



Concept Note
on
Central Bank Digital Currency

FinTech Department
Reserve Bank of India
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Preface

Central Bank Digital Currency (CBDC) is a digital form of currency notes issued by a central bank. While most central banks across the globe are exploring the issuance of CBDC, the key motivations for its issuance are specific to each country's unique requirements.

This Concept Note explains the objectives, choices, benefits and risks of issuing a CBDC in India, referred to as e₹ (digital Rupee). The e₹ will provide an additional option to the currently available forms of money. It is substantially not different from banknotes, but being digital it is likely to be easier, faster and cheaper. It also has all the transactional benefits of other forms of digital money.

The purpose behind the issue of this Concept Note is to create awareness about CBDCs in general and the planned features of the digital Rupee, in particular. The Note also seeks to explain Reserve Bank's approach towards introduction of the digital Rupee. Reserve Bank's approach is governed by two basic considerations – to create a digital Rupee that is as close as possible to a paper currency and to manage the process of introducing digital Rupee in a seamless manner.

The Concept Note also discusses key considerations such as technology and design choices, possible uses of digital rupee, issuance mechanisms etc. It examines the implications of introduction of CBDC on the banking system, monetary policy, financial stability, and analyses privacy issues.

The Reserve Bank will soon commence limited pilot launches of e₹ for specific use cases. It is expected that this note would facilitate a deeper appreciation and understanding of digital Rupee and help members of public prepare for its use.

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List of Abbreviations

AML/CFT	Anti-Money Laundering/ Combating the Financing of Terrorism
BBPOUs	Bharat Bill Payment Operating Units
BBPS	Bharat Bill Payment System
BIS	Bank for International Settlements
CBDC	Central Bank Digital Currency
CBDC-R	CBDC Retail
CBDC-W	CBDC Wholesale
CDD	Customer Due Diligence
CPMI-MC	Committee on Payments and Market Infrastructures and the Markets Committee
CTS	Cheque Truncation System
DEA	Department of Economic Affairs
DLT	Distributed Ledger technology
DPI	Digital Payment Index
ECB	European Central Bank
ECS	Electronic Clearing Service
FATF	Financial Action Task Force
FPS	Fast Payment Systems
GDP	Gross Domestic Product
IMF	International Monetary Fund
IMPS	Immediate Payment Service
IOSCO	International Organisation of Securities Commissions
KYC	Know Your Customer
NACH	National Automated Clearing House
NDTL	Net Demand and Time Liabilities
NEFT	National Electronic Funds Transfer
NETC	National Electronic Toll Collection
RBI	Reserve Bank of India
RTGS	Real Time Gross Settlement
TSPs	Token Service Providers
UPI	Unified Payments Interface

Summary

Management of currency is one of the core central banking functions of the Reserve Bank for which it derives the necessary statutory powers from Section 22 of the RBI Act, 1934. Along with the Government of India, the Reserve Bank is responsible for the design, production and overall management of the nation's currency, with the goal of ensuring an adequate supply of clean and genuine notes in the economy.

The history of money is fascinating and goes back thousands of years. From the early days of bartering to the first metal coins and eventually the first paper money, it has always had an important impact on the way we function as a society. The innovations in money and finance go hand in hand with the shifts in monetary history. In its evolution till date, currency has taken several different forms. It has traversed its path from barter, to valuable metal coins made up of bronze and copper which later evolved to be made up of silver and gold. Use of coins was a huge milestone in the history of money because they were one of the first currencies that allowed people to pay by count (number of coins) rather than weight. Somewhere along the way, people improvised by using claims on goods and a bill of exchange.

Money either has intrinsic value or represents title to commodities that have intrinsic value or title to other debt instruments. In modern economies, currency is a form of money that is issued exclusively by the sovereign (or a central bank as its representative) and is legal tender. Paper currency is such a representative money, and it is essentially a debt instrument. It is a liability of the issuing central bank (and sovereign) and an asset of the holding public.

Irrespective of the form of money, in any economy, money performs three primary functions - medium of exchange, a unit of account and a store of value. Money as a medium of exchange may be used for any transactions wherein goods or services are purchased or sold. Money as a unit of account can be used to value goods or services and express it in monetary terms. Money can also be stored or conserved for future purposes.

India has made impressive progress towards innovation in digital payments. India has enacted a separate law for Payment and Settlement Systems which has enabled an orderly development of the payment eco-system in the country. The present state-of-the-art payment systems that are affordable, accessible, convenient, efficient, safe, secure and available 24x7x365 days a year are a matter of pride for the nation. This striking shift in payment preference has been due to the creation of robust round the clock electronic payment systems such as Real Time Gross Settlement (RTGS) and National Electronic Funds Transfer (NEFT) that has facilitated seamless real time or near real time fund transfers. In addition, the launch of Immediate Payment Service (IMPS) and Unified Payments Interface (UPI) for instant payment settlement, the introduction of mobile based payment systems such as Bharat Bill Payment System (BBPS), and National Electronic Toll Collection (NETC) to facilitate electronic toll payments have been the defining moments that has transformed the payments ecosystem of the country and attracted international recognition. The convenience of these payment systems ensured

rapid acceptance as they provided consumers an alternative to the use of cash and paper for making payments. The facilitation of non-bank FinTech firms in the payment ecosystem as PPI issuers, Bharat Bill Payment Operating Units (BBPOUs) and third-party application providers in the UPI platform have furthered the adoption of digital payments in the country. Throughout this journey, the Reserve Bank has played the role of a catalyst towards achieving its public policy objective of developing and promoting a safe, secure, sound, efficient and interoperable payment system.

With the developments in the economy and the evolution of the payments system, the form and functions of money has changed over time, and it will continue to influence the future course of currency. The concept of money has experienced evolution from Commodity to Metallic Currency to Paper Currency to Digital Currency. The changing features of money are defining new financial landscape of the economy. Further, with the advent of cutting-edge technologies, digitalization of money is the next milestone in the monetary history. Advancement in technology has made it possible for the development of new form of money viz. Central Bank Digital Currencies (CBDCs).

Recent innovations in technology-based payments solutions have led central banks around the globe to explore the potential benefits and risks of issuing a CBDC so as to maintain the continuum with the current trend in innovations. RBI has also been exploring the pros and cons of introduction of CBDCs for some time and is currently engaged in working towards a phased implementation strategy, going step by step through various stages of pilots followed by the final launch, and simultaneously examining use cases for the issuance of its own CBDC (Digital Rupee (e₹)), with minimal or no disruption to the financial system. Currently, we are at the forefront of a watershed movement in the evolution of currency that will decisively change the very nature of money and its functions.

Reserve Bank broadly defines CBDC as the legal tender issued by a central bank in a digital form. It is akin to sovereign paper currency but takes a different form, exchangeable at par with the existing currency and shall be accepted as a medium of payment, legal tender and a safe store of value. CBDCs would appear as liability on a central bank's balance sheet.

Bank for International Settlement has laid down "foundational principles" and "core features" of a CBDC, to guide exploration and support public policy objectives, as per the need of existing mandate of Central Banks. The foundational principles emphasise that, authorities would first need to be confident that issuance would not compromise monetary or financial stability and that a CBDC could coexist with and complement existing forms of money, promoting innovation and efficiency.

Key Motivations

CBDC, being a sovereign currency, holds unique advantages of central bank money viz. trust, safety, liquidity, settlement finality and integrity. The key motivations for exploring the issuance of CBDC in India among others include reduction in operational costs involved in physical cash management, fostering financial inclusion, bringing resilience, efficiency, and innovation in payments system, adding efficiency to the settlement system, boosting innovation in cross-border payments space and providing

public with uses that any private virtual currencies can provide, without the associated risks. The use of offline feature in CBDC would also be beneficial in remote locations and offer availability and resilience benefits when electrical power or mobile network is not available.

Private virtual currencies sit at substantial odds to the historical concept of money. They are not commodities or claims on commodities as they have no intrinsic value. The rapid mushrooming of private cryptocurrencies in the last few years has attempted to challenge the fundamental notion of money as we know it. Claiming the benefits of de-centralisation, cryptocurrencies are being hailed as innovation that would usher in de-centralised finance and disrupt the traditional financial system. However, the inherent design of cryptocurrencies is more geared to bypass the established and regulated intermediation and control arrangements that play a crucial role of ensuring integrity and stability of monetary and financial eco-system.

As the custodian of monetary policy framework and with the mandate to ensure financial stability in the country, the Reserve Bank of India has been consistent in highlighting various risks related to the cryptocurrencies. These digital assets undermine India's financial and macroeconomic stability because of their negative consequences for the financial sector. Further, a wider proliferation of cryptocurrencies has the potential to diminish monetary authorities' potential to determine and regulate monetary policy and the monetary system of the country which could pose serious challenge to the stability of the financial system of the country.

In this context, it is the responsibility of central bank to provide its citizens with a risk free central bank digital money which will provide the users the same experience of dealing in currency in digital form, without any risks associated with private cryptocurrencies. Therefore, CBDCs will provide the public with benefits of virtual currencies while ensuring consumer protection by avoiding the damaging social and economic consequences of private virtual currencies.

Design Choices

As CBDCs are electronic form of sovereign currency, it should imbibe all the possible features of physical currency. The design of CBDC is dependent on the functions it is expected to perform, and the design determines its implications for payment systems, monetary policy as well as the structure and stability of the financial system. One of the main considerations is that the design features of CBDCs should be least disruptive.

The key design choices to be considered for issuing CBDCs include (i) Type of CBDC to be issued (Wholesale CBDC and/or Retail CBDC), (ii) Models for issuance and management of CBDCs (Direct, Indirect or Hybrid model), (iii) Form of CBDC (Token-based or Account-based), (iv) Instrument Design (Remunerated or Non-remunerated) and (v) Degree of Anonymity.

Type of CBDC to be issued

CBDC can be classified into two broad types viz. general purpose or retail (CBDC-R) and wholesale (CBDC-W). Retail CBDC would be potentially available for use by all viz. private sector, non-financial

consumers and businesses while wholesale CBDC is designed for restricted access to select financial institutions. While Wholesale CBDC is intended for the settlement of interbank transfers and related wholesale transactions, Retail CBDC is an electronic version of cash primarily meant for retail transactions.

It is believed that Retail CBDC can provide access to safe money for payment and settlement as it is a direct liability of the Central Bank. Wholesale CBDC has the potential to transform the settlement systems for financial transactions and make them more efficient and secure. Going by the potential offered by each of them, there may be merit in introducing both CBDC-W and CBDC-R.

Model for issuance and management of CBDC

There are two models for issuance and management of CBDCs viz. Direct model (Single Tier model) and Indirect model (Two-Tier model). A Direct model would be the one where the central bank is responsible for managing all aspects of the CBDC system viz. issuance, account-keeping and transaction verification.

In an Indirect model, central bank and other intermediaries (banks and any other service providers), each play their respective role. In this model central bank issues CBDC to consumers indirectly through intermediaries and any claim by consumers is managed by the intermediary as the central bank only handles wholesale payments to intermediaries.

The Indirect model is akin to the current physical currency management system wherein banks manage activities like distribution of notes to public, account-keeping, adherence of requirement related to know-your-customer (KYC) and anti-money laundering and countering the terrorism of financing (AML/CFT) checks, transaction verification etc.

Forms of CBDC

CBDC can be structured as 'token-based' or 'account-based'. A token-based CBDC is a bearer-instrument like banknotes, meaning whosoever holds the tokens at a given point in time would be presumed to own them. In contrast, an account-based system would require maintenance of record of balances and transactions of all holders of the CBDC and indicate the ownership of the monetary balances. Also, in a token-based CBDC, the person receiving a token will verify that his ownership of the token is genuine, whereas in an account-based CBDC, an intermediary verifies the identity of an account holder. Considering the features offered by both the forms of CBDCs, a token-based CBDC is viewed as a preferred mode for CBDC-R as it would be closer to physical cash, while account-based CBDC may be considered for CBDC-W.

Technology choice

CBDCs being digital in nature, technological consideration will always remain at its core. The infrastructure of CBDCs can be on a conventional centrally controlled database or on Distributed Ledger Technology. The two technologies differ in terms of efficiency and degree of protection from single point

of failure. The technology considerations underlying the deployment of CBDC needs to be forward looking and must have strong cybersecurity, technical stability, resilience and sound technical governance standards. While crystallising the design choices in the initial stages, the technological considerations may be kept flexible and open-ended in order to incorporate the changing needs based on the evolution of the technological aspects of CBDCs.

Instrument Design

The payment of (positive) interest would likely enhance the attractiveness of CBDCs that also serves as a store of value. But, designing a CBDC that moves away from cash-like attributes to a “deposit-like” CBDC may have a potential for disintermediation in the financial system resulting from loss of deposits by banks, impeding their credit creation capacity in the economy. Also considering that physical cash does not carry any interest, it would be more logical to offer non-interest bearing CBDCs.

Degree of Anonymity

For CBDC to play the role as a medium of exchange, it needs to incorporate all the features that physical currency represents including anonymity, universality, and finality. Ensuring anonymity for a digital currency particularly represents a challenge, as all digital transactions would leave some trail. Clearly, the degree of anonymity would be a key design decision for any CBDC. In this regard, reasonable anonymity for small value transactions akin to anonymity associated with physical cash may be a desirable option for CBDC-R.

