The ABCs of CBDCs and ASEAN+3 Developments[1]

January 19, 2022

I. Introduction

1. **There has been immense interest in Central Bank Digital Currency (CBDC) projects globally.** As of December 2021, the Bahamas, Nigeria, and the Eastern Caribbean Central Bank have launched CBDCs for commercial use; 14 countries have launched or completed pilot testing of CBDCs; 16 are in stages of development or proof-of-concept stage; and another 40 countries are conducting research on the product (Atlantic Council 2021). Many ASEAN+3 central banks have also made significant progress on this front (Figure 1). According to PwC (2021), Hong Kong, China (hereafter "Hong Kong"), Japan, Singapore, and Thailand are considered to have among the ten most mature **wholesale** CBDC projects globally, while China, Cambodia,[2] and Korea have among the ten most mature **retail** CBDC projects.

2. **Central bank interest in CBDCs has been motivated by both push and pull factors.** In particular:

- Pull factors include the development of Distributed Ledger Technology (DLT), of which blockchain is a well-known example. DLT enables elegant solutions for adopting virtual currencies. It provides a way to create virtual cash, which can be stored and exchanged securely and quickly between parties via a cost-effective mechanism without the involvement of a central agency.[3] Another key factor is the growing popularity and acceptance of digital payment systems and declining use of physical cash.

- Push factors include the rise of private players in the payment space, which comprises—to a large extent—digital payment systems provided by BigTechs, Fintechs, and other financial institutions. The popularity of cryptocurrencies and stablecoins has also risen in

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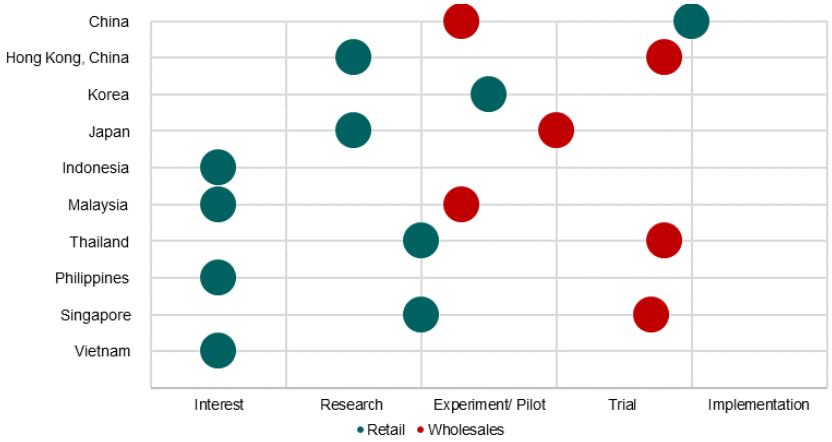
[2] We classify Cambodia's Bakong Project as a DLT-based payment system, rather than a CBDC, as explained in Section III.

[3] While the Bitcoin network can only process three to four transactions per second, newer DLT cryptocurrencies, such as Solana, can handle up to 56,000 transactions per second with the fees averaging as low as USD 0.00001 per transaction (PitchBook Data 2021).

the past decade and may pose financial stability risks (IMF 2021). The entry of an increasing number of less-regulated/unregulated private players in the payment universe (through digital payment systems, cryptocurrencies and stablecoins, and alternate payment systems like buy-now-pay-later schemes) can potentially undermine the authority of financial regulators (Bank for International Settlements (BIS) 2019a). For example, the use of crypto assets in cross-border flows effectively bypasses the traditional channels, which makes them difficult to track (BIS 2019b).

Figure 1. ASEAN+3: Progress of Regional CBDC Projects



Sources: Atlantic Council, Bank for International Settlements; national authorities; and AMRO staff.

3. **There is no single overarching objective that a majority of central banks is trying to achieve.** We look at the key goals and objectives stated for CBDC projects that have passed the research stage, that is, proof-of-concept, pilot, and launched CBDCs, and the most commonly mentioned include increases in efficiency, robust and secure systems, modernization or digitalization, efficient cross border transfers, lower costs, and financial inclusion (Figure 2). While existing digital payment systems do provide many of these benefits, they are maintained and operated by private institutions. The CBDC, on the other hand, is a liability of the central bank. Therefore, it is a more reliable, harder to counterfeit, and hence safer digital payment alternative. Based on the design, it can also provide instant settlement finality.

4. **The CBDC is not a "one-size-fits-all" solution, and different objectives call for different approaches to their design and implementation.** One of the major advantages of CBDC, as a concept, is the high degree of customization, which can be undertaken by authorities in order to meet specific goals. Traditional forms of money (such as cash and deposits) and digital payment systems, by comparison, offer less flexibility for financial innovation.

5. **In this note, we examine the various decision points that central banks encounter when considering CBDCs, and also take stock of the progress made by ASEAN+3 central banks.** Specifically, we take a deeper look at the key decisions that a central bank needs to make when assessing the feasibility, design, and implementation of the CBDC. Most of these decisions are not independent, and the choice of a particular parameter may drive the selection

of other parameters. It is one of the reasons why central banks tend to gravitate toward specific options but it does not mean that the alternatives will never be used.

Figure 2. CBDC: Key Objectives Listed for Projects Past the Research Stage

Word Cloud

Subjective Categorization

Goal/Objective	Number of Central Bank who Mention it in Mission Statement
Increase efficiency (transactional, payment systems)	7
Robust/Resilient/healthy/secure payment system	6
Modernize/advanced/streamline/digitalize financial/payment system	6
Enable efficient cross border payments/settlements	5
Reduce costs (service delivery, payment systems)	4
Financial inclusion	4
Interbank settlement	2
Automated market making	1
Liquidity management	1
Convenient payment system	1
Monetary sovereignty	1
Innovative products	1
Financial stability	1

Sources: Atlantic Council; national authorities; and AMRO staff.

