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# **Central Bank Digital Currencies: A Review of Operating Models and Design Issues**

Van Roosebeke, Bert and Defina, Ryan

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# **CENTRAL BANK DIGITAL CURRENCIES**

## **A REVIEW OF OPERATING MODELS AND DESIGN ISSUES**

### **Executive Summary**

The topic of Central Bank Digital Currencies (CBDC) is highly relevant to deposit insurers. As an increasing number of central banks further their research and planning efforts in CBDC, IADI members are encouraged to intensify their understanding of the potential impact of the introduction of a CBDC in their own as well as in other jurisdictions.

To assess the potential impact of a CBDC, a sound understanding of operating models and design features is crucial. These will affect factors of key interest to deposit insurers, such as the degree of replacement of bank deposits by CBDC. Also, the implications of choices regarding operating models and design features extend to the division of labour between central and commercial banks and the degree of privacy attached to CBDC usage.

The paper offers a review of key issues relevant to deposit insurers regarding operating models and design features for CBDC, and links these to early global policy standards. Whilst not recommending a particular CBDC design, deposit insurers are encouraged to develop a deeper understanding of the principles presented and how the different policy options may affect the provision of deposit insurance.

# 1 Introduction

Central Bank Digital Currencies (CBDC) have emerged as an area of increasing interest globally, and in particular for many deposit insurance systems. The motivations for central banks to engage in this matter are many and include issues such as competition in payment markets and monetary sovereignty.<sup>1</sup> A majority of central banks (54%) consider it “likely” or “possible” to issue wholesale CBDC within six years, while 65% think so for retail CBDC.<sup>2</sup>

Given the novel nature of CBDC, and the absence of a “typical” or “standard” CBDC configuration which central banks could easily adopt, many are conducting pilot studies (e.g. China, European Union, Russian Federation, and others<sup>3</sup>) and/or conducting academic research to bolster their knowledge with which to make decisions about whether or not to introduce a CBDC, and which operating models and design features to adopt. These decisions may have wide-ranging consequences, also for deposit insurers.

CBDC, particularly when viewed under the broader banner of Fintech initiatives, are an emerging area that warrants exploration and due consideration by policymakers. BIS officials note that CBDC “should be considered in the full context of the digital economy and the centrality of data, which raises concerns around competition, payment system integrity, and privacy”.<sup>4</sup> Additionally, in 2021 CBDC were flagged as a key issue for the deposit insurance community to prioritise.<sup>5</sup> Deposit insurers are encouraged to carefully consider the potential likelihood of a CBDC being introduced in their jurisdiction, and to consider the possible implications and appropriate measures to take for their deposit insurance systems.

This paper reviews the literature on CBDC and focusses on their potential operating and design features. These are expected to be fundamental in scoping the impact of CBDC on deposit insurers. We set out (in Section 2) high level policy principles on CBDC by international organisations as these may well be seen as early standards in this area. In Section 3, we differentiate between wholesale and retail CBDC to continue discussing operating models for the latter in Section 4. In Section 5, we deal with some of the most relevant design considerations for CBDC. Section 6 concludes.

## 2 High level policy principles for CBDC

The international community has agreed on a set of broad parameters to ensure ongoing CBDC developments remain focussed on primary strategic objectives and do not compromise other important policy considerations. Work has been mostly furthered by the Bank for International Settlements (BIS) which has ultimately fed into high level G7 and G20 statements.

### Foundational Principles for CBDC by the BIS and the Group of Central Banks (2020)

The BIS and some of the major central banks globally<sup>6</sup> explore CBDC as a means of payment that may complement cash as a form of central bank money available to the public. This may support a more resilient and diverse domestic payment system and may support innovation.

This group has set out three foundational principles for CBDC that must be satisfied for any jurisdiction to consider proceeding with a CBDC:<sup>7</sup>

1. **“Do no harm”.** New forms of money supplied by the central bank should continue supporting the fulfilment of public policy objectives and should not interfere with or impede a central bank’s ability to carry out its mandate for monetary and financial stability. For example, a CBDC should maintain and reinforce the “singleness” or uniformity of a currency, allowing the public to use different forms of money interchangeably.
2. **Coexistence.** Central banks have a mandate for stability and proceed cautiously in new territory. Different types of central bank money – new (CBDC) and existing (cash, reserve or settlement accounts) – should

<sup>1</sup> See Van Roosebeke & Defina (2021) for a non-exhaustive discussion of principles motivating CBDC exploration.

<sup>2</sup> Kosse & Mattei (2022), p. 9

<sup>3</sup> See Table 2 in Van Roosebeke & Defina (2021) for a more comprehensive list of activities.

<sup>4</sup> Auer et al. (2022)

<sup>5</sup> Van Roosebeke & Defina (2021a)

<sup>6</sup> This included the Bank of Canada, European Central Bank, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, and the Board of Governors of the Federal Reserve.

<sup>7</sup> BIS (2020a)

complement one another and coexist with robust private money (e.g. commercial bank accounts) to support public policy objectives. Central banks should continue providing and supporting cash for as long as there is sufficient public demand for it.