While the intent of CBDC and the expected benefits are well understood, it is important that the issuance of CBDC needs to follow a calibrated and nuanced approach with adequate safeguards to address potential difficulties and risks in order to build a system which is inclusive, competitive and responsive to innovation and technological changes. CBDC, across the world, is mostly in conceptual, developmental, or at pilot stages. Therefore, in the absence of a precedence, extensive stakeholder consultation along with iterative technology design may be the requirement, to develop a solution that meets the requirements of all stakeholders.

CBDC is aimed to complement, rather than replace, current forms of money and is envisaged to provide an additional payment avenue to users, not to replace the existing payment systems. Supported by state-of-the-art payment systems of India that are affordable, accessible, convenient, efficient, safe and secure, the Digital Rupee (e₹) system will further bolster India’s digital economy, make the monetary and payment systems more efficient and contribute to furthering financial inclusion.

Chapter 1: Introduction

1.1 Maintaining monetary and financial stability and explicitly or implicitly promoting broad access to safe and efficient payments, have been among the main objectives of the RBI. Monetary stability is secured by virtue of the statutory responsibility of currency management conferred on the Reserve Bank in the Preamble of the Reserve Bank of India Act, 1934, which mandates the Reserve Bank to regulate the issue of Bank notes and keeping of reserves. A core instrument by which central banks carry out their public policy objectives is by providing central bank money, which is the safest form of money to banks, businesses, and the public.

1.2 The history of money is fascinating and goes back thousands of years. From the early days of bartering to the first metal coins and eventually the first paper money, it has always had an important impact on the way we function as a society. The innovations in money and finance go hand in hand with the shifts in monetary history. In its evolution till date, currency has taken several different forms. It has traversed its path from barter to valuable metal coins made up of bronze and copper which later evolved to be made up of silver and gold. Somewhere along the way, people improvised and instead of actual goods for barter they started using claims on goods, a bill of exchange.

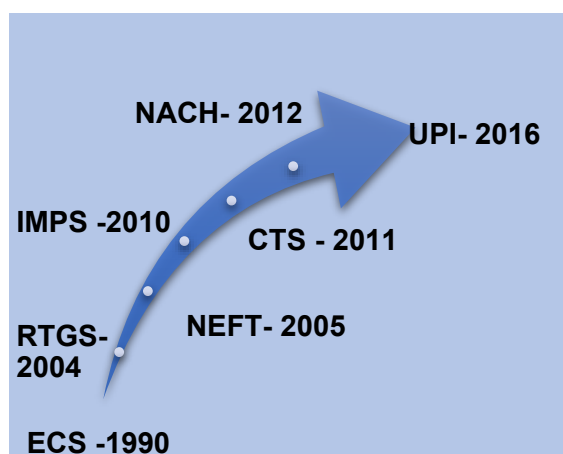
1.3 Money either has intrinsic value or represents title to commodities that have intrinsic value or title to other debt instruments.

In modern economies, currency is a form of money that is issued exclusively by the sovereign (or a central bank as its representative) and is legal tender. Paper currency is such a representative money, and it is essentially a debt instrument. It is a liability of the issuing central bank (and sovereign) and an asset of the holding public. Central Bank Money acts as medium of payment, a unit of account and a store of value for a jurisdiction.

1.4 Payment systems are changing at an accelerating pace. Today, users expect faster, easier payments anywhere and at any time, mirroring the digitalisation and convenience of other aspects of life (Bech et al,2017). Systems that offer near instant person-to-person retail payments are becoming increasingly prevalent around the world. India has always been a country that has fostered innovation and development in the area of payment and settlement systems. The past decades have witnessed the blossoming of a myriad of payment systems, all for the convenience of the common man. Reserve Bank of India has taken several initiatives since the mid-eighties to bring in technology-based solutions to the banking system. The developments have been indicated in the chart given below¹:

¹ ECS – Electronic Clearing Services; RTGS – Real Time Gross Settlement; NEFT – National Electronic Fund Transfer; IMPS – Immediate Payment Service; CTS – Cheque Truncation System;

NACH - National Automated Clearing House; UPI – Unified Payments Interface



(Figure 1. Developments in India's payment systems)

1.5 India has made impressive progress towards innovation in digital payments. India has enacted a separate law for Payment and Settlement Systems which has enabled an orderly development of the payment ecosystem in the country. The present state-of-the-art payment systems that are affordable, accessible, convenient, efficient, safe, secure and available 24x7x365 days a year are a matter of pride for the nation. This striking shift in payment preference has been due to the creation of robust round the clock electronic payment systems such as RTGS and NEFT that has facilitated seamless real time or near real time fund transfers. In addition, the launch of IMPS and UPI for instant payment settlement, the introduction of mobile based payment systems such as BBPS, and National Electronic Toll Collection (NETC) to facilitate electronic toll payments have been the defining moments that has transformed the payments ecosystem of the country and attracted international recognition. The convenience of these payment systems ensured rapid acceptance as they provided consumers an alternative to the use of cash and paper for making payments. The facilitation of non-bank FinTech firms in the payment

ecosystem as PPI issuers, BBPOUs and third-party application providers in the UPI platform have furthered the adoption of digital payments in the country. Throughout this journey, the Reserve Bank has played the role of a catalyst towards achieving its public policy objective of developing and promoting a safe, secure, sound, efficient and interoperable payment system.

1.6 Private virtual currencies sit at substantial odds to the historical concept of money. They are not commodities or claims on commodities as they have no intrinsic value. The rapid mushrooming of private cryptocurrencies in the last few years has attempted to challenge the fundamental notion of money as we know it. Claiming the benefits of de-centralisation, cryptocurrencies are being hailed as innovation that would usher in de-centralised finance and disrupt the traditional financial system. However, the inherent design of cryptocurrencies is more geared to bypass the established and regulated intermediation and control arrangements that play a crucial role of ensuring integrity and stability of monetary and financial eco-system.

1.7 As the custodian of monetary policy framework and with the mandate to ensure financial stability in the country, the Reserve Bank of India has been consistent in highlighting various risks related to the cryptocurrencies. These digital assets undermine India's financial and macroeconomic stability because of their negative consequences for the financial sector. Further, a wider proliferation of cryptocurrencies has the potential to diminish monetary authorities' potential to determine and regulate

monetary policy and the monetary system of the country which could pose serious challenge to the stability of the financial system of the country.

1.8 In addition to the process of making payments, even the types of money being used for making payments are undergoing change. The Central Banks provide money to the public through physical cash and to banks and other financial entities through reserve and settlement accounts. Recent technological advances have ushered in a wave of new private-sector financial products and services, including digital wallets, mobile payment apps, and new digital assets. While cash is still the king (Bech et al (2018)), innovations are pushing Central Banks to think about how new central bank digital currencies (CBDCs) could complement or replace traditional money (Committee on Payments and Market Infrastructures and the Markets Committee (CPMI-MC) (2018)). CBDC is a third form of base money, and central banks around the globe are exploring its feasibility, potential benefits, and the risks involved. As per the results of 2021 Bank for International Settlements (BIS) survey on CBDCs conducted on 81 central banks, 90% of central banks are engaged in some form of CBDC work and more than half are now developing them or running concrete experiments.

1.9 Recognising the global developments in the field of CBDC, the Reserve Bank had set up an Internal Working Group (WG) in October 2020 to undertake a study on appropriate design /

implementation architecture for introducing CBDCs in India. The WG in their February 2021 report made the following major recommendations:

- i. Need for a robust legal framework to back the issuance of **e₹ (Digital Rupee)**² as another form of currency. It was recommended to amend the RBI Act to cover e₹ in the definition of the term 'bank note' and also insert a new section in the RBI Act covering features pertaining to e₹ and necessary exemptions.
- ii. The design of e₹ may be decided depending on the circumstances and the need of the country. It recommended that the design of e₹ should be compatible with the objectives of monetary and financial stability.
- iii. The most widespread use and advantage of e₹ was expected to emerge from the token-based variant in the retail segment. Keeping this in mind, the WG recommended undertaking some pilot projects with phased implementation to serve as a learning experience.
- iv. Implementation of a specific purpose e₹, one each in the wholesale and retail segments to begin with. The proposed models could be implemented with little or no disruption to the market and help unravel the benefits of CBDC. For Wholesale CBDC (CBDC-W), a phased implementation strategy for wholesale account-based CBDC³ model, in securities

² CBDC to be issued by RBI is referred as e₹ by the WG

³ An account-based system would require the keeping of a record of balances and transactions of all holders of the CBDC and indicate the ownership of the monetary balances.

settlement (outright), was proposed. For Retail CBDC (CBDC-R), a token-based CBDC⁴ with tiered architecture model was proposed wherein the Reserve Bank shall only issue and redeem e₹ while the distribution and payment services will be delegated to the banks.

- v. As traceability, privacy and transaction costs vary for each CBDC type resulting in different cost implications for each stakeholder, the need to conduct more research on the technological aspects of CBDC implementation on a national scale was recommended.
- vi. The WG was of the view that finalising a model for implementation of e₹ within a short duration may not be desirable and reiterated that the initial models proposed be simple models that could be considered to commence work in this connection. The WG proposed to continue deliberations on CBDC over a longer period to refine and crystallise requirements for the implementation of other models of e₹ in future.

1.10 Earlier, in November 2017, a High Level Inter-ministerial committee was constituted under the chairmanship of the Secretary, Department of Economic Affairs (DEA), Ministry of Finance, Government of India (GoI) to examine the policy and legal framework for regulation of virtual / crypto currencies and

recommend appropriate measures to address concerns arising from their use. The committee had recommended the introduction of CBDCs as a digital form of sovereign currency in India.

1.11 Across the globe, more than 60 central banks⁵ have expressed interest in CBDC with a few implementations already under pilot across both Retail⁶ and Wholesale⁷ categories and many others are researching, testing, and/or launching their own CBDC framework. As of July 2022, there are 105 countries⁸ in the process of exploring CBDC, a number that covers 95% of global Gross Domestic Product (GDP). 10 countries have launched a CBDC, the first of which was the Bahamian Sand Dollar in 2020 and the latest was Jamaica's JAM-DEX. Currently, 17 other countries, including major economies like China and South Korea, are in the pilot stage and preparing for possible launches. China was the first large economy to pilot a CBDC in April 2020 and it aims for widespread domestic use of the e-CNY by 2023. Increasingly, CBDCs are being seen as a promising invention and as the next step in the evolutionary progression of sovereign currency.

1.12 Like other central banks, RBI has been exploring the pros and cons of introduction of CBDCs for some time. The introduction of CBDC in India is expected to offer a range of benefits, such as reduced dependency on cash, lesser overall currency management cost, and reduced settlement risk. It could provide

⁴ A token-based CBDC system would involve a type of digital token issued by and representing a claim on the central bank and would effectively function as the digital equivalent of a banknote that could be transferred electronically from one holder to another.
⁵ PwC CBDC Global Index, 1st Edition, April 2021, <https://www.pwc.com/gx/en/industries/financial-services/assets/pwc-cbdc-global-index-1st-edition-april-2021.pdf>

⁶ Retail currency is used to pay for things, to send money to friends and family, and to receive government incentives and subsidies

⁷ Wholesale currency is used by financial institutions to buy and sell financial assets and interbank settlement

⁸ CBDC Tracker, <https://www.atlanticcouncil.org/cbdctracker/>

general public and businesses with a convenient, electronic form of central bank money with safety and liquidity and provide entrepreneurs a platform to create new products and services. The introduction of CBDC, would possibly lead to a more robust, efficient, trusted, regulated and legal tender-based payments option (including cross-border payments).

1.13 However, CBDC could also pose certain risks that may have a bearing on important public policy issues, such as risk to financial stability, monetary policy, financial market structure and the cost and availability of credit. They need to be carefully evaluated against the potential benefits.

1.14 Government of India announced the launch of the Digital Rupee — a Central Bank Digital Currency (CBDC) from FY 2022-23 onwards in the Union Budget placed in the Parliament on February 01, 2022. In the budget announcement it was stated that the introduction of CBDC will give a big boost to the digital economy. The broad objectives to be achieved by the introduction of CBDC using blockchain and other technologies as a 'more efficient and cheaper currency management system' were also laid down in the budget.

1.15 The Government of India vide gazette notification dated March 30, 2022 notified the necessary amendments in the Reserve Bank of India Act, 1934, which enables running the pilot and subsequent issuance of CBDC.

1.16 An internal high-level committee on CBDC under the chairmanship of Shri Ajay Kumar Choudhary, Executive Director, RBI was constituted in February 2022 by the Reserve

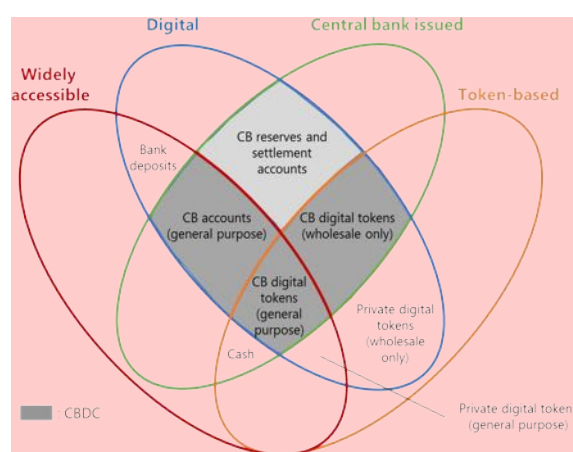
Bank to brainstorm and undertake an extensive study on various aspects of CBDC and explore the motivation for the introduction of CBDC, its design features and its implications on policy issues, choice of technology platforms and accordingly suggest measures for its successful introduction.

