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# **CENTRAL BANK DIGITAL CURRENCIES**

## **A systemic challenge**

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# Central Bank Digital Currencies

## A Systemic Challenge

by Massimo Amato, Alessandro Bonetti, Gregorio Capelli, Luca Fantacci

### Executive summary

A **Central Bank Digital Currency (CBDC)** is a digital money, issued by a central bank, not as a reserve asset and means of settlement between financial intermediaries, but as a means of exchange for retail payments involving businesses and households.

Most central banks are considering, planning or experimenting CBDCs, but none have yet gone beyond a pilot project, apart from the interesting but marginal case of Bahamas that launched the full deployment of their CBDC in October 2020.

Central banks have various **motivations** to contemplate the possibility of issuing a CBDC:

- to contrast the rise of private virtual currencies, particularly stablecoins
- to offer a cheap and clean alternative to physical cash
- to continue providing money as a common good in a cashless society
- to gain and maintain a more direct control over money supply
- to allow effective targeted liquidity injections
- to break the zero lower bound on interest rates

Like other monetary innovations, CBDCs represent an opportunity to overcome some flaws of the present monetary system, and particularly one that has worsened over the past few decades, namely the tendency of money to be withdrawn from circulation into hoards, excess reserves, idle cash balances and sterile speculative circuits. Ultimately, what is at stake is the possibility for central banks to issue a new kind of money that effectively circulates where it is needed to support the production and trade of actual goods and services, through adequate financial and payment systems.

Money is called to perform its traditional functions, but also to rearticulate them in response to new technological possibilities. Technology pushes towards a radical unbundling of the traditional functions of money and of the relationships among the actors called to perform them (banks, payment providers, central banks); but it also allows for a rebundling of functions and of relationships among actors that could lead to enhance old functions and to introduce new ones.

The specific goals pursued by a CBDC, and its ability to achieve them, depend on how it is designed. In principle, it is possible to conceive and build many different types of CBDC by combining in different ways the settings of a series of **institutional and technological options**:

- **Architecture.** The most immediate way to issue a CBDC is by opening the balance sheet of the central bank to households and businesses (direct). Alternatively, the CBDC can be used as backing for deposits at intermediaries, which would act as narrow banks (indirect). A preferable and perhaps more viable middle course would leave the handling of payments to

more efficient payment service providers, whilst retaining for the CBDC the nature of a claim on the central bank (hybrid).

- **Infrastructure.** Being a digital currency, a CBDC only exists as an accounting entity, as a number on a ledger. The relevant data may be stored on a centralized database or on a decentralized system (and particularly on a DLT). The former is generally considered more efficient, the latter more able to ensure privacy, while the comparison is less clear-cut in terms of resilience.
- **Access.** Since a CBDC is just a number on a ledger, to claim the ownership of the money and to transfer it requires access to the data, which can be authorized either through the certification of identity (account-based) or through the possession of a cryptographic key (token-based). The latter option safeguards privacy and universal access, but poses serious challenges for AML/CFT.
- **Issuance.** CBDCs can be issued by central banks to households and businesses in exchange for deposits (like cash), for securities (like QE), or even for nothing (with a loss for the central bank). In all three cases, CBDCs allow a more direct control by central banks, not just over the money base, but over the entire money supply.
- **Purpose.** A clear advantage of CBDC over physical cash is that it can be circulated broadly throughout the economy (general-purpose), but it can also be restricted within designated circuits (special-purpose). The digital technology allows to program money, potentially creating a variety of targeted currencies, tailored to specific needs or policy objectives.
- **Scope.** One significant restriction that can be imposed on CBDC is the circulation within national borders (domestic). Of course, this policy option is easier to impose with account-based access, whereas token-based CBDCs are by default accessible also to foreign residents. CBDCs can even be designed specifically to serve the purpose of cross-border payments.
- **Remuneration.** Programmability of digital money also allows the central bank to regulate the value of the currency over time, by setting a yield on digital cash: this may be zero, as for physical cash, to ensure neutrality; positive, to make CBDC more attractive than cash; or even negative, to discourage hoarding, incentivize circulation and limit the competition with bank deposits and the stability risks implied by disintermediation.

Further diversification of CBDCs can be achieved by introducing limits, caps, tiered systems, and other additional features, with a view to attain different levels of security, privacy and customization.

The case for a CBDC, and the peculiar configuration that it takes, depends on the potential advantages and drawbacks that it produces for central banks, financial intermediaries, governments, users, and the economy as a whole. The potential **effects** of a CBDC may be assessed on five different fronts:

- **Monetary policy.** The introduction of a CBDC would provide two additional monetary policy tools. First, by issuing digital cash, the central bank would be able to determine directly the dynamics of not only the money base ( $M0$ ) but also the money supply ( $M1$ ), without having to rely on banks to create digital money. Second, by regulating the yield on digital cash, the central bank would control the interest rate on ultra-liquid assets with the additional possibility of overcoming the zero lower bound (but also with the risk of undermining financial stability by competing with banks and with governments in the supply of safe assets).
- **Banking system and financial stability.** In fact, the substitutability between deposits and CBDC could cause the disintermediation of banks, weakening their balance sheets and inducing them to tighten credit conditions. This risk could be mitigated by new forms of cooperation between the central bank and commercial banks and by the adoption of a two-tiered system with different yields on CBDC balances, above and below a certain threshold.

- **Payment system.** CBDC would ensure universal access to efficient and secure digital money (especially in less advanced countries), avoiding the displacement of central bank money by private digital tokens. Different levels of anonymity (to safeguard privacy) and of traceability (to contrast tax evasion, money laundering and financing of terrorism) can be achieved according to the different forms of infrastructure and access.
- **Fiscal policy.** CBDC could be an effective instrument for governments to transfer money directly to businesses and households, allowing economic, social and industrial policies to be carried out more promptly and effectively, with lower costs and greater accountability. Issuance without a corresponding asset could allow for the monetization of public deficits. General-purpose CBDC could facilitate the distribution of a universal basic income (“helicopter money”). Special-purpose CBDC would allow to target government support to designated objectives and beneficiaries (“drone money”).
- **User experience.** By combining the features of cash and electronic money, CBDC would entail an increase in the welfare of the users. Compared to bank deposits, it would offer the advantages of digital money without counterparty risk. By introducing a substitute for other forms of electronic money, it would foster competition and innovation by private payment service providers. The possibility of programming digital cash would allow to create customized currencies, tailored to the needs of specific exchange circuits or policy objectives.



## 1 Why a CBDC?

The cryptocurrency phenomenon, both in its positive and in its negative aspects, has shown something that deserves attentive consideration: there is, at least in part, a dissatisfaction with the current payment systems together with a quest for new solutions.<sup>1</sup>

This does not necessarily mean that private-issued cryptocurrencies will become more and more important in the future, but that there is an actual demand for a means of payment which is fast, digital, innovative, and respectful of privacy, but which, at the same time, is marked with a public seal.

Indeed, this is the distinctive characteristic of money, since the very beginning of coinage in the form of *aes signatum* (“stamped bronze”), an early type of currency issued in the 5<sup>th</sup> century BC in the form of metal ingots embossed with the government stamp. Now, the need for a public seal remains a permanent feature of money, even if the way in which money is made public can and must change, in order to respond to the forces that enliven the economy.

The monetary and financial system, not only in advanced economies, is experiencing substantial innovations. These monetary innovations are driven by innovations in data technology. Maybe we are in a situation comparable with the appearance of the first minted coins in ancient Lydia in the 7<sup>th</sup> century BC. The innovation attributed to the mythical King Croesus did not invent payments, but it certainly provided economy and society with a freely, privately circulating yet *publicly guaranteed* means of payment. To put it more precisely: this means

could freely circulate among the public because it was so safely guaranteed. This *semantic* innovation was fundamental. But the digital revolution has important semantic implications.

We are faced with the political, economic, symbolic potential of a currency driven by information- and data-technology. Money is called to perform its traditional functions, but also to rearticulate them in response to new technological possibilities. Technology pushes towards a radical unbundling of the traditional functions of money and of the relationships among the actors called to perform them (banks, payment providers, central banks); but it also allows for a re-bundling of functions and of relationships among actors which is both challenging and promising.

Digitalization is having a strong impact on the payments system, questioning the role of physical cash. The share of transactions in cash is falling in many countries, albeit not at the same pace (see figure 1 below). Notwithstanding this, the total quantity of cash in circulation is not dropping in relation to GDP: the reason is that, except for some exceptions like Sweden, such persistent demand for cash is likely driven by store-of-value motives rather than payment needs, according to the Bank for International Settlements (see figure 2 below).<sup>2</sup>

In general, payments devices and architectures are changing at an accelerating pace. The development of distributed ledger technology (DLT), and particularly the blockchain, has fostered innovation. Tokenization is emerging as a new arrangement to represent goods, assets and rights, and the

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<sup>1</sup> Financial Times Editorial Board “Bitcoin’s crash is not the end of cyber currencies”,

<https://www.ft.com/content/ea80a128-ee6a-11e8-8180-9cf212677a57>

<sup>22</sup> (Bech et al., 2018)

appearance of new financial ecosystems requires new money functionalities (Mandeng & Velissarios, 2019).

New actors have entered payments services and financial intermediation, based on new technologies as well as on the new ideas that they foster. The emergence of alternative forms of private money, like Bitcoin, and in general cryptocurrencies, has been a major trend in the last years, which has been reinforced by the creation of less volatile private digital currencies, namely stablecoins. These new forms of digital payment could become alternatives to traditional banking and, *at the same time*, foster financial inclusion, particularly in emerging economies. But more in general, these new forms have an impact on the whole architecture of modern monetary and financial systems, and create potential threats to monetary sovereignty, financial stability and privacy (Panetta 2020).

Issues of public interest are clearly at stake. Therefore, the increasing importance of private actors in the monetary ecosystem is becoming a matter of concern for public actors. This is why Central banks are looking carefully at technological innovations in the monetary sector and are taking seriously the ensuing questions. Their alert stance is determined also by additional reasons, concerning their very role as regulators of the monetary and financial system.

First of all, *monetary policy* is proving less and less effective in achieving its inflation target (and still less in stimulating growth, even when the latter is explicitly included in its objectives), notwithstanding the huge expansion in central banks' balance sheets. Monetary policy transmission could be strengthened through innovative monetary instruments, which could find a fertile environment in the current circumstances.

The existence of an indefinitely storable, physical cash involves a "zero nominal lower bound" (ZNLB), since it represents an obstacle to driving interest rates substantially in negative territory. This would point at a potential advantage deriving from the abolition of cash and its substitution with a digital currency.

On the other hand, the complete abolition of physical cash could pose threats to privacy. In fact, in order to comply with anti-money-laundering and countering-the-financing-of-terrorism (AML/CFT) rules, it will never be possible to create a digital substitute to banknotes that guarantees total user privacy, which is an important characteristic of modern means of payments (Masciandaro 2018; Borghonovo et al., 2019). Completely removing the only form of money that fully guarantees privacy could lead to a decrease of trust in central bank money, and to a shift towards privately-issued cryptocurrencies and stablecoins, with detrimental effects on financial stability.

A second reason of concern for central banks is, indeed, the growing competition from global private digital currencies (like Facebook's Libra). These developments represent a potential threat to the monopoly of central bank money and fuel fears of gradually losing control of monetary policy, and ultimately of surrendering monetary sovereignty. Indeed, the availability of efficient alternative digital payment tools, disjointed from the banking system, could reduce the degree of control of central banks on the transmission of monetary policy.