- 3. Innovation and efficiency.** Without continued innovation and competition to drive efficiency in a jurisdiction's payment system, users may adopt other, less safe instruments or currencies. Ultimately this could lead to economic and consumer harm, potentially damaging monetary and financial stability. The payments ecosystem is comprised of public authorities (in particular the central bank) and private agents (e.g. commercial banks and payment service providers). There is a role for the public and private sectors in the supply of payment services to create a safe, efficient and accessible system. Private economic agents should generally be free to decide which means of payment they use to conduct their transactions.

### G7 Statements (2021)

G7 Finance Ministers and Central Bank Governors' Statement on Central Bank Digital Currencies (CBDC) and Digital Payments stressed that "any CBDC should be grounded in our long-standing public commitments to transparency, the rule of law and sound economic governance."<sup>8</sup>

G7 members endorsed the 'do no harm' policy set out in the BIS Foundational Principles. In addition, they stressed the importance for CBDC of:

- rigorous standards of privacy and data protection,
- cyber resilience,
- energy efficiency,
- an open, transparent and competitive environment that promotes choice, inclusivity and diversity in payment options,
- interoperability on a cross-border basis to enhance cross-border payments.

At the same time, G7 member states recognised a shared responsibility to minimise harmful spillovers of CBDC to the international monetary and financial system. The G7 also released a paper highlighting thirteen detailed public policy principles for retail CBDC.<sup>9</sup>

Principle 1: Monetary and financial stability  
Principle 2: Legal and governance frameworks  
Principle 3: Data privacy  
Principle 4: Operation resilience and cyber security  
Principle 5: Competition  
Principle 6: Illicit finance (~ AML/CFT)  
Principle 7: Spillovers

Principle 8: Energy and environment (~ ESG)  
Principle 9: Digital economy and innovation  
Principle 10: Financial inclusion  
Principle 11: Payments to and from the public sector  
Principle 12: Cross-border functionality  
Principle 13: International development

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<sup>8</sup> G7 (2021)  
<sup>9</sup> G7 (2021a)

### **G20 Roadmap on Cross-border Payments and CBDC (2021)**

The G20 Roadmap for Enhancing Cross-border Payments<sup>10</sup> also explicitly references CBDC. Building block 19 titled ‘Factoring an international dimension into CBDC design’ acknowledges the “... need for multilateral collaboration on macro-financial questions and the importance of interoperability between CBDC”. This would imply that CBDC development is best-informed through coordinated efforts among central banks and international organisations. International efforts of the BIS Innovation Hub, Committee on Payments and Market Infrastructures (CPMI), FSB, IMF and World Bank have led to various analyses informing such coordination efforts.

## **3 Scope of CBDC: Retail vs wholesale CBDC**

Central bank digital currencies tend to be categorised based on their intended user base. Central banks may wish to determine which, if any, of these two broad forms of CBDC might be applicable in their jurisdiction.

**Wholesale CBDC** are designed to be used by financial intermediaries (for wholesale transactions). They have existed for many decades in the form of commercial banks’ ability to settle wholesale transactions in central bank money in a digital manner. Whereas these existing wholesale CBDC typically work on a centralised ledger at the central bank, future wholesale CBDC may make use of a non-centralised ledger<sup>11</sup> (a distributed ledger technology (DLT), see section 5.4 below). As an example thereof, Project Helvetia, a joint initiative of the Bank for International Settlements Innovation Hub, Swiss National Bank and financial market infrastructure operator SIX, is an example of a wholesale CBDC in development. The initiative “demonstrated the feasibility and legal robustness of both alternatives in a near-live setup”.<sup>12</sup> Many central banks have cited wholesale CBDC as having the potential to make existing financial systems faster, less expensive, and more secure.<sup>13</sup> This applies in particular to cross-border payments and remittances.

### **Joint BIS, IMF and World Bank report to the G20 (2021)**

“The potential merits of wholesale CBDCs for cross-border payments – as a settlement asset ... possibly based on novel technologies – are clear and go beyond the clean-slate argument. To enhance cross-border payment, wholesale CBDC would enable expanding the set of parties who have direct access to digital central bank money, and would likely be accessible 24/7, thus eliminating operating hour mismatches. In addition, they could serve as a secure settlement asset for payment versus payment (PvP, ...) systems or PvP could be built into CBDC designs, thus mitigating credit and liquidity risk of cross-currency payments.”<sup>14</sup>

**Retail CBDC** are made available to a wider array of participants, constituting all economic agents in an economy, ranging from individual consumers to corporates. They are a direct claim on the central bank, and hence do not incur any credit risk to those participating in the system. Many central banks in emerging economies are leaning into retail CBDC as a means to support strategic objectives concerning financial inclusion through increasing aggregate levels of digitisation in the financial services sector. The remainder of this paper focusses on retail CBDC because of their importance to deposit insurers.