II. Key Features of CBDCs

A. Scope of Usage

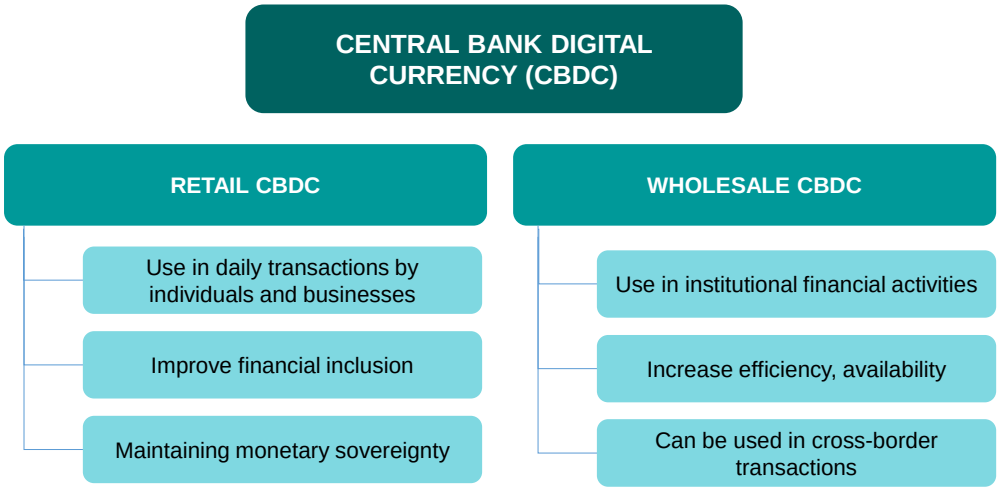
6. **Almost all CBDC projects may be classified as either retail or wholesale, and both have very different sets of goals.** Retail CBDCs have seen greater interest from central banks (Figure 3), representing around 70 percent of all CBDC projects undertaken by central banks globally (Atlantic Council 2021). It is worth highlighting that some of the regional central banks have made significant strides in CBDC projects and have ventured into both retail and wholesale CBDCs to investigate potential benefits. It is not unlikely that countries may implement separate retail and wholesale solutions in a way that is complementary.

7. **As the name suggests, retail CBDCs cater to retail transactions.** They may be used by individuals, corporations, and small businesses as a medium of exchange and, possibly, as a store of value. The retail CBDC aims to provide a secure digital payment system that can be accessed by consumers for daily transactions. Retail CBDCs may be designed to enable peer-to-peer transactions and, based on design, may allow varying levels of offline transaction capacity, settlement finality, and anonymity.

8. **Financial inclusion and maintaining monetary sovereignty are some of the key goals that are exclusively served by retail CBDC projects.** Using simple applications on mobile phones or smart cards, retail CBDCs can cater to those sections of society that are

otherwise left out of the financial system. For example, in China, a basic e-CNY wallet can be created with just a mobile number, making it much easier for almost anyone with a mobile phone to be a part of the financial system (Deutsche Bank 2021). Retail CBDCs also provide a means to counter threats from private digital currencies. For example, Facebook's Libra was launched in June 2019 with the aim of enabling domestic and cross-border money transfers in a low cost and secure way (Diez de los Rios and Zhu 2020). Increased adoption of such digital currencies could reduce a central bank's ability to stabilize prices, thus posing a potential threat to its monetary autonomy, and may reduce its ability to act as the lender of the last resort (LOLR).[4]

Figure 3. CBDC: Scope Of Usage



Source: AMRO staff.

9. **Wholesale CBDCs are exclusive to financial institutions, thus the designs and considerations would be more targeted than retail CBDCs.** The former would be used by financial institutions for transactions among themselves, and with central banks and overseas institutions. It can provide advantages such as settlement finality, efficient liquidity management/provisioning, 24/7 transactions, and quick and efficient cross-border transfers.

10. **There are a few projects aimed primarily at increasing the efficiency of domestic interbank operations while others are in collaboration with counterpart central banks to develop and test cross border transactions.** Domestically, central banks are looking for improvements in areas such as reducing settlement duration and increasing market efficiency. For example, the Bank of France created a test blockchain to settle treasury bonds as part of its wholesale CBDC experiment with BNP Paribas, HSBC, and Société Générale, in early 2021. Notable international projects include the 2019 Jasper-Ubin project between the Bank of

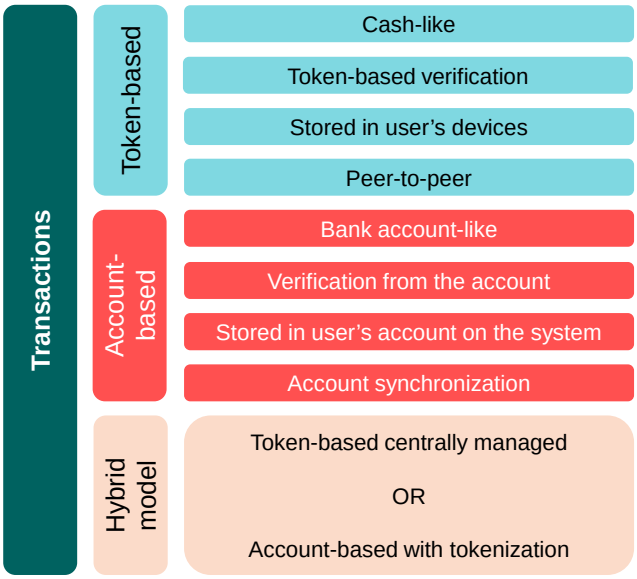
[4] The central bank would typically lend in local currency to a resident financial institution that is solvent but unable to source sufficient liquidity in the interbank market or from other facilities. However, if the financial system is facing a liquidity crunch due to a shortage of, say, Bitcoin, the central bank may need to sell its foreign exchange reserves to purchase and provide the Bitcoin liquidity, thus reducing its ability to act as LOLR.