Third, there is a known unknown, that is the evolution of physical cash. We have seen that the number of transactions per capita using non-cash alternatives has grown. Lower importance or even disappearance of cash as a means of payment would reduce the direct access of the public to central

### Number of transactions per capita using non-cash alternatives

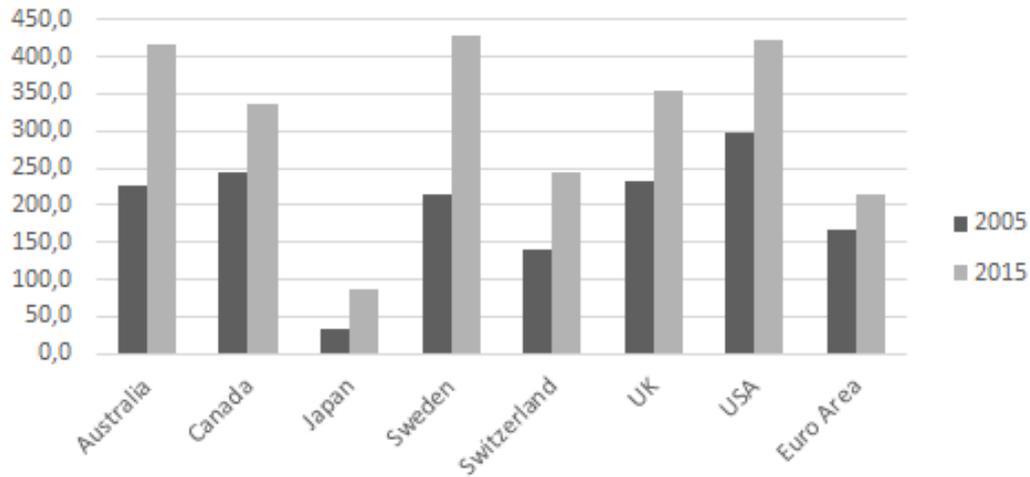


Figure 1. Source: Rinaldi (2017)

bank money. Thus, central banks are looking for alternative ways of granting its availability. As economics editor Martin Wolf stressed on the Financial Times<sup>3</sup>, “money is a foundational public good”. And central banks are well aware of this.

Another cash-related issue is that trust in banks’ deposits depends on their perceived

convertibility into cash. In a society where citizens would have no direct access to sovereign money, deposits would no longer be convertible, leading to possible detrimental effects on financial stability<sup>4</sup>.

In addition, the coronavirus crisis underscored another motivation for creating a reliable mean of transacting remotely. Paper

### currency in circulation/GDP

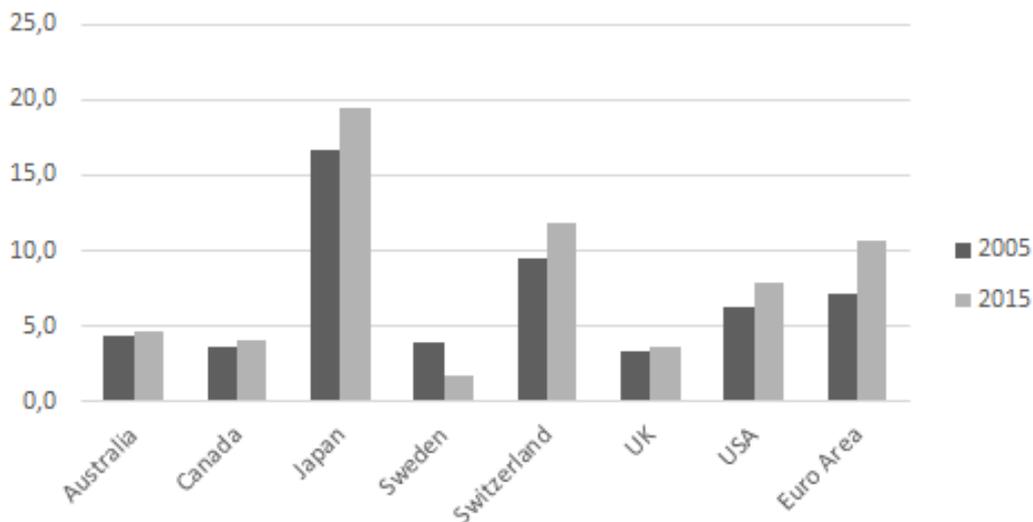


Figure 2. Source: Rinaldi (2017)

<sup>3</sup> Martin Wolf, “The threat and the promise of digital money”, <https://www.ft.com/content/fc079a6a-f4ad-11e9-a79c-bc9acae3b654>

<sup>4</sup> Jean-Pierre Landau, “Central banks should issue digital currencies of their own”,

<https://www.ft.com/content/ad1a6ae8-9be5-11e9-9c06-a4640c9feebb>

money could be a vehicle of the disease. As a matter of fact, in late February 2020, China began disinfecting its banknotes to slow the spreading of SARS-CoV-2<sup>5</sup>. It is not hard to see why, for example, the US Congress considered establishing a digital dollar for America in the third coronavirus relief bill<sup>6</sup>.

All these factors are pushing more and more central banks to consider the creation of a central bank digital currency (CBDC) that, at least in the beginning, would be complementary to paper money. The present report deals with all these issues, with the purpose of giving a picture as complete as possible of the matters related to CBDCs.

## 2 Definition

What exactly do we mean by “central bank digital currency”? The distinctive features are all in the name:

- First of all, a CBDC is a currency, that is a form of money, and as money it performs the typical monetary functions of means of payment, store of value and unit of account.
- Second, its only issuer is the central bank.
- Finally, it is a digital currency, not a cryptocurrency.

The last distinction is quite important. For the sake of clarity, we shall refer to the definition of cryptocurrency provided by the European Central Bank (ECB): cryptocurrencies are a “decentralized bi-directional” form of virtual currency, where “virtual currency” indicates “a digital representation of

value, not issued by a central bank, credit institution or e-money institution, which in some circumstances can be used as an alternative to money” (European Central Bank, 2015).

This means that, while a CBDC hinges on a central institution and is not regarded as a commodity, because it has a fixed value in terms of the official unit of account, a cryptocurrency is decentralised and “can be bought and sold according to (floating) exchange rates” with respect to legal tender money (*ibidem*).

This approach is followed also by the Commodity Futures Trading Commission (CFTC) in the United States, which defines virtual currencies (among which cryptocurrency is a prominent type) as commodities (LabCFTC, 2017)<sup>7</sup>.

After this short but fundamental clarification, we will look at different possible definitions of a CBDC to understand how literature has framed the concept of a work-in-progress form of money, and to possibly identify the best one.

According to Boar et al. (2020) CBDC is “central bank-issued digital money”. Nonetheless, nowadays also bank reserves have a digital form and are issued by the central bank.

So, this definition needs to be further specified. The Bank for International Settlements (CPMI-MC, 2018) defines CBDC as “a digital form of central bank money that is different from balances in traditional reserve or settlement accounts”. Similarly, Agur et al.

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<sup>5</sup> Agence France-Presse in Beijing, “Chinese banks disinfect banknotes to stop spread of coronavirus”, <https://www.theguardian.com/world/2020/feb/15/chinese-banks-disinfect-banknotes-to-stop-spread-of-coronavirus>

<sup>6</sup> Robert Hockett and Lawrence Rufrano, “Digital dollars for all”, <https://www.wsj.com/articles/digital-dollars-for-all-11586215100>

<sup>7</sup> Note however that the definitions of virtual currency adopted by the CFTC and the ECB are not perfectly coincident.

(2020) state that CBDC is “a new type of fiat money that expands digital access to central bank reserves to the public at large, instead of restricting it to commercial banks”.

This differentiates CBDCs from reserves, which can only be used by commercial banks for clearing purposes, and hence cannot. On the contrary, CBDC can work both as a means of discharge of debt positions and as a means of exchange of goods and services.

Central bank money	wholesale	retail
physical		coins and banknotes
digital	reserves	CBDC

### 3 Institutional and technological options

We have defined what a CBDC is. But different types of CBDC can be built according to a variety of institutional and technological options.

From a technological point of view, it is impossible to outline a single type of CBDC. Hence, any description of a real-world project of CBDC cannot disregard its concrete technical and institutional features. This is even more relevant if we consider that a CBDC’s effects on the economy are inseparable from its design.

We still have very few operational CBDCs and so we should consider in our analyses all the feasible typologies. Furthermore, there is the concrete possibility that CBDCs with different designs are issued by different central banks. The interaction between these different kinds of digital public money is an almost completely virgin field even in terms of research.

The design of a CBDC should be built on prospective users’ needs as well as on issuers’ (central banks’) institutional and policy goals. Of course, the purpose of this report is not to advise central banks on the various design options and on the most appropriate type of CBDC to implement. The objective is, rather, to sketch out different possible scenarios and to assess their likelihood. This is the reason why the present chapter discusses, nonetheless, advantages and drawbacks of the various solutions.

We identify, and analyze, seven main design choices:

- Architecture
- Issuance and backing mechanism
- Infrastructure
- Purpose
- Access
- Remuneration
- Cross-border interlinkages

#### 3.1 Architecture

The basic design consideration for a CBDC is the choice of the operational architecture. In this regard, the main issues are two:

- Is the CBDC a direct or indirect claim on the central bank?
- What operational role is played by the central bank and private sector intermediaries in day-to-day payments?

Three architectures are possible: “indirect CBDC”, “direct CBDC” and “hybrid CBDC”.

- **INDIRECT ARCHITECTURE.**  
The user does not have a direct claim on the central bank, but on an intermediary. We can call this mediator “CBDC bank” and the user’s asset ICBCD (because it is a CBDC-like liability; the prefix “I” before CBDC means “indirect”).

The intermediary has to fully back each

outstanding ICBC to users through its holdings of *actual* CBDC or other forms of central bank money<sup>8</sup>. Intermediaries manage communications with their customers, net payments, payment messages to other intermediaries and clearing instructions to the central bank.

So, the central bank keeps track only of wholesale accounts and is relieved of customer-related services and operations. However, it “cannot honour claims from users without information from the intermediary” (Auer & Boehme, 2020, p. 90). Therefore, the issues related to regulation, supervision and deposit insurance are similar to those of the current system.

- **DIRECT ARCHITECTURE.**

Customers have direct claims on the central bank, which keeps track of all transactions and balances and handles

payments. Therefore, a direct connection between the public and the central bank is built. This can be considered the “pure” form of CBDC, which eliminates dependence on intermediaries.

According to Auer and Bohme (2020), the direct CBDC implies risks in crucial elements of the payment system, namely reliability, speed and efficiency. Indeed, private sector actors are traditionally seen as more expert than public counterparts in building and operating technical capacity for payments.

