Blockchain in banking: a study on central bank digital currency

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Abstract The banking sector has been greatly impacted by the technological outburst of the twenty-first century. Bitcoin, the first crypto asset created on block chain technology, has firmly established itself in the financial sector since its introduction in 2009. The market capitalization of uncontrolled crypto assets has grown at an unprecedented rate, posing a threat to the banking industry and the economy. Illegal activities such as terrorist funding and money laundering find refuge in the unregulated world of crypto assets. To keep up with the demands of the computer-savvy Generation Next, banks worldwide have adopted various technologies and improved their service standards. However, central banks continue to follow the traditional system of issuing hard currency bank notes, which do not match the aspirations of most end users. As a result, Central Banks worldwide are currently brainstorming the introduction of a Central Bank Digital Currency (CBDC). This study aims to explore the theoretical aspect, feasibility, and status of CBDC. Four Central Banks have already issued CBDC, while others are in the process of doing so. Block chain under Distributed Ledger Technology is the most suitable and widely accepted platform for issuing CBDC. Robust computer security measures must be established to prevent hacking and ensure monetary stability for CBDC. During the initial stages of CBDC implementation, hard currency banknotes and CBDC will run parallelly until any possible initial hiccups are resolved. CBDC has the potential to boost banking and finance, trade finance, and cross-border international settlements.

Keywords: block chain, DLG, CBDC, crypto asset, crypto currency

1. Introduction

Technological innovations have been a recurring aspect of human evolution. The global barriers have been dismantled by the Internet and have opened up a plethora of knowledge and information to users. Smartphones have revolutionized the way people communicate. The latest technologies, such as Augmented Reality, Virtual Reality, Internet of Things (IoT), Artificial Intelligence, Machine Learning, Robotic Process Automation, Smart Workplace, Edge Computing, 5G, and Blockchain technology have changed the pace of the global industry, finance, education, trade, and business. In 2009, Satoshi Nakamoto introduced Blockchain technology. Bitcoin, the first crypto asset, was developed using Block chain technology. Data or information is preserved in each block of the chain, which is interconnected with a hash, making the data safe. Of the nearly 10,000 crypto assets in circulation, the most widely circulated assets are Bitcoin, Ethereum, Tether, USD Coin, and Binance Coin.

The twenty-first century has witnessed a great leap in global economic activities. Start-ups and venture capital companies are being developed in the business and financial sector by new-generation entrepreneurs. However, the banking sector has been passing through various setbacks due to the all-round decline in economic activities resulting from the Covid-19 pandemic and an increase in non-performing assets. Though the pandemic has turned global economic activity upside down, people have started to use more technologies like Internet banking, Mobile banking, National Electronic Fund Transfer (NEFT), Real-Time Gross Settlement (RTGS), Immediate Payment Service (IMPS), Unified Payments Interface (UPI), National Electronic Toll Collection (NETC: Fastag), Bharath Bill Payment System (BBPS), WhatsApp banking, online and virtual assistance chatbot, and various other digital Apps in their day-to-day financial activities. Digital banking has helped customers transfer funds, make investments, pay bills, and conduct shopping from their comfort zones. As per the Digital Payment Index (DPI) published by Reserve Bank of India (RBI), the Indian digital payments index has shown a remarkable increase from an index of 100 in the base year 2018 to an index of 347.30 in 2022 (Table 1). However, a study conducted by RBI during December 2018 and January 2019 in six Indian cities to find out the most preferred mode of receipts (Table 2) and payments (Table 3) revealed that the mode of cash ranks higher in demand, with 54% for payments and 50% for receipts compared to other modes of transactions like digital and cheques (RBI 2022). The year 2021-22 witnessed an increase in the circulation of bank notes by RBI due to high demand from the public as they hold more currency notes to withstand any possible outbreak of another variant of covid pandemic (RBI 2022).
The financial sector landscape has been changed by Fintech firms directly or indirectly. The growth of non-bank Fintech firms worldwide is another recent development in the financial sector. Various banking services are being provided by these firms, either fully or partially skipping some of the statutory checks, such as Know Your Customer (KYC) or Anti Money Laundering & Combating Financing of Terrorism (AML& CFT) rules, or crucial Asset Liability Management (ALM) criteria. Additionally, financial assistance is being granted to sub-prime business ventures for short-term gains, which may compromise the monetary and economic stability of the nation.