1.17 Based on the deliberations in the Committee, the Reserve Bank hereby releases this Concept Note to present the background, motivation, choices of design features and other policy frameworks for e₹ system for the country. The aim is to build an open, inclusive, interoperable and innovative CBDC system which will meet the aspirations of the modern digital economy of India.

Chapter 2: CBDC – Conceptual Framework

2.1 What is CBDC?

The report by the CPMI-MC published in 2018 defines CBDCs as new variants of central bank money different from physical cash or central bank reserve/settlement accounts. That is, a central bank liability, denominated in an existing unit of account, which serves both as a medium of exchange and a store of value. The four different properties of money are: (i) issuer (central bank or not); (ii) form (digital or physical); (iii) accessibility (wide or narrow); and (iv) technology (peer-to-peer tokens, or accounts) (Bech and Garratt (2017)). Based on these four properties, the CPMI-MC report provides a taxonomy of money ('The Money Flower'), which delineates two broad types of CBDC: general purpose and wholesale – with the former type coming in two varieties (Figure 1).



(Figure 2. The money flower: a taxonomy of money. CB = central bank. Source: CPMI-MC (2018); Bech and Garratt (2017))

Reserve Bank defines CBDC as the legal tender issued by a central bank in a digital form. It is the same as a sovereign currency and is

exchangeable one-to-one at par (1:1) with the fiat currency⁹. While money in digital form is predominant in India—for example in bank accounts recorded as book entries on commercial bank ledgers—a CBDC would differ from existing digital money available to the public because a CBDC would be a liability of the Reserve Bank, and not of a commercial bank.

2.2 Features of CBDC

The features of CBDC include:

- CBDC is sovereign currency issued by Central Banks in alignment with their monetary policy
- It appears as a liability on the central bank's balance sheet
- Must be accepted as a medium of payment, legal tender, and a safe store of value by all citizens, enterprises, and government agencies.
- Freely convertible against commercial bank money and cash
- Fungible legal tender for which holders need not have a bank account
- Expected to lower the cost of issuance of money and transactions

⁹ Central Bank Digital Currency – Is This the Future of Money, https://www.rbi.org.in/Scripts/BS_SpeechesView.aspx?Id=1111

Chapter 3 - Motivations for issuance of CBDCs

3.1 Different jurisdictions have justified the adoption of CBDC for very diverse reasons. Some of them are enumerated below:

- i. Central Banks, faced with dwindling usage of paper currency, seek to popularise a more acceptable electronic form of currency (like Sweden);
- ii. Jurisdictions with significant physical cash usage seeking to make issuance more efficient (like Denmark, Germany, Japan or even the US);
- iii. Countries with geographical barriers restricting the physical movement of cash had motivation to go for CBDC (e.g. The Bahamas and the Caribbean with small and large numbers of islands spread out);
- iv. Central Banks seek to meet the public's need for digital currencies, manifested in the increasing use of private virtual currencies, and thereby avoid the more damaging consequences of such private currencies.

3.2 Further, CBDCs have some clear advantages over other digital payments systems, as it being a sovereign currency, ensures settlement finality and thus reduces settlement risk in the financial system. CBDCs could also potentially enable a more real-time, cost-effective seamless integration of cross border payment systems. India has made impressive progress in innovation in digital

payments. The payment systems are available 24X7, 365 days a year to both retail and wholesale customers, they are largely real-time, the cost of transaction is perhaps the lowest in the world, users have a wide array of options for doing transactions and digital payments have grown at an impressive CAGR of 55% over the last five years.

3.3 Supported by the state-of-the-art payment systems of India that are affordable, accessible, convenient, efficient, safe and secure, the e₹ system will bolster India's digital economy, enhance financial inclusion, and make the monetary and payment systems more efficient. There are a large and diverse number of motivations for India to consider CBDC. Some of the important motivations for India to consider issuing CBDC are given below.

3.3.1 Reduction in cost associated with physical cash management

Cost of cash management in India has continued to be significant. The total expenditure incurred on security printing during April 1, 2021 to March 31, 2022 was ₹4,984.80 crore as against ₹4,012.10 crore in the previous year (July 1, 2020 to March 31, 2021)¹⁰. This cost, which does not include the Environmental, Social, and Governance (ESG) cost of printing money, is predominantly borne by four stakeholders –general public, businesses, banks, and the Central Bank. CBDC affects the overall value of the money issuing function to the extent that it reduces operational costs e.g. costs related to printing, storage, transportation and replacement of banknotes, and costs associated with delay in reconciliation and

¹⁰ RBI Annual Report 2021-22

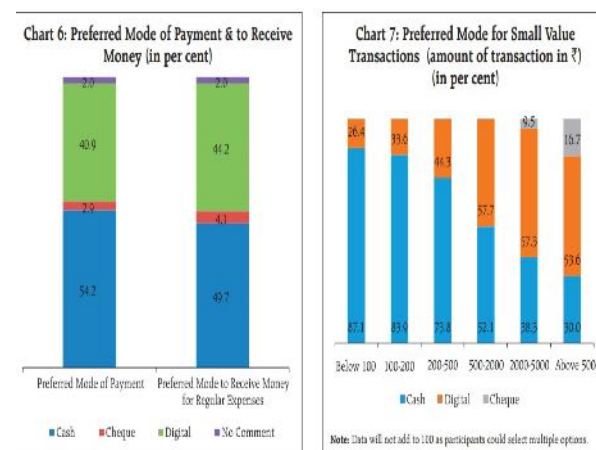
settlement. Though, at the outset, establishing a CBDC creation/issuance may entail significant fixed infrastructure costs but subsequent marginal operating costs shall be very low. Cost-effectiveness of cash management using CBDC vis-à-vis physical currency provides an additional motivation for introduction of CBDC, which may be also perceived to be environment friendly. Complementing the higher cash requirement of the country, CBDC will lead to lowering of cost as it would obviate the need of many processes associated with distribution of physical currency across the country. Further, given the geographical spread and pockets where making physical cash available is a challenge, CBDC is expected to facilitate seamless transactions.

3.3.2 To further the cause of digitisation to achieve a less cash economy.

India has a unique case where the cash in the economy has shot up despite rapid digitisation in the payments space. The growing use of electronic medium of payment has not yet resulted in a reduction in the demand for cash. The percentage increase in value of banknotes during 2020-21 and 2021-22 was 16.8 per cent and 9.9 per cent respectively and the percentage increase in volume of banknotes during 2020-21 and 2021-22 was 7.2 per cent and 5.0 per cent respectively. (Source: RBI Annual Report for the year 2021-22)

The year (2021-22) witnessed a higher than average increase in banknotes in circulation primarily due to precautionary holding of cash by the public induced by the second wave of COVID-19 pandemic. Further, a pilot survey conducted by the Reserve Bank on retail

payment habits of individuals in six cities between December 2018 and January 2019, indicated that cash remains the most preferred mode of payment and for receiving money for regular expenses; it was followed by digital mode. For small value transactions (with amount up to ₹500) cash is used predominantly.



(Figure 3: Source: RBI Bulletin April 2021)

CBDC can be a preferred mode of holding central bank money rather than cash in any uncertain situation like the one of pandemic COVID-19. Further, the preference for cash transactions for regular expenses and small payments for its anonymity, may be redirected to acceptance of CBDC, if reasonable anonymity is assured. This shall further the digitisation process in the country.

The Reserve Bank Digital Payment index (RBI-DPI) demonstrates significant growth in adoption and deepening of digital payments across the country since its inception.

Period	RBI - DPI Index
March 2018 (Base)	100
March 2019	153.47
September 2019	173.49
March 2020	207.84
September 2020	217.74
March 2021	270.59
September 2021	304.06
March 2022	349.30

(Figure 4: RBI-DPI, Source: RBI)

This increase indicates that the digital payments are further deepening and expanding in the country and is an indication that, Indian citizens have an appetite for digital payments. Therefore, the digital currency issued by the central bank shall provide yet another option for furthering the cause of digital payment, apart from the range of other digital payment instruments available, given its ease of usage coupled with sovereign guarantee.

3.3.3 Supporting competition, efficiency and innovation in payments

The digital revolution is taking the world by storm and no other area has witnessed such metamorphosis as payment and settlement systems, resulting in an array of digital options for the common man. Consumers now have a range of options to choose from when selecting a payment method to complete a transaction. They make this selection based on the value they attribute to a payment method in a certain situation as each payment mode has its own use and purpose. The shift from cash to electronic payments increases the reliance on electronic payment systems, which has implications for the diversity and resilience of the payments landscape.

CBDC could further enhance resilience in payments and provide core payment services outside of the commercial banking system. It can provide a new way to make payments and also diversify the range of payment options, particularly for e-commerce (where cash cannot be used, except for the Cash on Delivery (COD) option). The CBDC based payment system is not expected to substitute other modes of existing payment options rather it will supplement by providing another payment

avenue to the larger public. As has been the experience with many payment products, once CBDC is introduced, innovations around the product would only expand the choices available and healthy competition will help bringing about both cost and time efficiencies.

Most payments in a modern economy are made with private money maintained by commercial banks, which are in the form of demand deposits and therefore liabilities of these banks. A key feature of bank deposits is that commercial banks guarantee convertibility on demand to central bank money at a fixed price, namely, at par, thereby maintaining the value of their money. Nevertheless, in a fractional reserve system, a commercial bank—even if solvent—may face a challenge to meet with any sudden spurt in demand to convert substantial amount of bank deposits to central bank money. A significant difference between the central bank money and commercial bank money is that central bank can meet its obligations using its own nonredeemable money, while the latter entails counterparty risk. Central Bank money is the only monetary asset in a domestic economy without credit and liquidity risk. Therefore, it is preferred asset to settle payments in financial market infrastructures (see CPMI-IOSCO Principles for Financial Market Infrastructures (2012)).

Therefore, an e₹ would offer the public broad access to digital money free from credit risk and liquidity risk. As such, it could provide a safe foundation for private-sector innovations to meet current and future needs and demands for payment services. It shall also help in levelling the playing field in payment innovation for firms of all sizes. For some smaller firms, the costs

and risks of issuing a safe and robust form of private tender may be prohibitive. A CBDC could overcome this barrier and allow private-sector innovators to focus on new access services, distribution methods, and related service offerings. Finally, a CBDC might generate new capabilities to meet the evolving speed and efficiency requirements of the digital economy.

Further, payments using CBDCs are final and thus reduce settlement risk in the financial system. CBDC will eliminate the need for interbank settlement by giving choices to market participants to choose among the various settlement options such as settlement in Central Bank / commercial bank accounts with / without using clearing corporations; or settlement on a bilateral basis without use of central counterparty by directly using CBDC accounts. It can be compared to a cash-based transaction, where instead of banknotes, CBDC is handed over leading to instant settlement. This is expected to bring in further efficiency in the payment system.

3.3.4 To explore the use of CBDC for improvement in cross-border transactions

The present state-of-the-art payment systems of India are affordable, accessible, convenient, efficient, safe and secure and are a matter of pride for the nation. However, 'Cross Border Payments' is an area especially ripe for change and could benefit from new technologies. As per the World Bank, India is the world's largest recipient of remittances as it received \$87 billion in 2021 with the United States being the biggest

source, accounting for over 20 per cent of these funds. The cost of sending remittances to India, therefore, assumes critical relevance, especially in view of the large Indian diaspora spread across the world and from the point of view of the potential (mis)use of informal / illegal channels.

The G20 has also made enhancing cross-border payments a priority and endorsed a comprehensive programme to address the key challenges to cross border payment, namely high costs, low speed, limited access and insufficient transparency and frictions that contributed to these challenges. Faster, cheaper, more transparent, and more inclusive cross-border payment services would deliver widespread benefits for citizens and economies worldwide, supporting economic growth, international trade, global development and financial inclusion. BIS has published the results from a survey of Central Banks in June, 2021¹¹, which notes that CBDCs could ease current frictions in cross-border payments – and particularly so if central banks factor an international dimension into CBDC design from the outset.

As noted by BIS, the potential benefits will be difficult to achieve unless central banks incorporate cross-border considerations in their CBDC design from the start and coordinate internationally. Many central banks are currently investigating risks, benefits and various designs of CBDC, mainly with a strong focus on domestic needs. Implications of CBDCs, even if only intended for domestic use, are expected to go beyond borders, making it crucial to

¹¹ Central bank digital currencies: foundational principles and core features (<https://www.bis.org/publ/othp33.pdf>)

coordinate work and find common ground among CBDCs of various jurisdictions. If coordinated successfully, the ‘clean slate’ presented by CBDCs may be leveraged to enhance cross-border payments. According to BIS survey among central banks in late 2020, cross-border payments efficiency is an important motivation for CBDC issuance, especially with regards to wholesale CBDC projects. CBDCs can boost innovation in cross-border payments, making these transactions instantaneous and help overcome key challenges relating to time zone, exchange rate differences as well as legal and regulatory requirements across jurisdictions. Additionally, the interoperability of CBDCs presents means to mitigate cross-border and cross-currency risks and frictions while reinforcing the role of central bank money as an anchor for the payment system. Therefore, the potential use of CBDC in alleviating challenges in cross-border payment is one of the major motivations for exploring issuance of CBDC.