Moreover, electronic payments involve risk-taking by intermediaries, which accept such risk due to the relationship with customers. In order to provide efficient and effective payments services, the central bank should take responsibility for “know-your-customer” (KYC) and customer due diligence. In such case, it would have to expand hugely its

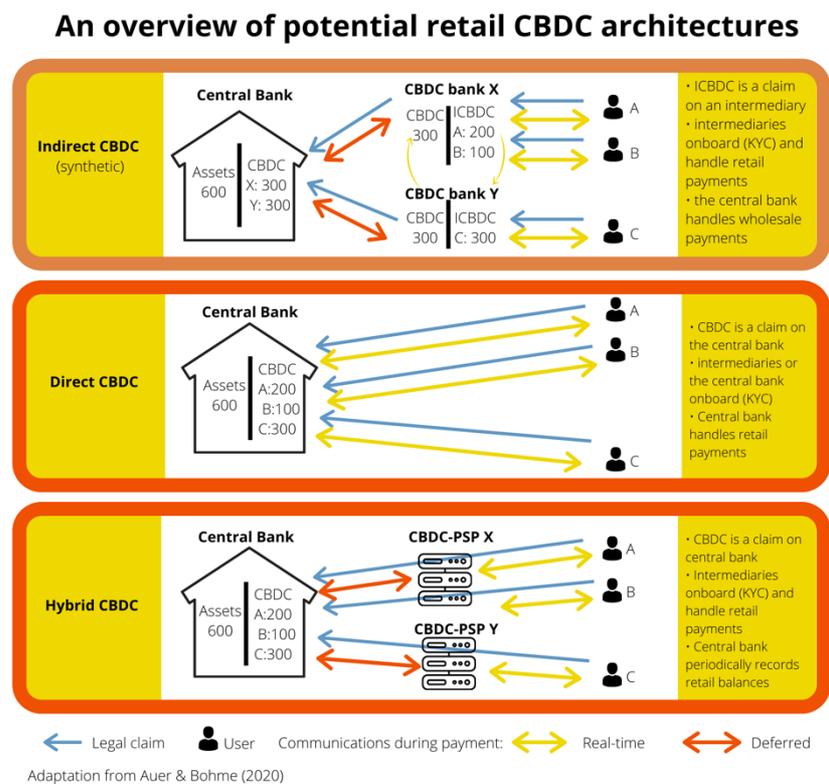


Figure 3

<sup>8</sup> By definition, the intermediary would have access to reserves or CBDC.

operations beyond existing mandates, and this could prove politically, organizationally and computationally difficult.

- **HYBRID ARCHITECTURE.**

In order to overcome the difficulties presented by the two preceding architectures and to maximize the advantages of both, we could think of a hybrid CBDC. It would be hybrid in the sense that it mediates between the two extreme positions illustrated above and distributes charges and obligations between the central bank and intermediaries according to their competences, skills and position in the monetary system.

Hence, users would have direct claims on the central bank, but intermediaries would handle payments. The key feature of this architecture is the legal framework underpinning claims, which keeps them separated from the balance sheets of the payments service providers (PSPs). Such arrangement allows for full portability, which is very important in case of financial or technical failure of a PSP.

In these situations, the central bank would have the power to transfer CBDC holdings from one PSP to another. Even if the central bank has to build the technical capability needed to retain a copy of all CBDC holdings, a hybrid CBDC is

simpler to operate than a direct one, because the central bank does not directly interact with users and can focus on core processes only.

In such an architecture, the central bank stays central for the “backing” function, even if it does not manage all the operations. Therefore, a hybrid CBDC would entail a more (less) complex infrastructure for the central bank with respect to an indirect (direct) CBDC. Hence, it might offer an optimum mix of resilience and lightness.

**BOX. Is “indirect CBDC” really a CBDC?**

In the indirect CBDC framework, financial intermediaries would issue liabilities matched by funds held at the central bank (Auer & Bohme, 2020). This architecture is also referred to as “synthetic” CBDC (Adrian & Mancini-Griffoli, 2019).

However, a recent paper jointly published by major central banks with the Bank for International Settlements (Bank of Canada et al., 2020) argues that the so-called indirect CBDC would not, by definition, be a real CBDC, because the end user would not have a direct claim on the central bank. On the contrary, such liabilities are a form of narrow-bank money.

These liabilities would also lack some key features of central bank money. Indeed, commercial financial intermediaries are driven by profit objectives, unlike the central bank. Moreover, it would be more difficult to adequate the indirect CBDC’s supply to its demand with respect to a proper CBDC (hybrid or direct). Indeed, the central bank can readily create additional liabilities, while a narrow bank cannot.

### 3.2 Issuance and backing mechanism

The issuance of a CBDC must comply with basic accounting rules. As CBDC is a form of central bank money, it must appear on the liabilities' side of the central bank's balance sheet.

The issuance of an indirect CBDC has already been described before and would resemble a narrow bank system. Here, we will focus only on the issuance of a direct or hybrid CBDC. Indeed, from central banks' work and experiments, indirect CBDC seems to be ruled out, at least for the moment.

In principle, a direct or hybrid CBDC could be issued in two ways:

1. in exchange for other financial instruments
2. recording a "loss" for the central bank (decreasing its equity)

As a CBDC is a central bank's liability, assets must increase (option 1) or liabilities must decrease (option 2) accordingly when it is issued.

We will show the issuance mechanism of CBDC both with a written description and with an example. We will start from the following simplified balance sheets, which represent the situation of a closed economy *before* the issuance of a CBDC (for simplicity, we do not show the balance sheet of the government).

central bank			
1100	fin. assets	800	reserves
100	real assets	200	cash
		200	equity
<b>1200</b>	<b>total assets</b>	<b>1200</b>	<b>total liabilities and equity</b>
banking sector			
800	reserves	3000	deposits
100	cash	700	bonds
2000	loans	200	equity
800	fin. assets		
200	real assets		
<b>3900</b>	<b>total assets</b>	<b>3900</b>	<b>total liabilities and equity</b>
users			
3000	deposits	3000	debt
100	cash	6300	net worth
200	fin. assets		
6000	real assets		
<b>9300</b>	<b>total assets</b>	<b>9300</b>	<b>total liabilities and equity</b>

#### *Issuance in exchange for other financial instruments*

- CASH-LIKE ISSUANCE

When a customer of a commercial bank wants to convert a deposit into cash, she just asks the bank. At that moment, the bank reduces both the amount of the customer's deposit and the amount of cash in its vaults. But how does a commercial bank obtain cash? It must convert some of its reserves at the central bank with cash.

A similar mechanism could be envisaged for CBDC. A commercial bank's customer could ask the bank to exchange a deposit of her with CBDC. The commercial bank needs to have already received CBDC from the central bank (and stored it in a "digital vault"). But how can a commercial bank get CBDC? It needs to convert some of its reserves with newly issued CBDC (theoretically, it could do the same with cash).

Therefore, the logical sequence is:

- issuance of CBDC by the central bank in exchange for reserves (or cash) held by the commercial bank
- conversion of commercial bank deposits into CBDC

In the following example, we suppose that depositors ask their banks to convert 100 units of deposits into CBDC:

1. First, the banks need to get CBDC from the central bank exchanging it with reserves

<b>central bank</b>			
		-100	reserves
		+100	CBDC
<b>banking sector</b>			
-100	reserves		
+100	CBDC		

2. Then, users can withdraw their deposits in exchange for CBDC, as they would do with cash

<b>banking sector</b>			
-100	CBDC	-100	deposits
<b>users</b>			
-100	deposits		
+100	CBDC		

3. The final result is the following:

- i. The central bank has the same amount of liabilities, but their composition is different
- ii. The banking sector loses reserves and deposits (disintermediation occurs)
- iii. Final users exchange commercial bank money (deposits) with central bank money (CBDC)

<b>central bank</b>			
1100	fin. assets	700 ↓	reserves
100	real assets	100 ↑	CBDC
		200	cash
		200	equity
<b>1200</b>	<b>total assets</b>	<b>1200</b>	<b>total liabilities and equity</b>
<b>banking sector</b>			
700 ↓	reserves	2900 ↓	deposits
100	cash	700	bonds
2000	loans	200	equity
800	fin. assets		
200	real assets		
<b>3800 ↓</b>	<b>total assets</b>	<b>3800 ↓</b>	<b>total liabilities and equity</b>
<b>users</b>			
2900 ↓	deposits	3000	debt
100 ↑	CBDC	6300	net worth
100	cash		
200	fin. assets		
6000	real assets		
<b>9300</b>	<b>total assets</b>	<b>9300</b>	<b>total liabilities and equity</b>

- QE-LIKE ISSUANCE

The central bank could match the issuance of CBDC with purchase of government (and possibly corporate) bonds from banks (or households and firms). In this way, banks, firms and families would get CBDC in exchange for bonds. This mechanism would resemble Quantitative Easing, except it would be extended to non-bank private actors. This strategy could prove effective if the central bank wanted to prevent disintermediation and to avoid intruding in the credit allocation process.

The large amount of bonds held by banks and non-bank private actors shows that there is some scope for CBDC before the central bank would have to play a larger role in credit allocation, as suggested by Bindseil (2019, p.14).

The issue of centralization of credit would emerge only if CBDC took very large dimensions, for which this kind of strategy could prove insufficient. In the following example we suppose that the central bank distributes CBDC buying bonds worth 100 units from the banking sector and bonds worth 100 units from users.

central bank			
+200	<i>fin. assets</i>	+200	<i>CBDC</i>
banking sector			
-100	<i>fin. assets</i>		
+100	<i>CBDC</i>		
users			
-100	<i>fin. assets</i>		
+100	<i>CBDC</i>		

The result right after the issuance of CBDC is the following:

- The central bank balance sheet becomes larger
- The banking sector and final users have more liquidity than before in the form of CBDC

central bank			
1300 ↑	<i>fin. assets</i>	800	reserves
100	real assets	200 ↑	<i>CBDC</i>
		200	cash
		200	equity
1400 ↑	<b>total assets</b>	1400 ↑	<b>total liabilities and equity</b>
banking sector			
800	reserves	3000	deposits
100	cash	700	bonds
2000	loans	200	equity
700 ↓	<i>fin. assets</i>		
100 ↑	<i>CBDC</i>		
200	real assets		
3900	<b>total assets</b>	3900	<b>total liabilities and equity</b>
users			
3000	deposits	3000	debt
100 ↑	<i>CBDC</i>	6300	net worth
100	cash		
100 ↓	<i>fin. assets</i>		
6000	real assets		
9300	<b>total assets</b>	9300	<b>total liabilities and equity</b>

In this way, users can enjoy immediate availability of CBDC. If some of them still wanted to exchange commercial bank deposits with CBDC, the balance sheet of banks and of the banking sector as a whole would shrink but they would not lose reserves. However, there is an open issue con-

nected to the utilization of this new liquidity, which crucially depends on the remuneration of CBDC.

If users wanted to invest the new available liquidity, they could buy new bonds emitted by commercial banks offsetting the shrinkage of their balance sheets (as envisaged by Bindseil, 2019), but this cannot be taken for granted. Moreover, how banks would invest the new liquidity on financial markets could have further unintended effects.

- **REFINANCING-LIKE ISSUANCE**  
According to another proposal (Brunnermeier & Niepelt, 2019), the central bank should always accompany the issuance of CBDC to new funding for commercial banks (as if it always “bought” deposits from private banks’ customers in a one-to-one exchange for newly emitted CBDC). With this strong commitment from the central bank, a transfer of funds from deposits to CBDC accounts would give rise to an automatic substitution of one type of bank funding (households and firms’ deposits) to another one (central bank funding)<sup>9</sup>. This “pass-through” mechanism would work as follows:
  1. households (or firms) expand their CBDC holdings and lower their deposits
  2. the central bank’s liabilities expand correspondingly
  3. simultaneously, in exchange for the CBDC, central bank’s assets expand by the same amount through the acquisition of claims vis-a-vis the banking sector<sup>10</sup>.