The financial sector has witnessed the growth and acceptance of crypto assets based on blockchain technology, which has led to the mushrooming and development of such assets among investors. The number of crypto asset firms increased from 66 in 2013 to more than 10,000 in 2022. During the same period, the market capitalisation of these assets surged from USD 9.17 billion to USD 2099.56 billion (Table 4). However, it is noteworthy that the top twenty crypto assets hold around 90% of the total market share, and the remaining assets remain inactive.

### Table 1 RBI Digital payment index.

<table>
<thead>
<tr>
<th>Period</th>
<th>RBI – DPI Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 2018 (Base)</td>
<td>100.00</td>
</tr>
<tr>
<td>March 2019</td>
<td>153.47</td>
</tr>
<tr>
<td>September 2019</td>
<td>173.49</td>
</tr>
<tr>
<td>March 2020</td>
<td>207.84</td>
</tr>
<tr>
<td>September 2020</td>
<td>217.74</td>
</tr>
<tr>
<td>March 2021</td>
<td>270.59</td>
</tr>
<tr>
<td>September 2021</td>
<td>304.06</td>
</tr>
<tr>
<td>March 2022</td>
<td>347.30</td>
</tr>
</tbody>
</table>

Source: RBI Concept note on CBDC, October 2022.

### Table 2 Preferred mode of payment.

Source: RBI Concept note on CBDC, October 2022.

### Table 3 Preferred mode to receive money for regular expenses.

Source: RBI Concept note on CBDC, October 2022.
Crypto assets are highly speculative and volatile as they are created privately. Central Banks are concerned that these crypto assets may undermine their official risk-free currencies, thereby reducing their ability to control inflation and execute monetary policies effectively. These developments may also have a negative impact on the retail banking business. Consequently, the traditional banking system must upgrade to match the technology that meets the demands of the new generation of end-users and establish a seamless and robust global economic system. In this article, digital money issued by Central Banks is only referred to as cryptocurrencies. Bitcoin, Ethereum and similar other cryptos are called crypto assets as private firms issue them and not by any monetary and regulatory authorities authorized to issue currencies.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Crypto assets</th>
<th>Market Capitalisation (in billion USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>616</td>
<td>13,396</td>
</tr>
<tr>
<td>2014</td>
<td>1,252</td>
<td>26,912</td>
</tr>
<tr>
<td>2015</td>
<td>5,044</td>
<td>68,26</td>
</tr>
<tr>
<td>2016</td>
<td>12,358</td>
<td>152,680</td>
</tr>
<tr>
<td>2017</td>
<td>35,58</td>
<td>234,800</td>
</tr>
<tr>
<td>2018</td>
<td>99,956</td>
<td>910,329</td>
</tr>
<tr>
<td>2019</td>
<td>138,199</td>
<td>2,348,300</td>
</tr>
<tr>
<td>2020</td>
<td>269,135</td>
<td>3,899,56</td>
</tr>
<tr>
<td>2021</td>
<td>1,039,778</td>
<td>7,557</td>
</tr>
<tr>
<td>2022</td>
<td>1,039,778</td>
<td>2,348,300</td>
</tr>
</tbody>
</table>

Table 4: Crypto assets: growth in number and market capitalisation.

Source: Statista.

These developments have prompted Central Banks worldwide to demonstrate their inclination towards digital currency, commonly known as Central Bank Digital Currency (CBDC). CBDC is the digital form of the physical currency notes issued by the Central Bank and possesses all the main features and functions as a medium of exchange and store of value. CBDC is the liability of the Central Bank (RBI 2022). The Central Bank of The Bahamas, Eastern Caribbean Currency Union (ECCU), Central Bank of Nigeria and Peoples Bank of China have successfully issued CBDC, while the Central Banks of three other countries, namely Sweden, Jamaica, and Ukraine, have completed testing the pilot project of CBDC. Many other countries, including India, are currently in initial discussions for the development of CBDC. The Bank for International Settlements (BIS), established to discuss and finalise monetary and regulatory policies and provide banking services to Central Banks, has conducted various projects in association with central banks of different countries, supporting them to adopt CBDC quickly.

2. Objectives

Possibilities have been opened for central banks worldwide to switch from physical currencies to digital currencies due to the progression of blockchain technology and crypto assets. The objectives of the present study are as follows:

- To grasp the theoretical aspect of Central Bank Digital Currency (CBDC).
- To determine the need, feasibility, and explore the implications of issuing CBDC.
- To highlight the current scenario on the adoption of CBDC by various central banks.