3.3.5 Support financial inclusion

The annual FI-Index for India for March 2022 is 56.4 vis-à-vis 53.9 in March 2021. It demonstrates the fact that despite various measures undertaken by various stakeholders in strengthening financial inclusion in the country, further coordinated effort is required by the policy makers to achieve the desired goal. Some of the existing challenges to financial inclusion include limited physical infrastructure - especially in remote areas, poor connectivity, non-availability of customized products, socio-cultural barriers, lack of integration of credit with livelihood activities or other financial services across insurance, pension etc. With suitable

design choices, CBDC may provide the public a safe sovereign digital money for meeting various transaction needs. It shall make financial services more accessible to the unbanked and underbanked population. The offline functionality as an option will allow CBDCs to be transacted without the internet and thus enable access in regions with poor or no internet connectivity. It shall also create digital footprints of the unbanked population in the financial system, which shall facilitate the easy availability of credit to them.

Universal access attributes of a CBDC including offline functionality, provision of universal access devices and compatibility across multiple devices, shall prove to be a gamechanger by improving the overall CBDC system for reasons of resilience, reach and financial inclusion.

3.3.6 Safeguard the trust of the common man in the national currency vis-à-vis proliferation of crypto assets

Christine Lagarde, President of the European Central Bank (ECB), chair of the group of central bank governors responsible for the report titled ‘Central bank digital currencies: foundational principles and core features’, while releasing the report stated that “... central banks have a duty to safeguard people's trust in our money. Central banks must complement their domestic efforts with close cooperation to guide the exploration of central bank digital currencies to identify reliable principles and encourage innovation.” The proliferation of crypto assets can pose significant risks related to Money Laundering & Financing of Terrorism. Further, the unabated use of crypto assets can be a

threat to the monetary policy objectives as it may lead to creation of a parallel economy and will likely undermine the monetary policy transmission and stability of the domestic currency. It will also adversely affect the enforcement of foreign exchange regulations, especially, the circumvention of capital flow measures.

Further, developing CBDC could provide the public a risk free virtual currency that will provide them legitimate benefits without the risks of dealing in private virtual currencies. It may, therefore, fulfil demand for secured digital currency besides protecting the public from the abnormal level of volatility which some of these virtual digital assets experience. Thus, safeguarding the trust of the common man in the Indian Rupee vis-à-vis proliferation of crypto asset is another important motivation for introducing CBDC.

Chapter 4 Design Consideration for CBDC

4.1 In the October 2020 report¹², the BIS, in collaboration with several leading central banks, outlined the core features and foundational principles of a CBDC. In formulating its foundational principles, BIS (2020) followed a risk-based approach. It highlighted the need to identify all potential risks associated with issuing a CBDC, particularly those that threaten financial stability or negatively impact financial market structures. BIS, thus outlined three important foundational principles for central banks to consider in issuing a CBDC:

- (i) It should not interfere with public policy objectives or prevent banks from performing their monetary stability mandate (a “do no harm” principle).
- (ii) It should be used alongside and complement existing forms of money (the coexistence principle).
- (iii) It should promote innovation and competition to increase the overall efficiency and accessibility of the payment system (the innovation and efficiency principle).

4.2 Considering the above principles, the design choices considered for issuing CBDCs are driven mainly by domestic circumstances. There will be no “one size fits all” approach to CBDC. A well-functioning CBDC will require an extremely resilient and secure infrastructure that can be scalable to support users on a massive scale. The design of CBDC is dependent on the functions it is expected to perform, and the design determines its implications for payment systems, monetary

policy as well as the structure and stability of the financial system. Given that designs and systems will differ by jurisdictions, so will the risk, which will require significant research by a central bank before implementation. A central bank should have robust means to mitigate any risks to financial stability before any CBDC is issued.

4.3 The key considerations that need to be borne in mind while making a design choice are discussed below. The committee recommended the followings in respect to these issues:

4.3.1 Types of CBDC

Based on the usage and the functions performed by the CBDC and considering the different levels of accessibility, CBDC can be demarcated into two broad types viz. general purpose (retail) (CBDC-R) and wholesale (CBDC-W).

CBDC-R is potentially available for use by all private sector, non-financial consumers and businesses. In contrast, wholesale CBDCs are designed for restricted access by financial institutions. CBDC-W could be used for improving the efficiency of interbank payments or securities settlement, as seen in Project Jasper (Canada) and Ubin (Singapore). Central banks interested in addressing financial inclusion are expected to consider issuing CBDC-R.

Further, CBDC–W has the potential to transform the settlement systems for financial transactions undertaken by banks in the G-Sec Segment, Inter-bank market and capital market more efficient and secure in terms of operational costs, use of collateral and liquidity

¹² Central bank digital currencies: foundational principles and core features (<https://www.bis.org/publ/othp33.pdf>)

management. Further, this would also provide coincident benefits such as avoidance of settlement guarantee infrastructure or the need for collateral to mitigate settlement risk.

According to a BIS report¹³, wholesale CBDCs are intended for the settlement of interbank transfers and related wholesale transactions. They serve the same purpose as reserves held at the central bank but with additional functionality. One example is the conditionality of payments, whereby a payment only settles if certain conditions are met. This could encompass a broad variety of conditional payment instructions, going far beyond today's delivery-versus-payment mechanism in real-time gross settlement (RTGS) systems. In effect, wholesale CBDCs could make central bank money programmable, to support automation and mitigate risks. Further, wholesale CBDCs would be implemented on new technology stacks. This clean-slate approach would let wholesale CBDC systems to be designed with international standards in mind to support interoperability.

CBDC-W could also be explored for the following:

1. Wholesale market for asset classes which are OTC and bilaterally or settled outside CCP arrangements- CPs, CDs, etc.
2. Access to retail for buying assets such as G-secs, CPs/CDs, primary auctions etc bypassing the bank account route

3. In case of g-secs, if assets are also tokenised, this could be extended to non-residents to investment in domestic asset classes.

The adoption will depend on exchanges and trading infrastructure being upgraded and CBDC-W to be integrated with RTGS. The adoption will also depend on whether the cost of CBDC-W settlement less than the cost of existing settlements including liquidity savings, guaranteed, margin funding etc.

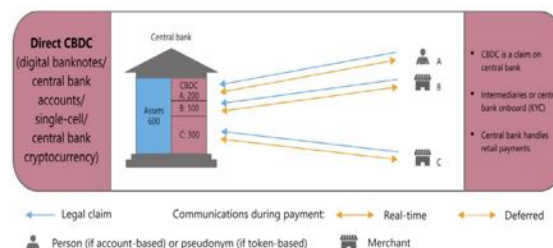
CBDC-R is an electronic version of cash primarily meant for retail consumption. India is already having a sound payment system with a different array of payment products ranging from RTGS, NEFT to UPI etc. coupled with an exponential increase in digital transactions. The introduction of CBDC-R will provide a safe, central bank instrument with direct access to the Central bank money for payment and settlement. It is also argued that it could also reinforce the resilience of a country's retail payment systems. CBDC can provide an alternative medium of making digital payments in case of operational and/or technical problems leading to disruption in other payment system infrastructures. CBDC could reduce the concentration of liquidity and credit risk in payment systems (Dyson and Hodgson (2016)). Looking at the different advantages of CBDC-W and CBDC-R, there may be merit in introducing both CBDC-W and CBDC-R.

4.3.2 Role of Central Bank and Other Entities: Who administers the CBDC

¹³ BIS Annual Economic Report June 2021

A key question in the design of a CBDC would be the respective roles of the central bank and the private sector in facilitating access to and use of a CBDC. There are three models for issuance and management of CBDCs across the globe. The key differences lie in the structure of legal claims and the record kept by the central bank.

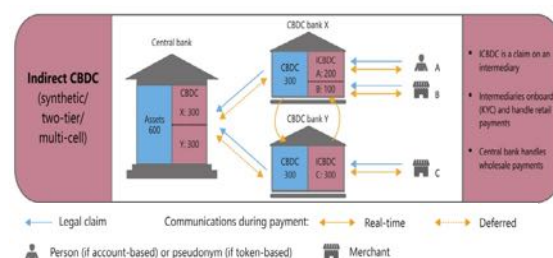
A) Single Tier model - This model is also known as “**Direct CBDC Model**”. A Direct CBDC system would be one where the central bank is responsible for managing all aspects of the CBDC system including issuance, account-keeping, transaction verification et. al. In this model, the central bank operates the retail ledger and therefore the central bank server is involved in all payments. In this model, the CBDC represents a direct claim on the central bank, which keeps a record of all balances and updates it with every transaction. It provides an advantage of a very resilient system as the central bank has complete knowledge of retail account balances which allows it to honour claims with ease since all the information needed for verification is readily available. The major disadvantage of this model is that it marginalises private sector involvement and hinders innovation in the payment system. This model is designed for disintermediation where central bank interacts directly with the end customers. This model has the potential to disrupt the current financial system and will put additional burden on the central banks in terms of managing customer on-boarding, KYC and AML checks, which may prove difficult and costly to the central bank.



(Figure 5: Direct Model, Source: Bank for International Settlements (BIS))

B) Two -Tier Model (Intermediate model) The inefficiency associated with the Single tier model demands that CBDCs are designed as part of a two-tier system, where the central bank and other service providers, each play their respective role. There are two models under the intermediate architecture viz. Indirect model and Hybrid Model.

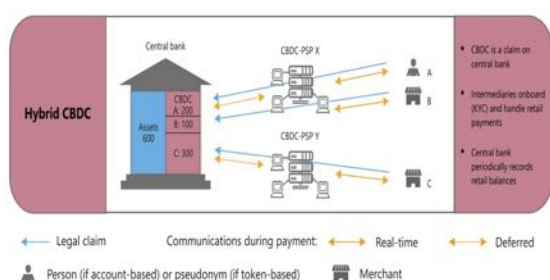
Indirect Model- In the “indirect CBDC” model, consumers would hold their CBDC in an account/ wallet with a bank, or service provider. The obligation to provide CBDC on demand would fall on the intermediary rather than the central bank. The central bank would track only the wholesale CBDC balances of the intermediaries. The central bank must ensure that the wholesale CBDC balances is identical with all the retail balances available with the retail customers.



(Figure 6: Indirect Model, Source: Bank for International Settlements (BIS))

Hybrid Model- In the Hybrid model, a direct claim on the central bank is combined with a private sector messaging layer. The central

bank will issue CBDC to other entities which shall make those entities then responsible for all customer-associated activities. Under this model, commercial intermediaries (payment service providers) provide retail services to end users, but the central bank retains a ledger of retail transactions.



(Figure 7: Hybrid Model Source: BIS)

This architecture runs on two engines: intermediaries handle retail payments, but the CBDC is a direct claim on the central bank, which also keeps a central ledger of all transactions and operates a backup technical infrastructure allowing it to restart the payment system if intermediaries run into insolvency or technical outages.

Comparison of three models

Aspect	Direct	Indirect	Hybrid
Liability	Central Bank	Central Bank	Central Bank
Issuer	Central Bank	Central Bank issues and intermediaries distribute it	Central Bank Issues and Intermediaries distribute it for retail use
Operations	Central Bank	Intermediaries	Intermediaries
Ledger	Central Bank	Intermediaries	Intermediaries as well as Central Bank
Settlement Finality	Yes	No	Yes

(Figure 8: Source: RBI Internal)

Considering the merits of different models, the Indirect system may be the most suitable architecture for introduction of CBDC in India.

As per the RBI Act, 1934, the Reserve Bank has the sole right to issue bank notes, which has now been amended to include currency in digital form also. Therefore, in this model, RBI will create and issue tokens to authorised entities called Token Service Providers (TSPs) who in turn will distribute these to end-users who take part in retail transactions. The rationale behind the same are as given below:

- (i) In the entire supply chain, there are a wide range of customer-facing activities where the central bank is unlikely to have a comparative and competitive advantage as compared to banks, especially in an environment where technology is changing rapidly, which inter-alia includes distribution of CBDCs to public, account-keeping services, customer verification such as KYC and adherence to AML/CFT checks, transaction verification, etc .
- (ii) Banks and other such entities have the expertise and experience to provide these services.
- (iii) These entities can provide their customers with the ability to transact in and out of CBDC and thus can enrich the customer experience and may facilitate wider adoption of CBDCs.

4.3.3 Instrument Design - Should CBDCs bear interest?

The economic design of CBDC could depend on the purpose of the CBDC and the technologies and entities involved. For example, most discussions around retail CBDC envisage it being introduced primarily as a method of payment like cash, with the presumption that it would not bear interest.

Remunerated CBDC

The payment of (positive) interest would likely to enhance the attractiveness of an instrument that also serves as a store of value. Some proponents support interest bearing CBDCs as it could improve the effectiveness of monetary policy by shifting the transmission leg from overnight money market rate to directly deposit rate (or CBDC as a substitute of deposits), strengthening the pass-through of the central bank's policy rate to the broader structure of interest rates in the financial system. But, designing a CBDC that moves away from cash-like attributes to a "deposit-like" CBDC could lead to a massive disintermediation in the financial system resulting from loss of deposits by banks, impeding their credit creation capacity in the economy. Further, in such a scenario, banks may be compelled to increase deposit rates, thus increasing their costs of funding and a decrease in Net Interest Income. As a response to this, banks could be motivated to pass on these additional costs to borrowers or resort to engage in riskier activities in search of higher returns. Moreover, banks would need to maintain additional liquidity buffers to support CBDC demand, as access to large central bank and money market liquidity would need to be backed by eligible collaterals. One possible way to mitigate the risk of disintermediation is to impose a cap or limit on individual holdings but these features will reduce the attractiveness and wide acceptability of CBDCs along with adding complexities to the CBDC system.