<sup>9</sup> If this were the case, the issuance of a CBDC would make the central bank’s (implicit) lender-of-last-resort guarantee explicit.

Thus, the central bank intermediates between non-bank private actors and banks, also preserving the banks’ choice sets.

In the following example, we assume that users (households and/or firms) want to exchange 100 units of their commercial bank deposits with CBDC.

- Users ask their banks CBDC in exchange for deposits
- The central bank creates CBDC and lends money to commercial banks to substitute the lost deposits (the final effect is equivalent to a purchase of deposits by the central bank)
- Commercial banks receive CBDC (assets) and central bank funding (liabilities).
- Then, they give CBDC to users and write off their deposits.

The final result is that banks exchange deposit funding from non-banks with central bank funding:

<b>central bank</b>			
+100	<i>CB funding</i>	+100	<i>CBDC</i>
<b>banking sector</b>			
+100	<i>CBDC</i>	+100	<i>CB funding</i>
-100	<i>CBDC</i>	-100	<i>ing deposits</i>
<b>users</b>			
-100	<i>deposits</i>		
+100	<i>CBDC</i>		

By behaving this way, the central bank does not interfere directly with the credit allocation mechanism – only banks screen and monitor investment projects. Such a swap of funding would

<sup>10</sup> This means that the central bank automatically provides substitute funding for banks at the same conditions as the previous deposit funding from non-banks.

be liquidity- and wealth- neutral and would lead to unchanged choices of economic agents. Indeed, the private sector balance sheets (of both banks and non-banks) would be unchanged.

**central bank**

1100	fin. assets	800	reserves
100 ↑	CB funding	100 ↑	CBDC
100	real assets	200	cash
		200	Equity
<b>1300 ↑</b>	<b>total assets</b>	<b>1300 ↑</b>	<b>total liabilities and equity</b>

**banking sector**

800	reserves	2900 ↓	deposits
100	cash	100 ↑	CB funding
2000	loans	700	bonds
800	fin. assets	200	equity
200	real assets		
<b>3900</b>	<b>total assets</b>	<b>3900</b>	<b>total liabilities and equity</b>

**users**

2900 ↓	deposits	3000	debt
100 ↑	CBDC	6300	net worth
100	cash		
200	fin. assets		
6000	real assets		
<b>9300</b>	<b>total assets</b>	<b>9300</b>	<b>total liabilities and equity</b>

Moreover, such solution would not undermine financial stability:

- it would not decrease banks' funding, neither automatically nor as an indirect effect
- a depositors' run to CBDC would automatically trigger "pass-through" funding
- there would not be excess liquidity in the system, as deposits would be exchanged with CBDC

However, important issues arise regarding how, if and when the central bank funding to commercial banks should be

repaid. In particular, if this funding became perpetual, it would be equivalent to a "hidden recapitalization" of commercial banks by the central bank. Moreover, if brought to the extreme, this arrangement would completely substitute deposit funding with central bank funding, with unpredictable effects, particularly in terms of moral hazard.

*Issuance with a "loss" for the central bank*

In principle, the central bank could issue a CBDC (i.e. an additional liability on its balance sheet) even without buying existing assets. Indeed, it could simply write off part of its equity.

Then, it could distribute the newly issued CBDC to the private sector (banks, households and firms). This technical option could be well-suited for "helicopter money" programs, where the central bank distributes money without buying a corresponding asset.

In the following example, we suppose that the central bank enacts a relief measure, distributing 100 units of CBDC directly to the population.

**central bank**

		+100	CBDC
		-100	equity

**users**

+100	CBDC	+10	net worth
		0	

We can see that this operation reduces central bank's equity and increases users' net worth.

The final form of the balance sheets is the following (we do not show the banking sector because in our example it is not directly affected):

central bank			
1100	fin. assets	800	reserves
100	real assets	200	Cash
		100 ↑	CBDC
		100 ↓	equity
<b>1200</b>	<b>total assets</b>	<b>1200</b>	<b>total liabilities and equity</b>

users			
3000	deposits	3000	debt
100	Cash	6400 ↑	net worth
100 ↑	CBDC		
200	fin. assets		
6000	teal assets		
<b>9400 ↑</b>	<b>total assets</b>	<b>9400 ↑</b>	<b>total liabilities and equity</b>

If this were an exceptional, one-time measure, the central bank's equity would remain positive.

However, if such mechanism were repeated in time and/or were big enough, it could completely wipe out central bank's equity and make it even negative. Throughout history, central banks have sometimes operated with a negative equity. Furthermore, on 19th November 2020 ECB's chair Lagarde said that the central bank can "neither go bankrupt nor run out of money" even if it suffers losses. Nevertheless, the discussion on the matter of negative equity is still open, especially regarding its long-term implications (Stella, 1997; Dalton & Dziobek, 2005; Bibow, 2018).

In all cases, CBDC seem to offer central banks a more effective control of the money supply, by allowing a direct regulation not only of the money base ( $M0 = \text{cash} + \text{reserves}$ ) but also of all the money that is readily usable for spending ( $M1 = M0 + \text{deposits}$ ).

### 3.3 Infrastructure

Infrastructure must be projected according to the chosen architecture and issuance. The indirect CBDC would entail a workload for the central bank similar to that of the

current system, while the direct CBDC would require the central bank to mobilize huge technological resources. The hybrid CBDC would be a half-way.

There are two main infrastructural options: a conventional centralized database and a decentralized system.

#### Comparison

- ORGANIZATION AND UPDATE OF DATA
    - In a centralized infrastructure data are stored over various physical nodes, "controlled by one authoritative entity – the top node of a hierarchy" (Auer & Bohme, 2020). The central bank would fulfill this role and would be the sole subject with the authority of updating the database.
    - In a decentralized system, there is not a single subject at the top. The most popular decentralized infrastructure today is distributed ledger technology (DLT), where the authority of updating the database is delegated to a network of identified and vetted validators, without a top node. Actually, this is a specific kind of DLT, called "permissioned", where some actions (validation in this specific case) can be performed only by certain identified participants. The ledger is "distributed", because each update has to be harmonized between the nodes that form the system, which often involves algorithms known as "consensus mechanisms".
- While a decentralized ledger could make peer-to-peer and offline payments easier (Bank of

Canada et al., 2020), it would outsource to external validators the authority to adjust claims on the central bank balance sheet. The feasibility of such an arrangement depends on trust in such (mostly) private networks. Preliminary assessments on DLT-based proofs-of-concept tend to be negative (Auer & Boehme, 2020).

- **PRIVACY**

A permissioned blockchain could enhance privacy with respect to a centralized system. Mandeng & Velissarios (2019) underline that in the last years there have been progresses in blockchain technology and that this infrastructure would make a *tokenized form of central bank money* easier to implement. Privacy would rest on the combination of tokenization, decentralization and secure information sharing. Indeed, although transactions via blockchain

are traceable, they can be made anonymous or configured to a varying degree of pseudonymity.

- **EFFICIENCY**

A centralized ledger seems to be more efficient than DLT, even if not all authors agree (see Mandeng & Velissarios, 2019). Although a permissioned network could overcome scalability problems (Bank of Canada et al., 2020), DLT would imply high costs and probable lower transaction throughput (Auer & Boehme, 2020), due to the functioning of the validation mechanism.

This would imply that DLT cannot be used for the direct CBDC except in very small jurisdictions. However, it could be used for the hybrid CBDC and for the indirect CBDC, which require less operational activity by the central bank (ibidem).

- **RESILIENCE**

For what regards resilience, there is no

**BOX. Is a “permissionless” DLT feasible?**

Most likely, central banks will not consider the adoption of a “permissionless” technology, for different reasons.

First, the economic costs of transaction validation would be very high. Second, the choice of a permissionless technology would amount *de facto* to the adoption of a cryptocurrency. According to Berentsen and Schar (2018), it makes little sense for central banks to issue cryptocurrencies, because their key characteristics “are a red flag” for them. This is due to three main reasons:

- reputational risks of issuing an anonymous virtual currency
- effects on commercial banks’ diligence: they would ask why they need to follow KYC/AML regulations, while the central bank circumvents such regulations by issuing a cryptocurrency with unpermissioned access
- large operational risks connected to the cryptocurrency technology.

This approach has already been rejected by central bankers. For example, Martin Diehl, Head of Section Payment Systems Analysis at the Bundesbank, ruled out the possibility of using a permissionless blockchain <sup>11</sup>.

<sup>11</sup> Helen Partz, “European central bank execs explain why CBDCs don’t need blockchain”, <https://cointelegraph.com/news/european->

[central-bank-exec-explain-why-cbdc-don-t-need-blockchain](https://cointelegraph.com/news/european-central-bank-exec-explain-why-cbdc-don-t-need-blockchain)

clear advantage of a type of infrastructure over the other. While in principle DLT may offer more benefits, by replicating information over many data sites<sup>12</sup>, the same could be done by a centralized ledger with a small number of data centers (Bank of Canada et al., 2020).

Additionally, the two infrastructures have different kinds of vulnerabilities. In a conventional architecture, the main problem would be the possibility of a breakdown of the top node (namely the central bank), from which all the transactions depend. On the other hand, the main weakness of a DLT is the functioning of the consensus mechanism, whose failure could hinder the smooth sequence of transactions. A well-functioning and resilient network of private actors supporting the system is needed.

### *Results of the comparison*

To sum up, in the literature there seems to be a preference towards a centralized infrastructure. Originally there used to be higher openness to DLT and blockchain, but the “technological window” has been partially closed.

DLT is considered an immature technology, currently less efficient, slower and much more energy-intensive than a centralized system. The only substantial advantage it would offer is anonymity (Claeys and Demertzis, 2019; Mancini-Griffoli et al., 2018).

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<sup>12</sup> “The decentralized nature of blockchain reduces systemic vulnerabilities. Blockchain-based applications rest on the coexistence of various data sites. This ensures there is no single point of failure. Break-

Moreover, in a retail scenario the use of a blockchain could run up against users’ technical capabilities or even their interest in acting as nodes of the system.

As Thomas Moser (alternate member of the governing board at Swiss National Bank) pointed out<sup>13</sup>, blockchain is useful especially when trust for applications without a central party needs to be provided. Nevertheless, in the case of a retail CBDC there is a central party which should provide trust, namely the central bank.

According to Moser, blockchain could still be useful for a wholesale CBDC. However, a wholesale blockchain-based infrastructure raises some technical and functional issues. Firstly, the setting by the central bank of the number of participants would be compatible only with a private blockchain. Other questions would be the interaction with other blockchains and the potential circulation of the wholesale CBDC on several blockchains. In these cases, a control by the central bank would be difficult and could have effects for financial stability and monetary policy transmission that cannot be easily anticipated (Pfister, 2020).

Thus, the adoption of a blockchain technology could be highly problematic and its drawbacks and weaknesses are not necessarily offset by the advantages that it offers. Moreover, a DLT would only allow a tokenized CBDC, not an account-based one (see next chapter).

A centralized database would be more stable and reliable, but it would not be exempt from problems:

down of an individual network node may exclude that node from participating in the network but does not preclude the rest of the network to operate” (Mandeng & Velissarios, 2019).