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<sup>10</sup> FSB (2021)

<sup>11</sup> Panetta (2022a)

<sup>12</sup> BIS (2020)

<sup>13</sup> Gupta (2020)

<sup>14</sup> BIS, IMF & World Bank (2021)

## 4 Operating Models for Retail CBDC

Similar to cash, retail CBDC represent a direct claim of end-users on the central bank but do so in a digital instead of analogue nature. Absent CBDC, end-users can use digital money only through private intermediaries, e.g. by using bank deposits which represent private money issued by a commercial bank.<sup>15</sup> CBDC would enable retail users to use digital money from a public issuer (the central bank) also. This innovation inevitably leads to a re-shuffling of the existing division of labour between central banks and commercial banks when making available money to retail users. The exact scope of change heavily depends on the modalities of future CBDC operating models.

The following (and the appendix) sets out the major operating models for CBDC that have been proposed and investigated by researchers and policymakers. They differ in the division of labour between public authorities and private actors, especially as to the consequences for the onboarding of new users (Know Your Customer ‘KYC’ process) and to the respective roles in handling effectuated payments.<sup>16</sup>

**TABLE 1: SUMMARY OF RETAIL CBDC OPERATING MODEL FEATURES**

<i>Operating Model</i>	<i>Type of design</i>	<i>Claim on central bank</i>	<i>Onboarding / KYC</i>	<i>Retail payment</i>
Direct CBDC	Single-tier retail CBDC	Direct	Central bank or intermediaries	Central bank handling all payments
Hybrid CBDC	Two-tier retail CBDC	Direct	Intermediaries	Intermediaries handling payments, but central bank keeping retail records
Intermediated CBDC	Two-tier retail CBDC	Direct	Intermediaries	Intermediaries handling payments, but central bank keeping wholesale records only
Indirect <sup>17</sup>	Alternative designs (not retail CBDC)	Indirect, via backed claim on intermediary	Intermediaries	Intermediaries handling

**Operating Model One: Direct CBDC** – In this model, central banks are the sole authority responsible for all operations of a CBDC, including issuing, managing all transactions and ledgers, and directly interfacing with users on all relevant matters. The primary advantage with this model is that central banks are typically well-respected institutions in the eyes of the general public, thus facilitating trust in the CBDC and allaying potential concerns over its interaction with traditional currency. There are also additional synergies that could perhaps be realised as issuance and distribution are consolidated without the need to involve additional third parties. However, direct interacting with retail users on all levels, including onboarding, is an activity untypical to most central banks.

**Operating Model Two: Hybrid CBDC** – In this two-tiered model, the central bank issues the CBDC but allows for private firms to take on an intermediary role. This entails the onboarding of end users, asserting that private actors such as deposit taking institutions or payment providers have a competitive advantage in this area. It may be more costly for

<sup>15</sup> The ownership structure of these commercial banks may vary and ranges from fully private to state-owned banks. Regardless, these banks are considered private intermediaries as liabilities on their balance sheet are not central bank liabilities.

<sup>16</sup> This section borrows heavily from Auer and Böhme (2021). Soderberg (2022) at the IMF has also presented a similar but less granular typology of operating models.

<sup>17</sup> Auer and Boehme (2021) note that this category could be considered a “narrow payment bank” or even a “rigid stablecoin”, while Adrian and Mancini-Griffoli (2019) term this architecture a “synthetic CBDC”.

a central bank to perform this role, with such additional costs ultimately needing to be met by either their balance sheet or passed on to the end users, contravening some cost efficiency arguments of CBDC.

In this model, private actors would also play a role in managing retail payments effectuated in CBDC. As opposed to the direct CBDC model, where the central bank would manage this process, private participation may allow for additional innovation. In the hybrid model, central banks would keep full retail records of all CBDC balances. This would enable them to react to any failure by private payment managers and to safeguard the business continuity of the CBDC payment process.

**Operating Model Three: Intermediated CBDC** – This model allows for further private intermediation by private actors in the payment process. Central banks would refrain from keeping retail records and keep wholesale records of payment actors only. To compensate for the lack of the central bank’s continuous insight in individual claims, and to safeguard its ability to compensate for a private payment actor’s failing, these private actors would need to be subject to close regulation and supervision.

**Operating Model Four: Indirect CBDC**– Central banks neither issue nor intermediate in this model. However, private firms may issue a “synthetic CBDC” that is fully backed with central bank liabilities, effectively forming a private stablecoin<sup>18</sup> rather than a CBDC per se. Although minimised through this backing at the central bank, the private nature of the issuer means a residual default risk remains in this scenario. All payment processes are managed privately.