Non – remunerated CBDC

If a CBDC is designed to be non-interest bearing, the public would have less incentive to switch from holding bank deposits to CBDC, and the effect of banking disintermediation would then be limited. The Bahamas and China currently do not pay interest on CBDC holdings. In both the cases, the reason is to limit CBDC competing with bank deposits. If there is no interest, CBDC can still be attractive as a medium of payment, even while its attractiveness as a store of value (savings instrument) diminishes. Further, a non-interest bearing CBDCs can avoid a major disruption to banking services and a possible disintermediation of banks. However, there is still a concern expressed in some quarters that there could be a possibility of shifting of some of the current accounts maintained by corporates and business entities with banks in favour of CBDC to gain access to central bank money. We believe that the current account is a relationship based and their association with banks is a function of multiple services offered to them and thus it is anticipated that scale of bank intermediation will be low for such deposits.

In a nutshell, the economic design of a CBDC should be least disruptive to the existing financial system. Moreover, CBDCs are electronic form of sovereign currency and should imbibe all the possible features of currency. Since, physical cash does not carry any interest it would be logical to offer Non-Interest bearing CBDCs. Banks would restrain themselves from distributing CBDCs if they find it as a threat to their bank deposits which can

hamper credit flows and adoption of CBDCs. Further, to begin with, many jurisdictions have opted to limit the holdings of CBDCs available to the public for transactional purposes (in wallets) to put a cap on the scale of disintermediation, as it is expected to be least disruptive.

Trade-off: A more effective CBDC vs more dynamic monetary policy transmission

Although a non-interest bearing CBDCs can avoid major disruption to banking services and a possible disintermediation of banks, the trade off with this consideration is that a non-interest bearing CBDC may not improve the monetary policy transmission in India. The trade-off challenge for policy resulting from interest bearing CBDC is between improved interest rate transmission and a clogged credit market resulting from financial disintermediation. Since the interest rate channel of transmission must operate by influencing the credit conditions and financial flows to the productive sectors of the economy, and non-interest bearing CBDC will not hamper the existing transmission dynamics, avoiding any scope for financial disintermediation should be the prime objective while dealing with this trade-off.

This can be achieved by setting a conversion limit between deposits or cash to CBDC or paying no interest or lower interest rates on CBDC relative to bank deposits.

4.3.4 Account-based or token-based?

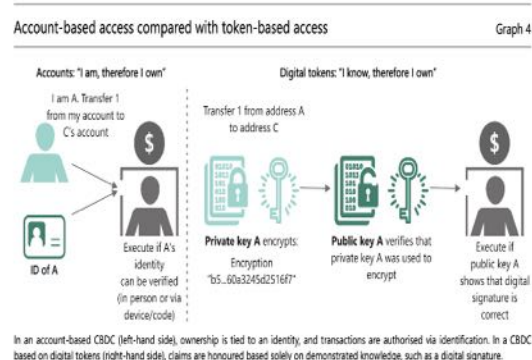
CBDC can be structured as ‘token’ or ‘account’ based or a combination of both.

Token vs Account

(i) A token-based CBDC system would involve a type of digital token issued by and representing a claim on the central bank and would effectively function as the digital equivalent of a banknote that could be transferred electronically from one holder to another. A token CBDC is a “bearer-instrument” like banknotes, meaning that whoever ‘holds’ the tokens at a given point in time would be presumed to own them. In contrast, an account-based system would require the keeping of a record of balances and transactions of all holders of the CBDC and indicate the ownership of the monetary balances.

(ii) Another difference between tokens and accounts is in their verification: a person receiving a token will verify that his ownership of the token is genuine, whereas an intermediary verifies the identity of an account holder. Transactions in account-based system would involve transferring CBDC balances from one account to another and would depend on the ability to verify that a payer had the authority to use the account and that they had a sufficient balance in their account. Transactions in token-based CBDC might only depend on the ability to verify the authenticity of the token (to avoid counterfeits just as in the case of a paper currency) rather than establishing the account holder’s identity.

(iii) In an account-based CBDC system, during the initial creation of each CBDC account, the identity of the account holder would need to be verified and from that point onward, payment transactions could be conducted rapidly and securely. By contrast, in a token-based system, the entire chain of ownership of every token must be stored in an encrypted ledger. In case of tokens on distributed ledger, new payment transactions are collected into blocks that must be verified before being added permanently to the ledger.



(Figure:9, Source: BIS Quarterly Review, March 2020)

The CBDC-W may be issued in account-based form, as legally, it attempts to offer instant settlement and their legal status is well understood and established. Moreover, the use case of CBDC-W warrants them to be account based to facilitate the transactions.

CBDC-R is mainly devised for consumption of common public with features akin to physical cash viz. anonymous, unique serial number etc. A token-based system would ensure universal access – as anybody can obtain a digital signature – and it would offer good privacy by default. Moreover, the token generated will have a unique token number which will enable the detection of counterfeiting of tokens and potentially also the restoration of value if an individual loses the device. Under a token-based CBDC-R regime, users would be able to withdraw digital tokens from banks in the same way they can withdraw physical cash. They would maintain their digital tokens in a wallet and could spend them online or in person or transfer them via an app. The token based CBDC also supports innovation with an ability to include programmable feature that supports efficiency such as standardisation of compliance rules, fraud detection, wrapped CBDC to other use cases in future. Further, token-based CBDC-R can be used to accomplish financial inclusion goals.

4.3.5 Anonymity¹⁴ - What degree of privacy would apply and who could hold CBDC?

For CBDC to substitute currency as a medium of exchange, it needs to incorporate all the features that physical currency represents –

anonymity (that currency transactions can be carried out without maintaining evidence of transacting parties), universality (that currency can be used for any transaction) and finality (that payment of currency unconditionally settles the transaction). Ensuring anonymity for a digital currency particularly represents a challenge, as all digital transactions leave a trail. Clearly, the degree of anonymity would be a key design decision for any CBDC and there has been significant debate on this issue. Most central banks and other observers have, however, noted that the potential for anonymous digital currency to facilitate shadow-economy and illegal transactions, makes it highly unlikely that any CBDC would be designed to fully match the levels of anonymity and privacy currently available with physical cash. An intermediate degree of privacy may be thought of and can also be possible. For example, the European Central Bank (2019) has experimented with the concept of a CBDC with elements of programmable money, by which individuals could be allotted a certain amount of ‘anonymity vouchers’ that could be used for small transactions, with larger transactions still visible to financial intermediaries and the authorities, including those responsible for AML and CFT.

¹⁴ <https://www.rba.gov.au/speeches/2020/sp-so-2020-10-14.html>

Trade-off: Anonymity vs AML/CFT compliance

Anonymity is one of the key traits of cash, and the rise of digital payments threatens the lawful or legitimate preference for anonymity as they leave digital trails. The anonymity will expand the user base for CBDC and will increase its acceptability and usage, but it is seen as a potential risk in the digital ecosystem. Anonymity can also be used for illicit purposes and can undermine AML/CFT measures. Anonymity, therefore, poses a policy trade-off—the more anonymous, the larger the risk for illicit use.

Considering the potential risks associated with privacy and anonymity, the idea of complete anonymity in digital world is a misnomer. To what extent a Central Bank should allow spending in digital currency to be anonymous is an open question. However, the principle of Managed Anonymity may be followed i.e., “anonymity for small value and traceable for high value,” akin to anonymity associated with physical cash. The importance of protecting personal information and data privacy needs to be considered to foster usability and wider adoption.

4.4 Fixed Denomination vs minimum Value based CBDCs

A token based CBDC may be issued either with minimum value or fixed denominations akin to existing physical currency denominations. The usage of minimum value of token may result in higher volume and, thus, lead to increase in processing time and performance issues. Further, the physical appearance (touch and feel) of cash in India imparts trust to public to undertake cash transactions. The introduction of CBDC with fixed Denomination as in physical currencies in denominations of Rs. 500, 100, 50 etc., shall facilitate in building the same level of trust and experience among public albeit in digital form. This similarity with existing currency is expected to induce wider acceptance and adoption of CBDC. Moreover, the fixed denomination CBDC shall facilitate transactions by way of exchange management of tokens in permissible legal tender of the country with help of TSPs. Therefore, introduction of fixed

denomination CBDC is presently considered as preferable taking into account the Indian scenario.

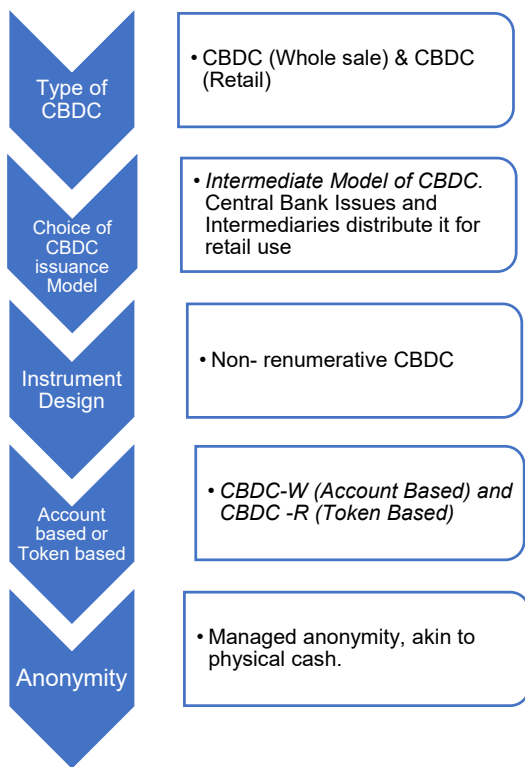
4.5 Summary of Design Features

The table below summarises the design features under consideration or deployed by the six central banks.

	Carry Interest or Not	Quantitative Restrictions	Anonymity	Offline	Cross-Border Payments
Bahamas	No	Yes	For lower tier	Yes /exploring	Future project
Canada	Undecided	Undecided	Undecided	Exploring	International collaboration
China	No	Yes	For lower tier	Yes	Experimenting /international collaboration
ECCU	No	Yes	For lower tier	No	Future project
Sweden	Undecided	Exploring	Undecided	Exploring	International collaboration
Uruguay	No	Yes	Yes, but traceable	No	Possible future project

(Figure:10, Source: IMF FinTech Notes (February 2022))

4.6 Preferred Design Choices: snapshot



(Figure:11: Design Choices snapshot)

Chapter 5: Technology Considerations for CBDC

5.1 CBDC being digital in nature, technology considerations shall always remain at its core. Technology is what will constitute any CBDC and technology is what will translate the abstract policy objectives to concrete forms. Having discussed the motivations and possible implications of CBDC, it is apt to deliberate on the technology considerations of the digital currency. While the “Why” has been discussed in previous chapters, the current chapter will focus on “How”.

The technical principle underlying the deployment of CBDC to achieve the intended objectives may include:

- i. Strong cybersecurity, technical stability and resilience.
- ii. Sound technical governance

The first and fundamental question that needs to be answered is the choice of technology platform. The platform can either be a distributed ledger or a centralised system. In addition to platform choices, other technical considerations shall flow from the policy imperatives. For example, if one of the motivations behind introduction of CBDC is financial inclusion, it should support offline capability. Further, the security aspects of CBDC shall also determine its resilience and will be necessary for robust, secured implementation. The business continuity planning will also need to be embedded in the technology architecture. In the end, the environment and energy intensiveness concerns shall also need to be factored while designing the technology choices.

5.2 Choice of Technology Platform

5.2.1 Platform features

CBDC should be developed in India as a large-scale enterprise-class digital platform which may have the following features:

- Highly scalable to support very high volume and rate of transactions without performance degradation.
- Robust to ensure stability of financial ecosystem
- Tamper-proof access control protocols and Cryptography for safety of data, both CBDC and transactional data
- Cross platform support, to allow development of large variety of client applications using CBDC for financial services
- Ability to integrate with other IT platforms in the financial ecosystem must be at the core of platform design
- Configurable workflows for quick implementation of policy level directives issued by RBI from time to time
- Comprehensive administration, reporting, and data analytics utilities
- Highly evolved fraud monitoring framework to prevent occurrence of financial frauds

5.2.2 Technology Architecture Options

5.2.2.1 Large scale digital platforms using traditional client-server architecture have been successfully implemented across the world in the banking, retail, health, and other sectors. These platforms provide all the platform features described in the earlier paragraphs but in the case of CBDC, careful planning is

required on account of following key requirements:

- a) *Zero downtime*, to keep the economy functioning
- b) *Zero frauds*, to prevent destabilization of the economy
- c) *Decentralization*, for effective participation of the ecosystem
- d) Need for confidentiality, authentication, data integrity, and non-repudiation
- e) *High volume and rate of Transactions*, will be a key requirement of the ecosystem partners to avoid choking of the CBDC platform resulting in delays in completing financial transactions
- f) *Design for unpredictable workloads*, the platform must handle both lean and peak load periods in a cost-effective manner.
- g) *Zero loss due to Distributed Denial of Service (DDoS) and other brute cyberattacks*
- h) *Mission Critical approach*, to meet all the above key requirements

5.2.2.2 DLT or non-DLT

The infrastructure selected for implementing CBDC could be based on a conventional centrally controlled database, or on a distributed ledger. Conventional and Distributed Ledger Technology (DLT)-based infrastructures often store data multiple times and in separate physical locations. However, the key difference between conventional and DLT based infrastructure lies in how data is updated. In conventional databases, resilience is ensured by storing data over multiple physical nodes, which are controlled by one authoritative central entity, i.e., the top node of the hierarchy. On the other hand, in DLT-based systems, the ledger is

usually managed jointly by multiple entities in a decentralised manner and each update needs to be harmonised amongst the nodes of all entities without the requirement of a top node. This consensus mechanism requires additional overhead which is the primary reason why DLTs enables lower transactions than conventional architectures. Given the above, DLT at this point of time, is not considered suitable technology except in very small jurisdictions, given the probable low volume of data throughput. However, DLT could be considered for the indirect or hybrid CBDC architecture. Further, it may also be possible that some layers of the CBDC tech stack can be on centralized system and remaining on distributed networks. The choice of tech architecture shall also factor in the resource intensiveness and energy efficiency associated with the solutions.