<sup>13</sup> *ibidem*

		ARCHITECTURE		
		DIRECT	HYBRID	INDIRECT
INFRASTRUCTURE	CENTRALIZED	<b>Central bank dominance</b> (Central ledger + central settlement)	<b>Centralized PPP</b> (Central ledger + privately run settlement)	<i>“Narrow banks” system</i>
	DECENTRALIZED (DLT)	<b>Central bank-supported DLT</b> (Distributed ledger + publicly run settlement)	<b>Decentralized PPP</b> (Distributed ledger + privately run settlement)	<i>“DLT narrow banks” system</i>

Figure 4. Interaction between architecture and infrastructure. Authors' elaboration.

- It would be more difficult to manage, requiring huge investments and constant supervision by the central bank.
- Increased centralization could imply less efficiency in the management of a CBDC. If CBDC is meant to be primarily an instrument for smoothing market transactions, the concentration of tasks and power in the hands of the central bank would raise critical issues.
- Diseconomies of scale could emerge. The central bank should build a huge capacity of data storage and processing, which could be better performed in a decentralized infrastructure.

At this point, it is clear that policy preferences must be taken into account. Whether competition or control must be prioritized depends on the political meaning of a CBDC.

#### *Interaction between architecture and infrastructure*

Much depends also on the interaction between architecture and infrastructure. Different combinations between these two design options can lead to a greater or smaller role for the central bank. If more functions

are managed by the central bank, the system could be simpler and focus more on objectives like universal access. However, it may hinder innovation needed for enhancing “flexibility, convenience and adoption” (Bank of Canada et al., 2020).

For the moment we will rule out the indirect architecture (shaded in grey in the figure above), because, as we have seen, it resembles a narrow banking system more than a proper CBDC.

We can identify a situation that we can call “central bank dominance”, where the infrastructure is centralized, and the architecture is direct (i.e. direct claims on the central bank, that manages payments).

The central bank could decide to reduce its power in three ways:

- “central bank-supported DLT”: adopting a DLT (instead of a central ledger) but maintaining direct control on settlements. This would imply a “State DLT”, where validators would be multiple and decentralized but subject to the central bank
- “centralized public-private partnership (PPP)”: maintaining a central

ledger but allowing financial intermediaries to manage payments

- “decentralized PPP”: adopting a DLT where validators would be private financial intermediaries.

The optimal solutions seem the last two, involving a hybrid architecture, namely a private-public partnership (PPP). They make the problem of the technological infrastructure less pressing. As intermediaries would handle payments, a hybrid architecture would solve one of the main issues connected to responsibility and would be compatible either with DLT or with a centralized ledger. Moreover, it would create new business opportunities for financial intermediaries and foster innovation. As a matter of fact, some major central banks (Bank of Canada et al., 2020) made the point for a hybrid CBDC, arguing that a centralized ledger would need an intermediary to handle and transfer liabilities.

Another relevant issue is the degree of development of the financial system in the central bank’s jurisdiction.

In a developed economy, the central bank would have more policy space to choose the preferred combination of architecture and infrastructure. Indeed, it could either exploit its higher internal technical knowledge to build a direct CBDC or rely on developed financial markets, involving financial intermediaries in the creation of a hybrid CBDC.

On the other hand, in emerging market economies (EMEs), the financial ecosystem is less developed and there is smaller scope for a public-private partnership. Therefore, the central bank could be pushed to try and build a direct CBDC, but its efforts could be hindered by the lack of needed know-how. So, the central bank could ask for support from international financial institutions (like the IMF, the BIS and the World Bank)

and/or involve foreign financial intermediaries to build the needed infrastructure.

### 3.4 Purpose

Current literature uses many different terms to define different types of CBDC with respect to its purpose: wholesale vs retail, widely available vs restricted, general vs special and so on.

In this report, we try to make sense of these taxonomies and we introduce a useful simplification. We distinguish a general-purpose CBDC from targeted (or special purpose) CBDCs:

- A general purpose CBDC can be used by any economic actor for any economic transaction in any territory of the central bank’s jurisdiction and in any function.
- Targeted CBDCs are programmable to select which economic actors can use them, for which transactions they can be employed and in which economic (territorial and/or functional) spaces they can be spent.

Therefore, the programmability of CBDC makes it conceptually different from cash, even if they could be seen as substitutes. The physical form of cash excludes the possibility of a further customization. The only differences in the types of cash are their denomination and the difference between banknotes and coins (which nevertheless have roughly the same functionalities).

Thanks to programmability, instead, a CBDC can have a “special purpose”, namely its circulation can be restricted to certain actors, transactions and spaces. Then, CBDC can have different institutional features.

- An example of a targeted CBDC is the wholesale CBDC, available only for wholesale payment and settlement

transactions by financial intermediaries.

A wholesale CBDC would provide financial intermediaries with an asset whose value is strictly equivalent to that of other forms of central bank money, like reserves or cash. Such innovation could boost financial sector productivity (Pfister, 2020) and further stimulate innovation. The introduction of a new means of wholesale payment could make settlement systems for financial transactions more efficient.

- Another example is a CBDC that the general public can use to buy only specific products.

In general, a great number of possible combinations and customizations can be envisaged, making CBDC a very flexible instrument for reaching specific policy objectives.

Moreover, as the Bank for International Settlements underlines (CPMI-MC, 2018), and as also a recent proposal by Bindseil and Panetta (2020) implies, the common distinction between retail and wholesale payments could become less relevant in a world with CBDC. Indeed, a general-purpose CBDC could be used both for wholesale transactions and retail transactions.

In the following sections, we will focus on a CBDC for the general public intended to be used mainly for retail payments, as this is the most discussed type of CBDC in the literature, the most likely outcome of central banks' work and the type of CBDC which is more clearly distinct from central bank reserves.

### 3.5 Access

The modality of access to CBDC is another fundamental issue. A CBDC can be either account-based or token-based.

#### *Account-based CBDC*

- Account-based access requires a central ledger. Thus, it is compatible only with a centralized infrastructure.
- The functioning of such a technology can be described by the expression "I am, therefore I own" (Auer & Boehme, 2020). Ownership is tied to an identity and claims are represented in a database that records values and transactions with reference to that identity.
- A transaction between holders of account-based CBDCs would be similar to transactions between commercial bank depositors, except for the fact that accounts would be held with the central bank (by final users in the case of a direct or hybrid CBDC or by intermediaries in the case of an indirect CBDC).
- However, such framework has some drawbacks. In particular, there is the need for "strong" identities, namely "schemes that map each individual to one and only one identifier across the entire payment system" (ibid.). This technical configuration could be problematic to put in place in some countries, especially in developing economies, impairing universal access.

#### *Token-based CBDC*

- The functioning of this access technology is summarized by the wording "I know, therefore I own". Ownership is tied to demonstrated knowledge of an encrypted value, such as a digital signature.
- Token-based access is compatible with a DLT.
- Moreover, a token may represent either central bank money (direct or hybrid CBDC) or a *claim* on central bank money (indirect CBDC)

- Transacting in token-based CBDC would involve more steps than exchanging cash but would offer the convenience of not having to meet in person.
- Another advantage is the easiness in providing both universal access and good privacy, even if, for matters of security, token-based transactions might not be entirely anonymous like cash.
- Furthermore, tokenization would make easier for CBDC to interact with communication protocols in the internet of things (e.g. NFC technology).
- Nevertheless, the shortcomings are severe:
  - There is high risk of losing funds if end users fail to keep their private key secret.
  - Moreover, tokenization poses a big challenge to the central bank to design an effective anti-money-laundering/combating-the-financing-of-terrorism (AML/CFT) framework.

### *Conclusions*

In conclusion, on one hand, an account-based CBDC looks simpler and more effective against money laundering and other illicit uses. It seems to allow for higher security and control of the circulating amount of CBDC base money (Bindseil, 2019). On the other hand, a tokenized CBDC could prove more effective in facing the challenges posed by the rise of private monies and would be a direct substitute for cash if it disappeared.

## 3.6 Remuneration

Remuneration<sup>14</sup> is a specific feature enabled by CBDC's programmability. If the central bank allows for remuneration, it gains another design instrument.

Nonetheless, introducing a remuneration on CBDC comes with some drawbacks which we are going to address in paragraph 4.1.

### *No remuneration*

Keeping the CBDC interest rate at zero would be incentive-neutral with respect to CBDC use. This can be an appropriate choice if network effects related to the use of different means of payment do not represent a constraint for policy decisions (Agur et al., 2020).

### *Negative remuneration*

However, when network effects bind and pose a threat to the variety of payment instruments, applying a negative interest rate can be a solution. This choice could prevent a reduction in the use of physical cash (adverse network effects) by making the CBDC less attractive as a store of value (though not necessarily less attractive as a means of payment within designated payment circuits). At the same time, negative remuneration would limit CBDC's impact on financial intermediation and credit creation by banks.

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<sup>14</sup> Noone and Kumhof (2018) claim that CBDC should pay an adjustable interest rate in order to clear the market and to control inflation

### *Positive remuneration*

Network effects are not the only reason to introduce or not to introduce a remuneration for CBDC. A case can be built also for a *positive* interest-bearing CBDC.

First, imperfect competition in the banking sector could push the central bank to set a positive remuneration on CBDC, as this would increase competition with bank deposits.

Furthermore, if there is public dislike for anonymity in payments, a positive interest rate can be used to attract agents into using CBDC and relinquishing other means of payment, so as to better monitor payments details and discourage illicit activities. However, this depends on the level of remuneration.

### 3.7 Cross-border payment technology

Another design choice is linked to transactions with the foreign sector.

If access is based on digital tokens, by default accessibility is guaranteed to foreign residents, even if some ways to prevent this can be envisaged. Otherwise, if access is based on accounts, accessibility to foreign residents would be a policy choice.

Many central banks in the world are exploring CBDC both from a theoretical and from a practical point of view. If they coordinated their design efforts, they could incorporate interlinkage options from the beginning. This is a project on which Saudi Arabia and

other Gulf countries are specifically working<sup>15</sup>. Interoperability would facilitate cross-border payments, separating the payment from the foreign exchange transaction. This would be a global response to private payments solutions, such as Libra, which is conceived to cross all borders.

### 3.8 Conclusions

In this chapter we have described all the basic design choices.

Other technological features are privacy, level of security, integration of additional services, and limits or caps, which can bring about further customizations of a CBDC.

Moreover, a CBDC system would need a “rulebook” to formalize roles and responsibilities of operators, users, other service providers and stakeholders (Bank of Canada et al., 2020).

Design-related decisions are inextricably linked to the central bank’s policy preferences. According to its stance and priorities, the CBDC would take a different form. This raises inevitable trade-offs, for example between speed and security, or between multiple functionalities and complexity-related issues.

In the table below we analyze the interaction between design choices and potential effects on the economy, which will be studied in detail in the next chapter.