Early evidence and the bulk of the literature suggest that central banks are amenable to private actors playing a significant role in the future development of CBDC.<sup>19</sup> While different structural configurations are likely to emerge, Operating Model One is not expected to be the prominent framework applied. A recent IMF paper sets out the expected distribution of tasks between public and private actors for a limited number of CBDC and demonstrates a significant role for private actors in offering services further downstream on the CBDC value chain.<sup>20</sup>

	Issuing		Validation		Ledger Update		KYC-AML/CFT		User Interface		User Data <sup>1</sup>		Customer Service	
	Owner	Executor	Owner	Executor	Owner	Executor	Owner	Executor	Owner	Executor	Owner	Executor	Owner	Executor
Bahamas	Central Bank	Central Bank	Central Bank	Central Bank	Central Bank	Central Bank	Both	Both	Private	Private	Private	Private	Private	Private
Canada	Central Bank	Central Bank	Central Bank	Central Bank	Central Bank	Central Bank	Both	Both	Private	Private	Private	Private	Private	Private
China	Central Bank	Central Bank	Both	Both	Both	Both	Both	Both	Private	Private	Private	Private	Private	Private
ECCU	Central Bank	Central Bank	Central Bank	Central Bank	Central Bank	Central Bank	Both	Both	Private	Private	Private	Private	Private	Private
Sweden	Central Bank	Central Bank	Both	Both	Both	Both	Both	Both	Private	Private	Private	Private	Private	Private
Uruguay	Both	Both	Both	Both	Both	Both	Both	Both	Private	Private	Private	Private	Private	Private

Color scheme:   Central Bank   Both   Private   Still Exploring

Source: Central banks and IMF staff.

Note: AML/CFT = anti-money laundering/combating the financing of terrorism; KYC = know your customer.

<sup>1</sup>One option is to grant central banks access to data stored by intermediaries. This is the practice in China.

Source: Soderberg (2022)

## 5 Design issues for Retail CBDC

This section focuses on some key design features for retail CBDC. It covers technical issues that link back to the high-level principles set out above.

### 5.1 Limiting CBDC use through caps and remuneration

To safeguard the “do no harm” policy principle, retail CBDC are generally expected to come with limits as to their allowable use. Absent such limits, CBDC may pose a risk to the business models of traditional banks (intermediation) and financial stability, as in times of stress, depositors may face an incentive to exchange bank deposits into CBDC. In this scenario, depositors would use CBDC for value storage purposes rather than for transaction purposes. They may do so given the lack of default risk of the central bank (as CBDC issuer) or to protect deposits in excess of an existing deposit insurance coverage limit. This may negatively impact bank liquidity and funding and may aggravate crises.

<sup>18</sup> In the absence of a commonly agreed definition, private stablecoins here are understood to be private cryptocurrencies that through their backing with fiat currency or other assets aim at safeguarding value stability.

<sup>19</sup> Auer et al. (2022) expect that “in advanced economies, CBDC would hence likely be offered by established commercial banks and non-bank payment service providers”.

<sup>20</sup> Soderberg (2022), with “ECCU” referring to the Eastern Caribbean Currency Union.

A number of possibilities are being discussed as to de-incentivise the use of CBDC as a storage of value and to ensure that the fundamental purpose of CBDC remains transactions.

- Caps are quantitative restrictions that set an upper limit to the amount of CBDC that can be held or transacted by households or corporates. In the euro area, a cap in the range of EUR 3,000 to 4,000 per capita has repeatedly been mentioned.<sup>21</sup> Nigeria (eNaira) and The Bahamas (Sand Dollar) have introduced caps both for transactions and holdings; these are tiered depending on whether or not the user has been identified.

However, caps come with at least three practical challenges.

- First, to avoid arbitrage, they require identification of the CBDC user upon opening the CBDC wallet. Without this safeguard, users could open different CBDC wallets as to circumvent the cap.
  - Second, a solution needs to be found for incoming payment transactions that lead to a surpassing of the CBDC limit. As senders are not aware of receivers' balances, this is something that is likely to occur. Reference is often made to a waterfall-solution, where the excess CBDC volume will be automatically transferred to a deposit account held by the CBDC holder at a commercial bank. However, this presupposes a role for private intermediaries, as presented in Operating Models two and three above. A further complication may arise when users hold CBDC wallets with different intermediaries. Effectively capping CBDC use will require a real-time monitoring of CBDC holdings by a given individual through different private intermediaries.<sup>22</sup>
  - Third, CBDC caps may be compromised during periods of macroeconomic stress. Political actors and/or policy makers could view ad hoc and temporary extensions of CBDC wallet limits as a mechanism to shore up market confidence. This is effectively analogous to ad hoc increases of the deposit insurance coverage limit in similar circumstances and introduces equivalent moral hazard concerns. These will, in all likelihood, be counterproductive to meeting market discipline long-term objectives.
- Remuneration policies may give price-based incentives for holding CBDC. This could cover both interest earnings and service costs related to CBDC holdings. Similar to cash – the current central bank money available to retail users – CBDC could be paid a zero interest rate.

In effect, this is the practice adopted by the four jurisdictions with operating CBDC (Bahamas, Nigeria, Eastern Caribbean Economic and Currency Union and China). Low CBDC interest rates may disincentivise CBDC holdings, as commercial bank deposits may generate a higher return. However, risk averse depositors may not be very price-sensitive and may attach higher value to the absence of default risk.<sup>23</sup> Given the storage and security advantage of CBDC as compared to cash, even upon negative CBDC interest rates, depositors may prefer CBDC over cash.