Canada (BoC) and the Monetary Authority of Singapore (MAS), and the 2020 Ithanon-Lionrock between the Bank of Thailand (BoT) and the Hong Kong Monetary Authority (HKMA).[5]

B. Design

11. **The designs that can be implemented for CBDCs could be token-based, account-based, or a hybrid.** Token-based CBDCs take the form of digital units of the currency, which can be transferred from one digital wallet to another without the involvement of a third party. Account-based CBDCs, on the other hand, need the account to be maintained with a financial intermediary and is then updated to reflect transactions. Both models have their advantages and disadvantages, motivating central banks to explore a hybrid model, which may be tailored to balance the pros and cons of each model (Figure 4).

Figure 4. CBDC: Design Alternatives



Source: AMRO staff.

12. **Token-based CBDC is parallel to cash.** Digital tokens (uniquely identifiable digital unit of value) have sophisticated ownership verification features and enable transactions that can be peer-to-peer and effected offline with settlement finality. The token-based CBDC has two key attributes: (1) a private key; and (2) tokens, that is, digital cash. In a pure-token-based implementation, both types of information are stored in the physical device of the holder of tokens. Depending on the technological implementation, tokens are typically less vulnerable to counterfeiting compared to physical cash, not susceptible to wear and tear, and cheaper to "print" and distribute.

13. **However, a pure token-based CBDC has some glaring disadvantages.** First, it provides a high degree (but not complete) of anonymity and makes it vulnerable to being used in illicit activities. A non-CBDC example is Bitcoin, which has been used for ransom payments and other undesirable activities. Second, tokens are vulnerable to loss or damage of the device

[5] See Banque de France (2021); BoC and MAS (2019); and BoT and HKMA (2020), respectively.

where they are stored. According to Chainalysis (2020), around 20 percent of Bitcoin could have been lost forever for various reasons, including loss of hardware and private keys,[6] driving central banks away from pure-token alternatives. That said, token-based CBDCs do find application in wholesale CBDCs, which are transacted within a closed group of verified institutions, thus minimizing the risk of illicit transactions. These institutions also typically install robust technological infrastructure to ensure the safety of their tokens. The BoT's wholesale CBDC project, Inthanon, uses token-based infrastructure where not only cash but also bonds are tokenized to automate liquidity provisioning (BoT 2019a, 2019b).

14. **Account-based CBDC is similar to bank accounts.** It can be credited and debited but may allow instantaneous and cost-effective settlements. Transactions in an account-based CBDC are verified based on the validity of the accounts, that is, if that account is verified and has sufficient funds to execute the transactions. It offers most of the advantages associated with token-based CBDC except anonymity and ability to support a completely offline transaction with settlement finality. Account opening mandates a rigorous Know Your Customer (KYC) and hence the transactions cannot be anonymous and it also ensures that illicit activities can be easily tracked.

15. **Account-based CBDCs also need an internet connection to update the account balances and transactions.** They can be designed to enable limited offline transactions but the final reconciliation with the network can only be executed when the account goes back online. For example, the Sand Dollar of the Bahamas successfully developed offline usage ability, which is critical in times of natural disasters, such as hurricanes (Central Bank of the Bahamas 2019). Users can make pre-set dollar value payments when communication access to the Sand Dollar Network is disrupted. Wallets will update against the network once communications are re-established.

16. **A hybrid model provides more flexibility than pure token- or account-based models.** The implementation of the hybrid models can vary based on the optimal trade-off, which is dependent on the preferences of the authorities involved. Broadly, there are two options:

- ***A token-based CBDC where tokens are stored in an account***. In this model, the tokens are stored in a digital safe, which may be provided by the central bank or by a financial intermediary. The private key may be stored locally on the users' devices or in the digital safe. For example, Sweden's pilot e-krona stores private keys locally as it helps to provide the user exclusive rights to execute transactions from the payment instrument where the key is stored (Sveriges Riksbank 2021). On the other hand, storing the private key in the digital safe provides the flexibility for the financial intermediary to execute transactions on behalf of the user and thus opens up avenues for innovative financial products.

- ***An account-based CBDC that enables offline transactions through tokens.*** This model allows the account to store the CBDC, with smaller limits to withdraw tokens for online transactions. China's e-CNY is described as an "account-based, quasi-account-

[6] According to Bitcoin's public ledger, these Bitcoin have not been moved for five years or longer.

based, and value-based hybrid payment instrument," which appears to be an account-based CBDC that also provides tokens for offline transactions (Chen 2020).

C. Money Creation

17. **All central banks confirmed their role as the sole issuer of their respective CBDCs in both pilots and early research.** In the traditional system, money is created in two ways: (1) central bank money, comprising banknotes and commercial bank deposits with the central bank; (2) commercial bank money, comprising customer deposits (McLeay, Radia, and Thomas 2014). Central bank money is a direct liability of central banks and therefore, practically risk-free. Deposits at commercial banks are "multiplied" through bank lending activities and, while this money can be converted to central bank money by converting to cash, it is a liability on the commercial banks' balance sheets and hence, not risk-free. By definition, CBDCs would form a part of central bank money and almost all central banks have reserved the issuance rights of CBDCs for themselves.