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<sup>15</sup> Khun, D. (2020, November 29). Bilateral Saudi, UAE Digital Currency Experiment Shows Benefits of Distributed Ledgers, Central Banks Say. CoinDesk. <https://www.coindesk.com/bilateral-saudi-uae-digital-currency-experiment-shows-benefits-of-distributed-ledgers-central-banks-say>;

Thurman, A. (2020, November 29). UAE, Saudi Arabian central banks release report on Project Aber CBDC trial. Cointelegraph. <https://cointelegraph.com/news/uae-saudi-arabian-central-banks-release-report-on-project-aber-cbdc-trial>

EFFECTS → DESIGN ↓	MONETARY POLICY IMPLEMENTATION	MONETARY POLICY TRANSMISSION, BANK- ING SYSTEM AND FI- NANCIAL STABILITY	EFFECTS ON THE PAY- MENT SYSTEM	FISCAL POLICY AND CRISIS MANAGEMENT	EFFECTS ON FINAL USERS
GENERAL FEATURES	<ul style="list-style-type: none"> <li>The introduction of a CBDC would give the central bank an additional monetary policy tool</li> </ul>	<ul style="list-style-type: none"> <li>CBDC is a direct liability of the central bank, which could gain higher control on money supply and on the financial markets</li> <li>By definition, CBDC would be absolutely liquid. This feature: <ul style="list-style-type: none"> <li>could attract wholesale demand, causing a decline in the depth of repo and short-term government bonds market.</li> <li>could worsen or provoke bank runs during periods of financial stress.</li> </ul> </li> <li>Different levels of disintermediation are connected to the degree of substitutability between commercial banks deposits and CBDC.</li> </ul>	<ul style="list-style-type: none"> <li>Provide direct access to efficient and instantaneous payment systems</li> <li>If CBDC decreased the use of physical cash, the cost of supplying central bank money to the public would be reduced</li> <li>Ensure universal access to efficient, secure and modern central bank money (especially in countries without high-quality electronic commercial bank money, and/or without a secure and efficient payment system)</li> <li>Provide a safe central bank instrument</li> <li>Help to maintain a direct link between the central bank and citizens</li> <li>Avoid that private digital tokens displace central bank money in</li> </ul>	<ul style="list-style-type: none"> <li>CBDC could be an effective facility for the government to transfer money to the public, to provide targeted support to designated categories, especially during a crisis</li> </ul>	<ul style="list-style-type: none"> <li>Satisfy the demand for digital money without counterparty risk</li> <li>Foster competition in the market for digital substitutes of cash increasing social welfare</li> </ul>

		<ul style="list-style-type: none"> <li>• Possible implications of disintermediation: <ul style="list-style-type: none"> <li>– tightening of credit conditions by banks</li> <li>– narrowing of commercial banks' balance sheets and activities</li> <li>– competition between central bank and commercial banks (only if the central bank does not fill funding gaps of commercial banks)</li> </ul> </li> </ul>	<p>transactions and slow the growth of crypto-assets</p> <ul style="list-style-type: none"> <li>• Lower transaction costs and offering a risk-free payment network</li> <li>• Promote competition and innovation in payment services</li> <li>• Create a common means of transferring funds between the other payment systems, overcoming fragmentation risk</li> </ul>		
<p><b>ARCHITECTURE, ISSUANCE &amp; INFRASTRUCTURE</b></p>	<ul style="list-style-type: none"> <li>• Issuance methods can <b>directly</b> influence both the quantity of the money base (M0) and of the money supply (M1) in the economy: <ul style="list-style-type: none"> <li>– Cash-like issuance: both aggregates don't change</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Cooperation of commercial banks with the central bank could be a solution to the financial disintermediation caused by CBDC. Possible forms of cooperation: <ul style="list-style-type: none"> <li>– Targeted refinancing operations to replace lost deposits</li> <li>– New commitment of the central bank as lender of last resort</li> <li>– Indirect CBDC</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Direct and hybrid CBDC give direct access to a digital form of central bank money</li> <li>• With a direct CBDC, KYC functions would fall on the central bank, which is not used to such tasks</li> <li>• On the other hand, a centralized infrastructure allows for easier data collection</li> </ul>	<ul style="list-style-type: none"> <li>• A CBDC makes programs of money distribution to citizens easier for the purpose of a variety of fiscal policies</li> <li>• Issuance without a corresponding asset would facilitate "QE for the people" (i.e. basic income financed by money creation)</li> </ul>	<ul style="list-style-type: none"> <li>• A DLT infrastructure is easily adaptable to all levels of privacy. In particular, it can facilitate pseudonymity and anonymity</li> </ul>

	<ul style="list-style-type: none"> <li>- QE-like issuance: M0 ↑ and M1 ↑</li> <li>- Refinancing-like issuance: only M0 ↑</li> <li>- Issuance with a loss: M0 ↑ and M1 ↑</li> </ul>				
<b>PURPOSE</b>		<ul style="list-style-type: none"> <li>• A general purpose CBDC could enhance financial inclusion and monetary policy transmission</li> </ul>	<ul style="list-style-type: none"> <li>• Targeted forms of CBDC could fulfil special functions in the payments system</li> </ul>	<ul style="list-style-type: none"> <li>• General purpose CBDC could make "helicopter money" possible</li> <li>• Special purpose (=targeted) CBDC could create the scope for special fiscal programs ("drone money")</li> </ul>	<ul style="list-style-type: none"> <li>• A general purpose CBDC needs to be compared to competing means of payment to evaluate effects on users' welfare</li> <li>• Targeted forms of CBDC can increase the welfare of some groups of final users</li> </ul>
<b>ACCESS AND PRIVACY</b>		No unambiguous <i>a priori</i> effects	<ul style="list-style-type: none"> <li>• Token-based: it can satisfy demand for anonymous transactions</li> <li>• Account-based: it would make easier to collect information on transactions and allow for better real-time data on economic activity</li> </ul>		
<b>REMUNERATION</b>	<ul style="list-style-type: none"> <li>• No remuneration means maintenance</li> </ul>	<ul style="list-style-type: none"> <li>• Thanks to remuneration monetary impulses would be</li> </ul>	<ul style="list-style-type: none"> <li>• A positive remuneration would incentivize</li> </ul>		

	<p>and possibly reinforcement of the zero lower bound</p> <ul style="list-style-type: none"> <li>• The interest rate on a remunerated CBDC could become the primary tool for monetary policy</li> <li>• Negative remuneration could make unconventional policies easier and help overcome the zero lower bound. However, it must be used carefully in order to avoid discouraging users to adopt CBDC</li> <li>• A positive interest rate would give to the general public access to central bank remuneration, but it risks giving rise to arbitrage</li> </ul>	<p>transmitted faster and more efficiently</p> <ul style="list-style-type: none"> <li>• Negative interest rates would also ease restrictions when the policy rate is near the effective zero lower bound</li> <li>• Lower remuneration with respect to other policy rates could prevent disintermediation and competition with government bonds</li> <li>• A two-tiered system could avoid disintermediation and digital bank runs</li> </ul>	<p>CBDC use and discourage other payment instruments. Thus, it may improve the application of rules aimed at anti-money laundering and countering the financing of terrorism (AML/CFT), and possibly help reduce informal economic activities</p>		
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	<p>between different forms of central bank money and interfering with the role of government debt as a safe asset and with the correct functioning of financial markets</p>				
<p><b>OTHER FEATURES</b></p>		<ul style="list-style-type: none"> <li>• <b>CONVERTIBILITY:</b> Limited convertibility could counter financial stability risks but would potentially undermine parity</li> <li>• <b>CAPS:</b> Maximum limits on holdings and transactions could prevent digital bank runs</li> <li>• <b>CROSS-BORDER INTERLINKAGES:</b> Very large net cross-border movements of CBDC may complicate the conduct of monetary policy and undermine financial stability</li> </ul>	<ul style="list-style-type: none"> <li>• <b>CAPS:</b> A CBDC without a limit on possible holdings would allow hoarding, strengthening the role of money as a store of value. Moreover, it would reduce the concentration of liquidity risk and credit risk in payment systems</li> </ul>		<ul style="list-style-type: none"> <li>• CBDC can increase welfare if it mixes features of cash and deposits and introduces additional characteristics</li> </ul>

## 4 Potential effects on the economy

The case for a CBDC, and the peculiar configuration that it takes, depends on the potential advantages and drawbacks that it produces for users, central banks, and the economy as a whole. In order to analyze this issue, we will discuss the effects that a CBDC could have on the economy. We will focus on five different fronts:

1. monetary policy implementation (central bank's toolkit),
2. monetary policy transmission, banking system and financial stability,
3. payments-related aspects,
4. fiscal policy and crisis management,
5. the effects on final users.

A sixth aspect will be discussed in a separate box, namely the relationship with stablecoins.

### 4.1 Monetary policy implementation

The traditional objectives of monetary policy are maximum employment, stable prices and moderate long-term interest rates. Furthermore, we need to distinguish between monetary policy implementation (tools that can be used) and transmission (how the use of these tools has effects on the economy). In this sub-chapter we focus on implementation.

#### *Interaction between CBDC remuneration and interest rate setting*

The effects on monetary policy implementation strongly depend on CBDC remuneration.

#### *CBDC without remuneration*

In this case, direct implications for monetary policy would not be very relevant, because the absence of remuneration would cancel potential effects on the zero nominal lower bound (ZNLB) and on liquidity traps. No additional tools would be provided to the central bank in terms of money supply or interest rates (Bordo & Levin, 2017).

However, this does not mean that the money demand would not be affected by the availability of a new form of currency in the form of digital cash. Indeed, the introduction of a CBDC would have an effect on storage costs, which would be lower than those on physical cash. Hence, a CBDC is more likely to be used as a store of value with respect to cash, unless limits on holdings apply. This could reinforce the existence of the lower bound, adding to the limits of current monetary policy.

#### *Remunerated CBDC*

The interest rate on CBDC could work as the primary tool of monetary policy (Berentsen & Schar, 2018), "thereby mitigating the need to deploy alternative monetary tools such as quantitative easing or to rely on fiscal interventions in order to restore price stability" (Bordo & Levin, 2017). It could be positive or negative according to the objectives of the central bank and the economic circumstances.

#### *Specific issues connected to a negative interest rate*

Monetary policy implementation could be strengthened by the introduction of a *negative interest-bearing* CBDC, because unconventional policies would become easier to carry out.

Before analyzing how such an arrangement would work, we have to recall that the existence of paper currency puts a constraint on central bank's ability to push policy rates below zero<sup>16</sup>, i.e. to break the zero nominal lower bound (ZNLB). Indeed, if interest rates on short-term assets were cut to a level far below zero, cash would become an increasingly attractive store of value and there would be the serious risk of disintermediation into cash, "similar to what happened during the bank panics of the early 1930s" (Bordo & Levin, 2017).

However, a properly designed CBDC (with a possibly negative interest rate) would allow overcoming both the risk of disintermediation into cash and the zero nominal lower bound (ZNLB).

We need to consider two different scenarios: one in which a CBDC coexists with paper money and another one in which cash is no longer in circulation.

In the former scenario, the constraint on monetary policy caused by cash would still be present. Such a constraint could be eliminated by limiting the use of cash, namely establishing tiered fees on transfers between physical cash and CBDC. Imposing substantial fees on large or frequent transfers would serve as a "wedge" that would reduce the incentive for investors to convert CBDC into cash during a period of negative nominal interest rates. In this way, monetary policy would no longer be constrained by an effective lower bound on nominal interest rates (Bordo & Levin, 2017).

In the latter scenario, instead, this problem would not exist at all. Interest rates could be cut without worrying about "runs to cash".

So, if cash use is disincentivized or eliminated and CBDC is adopted widely, policy rates applied on CBDC could be brought deeply below zero.

Moreover, in an environment of negative interest rates, a CBDC could reduce one of the potential side effects of quantitative easing (QE). If non-banks could hold CBDCs directly, QE would not affect the banking sector negatively (Claeys & Demertzis, 2019), because "reserves" could be given directly to the public and remunerated with negative interest rates.

Nevertheless, negative remuneration must be used carefully. An interest rate level that is too much below zero would excessively penalize the store-of-value function of CBDC and could lead users to adopt different (and maybe unregulated) kinds of money, discouraging people from using CBDC. This would make it impossible for the central bank to push the target rate lower than a certain limit. Therefore, a thorough elimination of the lower bound seems difficult.

