foreign exchange in multiple currencies. Both token-based and account-based CBDCs will be useful in the faster remittance of cross-border payments.

International banks, organizations, and economies collaborating will use CBDCs for easy conversions and build the necessary infrastructure for CBDC transfer and conversions. The collaboration between multiple world economies will lead to a faster CBDC remittance system that will allow faster value transfer in real-time while rapidly reducing the time taken by the system to transfer money.

4.4 Loan Disbursements and Tracking

Banks will be able to disburse loans and instantly lend the required amount to MSMEs (Medium Small and Micro Enterprises). As more organizations consider taking loans as a CBDC token it will be easier for RBI and banking organizations to track the risk profile of the borrower. This will work both ways by allowing MSMEs to borrow money as per requirements and allowing banks by avoiding the money from becoming NPAs (Non-Performing Assets).

The stimulus granted by the central banks to MSMEs will be directly transferred to the eligible enterprise bank accounts. These instant stimulus transfers will help in business sustainability in hard times when cash flow is limited. This will help in increasing transparency, easy value transfer, and avoiding forgeability.

4.5 Facilitating Rapid Transactions

India stands first when it comes to digital transactions (UPI) in the world. Replacing third-party applications with CBDCs will facilitate faster and more rapid retail transactions. Since RBI will be the central authority for value transfer, it will also allow offline payments in areas with low internet outreach.

Retail CBDCs as distributed by the central bank will enable the following type of payments:

- Consumer to consumer payments: Consumers will be able to exchange CBDCs among themselves.
- Consumers to business transactions: The consumer will be able to transfer CBDCs in exchange for goods and services provided by the business.
- Business-to-business settlements: Businesses can use CBDCs as a monetary tool for payments in their corporate

accounts.

CBDCs offer real-time instant settlements of funds with low or no waiting time. This will reduce the counterparty risks with faster payment clearance.

5. RISKS INVOLVED IN IMPLEMENTING CBDC PAYMENT SYSTEM

While CBDCs are offering the most advanced payment solution, some threats need to be considered before completely releasing the digital currency to a wider audience.

Let's understand some potential threats to the CBDC adoption:

5.1 Impact on the working structure of commercial banks

CBDCs can be issued and controlled by the central banks thus eliminating the role of commercial banks and the dependency of the public on them. CBDC will be issued to the individuals via central banks based on the cash deposits and securities provided to the bank.

Thus the role of the bank needs to be predefined by the central banks. Their role in the management of CBDCs and if the issuance is allowed then the distribution should also be included. Banks take away a chunk of the load from central banks by being intermediaries. If central banks take over distribution and management there will be a disintermediation of central banks.

Interests and large-scale currency management by intermediary banks help in stabilizing the financial system by taking up large financial loads.

5.2 Low Financial Inclusivity

India being a developing economy still have more than 550 million people still using feature mobile phones. While deploying CBDCs central banks should also consider those individuals still using feature phones and coming from a socio-economically backward background.

There can be a range of options through which a large population will be excluded from the CBDC adoption. Lack of knowledge, use of cash in tier-2 and tier-3 cities, and unawareness about the use and deployment of CBDCs will result in financial exclusions.

These problems need to be addressed to make CBDC a truly modern economic tool for wider economic inclusions. This can be solved by fostering innovations like offline payments.

5.3 Privacy Issues for Transactions Stored on Ledger

CBDC transactions will be secured and will offer rigorous security by storing the financial information on a distributed ledger. This will help in combating money laundering and financial terrorism activities. This will come at the cost of the privacy of users transacting on the ledger.

It will be the responsibility of the central bank to balance the confidentiality of users while being able to combat AML and CFT issues. The financial activities of the citizens are confidential matters and need to be protected.

6. CONCLUSIONS

The study sheds fresh light on CBDC involvement through the use of project index and DLT to allow us of digital money controlled by central banks. The study makes the case, supported by facts and statistics, that the use of these technologies can facilitate the creation and implementation of CBDCs.

This research asserts that the usage of a project index and DLT can facilitate the creation and uptake of CBDCs. In the future, if additional research on the issue becomes accessible, this assertion can be contested. To give a more balanced view, the paper discusses potential limitations in addition to the facts and evidence it uses to support its claims.

CBDCs will be impacting global economies at a substantial rate in the coming 5 years. Many countries are at the end of their trial while others have started their research in exploring ways to implement CBDC adoption. Token-based CBDCs will be the closest

replacement to cash in the form of retail CBDCs and the future of value transfer. While wholesale CBDCs will fill the gap of huge financial transactions among organizations, cross-border settlements, and inter-bank payments. The impact of this new asset class on the balance sheets of banks, customer value propositions, and the long-term sustainable benefits it brings in terms of rapid transactions while reducing settlement risks is overwhelming.

Global central banks are now more interested in CBDC projects due to their value proposition in providing a secure mechanism to fulfill public policy objectives, offering a safe and secure digital mode of payment for the general public, and maintaining economic stability.

Countries across the globe are testing multiple iterations, and technological architecture, and researching the use of CBDCs in their environment. While most CBDCs are in the development stage, many central banks have completed their testing and are rushing toward pilot testing and deployments. India is planning to launch their version of digital currency as early as 2024 and the RBI is still evaluating and researching the way how CBDCs can be used for wider public benefit.

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