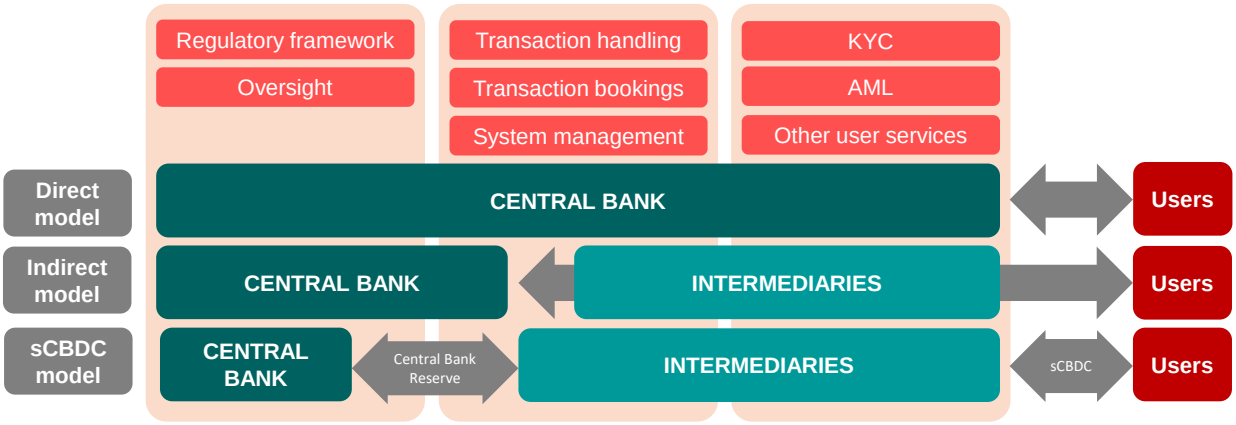
18. **CBDCs have the potential to disrupt commercial bank money creation.** CBDCs provide an alternative store of value for users and there could be scenarios where users prefer holding CBDC instead of placing their money in bank deposits. Such developments could lead to financial disintermediation as deposits move out of the banking system, thus restricting banks' ability to lend. Banks may also face liquidity risks if the migration to CBDCs is sizeable. Consequently, various CBDC designs have tended to focus on its function as a medium of exchange and deliberately discourage its use as a store of value, to safeguard the intermediation role of the banking system. It is one of the primary reasons that most CBDCs are not interest bearing, thus reducing their attractiveness relative to bank deposits. Some central banks have also imposed restrictions on amounts of CBDC holdings and transaction size, minimizing any big shift away from bank deposits. For example, the Central Bank of Nigeria has restricted the amount of e-Naira that could be held, based on the level of KYC completion (Central Bank of Nigeria 2021).

19. **Synthetic CBDCs (sCBDC) provide the means for an alternative approach, wherein the responsibility of money creation can be shared between public and private enterprises.** The primary model suggested by Tobias (2019) passes on the responsibility of issuing digital currency to financial intermediaries with the digital currency backed by central bank reserves (Figure 5). Auer and Böhme (2020) argue that technically, it would not qualify as a CBDC, given that the claim would not be on the central bank's book. But, it can act as a potent alternative, given that it can address many of the issues that CBDCs aim to address and, with an appropriate legal framework, sCBDCs can be made practically risk free as they are backed by central bank reserves. This concept has a parallel in the world of physical cash. Hong Kong has given authorization to three commercial banks to issue banknotes, which are accompanied by a set of terms and conditions agreed between the government and these banks. These notes are fully backed by assets deposited at the HKMA and are therefore practically risk-free. In the virtual payment space, an sCBDC-like structure also exists in China, where private payment providers need to back all their balances with central bank reserves.

20. **The CBDC model provides some advantages but also calls for a much stronger regulatory framework and oversight.** The sCBDC provides more room for innovation in financial products in that financial intermediaries can increase synergies between the design of

the virtual currency and the product offerings. They can also be used to improve the transmission of monetary policy by directly tying interest rates on central bank deposits to those paid on the digital currency. That said, it would mean that a much stronger regulatory framework needs to be implemented, and continuous oversight by authorities is required to ensure interoperability between different digital currency providers, monitor sufficiency of central bank reserves, and prevent monopolies. Although the synthetic CBDC significantly reduces customer-facing operational overhead for the central bank, the objective can also be achieved by using a two-tier distribution system.

Figure 5. CBDC: Money Creation and Distribution



Source: AMRO Staff.

D. Distribution

21. **There are two ways in which the CBDC can be distributed—via direct distribution by central banks to end-users or indirect distribution through intermediaries.** In the direct model (also known as the one-tier design), the central bank issues the CBDC and directly distributes it to end-users, which may be individuals, businesses, and corporates (Figure 5). In the indirect distribution (two-tier design), the central bank issues the CBDC to intermediaries, such as banks or fintech firms, that then distribute it to end-users. As of now, retail CBDC projects have gravitated toward the indirect distribution method, while wholesale CBDC projects generally prefer direct distribution.

22. **In the direct distribution model, central banks can send to or receive deposits from end-users by enabling direct connection from public CBDC wallets to the central bank.** The model is simple in structure and reduces dependence on intermediaries. It also bypasses the banking system and therefore provides an independent payment system for end-users. That said, it would also entail operational overheads for the central bank, which will have to take care of system management and customer onboarding (for example, establish accounts, oversee KYC/AML compliance, conduct transaction verification and settlement, dispute resolution, and carry a multitude of other functions), compared to just managing issuance and validation in the case of cash. While these overheads may not be significant when the number of users is limited, such as in the case of wholesale CBDCs, where only a handful of institutions is involved, the operational challenges could be overwhelming when the number of users increases, such as in the case of retail CBDC.

23. **The indirect distribution model creates a middle layer of designated intermediaries to receive the CBDC from central banks and distribute it to users.** This model is a better approach in leveraging institutional strengths. Central banks can focus on the issuance of CBDCs and oversight of the system. Financial intermediaries, such as commercial banks, would take care of the user-facing operations. The experience that commercial banks have in account opening and management, would come in handy when they assist end-users with opening retail CBDC accounts/e-wallets.

24. **Transactions can be handled by either the central bank or the intermediaries.** Intermediaries can conduct KYC/AML, help users open accounts with the central bank and provide other customer-facing activities, while central banks facilitate and maintain a record of the transactions (Auer and Böhme 2020). However, this too can prove to be a significant operational and infrastructure overhead for central banks. Hence, most CBDCs are moving toward a model where intermediaries invest in building and maintaining the infrastructure used for transactions, while providing appropriate backstops if one of the intermediaries experiences a technical/temporary failure. Depending on the design, the details of retail transactions (ledger entries) could either be maintained by the intermediaries (China) or maintained at a central repository with the central bank (Nigeria). In either case, central banks can keep track of any suspicious transactions using the appropriate infrastructure.