#### *Specific issues connected to a positive interest rate*

So far, we have considered only a negative interest-bearing CBDC. However, interest rates on CBDC can provide additional monetary policy instruments independently from the struggle to overcome the zero lower bound.

Paying a positive interest on a general purpose CBDC would reduce central bank's seigniorage, allowing the whole population to have access to central bank's remuneration and not just commercial banks. This would discourage possible political upheavals

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<sup>16</sup> Unless stamped money à la Gesell are adopted, as mentioned also by Benoit Coeuré, former member of the ECB board

(<https://www.ecb.europa.eu/press/key/date/2014/html/sp140909.en.html>)

with regard to central bank's interest payments (Berentsen & Schar, 2018). But how should a positive interest rate be paid? Should it be discretionary or automatic? There are two main possibilities (Bordo & Levin, 2017). In one case, the value of CBDC would be preserved by indexing it to the <sup>17</sup> Another option is an adjustable-interest-bearing CBDC.

However, there are important issues that need to be clarified. First, would the central bank pay the same interest on CBDC and on reserves? If banks could directly hold CBDC, a difference in policy rates could give rise to arbitrage between different forms of central bank money, impairing one-to-one convertibility. Moreover, a positively-remunerated CBDC could interfere with the role of government debt as a safe asset and with the correct functioning of financial markets. Indeed, CBDC would be the safest asset in the economy and as such its interest rate would work as a benchmark for interest rates on other assets. An interest rate too high would push upward all the interest rates in the economy. Another connected issue is the fact that the CBDC's store of value function would become more important than the means of payment function.

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<sup>17</sup> This option would be technically easy to put in practice, but it would become problematic during periods of low effective demand in which real interest rates would drop below zero. During such episodes the CBDC, bearing a zero real interest rate, would act as a floor for real interest rates, introducing a zero real lower bound

### Conclusions

Some of the most important central banks<sup>18</sup> think that monetary policy is "not the primary motivation for issuing CBDC" (Bank of Canada et al., 2020).

Risks and unknowns connected to the advantages of remunerated CBDC for monetary policy raise the need of further consideration.

#### *Interaction between CBDC issuance mechanism and control of monetary aggregates*

Apart from setting interest rates, the central bank influences the quantity of monetary aggregates.

Issuance methods, while changing the composition of the agent's balance sheets, have also a direct influence on monetary aggregates. For simplicity, we are going to consider only two of them, defined as follows:

- monetary base (H): the sum of the central bank's liabilities
- broad money (M): the sum of cash, CBDC, and deposits

We suppose that the central bank issues 100 units of CBDCs. The starting point is the same as the example in paragraph 3.2. We compare effects on monetary aggregates for different issuance methods:

- with cash-like issuance the level of both aggregates does not change

(ZRLB). Consequently, central banks would have to rely heavily on the same unconventional tools they used to address the liquidity trap of the Great Recession.

<sup>18</sup> Bank of Canada, European Central Bank, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, Board of Governors Federal Reserve System

- with refinancing-like issuance only H increases
- both H and M increase if the issuance is QE-like or it implies a loss for

be built between the central bank and individual economic agents, so that a direct transmission of monetary policy to the public would become possible. Moreover, a

	Starting point	cash-like issuance	refinancing-like issuance	QE-like issuance	issuance with CB loss
H	1000	1000 =	1100 ↑	1100 ↑	1100 ↑
M	3200	3200 =	3200 =	3300 ↑	3300 ↑

the central bank

CBDC would give the central bank much more influence on the monetary and financial system.

## 4.2 Monetary policy transmission, banking system and financial stability

According to most authors<sup>19</sup>, a CBDC presents three main risks for the financial system:

1. Unknowns related to a bigger role for the central bank
2. Disintermediation (depositors leave banks for CBDC)
3. Digital bank runs during crises

An appropriate CBDC design can help reducing the three outlined risks.

*A bigger role for the central bank: risks and opportunities for monetary policy transmission*

We have seen that a remunerated CBDC could enrich the policy toolkit of the central bank. It is also true that a direct link would

### Analysis

We analyze possible transformations due to the introduction of a CBDC, anchoring our exposition to four features of a CBDC that could have substantial effects on monetary policy transmission<sup>20</sup>:

- i) REMUNERATION  
If a CBDC were remunerated, monetary impulses would be transmitted faster and more efficiently. As we have already seen, the possibility to pay negative interest rates would also ease restrictions when the policy rate is near the effective zero lower bound.
- ii) AVAILABILITY  
Transmission could be strengthened if CBDC were to enhance financial inclusion, thanks to wide availability to users.
- iii) DIRECT LIABILITY OF THE CENTRAL BANK  
As a CBDC is a direct liability of the central bank, the central bank could gain a

<sup>19</sup> Some scholars do not regard these as problems, because they think that such transformations could lead to a full sovereign money system. However, this would be a radical change, and most authors agree that it should be avoided.

<sup>20</sup> However, according to some authors, the effects of a CBDC on monetary policy transmission would be limited (see for example Mancini-Griffoli et al., 2018; Bindseil, 2019; Pfister, 2020).

higher control on money supply, opening new pathways for monetary policy. So far, monetary policy has focused on interest rates management. CBDC could pave the way:

- either for a revival of monetarist policies, like the ones enacted by Paul Volcker (Fed chairman between 1979 and 1987)
- or for a more accommodative stance, where the central bank could let the CBDC quantities adapt to demand, issuing and redeeming them according to the needs of the general public.

If demand for CBDC holdings became very large and if the central bank decided to accommodate the increased demand, by expanding supply proportionally, the Bank should choose the most appropriate issuance method. Each method has different implications, as we have already seen. For example, if the central bank buys bonds in exchange for CBDC (QE-like issuance), it could end up holding less liquid and riskier securities. This would influence the prices of such assets and could alter market functioning.

Moreover, the central bank could be forced to provide occasionally substantial maturity, liquidity and credit risk transformation to banks and markets. (CPMI-MC, 2018). There might be “a collateral upgrade for private balance sheets if central banks end up holding some less liquid and lower-rated assets to accommodate the issuance of CBDC” (ibidem), with possible adverse effects on market prices of such assets. Market liquidity and interlinkages could also be affected. If the central bank passively accommodated the demand for CBDC, it could potentially introduce volatile demand for government debt. Larger holdings of CBDC could disrupt

markets if they reduce the freely-floating share of outstanding bonds, if bonds were exchanged on-demand for CBDCs newly issued by the central bank. However, adapting supply to demand is a central bank’s decision. An alternative could be to charge CBDC holdings with a negative interest rate, so as to reduce demand.

#### iv) LIQUIDITY

CBDC is absolutely liquid by definition. However, this characteristic could end up reducing liquidity and increasing “specialness” in collateral markets. Indeed, wholesale demand could be redirected to CBDC and the depth of repo and short-term government bonds markets would decline as a consequence. The central bank could step in and sustain demand in these markets, increasing its assets. However, this bigger role of the central bank in wholesale markets could reduce interbank activity and the price setting role of market forces. However, according to some, a CBDC could reduce the concentration of liquidity risk and credit risk in payment systems (improving financial stability). A CBDC could decrease moral hazard of banks by downscaling the role of the banking system in money creation (as we will explain below), especially if it takes over to large or full extent sight deposit issuance by banks. This interpretation is linked to the “sovereign money” approach, but it is a debated issue, because such configuration would give much more power to the central bank. Public authorities would play a much larger role, as seigniorage income would be redirected to the central bank. Therefore, it becomes clear that a redefinition of the relationship between the central bank and the financial industry is one of the most pressing issues at stake with a CBDC.

### *Conclusion and additional implications*

As the central bank could assume a more important role in the financial markets after the introduction of a CBDC, it could exert a larger influence on credit and financial conditions. A CBDC would also allow the central bank to play a greater role in credit allocation, which raises political issues and implies overall economic losses if the central bank is less efficient than the private sector at allocating resources.

In conclusion, a CBDC would not help solve the tradeoff faced by central banks between offering a secure store of value and promoting financial intermediation (Mancini-Griffoli et al., 2018), but it would give rise to new questions about the role of the central bank. However, new possibilities offered by a bigger role of the central bank could be used to ensure a more effective transmission of its policy stance.

### **4.3 Financial stability risks**

There are two main scenarios for what regards the direct effects of a CBDC on financial stability:

1. Risk of financial disintermediation in calm times
2. Risk of systemic bank runs in times of financial distress

#### *The risk of disintermediation*

##### *i) Explanation of the disintermediation process*

If households substitute banknotes with CBDC, then the central bank's and commercial banks' balance sheets do not change. However, a CBDC may reduce the desire of non-bank public to hold bank deposits and could lead to a gradual withdrawal of funding from commercial banks.

If some households substituted commercial bank deposits with CBDC, there would be a funding loss for commercial banks, which could lead to disintermediation. Banks would have to try and offer better conditions on their deposits, increasing deposit rates. However, this would increase funding costs for banks, reduce their profit margin and decrease commercial banks' seigniorage.

Banks could try to replace the deposits that shift to CBDC with other forms of funding, such as commercial paper, term deposits, bonds and equity. This has three main implications:

1. funding would likely become more expensive,
2. funding could become less stable,
3. market discipline could decline if banks lost more uninsured than insured depositors. This could push banks to take on more risk.

As a consequence of higher rates on deposits and possibly of higher funding costs from alternative sources, banks would have to increase lending rates and transaction fees to maintain profitability. The overall effects would depend on banks' market power: the greater it is, the less loan demand would decrease, and the more banks could preserve profits.

On the contrary, if banks were not able to maintain profits, they might have to shrink their balance sheets, with possible adverse consequences for the economy. Such process would be influenced by market structures, including the importance of retail versus wholesale funding.

##### *ii) Implications of the disintermediation process*

- First, the *tightening of credit conditions by banks* could act as a drag on investment and on economic activity

- Moreover, the possible *narrowing of commercial bank balance sheets and activity* would lower credit creation by banks. The Bank for International Settlements (CPMI-MC, 2018) suggests that a reduced bank-funded credit creation can be offset by higher credit creation by non-bank financial firms. On the other hand, Bindseil (2019) highlights that, if credit provided by commercial banks effectively decreased, the central bank would have to fill the funding gaps of the banks.
- A possible effect if the central bank does not fill funding gaps of commercial banks (contrary to the previously mentioned proposals), is that *banks would compete with the central bank to hold deposits*. Possible outcomes of such competition are (in order of the intensity of the transformation):
  1. Smaller importance of commercial banks in credit allocation.
  2. Evolution towards a system of narrow banks that are less reliant on deposits. The banks would first have to get CBDC from the central bank and then they could give it to private agents in exchange for a loan. So, at the end banks would grant loans denoted in CBDC. This process would resemble a loanable fund process, or a 100% reserve system (Gross & Siebenbrunner, 2019).
  3. In an extreme case, the complete disappearance of banks' credit creation. This point would entail the direct credit creation by the central bank. Loans would originate on the central bank sheet. If commercial banks committed to purchasing these loans before they were granted, they would

act as an operating arm of the central bank. Indeed, they would bear the burden of screening and controlling debtors. Advocates of "full money" see complete bank disintermediation as precisely the goal of a CBDC. On the other hand, other scholars worry that disintermediation could lead to adverse effects. The central bank could exploit an unfair competitive advantage in deposit collection and the economic system as a whole could experience competitive disadvantages in credit provision and economic efficiency. Finally, there would be the scope for greater political interference.