- Caps and remuneration policies may be combined, which in essence boils down to tiered pricing of CBDC holdings to reflect different price elasticities of different user groups.

Dependent on the volume of CBDC held or transferred, different interest rates or service costs could apply. Holdings above a level seen as appropriate could be subjected to negative interest rates or additional service costs.<sup>24</sup> In addition, caps can be set at different levels for different user groups (businesses and household users) and can be subjected to different remuneration policies.<sup>25</sup>

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<sup>21</sup> Bindseil (2020) and recently also by the ECB Executive Board Member, Panetta (2022)

<sup>22</sup> Bank of England (2020), p. 39

<sup>23</sup> CPMI (2018), p. 17

<sup>24</sup> BIS (2021), p. 80

<sup>25</sup> See Morales-Resendiz et al. (2021) for further discussion. It is important to note that many central banks undergoing development and/or trial of a CBDC are yet to make a definitive determination on these design features.



- Time caps are a measure that is discussed less often. Limits on the length of time during which CBDC can be held could set incentives to use CBDC as a means of payment rather than a means of storing value.

## 5.2 Transaction costs

Building and running a CBDC environment will cause costs – likely these will be high fixed costs and low marginal costs. Decisions will need to be made as to who will absorb the costs related to user identification, IT systems, etc. Although the choice of the CBDC operating model will to some degree determine where costs are incurred, these may be compensated through policy decisions regarding the CBDC pricing model.

As driving force behind CBDC, central banks will seek to safeguard that the respective CBDC is a success, i.e. that it generates sufficient demand by retail users. These users are likely to have a number of payment alternatives at hand, ranging from cash and fast payment bank transfers to private stablecoins. Given this competition, it is not ex-ante certain that CBDC will attract sufficient demand as a means of payments.

In addition to design and ease-of-use features, the cost of use is likely to be a decisive factor for future CBDC demand. As a consequence, central banks may be reluctant to pass on costs to retail users. Some of the building and running costs may be covered by income generated through negative interest rates on CBDC holdings and a potential increase of seigniorage income by the central bank.<sup>26</sup> As it remains to be seen whether and in how far the CBDC value chain will allow for fees payable by private payment providers (and in how far these can pass them on to merchants in a competitive payment market), the central bank may remain as main financial contributor. Depending on regional legal frameworks on issues such as competition law, state aid and the public policy goal of a CBDC, and the fact that CBDC would stand in competition with other, private payment product, the central bank may be subjected to limits as to the allowable degree of subsidising.

## 5.3 Privacy

Concerns regarding privacy and the use of personal data are increasingly cited as both a key motivation for central banks to develop CBDC<sup>27</sup> and as a key desire by future users of CBDC.<sup>28</sup> Although privacy may be a legitimate and lawful desire upon conducting payments, it may also be used to shield criminal action. Privacy in payments is seldom absolute and varies from full anonymity, pseudonymity to confidentiality.<sup>29</sup>

The existing form of retail central bank money (cash) allows for far-reaching privacy in use.<sup>30</sup> Anonymity generally applies to both the transaction itself (being not traceable by others) and to the executing parties (that may not be identifiable).

Other payment services use private money and generally offer lower, although varying degrees of privacy. Bank transfers are typically observable to financial institutions and public authorities only, and parties can be easily identified by these. Crypto transfers are more easily observable by a large proportion of users<sup>31</sup>, but the identity of parties involved is typically better protected, making these products attractive for those seeking to undertake illegal activities.<sup>32</sup>

It is unlikely that CBDC will offer the same degree of privacy as cash does today.<sup>33</sup> Central banks are expected to adopt a CBDC design that requires a minimum level of user identification. This would seek to address safety and integrity concerns, along with mitigating against fraudulent behaviour.

Even though the central bank – unlike private money or payment service providers – may credibly state not having a commercial interest in accessing individual payment data, different design approaches for CBDC would in theory lead

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<sup>26</sup> For an explanation of potential effects of CBDC on central bank seigniorage income, see CPMI (2018), Annex C.

<sup>27</sup> BIS (2021a).

<sup>28</sup> A recent public consultation by the European Central Bank on the Digital Euro has revealed that privacy is the key feature that end-users expect a CBDC to offer (see ECB (2021), p. 10 ff).

<sup>29</sup> Anonymous transactions do not contain data on the identity of parties; pseudonymous transactions contain data, but not sufficient as to identify the parties and confidential transactions contain identity data, but disclose these to a limited set of parties only. A similar distinction can be made as to the subject of the payment (e.g. goods purchased) as this can allow for conclusion on payment parties' preferences, economic status, etc.

<sup>30</sup> In a number of jurisdictions, limits to anonymity in cash apply to high value transactions.

<sup>31</sup> Many crypto transactions that take place on a distributed ledger are publicly visible.