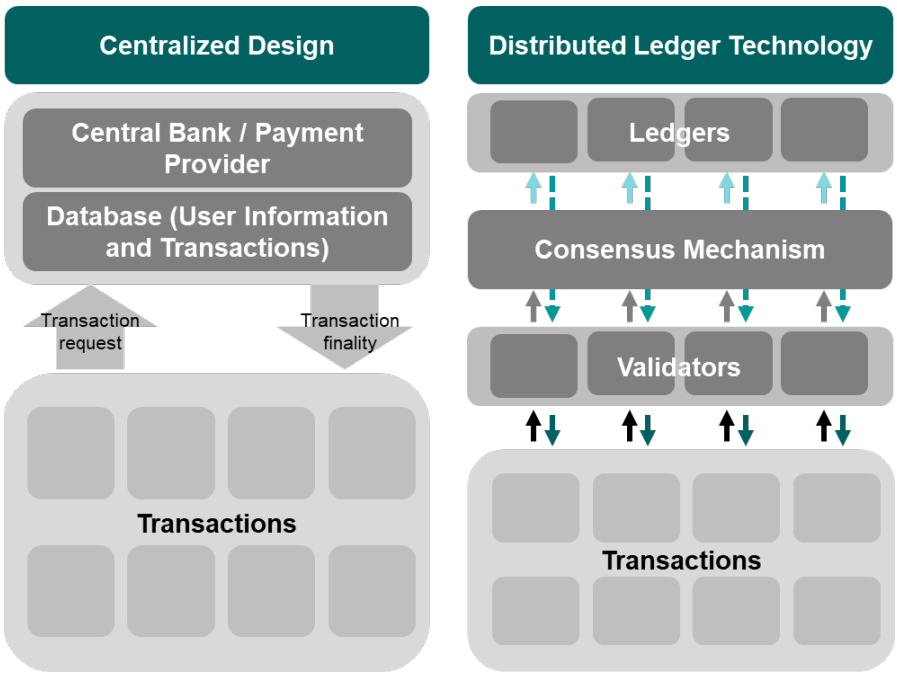
E. Technological Design

25. **The application of Distributed Ledger Technology (DLT) in virtual currencies has been a key motivator for CBDC projects and forms the core of many such projects.** The technological design affects the storage of transactions and ensures that different components of the system are synchronized. A DLT system allows the data to be managed by multiple entities (called validators) (Natarajan, Krause, and Gradstein 2017). Each validator stores a copy of the database and synchronizes with others in a decentralized manner without a centralized management entity. The decentralization allows the system to avoid a single-point-of-failure but needs increased processing capabilities.

26. **The DLT achieves synchronization between validators via "consensus mechanisms."** The mechanism dictates which transactions should be accepted and updated back to all other ledgers (Figure 6). This mechanism adversely affects the speed with which the transaction is recorded, especially in a public DLT, where the consensus mechanism has to be robust to ensure transaction validity.[7] Therefore, CBDC implementations have tended to use a limited number of validator nodes and form a private DLT, which both simplifies the validation process and ensures that the validators are trusted. One such example is the Inthanon-LionRock mCBDC project between the BoT and the HKMA. The project deployed a shared DLT environment between the two CBDCs (BoT and HKMA 2020). To ensure appropriate authority, the system separated nodes into validating nodes and standard nodes. The validating nodes are managed by the central banks to validate the information, and the standard nodes by commercial banks to read and write information to the blockchain.

[7] Delays can also originate from the DLT design. As for the case of Bitcoin, which uses a blockchain DLT, transaction records are limited in size and frequency.

Figure 6. CBDC: Technological Architecture



Source: AMRO staff.

27. **However, the preference for DLT does not mean that a centralized system based on traditional technologies finds no application.** In fact, Finland's Avant smart card system, which was launched in 1992 and is now considered the world's first CBDC, was not based on DLT and instead, used a simple smart pre-paid card for cashless transactions (Grym 2020). Non-DLT technologies are also applied in virtual payment systems and are still in use in some of the CBDC projects. A centralized system allows the whole system to be controlled by a single entity (for CBDCs, it should be the central bank). The centralized system can have inbuilt redundancies, data backups, or multiple data storages to ensure resilience, but will still be governed by the central controlling authority. As a middle ground, China's e-CNY project considered both centralized and distributed architecture to form a hybrid technology design; however, the central bank acknowledges that there is room for further exploration of the role of DLT (People's Bank of China (PBC) 2021). It remains unclear whether a DLT-based system is more resilient than the conventional one. Whereas a conventional system is at risk of centralized attack, DLT-based system is vulnerable to certain types of attack that can delay or prevent transactions.

28. **Data privacy can be achieved to a certain degree using DLTs, but it may not guarantee complete anonymity.** Data privacy can take two forms: (1) the identity and personal details of the transacting parties are hidden from each other; or (2) the transactions and identities of every individual are hidden from everyone:

- ***DLT implementation provides the first form of data privacy, by default.*** Payment can be made just by knowing the "address" of the e-wallet and no other detail is needed. This level of privacy, however, is also available through traditional technologies. Various digital payment systems can receive payments by merely scanning a QR code or

knowing the recipient's phone number. To enhance privacy, a CBDC system can use cryptography, which is currently used in cryptocurrencies. Cryptography allows users to hide critical information in a secret key and only show an encrypted public address to make transactions. Users can create new public addresses from the secret key to further protect their identities. Regulators will be able to retain the ability to trace suspicious transactions if the secret key is managed by institutions.

- ***The second form of privacy is difficult to achieve.*** In any CBDC implementation, users will need to verify their identities to the authorities before using CBDCs, although transaction information may be managed differently under the two techniques. In traditional systems, the central governing body will always have access to details of all transactions. Although difficult, it is possible to trace transactions back to the individual accounts in DLT systems as well. Most DLT systems require previous transactions information to be included in future transactions to ensure the authenticity of assets, thus making transaction record activities inevitable. In addition, validators in a DLT can be a network of institutions regulated by central banks or the central bank itself.