5.3 Scalability

It is expected that every CBDC project will start with a limited scale pilot and would subsequently be scaled up at population scale. Despite being a limited pilot, it will always be essential that the system should be designed so that it can be extended in the future and used in production or large-scale deployments. To begin with, the system should be able to accommodate the likely volume of transactions (Billions per day) involved in a large-scale deployment. The architecture should not be redesigned or reworked to achieve this. Additionally, the system should be designed so that it can be expanded in the future without needing to be redesigned or reworked.

5.4 Trusted Environment

It is essential that entire lifecycle of CBDC should be within an end-to-end trusted environment. It can be achieved by ensuring that Double-spend and malicious token creation or manipulation is avoided, monitored and checked regularly. It also needs to be confirmed that data is shared only with the relevant parties and does not need to be shared across the whole network (distributed or otherwise) for verification. Further, systemic checks through third party validation should ensure that in case of a token system, only such tokens issued by the Central bank are circulating in the ecosystem. Additionally, a competent party should be able to verify identity information before a participant is allowed to join the CBDC network.

Policy related Tech Considerations

5.5 Recoverability

In case of account-based models, the issue of recoverability does not arise as the identity of user shall always be available where the account is held. In the case of token-based models, based on whether CBDCs will be recoverable or not, the system can support two types of wallets based on User Consent:

- *Custodian Model* – Token service provider (TSP) is responsible for managing the keys of wallet holding tokens on behalf of user. In this model, wallet is recoverable with same public address, Wallet Pin and Tokens held by user. Since the user details are held in custody by the service provider, the security of the tokens shall be dependent on the

robustness of security protocols of the TSP. While dependency on external entity shall allow recoverability, it may also compromise with anonymity as the service provider shall always have visibility over the token movements in and out of the wallet.

- *User Held Model* – The responsibility of key holding is with User and its device. Wallet is not recoverable in case of loss of user held device.

5.6 Offline Functionality

Digital payments traditionally rely on online communications with several intermediaries such as banks, payment networks, and payment processors to authorise and process payment transactions. While these communication networks are designed to be highly available with continuous uptime, there may be times when CBDC users will experience little or no access to network connectivity.

In India out of the 1.4 billion (143.3 crores) population, 825 million people have internet access. This means many Indians will not be able to use CBDCs due to connectivity unavailability. To ensure widespread use of CBDC, offline capabilities need to be incorporated.

The Bank of Japan (BoJ) has published a research paper¹⁵ exploring the potential offline use of a digital yen using central bank digital currency (CBDC). Some of the solutions examined in the paper include using a chip (IC) on a SIM card but with a feature phone rather than a smartphone. The paper concludes that these solutions may not be very user friendly.

¹⁵ Payment and Settlement Systems Report, Bank of Japan, <https://www.boj.or.jp/research/brp/psr/data/psrb200702.pdf>

BoJ also explored the potential use of PASMO/Suica cards, which are used for railway and transport ticket passes as well as electronic money.

Visa¹⁶ has also proposed an Offline Payment System (OPS). The protocol outlined by Visa allows CBDCs to be directly downloaded onto a personal device, such as a smartphone or tablet. The money is stored on a secure hardware embedded in that device and managed by a wallet provider. The CBDC can be transacted from one device to another device directly without any intermediaries such as banks, payment networks, or payment processors using Bluetooth and Near Field Communication. However, Visa's solution does not account for double spending of tokens.

In offline mode, the risk of "double-spending" will exist because it will be technically possible to use a CBDC unit more than once without updating the common ledger of CBDC, however, the same can be mitigated to a larger extent by technical solutions and appropriate business rules including monetary limit on offline transactions.

The use of offline transactions would be beneficial in remote locations and offer availability and resilience benefits when electrical power or mobile network is not available. For offline transactions, the wallets must be able to independently verify the authenticity of any CBDC transaction without communicating with the server during the transactions. It may be highlighted that even in

the case of offline transactions, there would still be a periodic need for power and network connectivity to reload or redeem CBDC balances or to synchronize the local wallet balances with central servers.

It is thus desirable that CBDC should have offline capabilities, without which it will not prove to be an attractive and accessible medium of payment for a wide category of users.

It is essential to devise uniform standards and protocols for the offline exchange of CBDC. To make sure that these standards and protocols are robust and future ready, it is necessary to have extensive industry consultation.

5.7 Programmability

One interesting application of CBDC is the technical possibility of programmability. CBDCs have the possibility of programming the money by tying the end use. For example, agriculture credit by banks can be programmed to ensure that is used only at input store outlets. Similarly, for MSMEs etc., that may take care of the issue of diversion of funds and further financial inclusion. This may help in ensuring the end-use which banks have to continuously grapple with across the globe. However, the programmability feature of CBDC needs to be carefully examined in order to retain the essential features of a currency. It can also have other implications for monetary policy transmission as tokens may have an expiry date, by which they would need to be spent, thus ensuring consumption. The programmability of tokens can be achieved using the following:

¹⁶ Finding a secure solution for offline use of

central bank digital currencies (CBDCs),
<https://usa.visa.com/dam/VCOM/global/sites/visa-economic-empowerment-institute/documents/veei-secure-offline-cbdc.pdf>

- Smart contracts: Business rules are stored as code that is executed during transactions to verify that the token is being used correctly.
- Token version: The version of the token can be tightly linked to the technical code class. The alternative is that the version is stored as a token data field.

5.8 Integration with existing Payment Systems and interoperability: Domestic and Cross-Border

India is leading the world in terms of digital payments innovations. Its payment systems are available 24X7, available to both retail and wholesale customers, they are largely real-time, and the cost of transaction is perhaps the lowest in the world.

An Indian CBDC should be able to utilise the current payments infrastructure like UPI, digital wallets like Paytm, Gpay etc. Interoperability between payment systems contributes to achieving adoption, co-existence, innovation, and efficiency for end users. It would be key to integrate a CBDC into the broader payments landscape of India which would possibly help drive end user adoption (both for the public and merchants). This will obviate the need for the creation of a parallel acceptance infrastructure. RBI would have options in how it plans to achieve interoperability, from the use of established messaging, data, and other technical standards to building technical interfaces to communicate with other systems. Integration between systems through APIs shall

allow a light yet secure inter-operable architecture. It will be necessary to ensure the robustness of APIs as well for heightened cyber-security. Yet barriers to interoperability would likely to exist, covering technical, commercial, and legal aspects. Dialogue with stakeholders would be key in addressing these. Achieving interoperability is a collaborative process and will require the active involvement of all industry players in the Indian payments landscape.

Cross Border Payments Enabler

When engaging in cross- border CBDC transactions, RBI will sometimes deal with different networks for each major currency transaction. Here, interoperability between networks will become important. Being able to conduct exchanges of assets in coordinated transactions across two different ledgers (centralized or decentralized), without requiring an intermediary, will help enhance efficiency and mitigate risk. An example of wholesale CBDC involving different currencies is the BIS innovation hub project involving the central banks of China, Hong Kong, United Arab Emirates and Thailand collaborating on the Multiple Central Bank Digital Currency (m-CBDC) Bridge Project¹⁷. This project aims to develop an international settlement platform through which central banks can utilise CBDC for transactions by financial institutions. The mCBDC project would enable cross-border payments that can be done in real-time between the four jurisdictions 24X7, with the foreign exchange leg settled in real time.

¹⁷ Multiple CBDC (mCBDC) Bridge, https://www.bis.org/about/bisih/topics/cbdc/mcbdc_bridge.htm

Similarly, Project Dunbar brings together the Reserve Bank of Australia, Bank Negara Malaysia, Monetary Authority of Singapore, and South African Reserve Bank with the BIS Innovation Hub to test the use of CBDCs for international settlements.

In case of different jurisdictions functioning with two disparate technical architecture, interoperability can be achieved through a common bridge that is able to standardize the inputs and outputs from different systems in a common form understandable to every stakeholder. Such a bridge shall also need to configure various country specific regulations related to access, and legislations relating to foreign exchange, respective jurisdictional boundaries, governance issues etc. Various control mechanisms would also need to be put to prevent any spillover effects in an interconnected global world.

It may, thus, be preferred if a jurisdiction works on developing the robust standards required to enable interoperability between CBDC with the existing or proposed payment systems. Collaboration with stakeholders including with BIS on developing common global standards for facilitating easy cross-border transactions, will be a way forward.

5.9 Security Considerations

CBDC ecosystems may be at similar risk for cyber-attacks as the current payment systems are exposed to. The cybersecurity considerations need to be taken care of both for the item and the environment. For example, while the token creation process should ensure the highest levels of the cryptography to ensure

security at the item level, the transaction of tokens also needs to be secured to ensure trusted environment.

5.9.1 Further, in countries with lower financial literacy levels, the increase in digital payment related frauds may also spread to CBDCs. Ensuring high standards of cybersecurity and parallel efforts on financial literacy is therefore essential for any country dealing with CBDC. It is also understood that the CBDC ecosystem would be a high value target owing to its significance for maintaining public trust.

5.9.2 Much of the plans to address cyber risks would depend on the underlying technology. Public blockchains preserve transparency but that does not provide cyber security by itself. On the other hand, centralised systems will have the same cyber security concerns as is applicable to the existing Fast Payment Systems (FPS). While the plan to address cyber risks shall be very specific as per respective cases, certain principles that can be applied for CBDCs are:

- (i) Security has to be the prime design concern while designing CBDCs **since inception**.
- (ii) Users with privileged roles within the CBDC network should be made subject to an **enhanced risk management framework**.
- (iii) While the back-end infrastructure shall certainly be robust, the user interface should also be **rigorously tested** to prevent the exploitation of any vulnerabilities.
- (iv) **Vertical Segmentation & No Single Point of Failure**: The entire CBDC eco-

system would be segregated into different segments like wholesale or retail, with different forms like account based or token based which will not have any single point of failure. Any breach in one segment will not automatically affect other segments.

- (v) **Cryptography & Quantum Resistance:** CBDCs shall be using cryptography that will render the system safer as compared to the existing payment infrastructure. However, the futuristic scenario of tackling quantum resistance also needs to be factored in while designing the CBDCs. Quantum computers are machines whose processing power far outstrips even the most powerful supercomputers available today. Quantum-resistant algorithms — also known as post-quantum, quantum-secure, and quantum-safe — are cryptographic algorithms that can fend off attacks from quantum computers. Every CBDC will aim to be resistant to quantum computing. Therefore, robustness of cryptographic techniques along with that of other encryption methods and ensuring quantum resistance shall be highly important to have a safe and secure CBDC technical infrastructure.
- (vi) **Recall Feature:** In case any specific series of tokens get hacked, it may be technically possible to recall them on an instant basis or release new security features digitally.
- (vii) **Recoverability:** The CBDCs would need to factor in the principle of

recoverability, as per which even if the system gets breached, it should be resilient enough to recover as soon as possible. Further, to the maximum extent possible, the adverse impact on production systems and business processes should be minimised. The use of APIs (Application Program Interfaces) facilitate interaction with required currency management systems at central banks and token service providers.

Therefore, in addition to technology solutions, security risks would also need to be mitigated through policy calls like putting caps, enhanced risk management and governance framework and rigorous testing of functionalities through pilot before rolling out the CBDCs for public.

5.10 Data Analytics

The CBDC platform is expected to generate huge sets of data in real time. After factoring in the concerns related to anonymity, appropriate analytics of Big Data generated from CBDC can assist in evidence-based policy making. It may also become a rich data source for service providers for financial product insights. Further, the data would be highly useful for enforcing money laundering regulations. It may also generate intelligent leads that may assist in curbing non-compliance of existing rules and regulations, thus assisting in risk-based approach to curb money laundering by identifying potential risks and assisting in developing strategies to mitigate them

5.11 Technology choices

It is, therefore, imperative that while crystallising the design choices in the initial stages, the

technical choices should not be frozen. As technology evolves, the policy related, and security related considerations shall also change. Therefore, it is necessary to have an open-ended flexible approach while zeroing in on the technical choices. It is also necessary that while engaging any technology service provider, there should not be a vendor lock in and in case any proprietary systems are being used, there should be enabling clauses to allow complete ownership by the Central Bank. Further, Central Banks shall be issuing CBDCs based on algorithm driven processes rather mining through competitive reward methods. These algorithms shall have energy efficiency and environment friendliness as their core principles. Therefore, issuance and management of CBDCs is expected to have much lesser energy consumption vis-à-vis more energy intensive processes normally associated with mining and distribution of private cryptocurrencies. Therefore, technology choice also needs to factor the resource intensiveness of the system.