3. Literature Review

The traditional banking model is at risk of being disrupted by the power of blockchain technology, which has the potential to create a new cashless banking model that reduces risks and frauds, facilitates cost-effective and rapid transfer of funds and information between banks, and optimizes global financial infrastructure to accelerate economic growth and support a greener banking system (Cocco, 2017). Block chain technology will significantly change payment clearance and credit information systems in banks, and present-day concerns regarding this technology include adequate regulation and security (Guo 2016). Blockchain technology is secure, auditable, accelerates digitalization, and reduces the cost of banking services (Semenchenko 2016).
In India, government financial transactions such as tax collection and distribution of social security amounts face significant delays due to the involvement of several intermediaries in the process. Implementing blockchain technology can reduce these delays by eliminating intermediaries, making financial inclusion and correspondent banking more accessible and profitable (Saripalli 2021). The introduction of a Central Bank Digital Currency (CBDC) directly impacts monetary policy, improves money demand, optimizes payment systems between institutions, and expands the money multiplier effect (Yang J, 2022). Factors such as the financial inclusion strategy of the country and the method adopted for risk mitigation from fraudulent operations will influence the implementation of CBDC (Engert 2017). The introduction of CBDC significantly affects the financial system and the economy, and complete anonymity is recommended. While central banks worldwide do not have strict rules in place to address the risks associated with digital currency on blockchain platforms, innovative technologies in finance, such as digital payment systems, and an increase in crypto assets in the market make it necessary to introduce a digital euro without hesitation (Pelagidis 2022).

4. Theoretical Aspect of CBDC

CBDC is implemented on Distributed Ledger Technology (DLT), specifically using blockchain, the platform utilized to create crypto assets such as Bitcoin and Ethereum. DLT and blockchain are interconnected, with blockchain being a distributed ledger. DLT is the latest and most popular technology for recording and sharing information across multiple ledgers. Transactions are recorded in blocks, with subsequent transactions linked to the initial transaction in a chain-like manner, creating the blockchain. All participants have access to the distributed ledger, allowing them to view the entire chain of transactions. DLT is highly reliable and ensures protection against data tampering. This disruptive technology can render current bank notes obsolete and lead to a fully digital currency system in the long run, significantly changing the banking and financial sector.

There are two variants of CBDC under consideration. The first is called ‘wholesale CBDC,’ exclusively available by participating intermediaries, such as banks and financial institutions. The second variant, called ‘general purpose CBDC,’ is open to the general public.

There are two main operational models for CBDC, with central banks able to choose the most suitable option based on their specific requirements. The first model is known as ‘unilateral CBDC,’ where central banks take full responsibility for issuing, distributing, and dealing with end-users without the help of intermediaries. The second model is known as ‘intermediated CBDC,’ where central banks are responsible for issuing CBDC but receive assistance from intermediaries such as banks, financial institutions, or even private entities for distribution and dealing with end-users. Under this model, central banks are more responsible for monitoring private entities. The prevailing banknotes operate under an intermediated operational model, making this model the generally accepted one for CBDC (Soderberg 2022).

5. Need, Feasibility, And Implications of CBDC

The technology boom of the 21st century has been fueled by digitalization, which received a boost during the Covid-19 pandemic. Visible changes include the widespread use of smartphones and tablets, social media, and increased digital transactions. Investment in crypto assets has gained wide acceptance, particularly among the tech-savvy Generation Next, which has pushed Central Banks to consider the possibility of transitioning their currency to CBDC. CBDC uses blockchain technology, which streamlines the country’s monetary policy, facilitates fast money circulation, and promotes rapid money multiplication (Yang J 2022). Effective payment systems are promoted by quick peer-to-peer settlements, which do not create additional risks to monetary stability. CBDC is expected to result in tremendous improvements in trade finance settlements, reducing intermediaries to a minimum, reducing transactions, saving time and expenses, and seamless auditing.

Transactions made in blockchain under DLT remain permanently in the system and cannot be modified or deleted, ensuring a reduction in fraud and improving operational and service efficiency. This system eliminates the circulation of counterfeit notes and puts a brake on money laundering and using the money for criminal activities such as terrorism, drug deals, etc. In the long run, there will be a considerable reduction in ATMs, personnel, and machinery engaged in printing, upkeep, and distribution of banknotes, resulting in cost savings. CBDC also addresses the issue of climate change and boosts the goal of greening the banking system. It also acts as an efficient medium for financial inclusion.

Although CBDC presents opportunities, it is not free from risks. There may be chances of security threats and hacking of the system. To ensure transparency in transactions and check security threats, a study by the Central Bank of Canada recommended continuous testing, authentication, following best practices, conducting periodic audits, and using dedicated single-purpose devices instead of shared devices (Minwalla 2020).