<sup>32</sup> Privately issued cryptocurrencies are regularly accused of providing an avenue for money laundering and the financing of terrorist activities. The extent to which this occurs in practice and at what scale as compared to other payment means is subject of discussion.

<sup>33</sup> See Carstens (2021) and BIS (2020a) on privacy; and Mu (2022) on the People's Bank of China's "managed anonymity" policy for CBDC.

to a varying degree of data access by intermediated parties. Domestic privacy rules and the central bank's policy will determine the degree of access to data these intermediaries may be granted in practice.<sup>34</sup>

Different approaches to authenticating users are being considered in CBDC designs. These choices seek to balance AML/CFT concerns with the rights of consumers to some degree of privacy in their transactions. One suite of approaches use token-based access<sup>35</sup> which sees credentials authenticated initially and issued a token to conduct transactions (often characterised as a “digital signature”). The user does not need to be re-authenticated before every transaction. Transactions under this approach do not require reconciling of multiple databases, and hence are finalised almost immediately. In this regard, the tokenised approach can be viewed as “cash-like”. Mapping between tokens and sensitive private information is (in theory) protected through sophisticated encryption methodologies. Other authentication methods place increased focus on verifying the user's identity regularly. Depending on the division of tasks between the public and the private sector, central and/or commercial banks may be required to maintain a database of accounts (sometimes described as a “digital identity scheme”) and be more directly engaged in the reconciliation process. Such designs can enable money laundering, terrorist financing, and other illicit/fraudulent activities to be monitored and further investigated if warranted. Privacy considerations are not necessarily compromised under either approach, and would ideally be complemented with further safeguards.

It should be clarified that both of the approaches aforementioned can lead to various degrees of identifiability (anonymous, pseudo-anonymous or fully identifiable) pending their precise design features and implementation. A more pertinent issue is the need to prioritise cryptographic security as it is fundamental to managing a CBDC operational infrastructure.<sup>36</sup> This area is constantly evolving and therefore requires sustained long-term investment to ensure the likelihood of a privacy breach is reduced to near-zero, propagating public confidence in the system as a whole.

#### 5.4 Centralised vs distributed CBDC ledgers

To keep records of all CBDC transactions and to prevent illegitimate use such as double spending, any CBDC will require a ledger. The design of this ledger is another key design consideration for CBDC.

Traditionally, ledgers in payment services such as (fast) bank transfer payments have been operating in a centralised manner, often with a critical role for the central bank in providing for final settlement in central bank money. More recently, distributed platform technologies have been a significant driving force in the establishment and promotion of private digital currencies such as cryptocurrencies regularly utilising non-centralised approaches.

- **Fast payment systems (FPS)** typically work on centralised ledgers which enable transactions to be made final in central bank money, and associated funds made available in real or near-real time.<sup>37</sup> A major difference between FPS and a DLT-configured retail CBDC is in terms of intermediary involvement. An FPS generally requires intermediaries (commercial banks) to interface between the parties undertaking a transaction and central bank.
- **Distributed ledger technology (DLT)** corresponds to “processes and related technologies that enable nodes in a network (or arrangement) to securely propose, validate and record state changes (or updates) to a synchronised ledger that is distributed across the network's nodes”.<sup>38</sup>

One prominent type/adaptation of DLT is the blockchain methodology, which maintains a history of transactions recorded in blocks, and “chains” these blocks to all previous transactions in the ledger regularly. A key property of DLT is that the relevant ledger is updated in a non-central manner by multiple nodes. Such

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<sup>34</sup> In this context, it remains to be seen if and how central banks will allow for a CBDC-based value chain with downstream services and which role data access will play therein. This may affect the attractiveness and costs of a given CBDC, that is likely to stand in competition with other public or private digital coins.

<sup>35</sup> According to okta.com: “Token-based authentication is a protocol which allows users to verify their identity, and in return receive a unique access token. During the life of the token, users then access the website or app that the token has been issued for, rather than having to re-enter credentials each time they go back to the same webpage, app, or any resource protected with that same token.”

<sup>36</sup> Bank of England (2020)

<sup>37</sup> CPMI (2016)

<sup>38</sup> CPMI (2017)

nodes can be deployed across multiple sites and assist in perpetuating the decentralised underpinnings.<sup>39</sup> DLT also enables smart contracts, which involve the automatic execution or termination of transactions based on pre-specified agreed conditions.

It is important to note that a CBDC can be built using either approach. Centralised and distributed ledgers have their respective advantages and disadvantages. The central bank will have to decide on how to best manage numerous trade-offs. These include, but are not limited to:

- Performance (central ledgers may be faster in processing a high number of payments);
- Security (risk of hoarding data centrally vs the risk of providing multiple targets in decentral systems);
- Privacy (when allowing more decentral nodes); and
- Programmability (the technical ease in which the system can be developed, implemented and managed).

## 5.5 Cross-border considerations

Most of the current debates on CBDC focus on domestic considerations and not on cross-border implications. However, the introduction and potential cross-border use of domestic CBDC may have far-reaching consequences. Early discussions focus on how coordination between central banks can increase interoperability of CBDC. This will impact cross-border payments and broader macro-financial issues.