5.12 Ownership on creation and distribution of CBDCs

For the purpose of creating CBDCs, RBI can either do it internally or create a separate technical subsidiary for the same. For distributing CBDCs, external agencies can certainly be engaged.

Chapter 6: Other Considerations

6.1 Resource Intensiveness

The resource intensiveness also needs to be factored in while designing the technology architecture of CBDC. In the case of centralised systems, the resource consumption shall be comparable with that of existing payment systems. In the case of distributed systems, much would depend on whether there is any consensus protocol and if there is one, whether it is a highly resource intensive one like “Proof of Work” or otherwise. It is generally understood that CBDCs would not be “mined” as is understood in the context of private cryptocurrencies, wherein, any individual can compete to mine and create the cryptocurrency. In the case of CBDC, it will only be the sovereign/ central bank that would be competent and authorised to issue the CBDC and can simply opt for conversion of the bank’s existing balances to CBDC balances. However, in the case of token-based systems, unique tokens based on agreed techniques would need to be created, which may be slightly resource intensive. Further, the energy consumption in case of validating the transactions and their storage on the distributed or centralised systems shall also need to be accounted for while determining the resource intensiveness of the CBDC eco-system.

6.2 Business Continuity Planning

As CBDCs would carry the sovereign guarantee, the Business Continuity Planning of CBDC would need to be of a higher standard as compared to the existing payment infrastructure or other banking systems. The business

continuity aspects would need to be implemented at the central bank, intermediary and third-party service provider levels. Requirements in this regard would need to be set and overseen to ensure high standards.

6.3 Consumer protection and Grievance Handling

6.3.1 CBDC being digital in nature is likely to bring with itself the issues relating to consumer protection issues for its users. Positive outcomes of CBDC includes greater access to, and choice of products and services available at lower costs, expanded speed, convenience. The risks include digital fraud, data breaches, lack of privacy and digital security incidents etc. Considering the CBDC architecture and technological design considerations, the major consumer related risks associated with CBDC may be summarised as under:

- (i) Privacy risk: The wide adoption of CBDC poses the entire ecosystem to enhanced privacy risk as the CBDC provides anonymity and privacy up to a certain extent. The design principles of the CBDC will determine the extent of privacy risk posed to the consumers as well as the potential ways to mitigate the risk.
- (ii) Security and technology risks: The technology design of the CBDC will be a determinant of the security risk posed to the users. Several issues regarding how security protocols are designed, as well as how they are technically implemented would prove critical for the safety and soundness of the products/ services. Given that a detailed technical understanding of the systems underlying issuance of CBDC will be beyond the understanding of an

average consumer, appropriate technical and audit standards may be necessary to neutralize technical impediments which can indirectly cause consumer risk.

(iii) **Accountability Risk:** The identification of who is accountable to consumers in case of loss is crucial and a core issue in respect of the consumer protections associated risk.

6.3.2 The consumer protection is an important pillar of the financial stability as it aids in building and maintaining consumer confidence and trust in financial markets and helps to promote efficiency and stability which in turn create positive outcomes for both financial institutions and their customers. The customer protection framework for CBDC must consider the variations in the digital literacy of consumers and ways to increase consumer understanding and transparency so that an informed choice is made by them while adopting the CBDC. The central bank must ensure that both the infrastructure and participants of a CBDC system should be extremely resistant to cyber-attacks and other threats. This should also include ensuring effective protection from counterfeiting.

6.3.3 With an objective to maintain the trust of the public in the CBDC, it is essential that the CBDC system of the country is scalable enough to meet the demands of the CBDC by public. The intermediaries should also be able to fulfil their obligations of meeting the demand.. Further, the access to CBDC for initiating a transaction by public should be seamless. Moreover, the digital nature of CBDC may lead to origination of various type of customer

grievances such as deficiency in service by the intermediaries, technical disruption in supply of CBDC, transaction etc. The effective and efficient resolution of customer grievances will play a key role in facilitating adoption of CBDC by the public. The scope of CBDC related grievance may be covered under a robust and efficient grievance redressal mechanism.

Chapter 7 Policy Implication of introduction of CBDC

7.1 Implications of CBDC for Monetary Policy

7.1.1 According to BIS CPMI-MC Report (2018), CBDC does not alter the basic mechanics of monetary policy; rather, it has the potential to enable timely transmission of monetary policy. The implications of central bank digital currency (CBDC) for monetary policy essentially depends on the way it is designed and its degree of usage. In particular, it would depend on the following policy decisions:

- (i) whether CBDC will be non-remunerated or remunerated;
- (ii) whether it would be widely accessible just like physical currency, or limited to wholesale customers such as banks (as in the case of central bank reserves); and
- (iii) whether it will be anonymous like physical currency or ownership will be identifiable, which leaves the trail of different entries.

7.1.2 If the CBDC could function like physical cash and fetch no interest income, in normal times, economic agents would prefer to keep their money in interest bearing bank deposits as opposed to CBDC. However, in the tail-risk event of economic instability or a system-wide bank run, CBDC could be viewed as a safer substitute of bank deposits. It is fully guaranteed by the central bank with no risk of losing its face value and easily stored in large amounts. This easy switch to CBDC can potentially speed up a bank run. The consequent impairment to financial intermediation would directly weaken the efficacy of monetary policy. An associated reduction in the availability, and/or an increase

in the cost of credit from the banking sector would likely to have important consequences for both aggregate supply and demand in the economy. Any fall in the total amount of bank lending would also lessen the importance of bank lending in the overall transmission of monetary policy. However, such issues can be addressed by ensuring limits on CBDC holdings and transactions.

7.1.3 Another school of thought advocates that interest bearing CBDC could transmit monetary policy actions directly to economic agents, increasing the efficiency of monetary policy. Under this modality, economic agents could also switch to CBDC from bank deposits, which could lead to a deposit outflow. This outflow of deposits (or banks' durable liquidity) to CBDC could motivate banks to compete for deposits, which in turn could increase deposit rates and thus also retail lending rates, despite no increase in the policy rate. To avert this risk, the central bank may have to pro-actively inject larger durable liquidity to the banking system more regularly.

7.1.4 In conclusion, the potential impact on monetary policy from an introduction of CBDC is still unclear and is purely speculative given that only limited CBDCs are currently in existence as few nations have issued till date.

7.2 Implications of CBDC for Liquidity Management

7.2.1 CBDC – like physical currency – will be an autonomous source of system wide change in liquidity which needs to be projected by the central bank to plan and execute its

‘discretionary’ liquidity (injection/absorption) measures. An increase in demand for CBDC (just as an increase in demand for physical cash) is a leakage (of deposits) from the banking system. The change in form of the currency (from physical to digital) may bring about a change in the behaviour of public holding of money (i.e., currency versus deposits, and within currency between physical and digital). The nature of change cannot be gauged *a priori* given that most of the central banks are still exploring issuance of CBDCs.

7.2.2 There would be a much larger impact on reserve money, money supply and net demand and time liabilities (NDTL) of banks if CBDC is remunerated because of potential scope for substitution of deposits of commercial banks by CBDCs. Consequently, commercial banks will be constrained for funds and rely more on central bank liquidity provisions. As a result, the central bank balance sheet will get bloated increasing reserve money due to financial disintermediation. Non-remunerated CBDC can significantly minimise potential disruptions to monetary policy and the financial intermediation process. Interest bearing CBDC, in turn, would require a comprehensive review of the operating framework of monetary policy, and even the monetary policy framework, as that would require a decision on the rate of interest to be paid on CBDC, and also to deal with the challenge of financial disintermediation.

7.2.3 The impact of CBDC on key monetary variables can be summarised as:

Impact of CBDC on Monetary Variables

Impact on	Non-remunerated CBDCs	Remunerated CBDCs
Reserve Money	Yes/No	Yes
Money Supply	No	Yes
Velocity	No	Yes
Money Multiplier	Yes/No	Yes
Liquidity Conditions/LAF	Yes/No	Yes
Monetary Policy (Repo Rate)	No	Yes

(Figure 12 Source: RBI Internal)

7.3 Implications of CBDC for Financial Stability

7.3.1 BIS has set out three common foundational principles for considering issuing a central bank digital currency (CBDC) as mentioned at para 4.1 above. The first of these principles was “do no harm” – this does not mean “have no impact”, but rather that new forms of money supplied by the central bank should continue supporting the fulfilment of public policy objectives and should not impede and ideally enhance, a central bank’s ability to carry out its mandate for monetary and financial stability. This principle arose from a recognition that while a CBDC has the potential to provide benefits to the operation and resilience of the financial system, it could also affect existing financial market structures and business models, which may pose risks to financial stability as the financial system evolves, particularly via the potential disintermediation of banks.

7.3.2 Potential demand for a CBDC is highly uncertain. It would be affected by its design and implementation framework (Group of central banks (2021a and 2021b)). However, there are two main concerns: first that, in times of

financial crisis, CBDC may hypothetically result in faster bank runs; and second, financial disintermediation could lead banks to rely on more expensive and less stable sources of funding. However, such scenarios can be addressed through appropriate limits on CBDC holdings and transactions.

7.3.3 Central banks are exploring safeguards that could be built into any CBDC to address financial stability risks; although such measures may need careful consideration before they are used. Central banks might consider measures to influence or control CBDC adoption or use. This may include measures such as access criteria for permitted users, limits on individuals' CBDC holdings or transactions, and particular choices around CBDC remuneration.

7.3.4 Many studies argue that CBDC is likely to weigh on bank profitability and lending. If banks respond to a CBDC by increasing reliance on market funding, then depending on the type of market funding banks' maturity transformation and their liquidity risk may face upward pressure because of more reliance on less stable funding sources, or some downward pressure if market discipline increases. The volatility of market-based funding may also increase the procyclicality of bank lending.

7.4 Legal Implications of CBDC

7.4.1 CBDC requires a legal framework that clarifies whether the central bank has the mandate to issue CBDC and what status it would have legally. Existing legal frameworks were typically enacted in a pre-digital age and investigating CBDC therefore also entails ascertaining whether law reform is necessary to

ensure that a CBDC can be issued by the central bank.

7.4.2 The legal considerations for issuing CBDC will mainly be dependent on the final operational and technological design features. Depending on the forms of issuance either as account or token based CBDCs, they shall carry different legal significance. The account based CBDCs which is like the existing account forms of money shall not be considered to be a new form of money, instead as the digital form of 'book money', which are credit balances on accounts. In contrast, token-based CBDCs are a new form of money where the central banks' liability is incorporated in the token.

7.4.3 Most of the central banks derive their powers from their laws to issue a currency in the form of banknotes and coins, book money and bills. Some central banks even have broader remit to issue currency more generally, which could encompass CBDC. If the central banks decide to issue token based CBDCs, central banks shall need to have the power to issue currency in general rather than limiting their powers to only banknotes and coins. Similarly, if the central banks decide to issue the CBDCs in account form, legal amendments shall be required to allow central banks to open accounts for the public since currently the central banks are generally capable of opening bank accounts but with certain restrictions as to who can hold an account with the central banks. The issuance of CBDC in token-based form shall create a parallel payment system and if the payment system function of central banks is restricted to only interbank systems, the implications of the CBDC issuance on laws

pertaining to payment systems shall also need to be considered.

7.4.4 Along with the central bank laws, the monetary law of the country also needs to be changed on the issues including the right of issuance of CBDC, legal tender status, and criminal law protection from counterfeits etc. However, there isn't much distinction between central bank and monetary law and the amendments in the legislation shall be replicated in the central bank law. Accordingly, in order to create and issue CBDC, we need to carefully consider the potential amendments of existing laws or the creation of laws before CBDC issuance.

7.4.5 The introduction of CBDC in India by the Reserve Bank required enabling legal framework since the legal provisions were made keeping in mind currency in paper form. Under the Reserve Bank of India Act, 1934, the Bank is empowered to "...regulate the issue of bank notes and the keeping of reserves with a view to securing monetary stability in India and generally to operate the currency

and credit system of the country to its advantage" (Preamble). The Reserve Bank derives the necessary statutory powers from various sections of the RBI Act – with respect to denomination (Section 24), form of banknotes (Section 25), status as legal tender (Sec 26(1)) etc. The necessary amendments to the Reserve Bank of India Act, 1934 relating to enhancing the scope of the definition of 'bank note' to include currency in digital form and non-applicability of certain sections that are applicable to physical currencies alone and not

relevant for digital currency, have since been passed by the Parliament.

7.5 Balance Sheet implications of CBDC

CBDC would only have benefits if general public and businesses hold it and use it to make payments. This means they must switch some of their funds out of banknotes and commercial bank deposits into central bank money in the form of CBDC. But this switching from deposits to CBDC can have potentially significant implications on the banking system, monetary policy and financial stability. To understand these implications, it is important to understand the impact of a switch from deposits to CBDC on the balance sheets of the Reserve Bank of India and commercial banks.

The balance sheet impact of a switch from cash or deposits to CBDC

Switching from cash to CBDC: Banknotes and CBDC are just two different types of central bank liability, so a switch from banknotes to CBDC affects the composition — but not the size — of household and central bank balance sheets. The household swaps one asset (cash) for another asset (CBDC) and the central bank swaps one liability (cash) for another liability (CBDC). Although banks may facilitate this conversion from cash to CBDC, the process has no impact on the size of the banking sector's balance sheet.