6. Adoption of CBDC by Various Central Banks

6.1. Countries issued CBDC

CBDCs have been issued by a limited number of countries so far, with blockchain technology being the platform of choice for all four central banks. The status of CBDCs in these countries is detailed below.
**The Bahamas:** The Central Bank of The Bahamas issued 'Sand Dollar', the world’s first CBDC, in October 2020. The country’s geography makes it difficult to achieve financial inclusion, with only 20 to 25 percent being achieved so far. As of December 2021, the total amount of banknotes and CBDC in circulation was $535.5 million and $0.304 million, respectively.

**Eastern Caribbean Currency Union:** (The Eastern Caribbean Central Bank 2022) issues the official currency, the 'EC Dollar', for eight Caribbean countries. In March 2021, the central bank launched 'D Cash', its CBDC. Although it experienced some technical issues in January 2022, these were resolved, and there is now 40,000 D-Cash wallet holders.

**Nigeria:** (The Central Bank of Nigeria 2019) issued 'eNaira', its CBDC, in October 2021 in response to the widespread use of unregulated private crypto assets in the country.

**China:** CBDC study was initiated by the Peoples Bank of China from 2014 and 'e-CNY' pilot testing has been conducted in batches in various cities since 2019. More than 25 cities have now introduced 'e-CNY'. As of December 2021, around 260 million personal 'e-CNY' wallets and 10 million public 'e-CNY' accounts have been opened, with a cumulative amount of approximately 87.5 billion yuan, as reported by Yang (2022).

### 6.2. Countries started the pilot project of CBDC

The pilot projects of CBDC in three countries have been completed, and they are waiting for final rollout.

**Sweden:** Riksbank, which is the central bank of Sweden, a developed country in Europe, has completed the pilot study of CBDC named ‘e-Krona’ that began in 2017, and the technical and legal checking is ongoing.

**Jamaica:** Bank of Jamaica completed its pilot study in 2021, and it has invited interested providers for developing a test of potential CBDC as the bank has decided to go ahead with it. The official currency of Jamaica is known as the Jamaican Dollar.

**Ukraine:** The National Bank of Ukraine issued its official currency 'Hryvnias.' The bank initiated its discussion on CBDC, named 'e-Hryvnias,' in 2018, and the pilot study began under blockchain technology. However, it is not finalized due to technology issues and war.

### 6.3. Countries started a formal discussion on CBDC

On September 16, 2022, the government approved the issuance of CBDC and released a framework indicating digital currency regulations. A paper was published by the Board of Governors of the Federal Reserve System in January 2022 as an initial step towards gathering public opinion on CBDC in the United States of America. CBDC issuance is being planned by twenty European countries, with initial discussions starting and the final decision set to be taken by October 2023.

Respective Central Banks have reached different levels in their pursuit of CBDC. Project studies on CBDC have been initiated by the Bank for International Settlements (BIS) jointly with many Central Banks to help them roll out their CBDC and ensure international monetary stability and cooperation. Brief information on such project studies is given below, which is a clear indication that Central Banks around the globe are now chasing for introducing digital currencies (Bank for International Settlements 2022).

**Project Icebreaker** is exploring the advantages of using retail CBDC for settling international settlements conducted by BIS jointly with Bank of Israel, the Central Bank of Norway, and Sveriges Riksbank of Sweden. Project Dunbar is basically for studying the impact of international settlements using multi CBDCs conducted by BIS jointly with Reserve Bank of Australia, Bank of Negara Malaysia, Monetary Authority of Singapore, and South Africa Reserve Bank. Project Rosalind is being conducted for developing a prototype for CBDC by BIS jointly with Bank of England.

Several projects related to CBDC have been initiated by the Bank for International Settlements (BIS) in partnership with different central banks. The settlement project named ‘Project Helvetia’ is being studied by BIS and the Swiss National Bank, while ‘Project Jura’ is being conducted for cross-border settlements between French and Swiss commercial banks. ‘Project Multiple CBDC Bridge’ aims to explore the capability of DLT to support multiple CBDCs for cross-border settlements, while ‘Project Aurum’ is focused on studying a hybrid model of CBDC and private CBDC.