Central banks have commenced discussing the interoperability of CBDCs in part to avoid the need for private digital currency in cross-border transactions (likely in the form of a stablecoin).<sup>40</sup> Auer & Haene et al. (2021) propose three plausible configurations for mCBDC (multiple CBDC), with differing degrees of integration.<sup>41</sup>

- Based on **compatible CBDC systems** – Multiple CBDC systems and corresponding clearing services can operate independently, with compatibility measures and minimum usage requirements in place to facilitate interoperability. This model very much resembles existing governance arrangements for cross-border payments.
- Based on **linking multiple CBDC systems** – This “middle ground” option sees the introduction of a common technical interface and/or centralised/decentralised clearing system to more closely stitch together multiple CBDC systems.
- Based on **integration into a single multi-currency system (mCBDC)** – A single set of agreed conduct rules and governance arrangements, combined with a single suite of infrastructure and associated record keeping/ledgering, and single set of users ensure a system with comprehensive integration.

In addition to these mostly technical integration issues, policy decisions will need to be made regarding the use of domestic CBDC in foreign jurisdictions and/or by non-residents. Foreign residents may only be allowed to utilise a given CBDC provided they are physically present within the respective jurisdiction, or even when permanently residing abroad. Alternatively, central banks may choose to limit such use. Most central banks have not yet taken a firm position on this.<sup>42</sup> These policy choices will need to be reflected in the design of the CBDC, both in the identification and KYC processes and also in privacy arrangements. As an example, use of CBDCs by non-residents may require cross-border cooperation on KYC processes, well-calibrated settlement arrangements and/or could be subject to lower caps in use as compared to domestic resident users.<sup>43</sup>

On a more fundamental level, the ease of CBDC cross-border usage may impact a number of macro-financial issues. If – as a consequence of the above policy choices – foreign CBDC were widely available in a given jurisdiction, the costs of buying, holding, spending and selling foreign currencies may fall significantly in some jurisdictions. This may lead to currency substitution and to changes in net international capital flows that could have profound effects. In such an instance, exchange rates might be subject to higher levels of volatility. A number of monetary policy transmission channels could also be constrained if currency substitution (via wide-spread foreign CBDC usage) were substantial.

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<sup>39</sup> Proponents of decentralised methodologies readily argue that such approaches reduce the likelihood of cyber-attacks given that multiple nodes of the network would need to be compromised simultaneously to constitute a successful attack. This however does not make such approaches immune to nefarious activities, with more sophisticated hacking techniques being developed all the time.

<sup>40</sup> The Bank for International Settlements is one such actor. See Auer & Haene et al. (2021) for details.

<sup>41</sup> These configurations are currently subject to pilot tests (mostly on wholesale level) in a number of jurisdictions.

<sup>42</sup> CPMI (2021) with references to Auer & Boar et al. (2021).

<sup>43</sup> See for example the Bahamas, which allow for non-residents (tourists) to hold up to 500 Sand Dollars only.

Finally, limitations may be observed concerning the effectiveness of domestic fiscal backstops and lender of last resort functions in domestic currency e.g. if commercial banks build up significant liabilities in foreign CBDC.

## 5.6 IT security

Cyber security has received deserved attention in recent times given the unprecedented risks corporations are being exposed to. The increasing uptake of fintech initiatives (of which CBDC is one realisation) by central banks has, in parallel, increased their nonfinancial risks. Researchers at the International Monetary Fund have recently explored this issue in considerable detail (within the broader context of central bank risk management), drawing on findings from the IMF Article IV Database, selected Financial Sector Assessment Program (FSAP) and country study reports.<sup>44</sup>

IT infrastructure supporting any CBDC must be sufficiently robust to ensure availability, and this may be impacted by the degree of centralisation of the ledger-setup (see above). The primary litmus test in said systems' capacity is whether they can withstand cyber-attacks. These include Distributed Denial of Service (DDoS) attacks which attempt to temporarily disable user access and would have dire ramifications within the context of any national payments system, including a CBDC. There are a wealth of cyber security methodologies and techniques now available to mitigate such risks.<sup>45</sup> Individuals trained in implementing such methods are being viewed as increasingly important in administering contemporary payment systems.

## 6 Concluding remarks

This paper has identified key CBDC considerations for policy makers, branching across both technical and non-technical areas. Importantly, no particular CBDC design has been recommended. Instead, deposit insurers are encouraged to develop a deeper understanding of the principles presented and how the different policy options may affect the provision of deposit insurance.

CBDC operating model and design choices may play a decisive role in shaping the future of payment systems worldwide. Given the inherent links between such systems and the objectives and operations of deposit insurers, it is expected that the topic of CBDC will likely continue to grow in relevance for IADI and its members. Central banks and global standard setters remain committed to building capability in this space, and deposit insurers may be well advised to keep abreast of developments and policy deliberations as they emerge. For this reason, the International Association of Deposit Insurers is continuing to engage with central bank digital currencies as a priority area of research in the medium term.