III. Regional Developments

29. **China plans to expand the usage of its retail CBDC– e-CNY—at the 2022 Winter Olympics—and has therefore made significant strides in designing and pilot testing.** The research started in 2014 and the PBC has launched various pilots at different stages across major cities, since 2019. The e-CNY is an outcome of the PBC's efforts to provide a safer, inter-operable, and more inclusive retail payment infrastructure as the economy moves further toward digitalization, keeping threats posed by cryptocurrencies and stablecoins at bay. The retail CBDC is issued solely by the central bank and distributed through a two-tier system, where authorized operators manage e-CNY through its entire life cycle. The CBDC is identifiable as both an account-based and a value-based hybrid system with managed anonymity. One key characteristic of the e-CNY is its interoperability—it integrates with existing electronic payment systems and connects the digital wallets of different operators and bank accounts with the e-CNY wallet. This feature enables further diversification of the payment system while making it more efficient and safe.

30. **Since 2017, the HKMA has been exploring the use of DLT in designing CBDC.** The authority's wholesale CBDC proof-of-concept with the BoT explored functionalities of DLT in cross-border transactions and FX settlements in 2019. The research developed a shared platform to allow real-time cross-border fund transfers between the participating banks on a peer-to-peer basis. From February 2021, the HKMA participated in subsequent cross-border research with additional participation from the Digital Currency Institute of the PBC and the Central Bank of the United Arab Emirates. The HKMA has also published a technical research paper in developing a retail CBDC in October 2021, although the decision to issue a CBDC had not yet been discussed (HKMA 2021).

31. **In association with the European Central Bank (ECB), the Bank of Japan (BoJ) launched a joint study, Project Stella.** The research examines the use of DLT in the fields of financial market structure and payments to improve the safety and efficiency of existing systems. The project was launched in December 2016 and has completed four phases:

- The first phase focused on the speed of processing, operational resilience, and liquidity saving mechanisms (ECB and BoJ 2017).

- The second phase investigated settlements of linked obligations based on Delivery versus Payment (DvP) mechanisms (ECB and BoJ 2018).

- Phase three explored innovative solutions for cross-border payments and involved entities across multiple jurisdictions (ECB and BoJ 2019).

- The fourth phase looked at privacy and confidentiality while sharing transaction information on distributed ledgers (ECB and BoJ 2020).

The functionalities studied under Project Stella cater to objectives that are generally achieved through wholesale CBDCs. The BoJ is also studying retail CBDC (or a general purpose CBDC) and has already launched Phase 1 of its Proof of Concept (BoJ 2021).

32. **The Bank of Korea (BoK) also launched a pilot project, in August 2021, to study the feasibility of retail CBDC.** The first phase of the pilot, which is in progress, aims to check the technical feasibility of issuance, distribution, and redemption of CBDCs, and to examine the roles of central banks versus private banks (Jung 2021). The initial plan is to implement a two-tier system where the central bank "prints" the CBDC and commercial banks "distribute" it to consumers. The second phase, which is scheduled to end by June 2022, will address issues related to privacy, offline payments, use in purchasing digital assets, and international remittances.

33. **Singapore's Ubin CBDC project is one of the most holistic exploration studies on the usage of DLT technology in retail and wholesale environments**. The project consists of five phases, each covering an aspect of DLT in financial markets, over the period November 2016–July 2020:

- In a retail context, the project produced an example of a two-tier CBDC that can facilitate peer-to-peer transactions using tokenized Singapore dollars. The experiment also considered the interoperability of such a design with the current financial system (MAS 2017a).

- In a wholesale context, the DLT was used in multiple usage scenarios, ranging from inter-bank transactions to DvP and cross-border transactions (MAS 2017b, 2018, 2020).

Internationally, the MAS has conducted experiments, with participation from the BoC and Bank of England (BoE), to assess different models—both with and without DLT—that could enhance cross-border payments and settlements (BoC, BoE, and MAS 2018). Although in most cases, DLT was proven to have great potential to increase efficiency and availability, further considerations are still needed, both in terms of technology and regulation capacity, especially in cross-border projects. Singapore has continued to explore CBDCs after Project Ubin. As of November 2021, the MAS is participating in another cross-border CBDC project with the Reserve Bank of Australia, Bank Negara Malaysia, and South African Reserve Bank, with the BIS Innovation Hub (MAS 2021).

34. **Thailand has made great strides in its wholesale CBDC project, Inthanon, and has commenced research into retail CBDC as well**:

- Phase 1 was launched in August 2018 and explored DLT-based RTGS. The key functionalities tested in this phase included cash tokenization, bilateral transfer, queueing mechanisms, gridlock resolution, and a couple of innovative functionalities, such as bond tokenization and automated liquidity provisioning (BoT 2019a). The decentralized payment system includes the BoT (which is the sole issuer of the CBDC) and participating banks that can convert RTGS balances into cash tokens and use them for peer-to-peer transactions with other nodes in the system. The bond tokenization enables seamless central bank liquidity provision, which allows banks to enter into repurchase agreements with the BoT for automated liquidity provisioning.

- Phase 2 focused on more complex issues of bond life cycle, fraud prevention, and regulatory compliance (BoT 2019b).

- Phase 3 explored cross border payments in collaboration with other central banks. The two key pilots undertaken were: (1) Inthanon-Lion Rock with HKMA; and (2) mBridge with the HKMA, PBC, Central Bank of the UAE, and the BIS.[8]

- A live pilot of retail CBDC is planned for late 2022 (BoT 2021).

35. **The Bakong payment system of Cambodia provides a real-life case of deploying private DLT in payment infrastructure, although *the project is not a CBDC system* because no digital native money is involved.** The technology has provided a platform for connecting all financial institutions and payment service providers, and enabled real-time transactions amongst participants in a decentralized manner. The usage of DLT in the project has achieved important features, such as transaction finality and scalability, with transaction output of up to 2,000 transactions per second and less than 5 seconds in execution time, according to the National Bank of Cambodia (2020). In the system, participating institutions act as both, an onboarding channel for the end-users to enter the system, and as extra decentralized nodes that increase the system's resilience. The project was officially launched in October 2020.