In India, the adoption of digital technology has been increasing rapidly, and the COVID-19 pandemic has further accelerated the use of digital payments. Investment in crypto assets is also rising quickly, which the Reserve Bank of India perceives as a threat to monetary stability. As a result, the bank has issued a circular advising transactions related to the purchase and sale of crypto assets. However, this order has been overturned by the (Supreme Court of India 2018), which ruled that the ban would negatively impact the economy if bank accounts used for crypto trading were no longer operational. Although there is no legal ban on crypto assets or regulation of crypto assets in India, technological advancements indicate a quicker adoption of new technology and the introduction of CBDC.

According to (Cocco 2017), amendments to the RBI Act were made through Section 125 of The Finance Act of India 2022, which included the insertion of digital form of notes in the definition of bank notes (Section 2 [aiv] of RBI Act 1934). (The Reserve Bank of India 2022) has completed the initial stage of feasibility testing for introducing the Central Bank Digital Currency (CBDC), ensuring conformity with the objectives of monetary policy, financial stability, effective currency operations, and payment systems.
On December 1, 2022, the Reserve Bank of India introduced the Retail E Rupee on a pilot basis in selected cities in India, including Mumbai, Delhi, Bengaluru, and Bhubaneswar, and will later be extended to Ahmedabad, Gangtok, Guwahati, Hyderabad, Indore, Kochi, Lucknow, Patna, and Shimla. The Retail E Rupee is circulated through identified participating banks, such as State Bank of India, ICICI Bank, IDFC First Bank, and Yes Bank, and later also through Bank of Baroda, Union Bank of India, HDFC Bank, and Kotak Mahindra Bank. All features of existing legal tender currency are included in the Retail E Rupee except the physical existence. Participating banks will circulate the Retail E Rupee among closed user groups through digital wallets which can be stored in mobile phones or any other devices. The holder can use it for payments either to person to person or use it in merchant establishments using QR codes with them.

(Lu 2022) found that while studying the progress of implementation of CBDC in 109 countries, they stand at different stages - pilot study, development, research, etc. According to the Atlantic Council CBDC Tracker 2022, 11 countries have already launched CBDC (8 countries in ECCU are individually counted), 14 countries are in the pilot study stage, 26 countries are on the development stage, 47 countries are carrying out research, 10 countries are not active so far, and 2 countries have currently cancelled their proposal (Figure 1). The global and continental-wise map showing the status of CBDC progress is presented from Figure 2 to 7.

![Figure 1 Status of CBDC progress in 109 countries. Source: Atlantic council, CBDC tracker 2022.](image)

![Figure 2 Global status of CBDC progress - at a glance. Source: Atlantic council, CBDC tracker 2022.](image)
Figure 3 Status of CBDC progress in Africa. Source: Atlantic council, CBDC tracker 2022.

Figure 4 Status of CBDC progress in East Asia and Oceania. Source: Atlantic council, CBDC tracker 2022.
Figure 5 Status of CBDC progress in Middle East. Source: Atlantic council, CBDC tracker 2022.

Figure 6 Status of CBDC progress in South America. Source: Atlantic council, CBDC tracker 2022.
Figure 7 Status of CBDC progress in North America. Source: Atlantic council, CBDC tracker 2022.

7. Future Challenges of CBDC

(i) The non-acceptance and unwillingness of the public to switch from physical currency to embrace CBDC is observed.
(ii) Infrastructure and other resources, such as staff and finance, need to be arranged for the project, including pilot studies, testing, and implementation, as the process incurs significant costs.
(iii) A fool proof cyber security system needs to be established.
(iv) Technological uncertainty is also a concern.

8. Conclusions

The CBDC is still in its early stages, and central banks are compelled to shift from physical banknotes to digital currency due to technological advancements and digitalization. Although existing crypto assets have gained widespread acceptance, they are highly volatile and insecure. CBDC has been introduced by some central banks, and it is recommended that others do the same; otherwise, countries that have issued CBDC may gain an advantage by establishing an efficient network, potentially usurping a large amount of business from other countries.

Ongoing discussions are taking place regarding the operational aspect of CBDC, including whether it should be operated by the central bank itself or partially outsourced to private agencies. However, involving private agencies in the process may pose a security risk, leading to data breaches and negatively impacting the economy, given that central bank money plays a significant role in monetary policy and establishing a robust economy.

The success of CBDC depends on the technology platform and how it is developed to meet the specific needs of each country. Therefore, a series of pilot studies and testing must be conducted before CBDC issuance. Furthermore, physical currency notes should be issued parallel to CBDC as they are a complement rather than a replacement to the current system of paper currency until CBDC is accepted and stabilized.

Ethical considerations

Not applicable.

Declaration of interest

The authors declare no conflicts of interest.

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