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<sup>44</sup> Khan & Malaika (2021)

<sup>45</sup> Minwalla (2020)

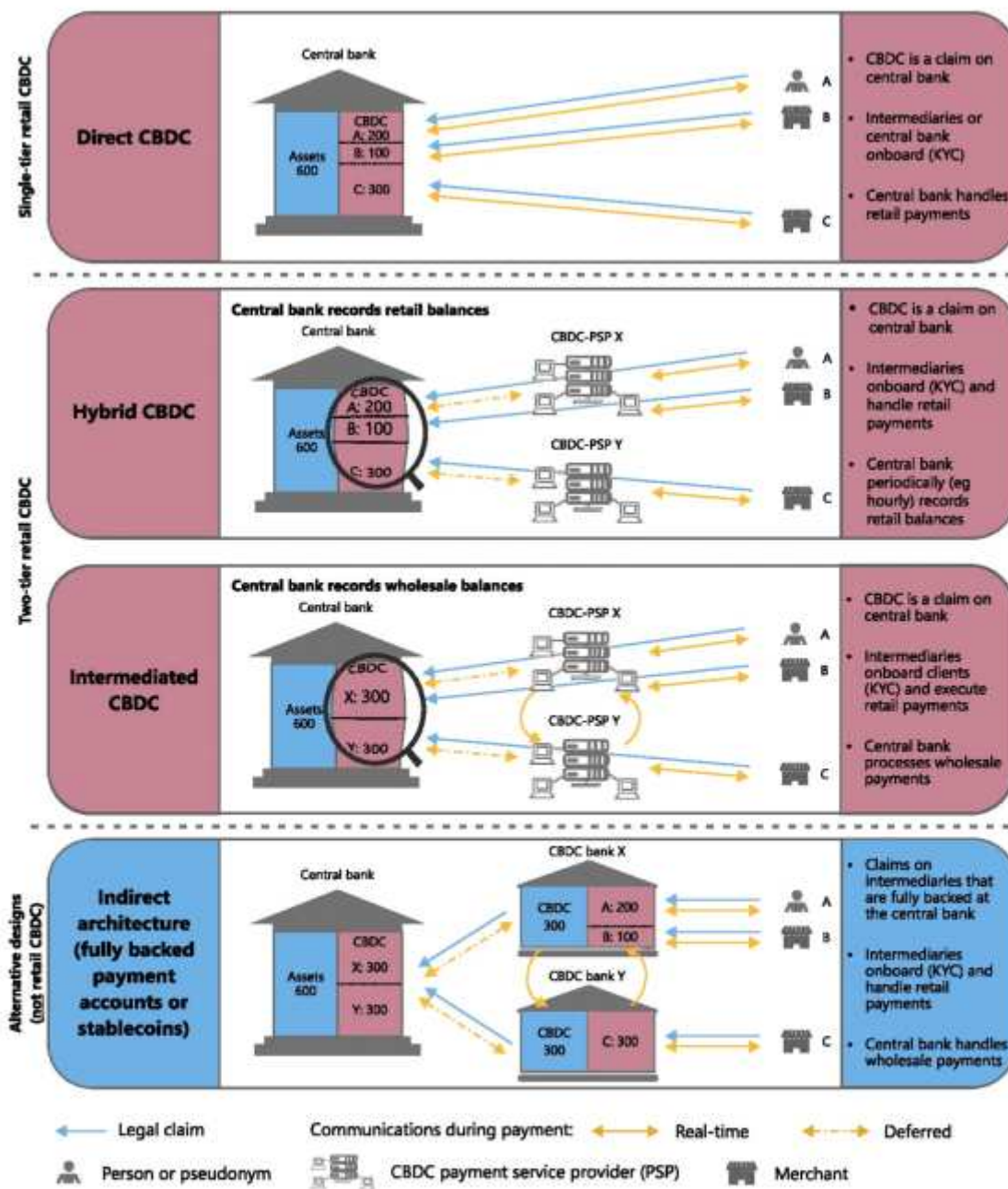
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Retail CBDC architectures and fully backed alternatives

Graph 4



In the "Direct CBDC" model (top panel), the CBDC is a direct claim on the central bank, which also handles all payments in real time and thus keeps a record of all retail holdings. Hybrid CBDC architectures incorporate a two-tier structure with direct claims on the central bank while real-time payments are handled by intermediaries. Several variants of the hybrid architecture can be envisioned. The central bank could either retain a copy of all retail CBDC holdings (second panel), or only run a wholesale ledger (third panel). In the indirect architecture (bottom panel), a CBDC is issued and redeemed only by the central bank, but this is done indirectly to intermediaries. Intermediaries, in turn, issue a claim to consumers. The intermediary is required to fully back each claim with a CBDC holding at the central bank. The central bank operates the wholesale payment system only.

Sources: elaboration based on R Auer and R Böhme, "The technology of retail central bank digital currency", *BIS Quarterly Review*, March 2020, pp 85–100.

Source: Auer and Böhme (2021)