IV. Conclusion

36. **The CBDC is an important, developing area toward increased financial digitalization, but design and adoption will be strongly influenced by country specific issues.** The CBDC is not a one-size-fits-all solution, and hence monetary authorities have invested significant time and resources to identify key issues that need addressing, design the CBDC itself, and conduct elaborate pilots before implementation. The CBDC concept represents a paradigm shift in the way money works, but as of now, most central banks appear to see their respective roles as complementing existing payment systems—both physical and

[8] See BoT and HKMA (2020) and BIS Innovation Hub Hong Kong Centre and others (2021).

digital. In our view, the CBDC is an important development with regard to the future of money but the urgency of adoption will depend on the environment of each economy.

37. **CBDCs could potentially have material impact on financial stability and monetary policy in the ASEAN+3 region.** While CBDCs create opportunities for central banks to achieve their varying goals of efficiency, security, lower costs, and financial inclusion, the risks are not yet fully understood. Going forward, key areas for further investigation that are relevant to the financial systems in the region would include the implications of CBDCs for monetary policy, liquidity management, payment infrastructure, cross-border payments, financial system stability, regulatory changes, and the attendant spillovers within the region.

References

Atlantic Council. 2021. “Central Bank Digital Currency Tracker.” Washington, DC, accessed on December 28, 2021. https://www.atlanticcouncil.org/cbdctracker.

Auer, Raphael, and Rainer Böhme. 2020. “The Technology of Retail Central Bank Digital Currency.” BIS Quarterly Review, Bank for International Settlements, Basel, March 1. https://www.bis.org/publ/qtrpdf/r_qt2003j.htm.

Bank for International Settlements (BIS). 2019a. “Big Tech in Finance: Opportunities and Risks.” BIS Annual Economic Report 2019, Bank for International Settlements, Basel, June 23. https://www.bis.org/publ/arpdf/ar2019e3.htm.

———. 2019b. “Investigating the Impact of Global Stablecoins.” Committee on Payments and Market Infrastructures Papers No. 187, Bank for International Settlements, Basel, October 18. https://www.bis.org/cpmi/publ/d187.htm.

Bank of Canada (BoC), Bank of England (BoE), and Monetary Authority of Singapore (MAS). 2018. “Cross-Border Interbank Payments and Settlements: Emerging Opportunities for Digital Transformation.” Ottawa, London, and Singapore, November 15. https://www.mas.gov.sg/news/media-releases/2018/assessment-on-emerging-opportunities-for-digital-transformation-in-cross-border-payments.

———, and Monetary Authority of Singapore (MAS). 2019. “Jasper–Ubin Design Paper: Enabling Cross-Border High Value Transfer Using Distributed Ledger Technologies.” Ottawa and Singapore, May 2. https://www.mas.gov.sg/news/media-releases/2019/central-banks-of-canada-and-singapore-conduct-successful-experiment-for-cross-border-payments.

Bank of Japan (BoJ). 2021. “Commencement of Central Bank Digital Currency Experiments.” Tokyo, April 5. https://www.boj.or.jp/en/announcements/release_2021/rel210405b.pdf.

Bank of Thailand (BoT). 2019a. “Project Inthanon Phase I: An Application of Distributed Ledger Technology for a Decentralized Real Time Gross Settlement System Using Wholesale Central Bank Digital Currency.” Bangkok, January 29. https://www.bot.or.th/English/PressandSpeeches/Press/2019/Pages/n0562.aspx.

———. 2019b. “Project Inthanon Phase 2: Enhancing Bond Lifecycle Functionalities and Programmable Compliance Using Distributed Ledger Technology.” Bangkok, July 18. https://www.bot.or.th/English/PressandSpeeches/Press/2019/Pages/n3962.aspx.

———. 2021. “Retail Central Bank Digital Currency (Retail CBDC): Implications on the Thai Financial Sector and Survey Results.” Bangkok, August 19. https://www.bot.or.th/English/PressandSpeeches/Press/2021/Pages/n6064.aspx.

Bank of Thailand (BoT), and Hong Kong Monetary Authority (HKMA). 2020. “Inthanon-LionRock: Leveraging Distributed Ledger Technology to Increase Efficiency in Cross-Border Payments.” Bangkok and Hong Kong, China, January 22. https://www.bot.or.th/English/AboutBOT/Activities/Pages/Inthanon_LionRock.aspx.

Banque de France. 2021. “Experiment on the Use of Central Bank Digital Currency (CBDC).” Paris, April 29. https://www.banque-france.fr/en/communique-de-presse/experiment-use-central-bank-digital-currency-cbdc.

BIS Innovation Hub Hong Kong Centre, Hong Kong Monetary Authority, Bank of Thailand, Digital Currency Institute of the People's Bank of China, and Central Bank of the United Arab Emirates. 2021. “Inthanon-LionRock to mBridge: Building a Multi CBDC Platform for International Payments.” Hong Kong, Bangkok, Beijing, and Abu Dhabi, September 28. https://www.bis.org/publ/othp40.htm.

Central Bank of Nigeria. 2021. “Design Paper for the e-Naira.” Abuja. https://enaira.com/download/eNaira_Design_Paper.pdf.

Central Bank of the Bahamas. 2019. “Project Sand Dollar: A Bahamas Payments System Modernization Initiative.” Nassau, December 24. https://www.centralbankbahamas.com/publications/main-publications/project-sanddollar-a-bahamian-payments-system-modernization-initiative.

Chainalysis. 2020. “60% of Bitcoin is Held Long Term as Digital Gold. What about the Rest?” New York, June 18. https://blog.chainalysis.com/reports/bitcoin-market-data-exchanges-trading.

Chen Jia. 2020. “'Offline Payment Services' Added to Digital Currency Trials.” *China Daily*, December 16. https://www.chinadaily.com.cn/a/202012/16/WS5fd94b02a31024ad0ba9c08d.html.

Deutsche Bank. 2021. “Digital Yuan: What Is It and How Does It Work?” July 14. https://www.db.com/news/detail/20210714-digital-yuan-what-is-it-and-how-does-it-work.