Switching from deposits to CBDC: A shift from deposits into CBDC has the same impact on bank balance sheets as a withdrawal of banknotes from an ATM or bank branch, reducing both the assets and liabilities of the bank and shrinking the bank's balance sheet. Such transfer changes the composition of the central bank liabilities as reserve liabilities decrease and CBDC liabilities increase but there is no immediate change in the size of the central bank's balance sheet. A flow from deposits to CBDC may result in commercial banks as a whole holding fewer reserves. If they end up holding fewer reserves than they need to meet their own or supervisory liquidity risk measures, they may wish to acquire more reserves from the central bank. If the central bank chooses to meet this demand by issuing new reserves, then the central bank's balance sheet will expand by the amount of newly issued reserves.

7.6 Central Bank Digital Currency (CBDC): AML/CFT Perspective

7.6.1 It is pertinent to mention that central banks are expected to design CBDCs that conform to the AML/CFT requirements (along with any other regulatory expectations or disclosure laws). A CBDC payment system would need to be compliant with AML and CFT regulations and requirements. This means that the identity of CBDC users would need to be known to at least some authority or institution in the wider CBDC network who can validate the legitimacy of their transaction.

7.6.2 AML responsibilities could be handled entirely by the Payment Interface Providers (commercial banks). Under the intermediate model, commercial banks may be best placed to conduct AML/CFT checks and the responsibility for compliance with AML/CFT guidelines should rest with them. Opening and maintenance of CBDC accounts with commercial banks would not require any change in the current AML/ CFT guidelines unless there is a new Financial Action Task Force (FATF) recommendation specifically for CBDCs. This arrangement means that the Bank would not hold granular personal data on any user, reducing the privacy concerns that could arise in connection with holding personal user data, but AML requirements could still be met by the CBDC system as a whole.

7.6.3 In a nutshell, from the perspective of AML/CFT, the CBDC framework should address the following two aspects:

- i. It needs to be ensured that the ultimate responsibility for Customer Due Diligence (CDD) is clearly delineated in the framework.
- ii. The design of the CBDC should have the embedded mechanism for identifying and monitoring the transactions, as per the threshold limit as applicable in case of cash, to maintain the financial sector integrity.

7.7 Privacy and data protection considerations

7.7.1 It will be essential to consider the way the privacy is respected, and the data is protected in a CBDC system. Privacy and data protection is an issue that is of concern to policymakers in government and other authorities and should be considered carefully when designing CBDCs.

7.7.2 The appropriate degree of anonymity in a CBDC system is a political and social question, rather than a narrow technical question. As discussed above, CBDC would need to be compliant with AML regulations, which rules out truly anonymous payments. However, CBDC could be designed to protect privacy and give users control over who they share data with, even if CBDC payments are not truly anonymous (or secret). Some discussions of CBDC assume that CBDC is equivalent to cash and so should offer the same degree of anonymity in payments, as applicable to different threshold of payments in respect of cash. When a payer hands over cash to a payee, for example in a shop, the payee does not receive any data about the identity of the payer, and there is no digital record that links the payer and payee. But the fact that an in-person cash payment provides an

anonymous means of payment is a result of the nature of this payment method.

7.7.3 As more central banks begin researching the possibilities of issuing a CBDC, there is a common concern around the impact this will have on privacy and should be considered carefully when designing CBDC. Awareness regarding privacy and data protection issue is increasing, accordingly stronger data protection regulation is being introduced in different jurisdictions. In December 2019, India's Ministry of Electronics, and Information Technology tabled the Personal Data Protection Bill, 2019 (the PDP) in the Lok Sabha. The Bill sought to provide for protection of personal data of individuals and proposed to establish a Data Protection Authority. However, the PDP Bill has now been withdrawn and the government is expected to bring in a new legislation with comprehensive legal framework for the digital economy.

While issuing CBDC, the central bank collects range of customer related data and, it is, therefore, essential to have defined privacy principle and data subjects rights. India presently do not have data protection law, however, in August 2017, the Supreme Court held that privacy is a fundamental right, flowing from the right to life and personal liberty under Article 21 of the Constitution. The Court also observed that privacy of personal data and facts is an essential aspect of the right to privacy. It is therefore imperative that while collecting data for issuance of CBDC, best interest of the citizens should be prioritised, only those personal identifiable data may be collected

which is necessary and use these data only for the purpose for which it is collected.

7.7.4 A Central Bank while considering the security aspect of the CBDC may be guided by some of the most-used risk and security frameworks, guidance, and standards. RBI may refer to CPMI-IOSCO Principles for Financial Market Infrastructures particularly, Principle 2 on Governance and Principle 17 on Operational Risk which set standards that are particularly relevant for managing operational risk, including information security risk. The description of Principles is discussed below:

Principle	Description
Principle 2: Governance	An FMI should have governance arrangements that are clear and transparent, promote the safety and efficiency of the FMI, and support the stability of the broader financial system, other relevant public interest considerations, and the objectives of relevant stakeholders.
Principle 17: Operational Risk	An FMI should identify the plausible sources of operational risk, both internal and external, and mitigate their impact through the use of appropriate systems, policies, procedures, and controls. Systems should be designed to ensure a high degree of security

	<p>and operational reliability and should have adequate, scalable capacity. Business continuity management should aim for timely recovery of operations and fulfilment of the FMI's obligations, including in the event of a wide-scale or major disruption.</p>
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(Figure 13: Source: CPMI-IOSCO)

Chapter 8: Way Forward

8.1 RBI has been exploring the pros and cons of introduction of the CBDCs for some time. As there are multiple compelling motivations for the introduction of CBDCs, RBI is currently engaged in working towards a phased implementation strategy, going step by step through various stages of pilots followed by the final launch, and simultaneously examining use cases that could be implemented with minimal or no disruption. Depending on the different use cases, multiple technological options shall be tested and based on the outcomes, the final architecture shall be decided. As per recommendations of the internal Working Group (WG) set up by Reserve Bank in October 2020, RBI is exploring the option of implementation of account-based CBDC in Wholesale segment and token-based CBDC in Retail segment vide a graded approach.

8.2 This phase involves the following steps:

- i. Build a prototype as per the recommendations of the WG. Specify technical requirements to technology partners.
- ii. Test the idea in an operationally controlled environment to examine its functionality, including the design, deployment plan and success criteria.
- iii. Perform test cases with both positive and negative scenarios to examine its durability and document the results.

- iv. Evaluate Test Results and finalise the design of the prototype
- v. *Pilot*: Conducting large scale pilots with a diverse and larger user base. Participants of the pilots must include users from different income levels, literacy levels, regions, genders and age groups. This will help RBI understand the potential use of the CBDC in a diverse country like India. The results and learnings of the pilot need to be carefully evaluated and must be incorporated into the final design of the CBDC.

8.3 The recommendations of internal high-level committee on CBDC facilitated firming up views on the issues of motivation for introduction of CBDC, its design features, choice of technology platforms, its implications on policy issues, and a way forward.

8.4 It will be incumbent on RBI to continue monitoring CBDC developments around the world while staying abreast of and potentially contributing to research and technical experimentation. This shall facilitate to stay up to date with the latest research, trends and findings related to CBDC, including those that can affect the economy and design policy measures to address the reputational risk associated with widely available retail CBDC.

8.5 The Bank is deliberating on the various aspects of technological choices available, which includes, suitability of Tech

Architecture(DLT/ Centralized/ Hybrid; Open Source/Proprietary), security of the Token Creation Process and Central Bank Node, standards and protocols to be followed by each stakeholder, robust preventive counterfeiting tech choices (Robustness of Verifier technology), security considerations; especially in offline transactions and smart contract features and its use cases in CBDC in both, Wholesale(W) and Retail(R) segment.

8.6 It is envisaged to continue the ongoing CBDC research through:

- i. Accessing online resources that compile and share research publicly
- ii. Attending international meetings, discussions and working groups related to CBDC
- iii. Engaging with international organisations such as the BIS, IMF, World Economic Forum and other standard setting bodies.
- iv. Developing bilateral relationships with CBDC research teams around the world.
- v. Engaging with all stakeholders including academicians, technology providers.

8.7 Conclusion

CBDC, the central bank digital currency, holds a lot of promises by way of ensuring transparency, and low cost of operation among other benefits and the potential to expand the existing payment systems to

address the needs of a wider category of users.

CBDC, across the world, is in conceptual, development, or at pilot stages. Therefore, in the absence of a precedence, extensive stakeholder consultation along with iterative technology design must take place to develop a solution that meets the requirements. While the intent of CBDC and the expected benefits are well understood, it is important to identify innovative methods and compelling use cases that will make CBDC as attractive as cash if not more.

This Concept Note provides a high-level view of motivations for the introduction of CBDC in India, its potential design features, implications on various policy issues, and the possible requirements of a technology platform. Inferences drawn here are exploratory in nature though they appear to be most suitable at this juncture.

The way forward stated in this Concept Note requires elaborate planning in terms of scope, cost, and timelines to ensure the timely roll out of different phases of CBDC introduction.

References:

1. PwC CBDC Global Index, 1st Edition, April 2021,
(<https://www.pwc.com/gx/en/industries/financial-services/assets/pwc-cbdc-global-index-1st-edition-april-2021.pdf>)
2. CBDC Tracker,
(<https://www.atlanticcouncil.org/cbdctracker/>)
3. RBI Speeches - Central Bank Digital Currency – Is This the Future of Money,
(https://www.rbi.org.in/Scripts/BS_SpeechesView.aspx?Id=1111)
4. Accelerating the growth of digital payments in India, Visa
(<https://www.visa.co.in/about-visa/newsroom/press-releases/accelerating-growth-of-digital-payments-to-save-indian-economy-inr-70000-crores-usd-10point4-billion-over-next-five-years-visa-study.html>)
5. Anton N. Didenko and Ross P. Buckley(2021): “Central Bank Digital Currencies: A potential response to the financial inclusion challenges of the pacific;
(<https://www.adb.org/sites/default/files/publication/720016/central-bank-digital-currencies-pacific.pdf>)
6. Nikhil Sridhar and Patrick Horan (2021): “Should Central Banks Offer the Public Token-Based Digital Currencies?”;
(<https://www.discoursemagazine.com/economics/2021/06/08/should-central-banks-offer-the-public-token-based-digital-currencies/>)
7. Ahmat, N and S Bashir (2017): “Central Bank Digital Currency: a monetary policy perspective”, Bank Negara Malaysia Staff insights, 2017/11, September
(https://www.bnm.gov.my/documents/20124/826874/CB_Digital+Currency_Print.pdf/e8e3bee6-4763-9c92-cba0-f33d5b2065f5?t=1585033291374)
8. Bank of England: Discussion Paper Central Bank Digital Currency Opportunities, challenges and design March 2020;
(<https://www.bankofengland.co.uk/paper/2020/central-bank-digital-currency-opportunities-challenges-and-design-discussion-paper>)
9. PWC: Central Bank Digital Currency in the Indian context (September 2021);
(<https://www.pwc.in/assets/pdfs/consulting/financial-services/fintech/point-of-view/pov-downloads/central-bank-digital-currency-in-the-indian-context.pdf>)
10. BIS: Central bank digital currencies: financial stability implications September 2021;
(https://www.bis.org/publ/othp42_fin_stab.pdf)
11. Sahil Deo and Shardul Manurkar (2020); Central Bank Digital Currency in India: Deeper engagement and thorough exploration needed before execution ;

- [\(https://www.orfonline.org/expert-speak/central-bank-digital-currency-india-deeper-engagement-thorough-exploration-needed-before-execution-66476/\)](https://www.orfonline.org/expert-speak/central-bank-digital-currency-india-deeper-engagement-thorough-exploration-needed-before-execution-66476/)
12. Michael D Bordo and Andrew T Levin (2017): NBER Working Paper Series - Central Bank Digital Currency and the future of monetary policy;
https://www.nber.org/system/files/working_papers/w23711/w23711.pdf
 13. Charles M. Kahn, Francisco Rivadeneyra and Tsz-Nga Wong (2018); Should the Central Bank Issue E-money?; Bank of Canada Staff Working Paper;
<https://www.bankofcanada.ca/wp-content/uploads/2018/12/swp2018-58.pdf>
 14. Raphael Auer and Rainer Böhme (2020): CBDC architectures, the financial system, and the central bank of the future;
<https://voxeu.org/article/cbdc-architectures-financial-system-and-central-bank-future>
 15. Committee on Payments and Market Infrastructures (2018): Central bank digital currencies;
<https://www.bis.org/cpmi/publ/d174.pdf>
 16. SETL; Community Article (2020): Token or Account Based CBDC?;
<https://setl.io/token-or-account-based-cbdc/>
 17. Rod Garratt, Michael Lee, Brendan Malone, and Antoine Martin (2020): Token- or Account-Based? A Digital Currency Can Be Both; Federal Reserve Bank of New York;
<https://libertystreeteconomics.newyorkfed.org/2020/08/token-or-account-based-a-digital-currency-can-be-both/>
 18. Raphael Auer and Rainer Böhme; The technology of retail central bank digital currency: BIS Quarterly review, March 2020;
https://www.bis.org/publ/qtrpdf/r_qt2003j.pdf