Diez de los Rios, Antonio, and Yu Zhu. 2020. “CBDC and Monetary Sovereignty.” Staff Analytical Note 2020-5, Bank of Canada, Ottawa, February. https://doi.org/10.34989/SAN-2020-5.

European Central Bank (ECB), and Bank of Japan (BoJ). 2017. “Payment Systems: Liquidity Saving Mechanisms in a Distributed Ledger Environment.” Frankfurt and Tokyo, September 6. https://www.boj.or.jp/en/announcements/release_2017/rel170906a.htm.

———, and ———. 2018. “Securities Settlement Systems: Delivery-Versus-Payment in a Distributed Ledger Environment.” Frankfurt and Tokyo, March 27. https://www.boj.or.jp/en/announcements/release_2018/rel180327a.htm.

European Central Bank (ECB), and Bank of Japan (BoJ). 2019. “Synchronized Cross-Border Payments.” Frankfurt and Tokyo, June 4. https://www.boj.or.jp/en/announcements/release_2019/rel190604a.htm.

———, and ———. 2020. “Balancing Confidentiality and Auditability in a Distributed Ledger Environment.” Frankfurt and Tokyo, February 12. https://www.boj.or.jp/en/announcements/release_2020/rel200212a.htm.

Grym, Aleksi. 2020. “Lessons Learned from the World’s First CBDC.” BoF Economics Review No. 8/2020, Bank of Finland, Helsinki. https://www.suomenpankki.fi/en/media-and-publications/publications/studies-and-reports/bof-economics-review/.

Hong Kong Monetary Authority (HKMA). 2021. “e-HKD: A Technical Perspective.” Hong Kong, October 4. https://www.hkma.gov.hk/eng/news-and-media/press-releases/2021/10/20211004-3/.

International Monetary Fund (IMF). 2021. “Chapter 2: The Crypto Ecosystem and Financial Stability Challenges.” Global Financial Stability Report: COVID-19, Crypto, ad Climate. Washington, DC: International Monetary Fund, October. https://www.imf.org/en/Publications/GFSR/Issues/2021/10/12/global-financial-stability-report-october-2021.

Jung Min-Kyung. 2021. "Kakao’s Ground X Picked as Preferred Bidder for BOK’s Digital Currency Project.” *The Korean Herald*, July 20. http://www.koreaherald.com/view.php?ud=20210720000920.

McLeay, Michael, Amar Radia, and Ryland Thomas. 2014. “Money Creation in the Modern Economy.” Quarterly Bulletin 2014 Q1, Bank of England, London, March 14. https://www.bankofengland.co.uk/quarterly-bulletin/2014/q1/money-creation-in-the-modern-economy.

Monetary Authority of Singapore (MAS). 2017a. “Project Ubin: SGD on Distributed Ledger.” Singapore, March 9. https://www.mas.gov.sg/news/media-releases/2017/mas-working-with-industry-to-apply-distributed-ledger-technology.

———. 2017b. “Project Ubin Phase 2: Re-imagining Interbank Real-Time Gross Settlement System Using Distributed Ledger Technologies.” Singapore, November 14. https://www.mas.gov.sg/news/media-releases/2017/source-codes-of-successful-distributed-ledger-prototypes-publicly-released.

———. 2018. “Project Ubin: Delivery versus Payment on Distributed Ledger Technologies.” Singapore, November 12. https://www.mas.gov.sg/news/media-releases/2018/mas-and-sgx-successfully-leverage-blockchain-technology-for-settlement-of-tokenised-assets.

———. 2020. “Project Ubin Phase 5: Enabling Broad Ecosystem Opportunities.” Singapore, July 13. https://www.mas.gov.sg/news/media-releases/2020/project-ubin-fifth-and-final-phase-highlights-commercial-potential-paving-way-towards-live-adoption.

Monetary Authority of Singapore (MAS). 2021. “BIS Innovation Hub and Central Banks of Australia, Malaysia, Singapore, and South Africa Will Test CBDCs for International Settlements.” Singapore, September 2. https://www.mas.gov.sg/news/media-releases/2021/project-dunbar.

Natarajan, Harish, Solvej Krause, and Helen Luskin Gradstein. 2017. “Distributed Ledger Technology (DLT) and Blockchain.” Fintech Note No. 1, World Bank, Washington, DC, December 1. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/177911513714062215/distributed-ledger-technology-dlt-and-blockchain.

National Bank of Cambodia (NBC). 2020. “Project Bakong: Next Generation Payment System.” Phnom Penh, June. https://bakong.nbc.org.kh/download/NBC_BAKONG_White_Paper.pdf.

People's Bank of China (PBC). 2021. “Progress of Research and Development of E-CNY in China.” Beijing, July. http://www.pbc.gov.cn/en/3688110/3688172/4157443/4293696/20210716145846918 71.pdf.

PitchBook Data. 2021. “Defi Primer: An Overview of Defi Funding Activity, Concepts, and Select Protocols.” London, New York, San Francisco, and Seattle, August 27. https://pitchbook.com/news/reports/q3-2021-pitchbook-analyst-note-defi-primer.

PwC. 2021. “PwC CBDC Global Index.” April. https://www.pwc.com/gx/en/industries/financial-services/assets/pwc-cbdc-global-index-1st-edition-april-2021.pdf.

Sveriges Riksbank. 2021. “E-krona Pilot Phase 1.” Stockholm, April 6. https://www.riksbank.se/en-gb/payments--cash/e-krona/e-krona-reports/e-krona-pilot-phase-1-report-3/.

Tobias Adrian. 2019. “Stablecoins, Central Bank Digital Currencies, and Cross-Border Payments: A New Look at the International Monetary System.” Remarks at the IMF-Swiss National Bank Conference, International Monetary Fund, Washington, DC, May 14. https://www.imf.org/en/News/Articles/2019/05/13/sp051419-stablecoins-central-bank-digital-currencies-and-cross-border-payments.