Therefore, financial disintermediation is a delicate issue. We will analyze later some possible ways to avoid it.

### *The risk of bank runs*

Financial disintermediation could be an effect of the introduction of a CBDC in tranquil times. However, we must also consider the implications of a CBDC in times of systemic financial distress.

In situations of financial distress, households and other non-bank private agents tend to rapidly move their deposits towards safe assets, i.e. private financial instruments perceived as safer, government securities and cash. The conversion of bank money into central bank money is very problematic, as it often results in bank runs.

During crises, the solvency of private banks is often called into question. In such situations, a CBDC, being a form of digital cash, could allow for digital bank runs towards the central bank with "unprecedented speed

and scale" (CPMI-MC, 2018), even if it had a lower interest rate with regards to bank deposits.

However, Mancini-Griffoli et al. (2018) suggest that flight-to-safety would be less likely if very safe and liquid alternatives already exist in the economic system, such as reserves-only narrow banks, Treasury-only mutual funds or healthy state banks. Moreover, they suggest that in some cases a CBDC could even help the central bank ease liquidity pressures and thus contain bank runs. Indeed, a CBDC could facilitate the provision of liquidity to banks, helping to calm down bank runs.

Thus, a CBDC presents both advantages and drawbacks in the case of an event of financial stress. In order to maintain the advantages and minimize the drawbacks, scholars have proposed some solutions, which we are going to analyze in the following paragraphs.

#### Other financial stability and integrity issues

The biggest financial stability issues are disintermediation and the increased risk of bank runs. However, there are also other minor questions that must not be overlooked, related both to stability and integrity:

- First, the introduction of a CBDC could be a negative productivity shock to the financial system. The reduced pace in financial markets activity could exert a temporarily deflationary impact on the economy (Pfister, 2020).
- Secondly, the higher cost of retail funding could push banks to engage in riskier forms of lending to restore profitability, which could create financial stability risks.

- Furthermore, if we take into account the international environment, very large net cross-border movements of CBDC may complicate the conduct of monetary policy and undermine financial stability.
- Finally, the effects of CBDC on financial integrity depend on its design. Strict limits on the size of transactions, coupled with facilitation of identity authentication and tracking of payments and transfers would strengthen financial integrity. Moreover, if it is account-based, a CBDC could help prevent illicit payment and store of value with central bank money. On the other hand, a design which allows for full anonymity and large-value transactions would undermine financial integrity. Once again, we can see that the effects of a CBDC on the economy inevitably depend on its concrete design, which has to be planned according to policy preferences, without overlooking real-world impacts.

#### Solutions to financial stability risks

The main solutions proposed with respect to the risks of financial disintermediation and electronic bank runs are:

1. lower remuneration of CBDC with respect to other policy rates (Pfister, 2020; Claey's and Demertzis, 2019);
2. limited convertibility of CBDC (Noone and Kumhof, 2018);
3. cooperation of the central bank with commercial banks (Claey's and Demertzis, 2019; Mancini-Griffoli et al., 2018; Brunnermeier & Niepelt, 2019);
4. control of CBDC volumes (Bindseil, 2019; Pfister, 2020; Gross and

Siebenbrunner, 2019; Berentsen & Schar, 2018);

There are also other more traditional solutions (*traditional* lender of last resort, deposit insurance), but they are not specifically related to CBDC.

### 1. Lower remuneration

Remunerating a retail CBDC could make it even more competitive with respect to bank deposits and government bonds. Therefore, it could end up reducing the quantity of bank lending to the economy and interfering with the role of government debt as a safe asset.

Remuneration on CBDC should be set in a way that avoids adverse effects on financial stability:

- Remunerating CBDC at a slightly lower rate than the one paid on excess reserves would help preventing excessive competition with commercial banks (Pfister, 2020) and reducing *ex ante* the incentive to use CBDC as a main store of value (Claeys and Demertzis, 2019).
- Even negative interest rates could be applied to reduce attractiveness of CBDC with respect to bank deposits (Gross & Siebenbrunner, 2019). However, this strategy is unlikely to succeed when economic agents seek safety at any price, i.e. during systemic financial stress. This strategy may even succeed, but at a cost.
- Moreover, remuneration should be set consistently with interest rates on government debt. If CBDC has a higher rate of return than public debt, it could undermine its role as a

safe asset. Therefore, the CBDC interest rate should be lower than the one on government bonds.

### 2. Limited convertibility of CBDC

Some scholars think that limited convertibility of CBDC with other assets could prove effective in countering financial stability risks.

- The “light” approach is to discourage convertibility from bank deposits to CBDC through fees (Mancini-Griffoli et al., 2018; Pfister, 2020).
- The “hard” approach is to break the link between CBDC and other forms of money. CBDC and reserves would be distinct, and not convertible into each other. Moreover, there would be no guaranteed, on-demand convertibility of bank deposits into CBDC at commercial banks in order to avoid a flight to CBDC. An appendix to such system would be the possibility for the central bank to issue CBDC only against eligible securities (Noone and Kumhof, 2018).

However, in this way core principles of banking and central banking relating to convertibility would be put into question. The convertibility of a kind of central bank money (i.e. CBDC) into other forms of central bank money (i.e. reserves) or private money (i.e. bank deposits) would be put into question, potentially undermine parity and introducing arbitrage opportunities. This would be a major change to the rules of the current monetary system, which does not seem fully justified and could create bigger risks than the ones it solves.

### *3. Cooperation of the central bank with commercial banks*

Another proposed solution to the disintermediation issue is an enhanced collaboration of the central bank with commercial banks.

- The central bank could structurally provide more funding to commercial banks to replace the lost deposits (Claeys and Demertzis, 2019).
  - Such cooperation could take the form of targeted refinancing operations. This could increase the central bank's ability to redirect commercial banks' activities towards specific objectives and foster re-specialization of the banking sector. The central bank would become more involved in the credit allocation process only indirectly. In other terms, it would not decide which individual businesses would have access to funding, but it would direct bank credit towards specific sectors or purposes, by regulating refinancing conditions. This could lengthen the central bank's balance sheet and expose it more to the banking sector.
  - Another solution is envisaged by Brunnermeier & Niepelt (2019). As we have seen in paragraph 3.2 on issuance, they propose a new commitment of the central bank to serve as a lender of last resort for the banking sector with a particular monetary policy accompanying the is-

suance of the CBDC. The central bank would substitute household deposits with central bank deposits at commercial banks, as backing for loans.

- An alternative solution is the creation of an indirect CBDC, instead of a direct one. The central bank would not provide CBDC directly, but indirectly. This would take place through full reserve banks or through "normal" banks that would fully back their CBDC liabilities with CBDC assets towards the central bank. However, such solution would not allow one of the main innovations of a CBDC, i.e. building a strong, direct link between the central bank and the public.

### *4. Controlling CBDC volumes*

Additional solutions are related to some form of control of CBDC holdings.

- The central bank could step in and set maximum limits on CBDC holdings (Mancini-Griffoli et al., 2018; Pfister, 2020). Gross & Siebenbrunner (2019) claim that limits on holdings and transaction volumes of CBDC could help preventing digital bank runs.
- The most elaborate proposal comes from Bindseil (2019), who advocates a two-tier remuneration system for CBDC. In such a system a relatively attractive remuneration rate is applied up to some quantitative ceiling (tier one), while a lower interest rate is applied for amounts beyond the threshold (tier two).

Advantages would be multiple.

- First, the payment function would be promoted by tier

one CBDC and the store of value function by tier two. Thus, hoarding could be discouraged by adjusting interest rates. Then, such a technology would ensure that CBDC is attractive for all households, as there is never the need to disincentivize tier one CBDC by a particularly low remuneration rate.

- A two-tier system would also allow better steering of the amount of CBDC, not through direct control of issued quantities, but by use of different combinations of remuneration.
- Moreover, the central bank could provide a commitment with regard to the quantity of tier one CBDC. For example, it could promise to always provide a tier one quota of 3,500 euros to each citizen of the euro area. This amount would work as a safe pocket of digital money for everyone.
- Finally, Bindseil's proposal has also political implications. A two-tier system reduces the scope for popular criticism of the central bank, if the central bank promises to never charge negative interest rates on tier one CBDC and clearly communicates in advance that remuneration of tier two CBDC is not meant to be attractive.

Nevertheless, there could be some shortcomings.

- CBDC volumes could fluctuate as a consequence of rate spreads.
- There is a potential risk of bank disintermediation also with low-volume CBDC. Users may shift to central bank accounts and non-bank financial services and no longer have any bank deposit account. This will also depend on the differences between the regulatory treatment of commercial banks and other financial intermediaries. Anyway, a two-tier remuneration system would make the change less rapid and disruptive.

In conclusion, the tiered system would work better than other solutions, also because central banks have big experience with tiered remuneration systems, which could be readily applied to account-like CBDC. The central bank could set the remuneration of tiered CBDC as to make CBDC both attractive and controllable and could resort to other solutions if the tiered system proves insufficient to avoid financial disintermediation and bank runs.

##### *5. Additional solutions*

There are also some solutions that are not directly connected to the design of a CBDC. First, in moderate cases of disintermediation policy rates could be lowered structurally, in order to make alternative forms of funding more attractive to commercial banks (Claeys and Demertzis, 2019).

Secondly, traditional instruments like deposit insurance and the role of the central bank as a lender of last resort could increase the confidence of the public and prevent runs to CBDC in situations of financial distress.

### **BOX. Unbundling and re-bundling money functions**

The introduction of digital currencies can unbundle the functions of money, namely store of value, unit of account and means of payment, and then re-bundle them with additional features (Brunnermeier et al, 2019).

Being a new digital currency, also CBDC can foster the process of unbundling, separating the functions served by money. This, in turn, would enhance competition with other digital currencies.

Competition between digital currencies, at the same time, can encourage "re-bundling" of unbundled money functions inside digital platforms, embedding new characteristics into money (such as social networking) and differentiating "money products". Examples are interoperability, smart contracts, additional services and user experience.

The result would be a reconfiguration of the relationships between money functions and between actors of the financial ecosystem.

This effect would be stronger with a hybrid infrastructure, where users would have direct claims on the central bank, but intermediaries would handle payments and would compete to offer additional services.

#### *Some examples of programmability of money and re-bundling*

CBDC allows for programmability of money and of payments<sup>21</sup> which is essential for re-bundling.

CBDC can be adapted to several use cases and can be connected to specific programs. A couple of possible applications: automatic reimbursement of failed online purchases; immediate VAT collection from merchants on payments executed via CBDC.

More in general a CBDC can be designed in a way that allows interaction with smart contracts<sup>22</sup>, which are generally associated with blockchain. For example, if you use CBDC to buy a ticket for a concert and then that concert is canceled, the purchase contract can contain a clause that ensures to you an immediate and automatic refund.

But a CBDC can also work as proper programmable money. For example, one can envisage the issuance of CBDC units which can be used to buy only certain products or services. They would be in effect a "targeted money", designed to have a specific intended use. Such a CBDC could be employed either to distribute benefits such as a "culture bonus" (to support cultural companies and societies) or to direct and control the utilization of special benefits, like Italy's "Reddito di cittadinanza".

#### *Regaining monetary sovereignty and fostering collaboration with the private sector*

Thanks to CBDC, the central bank would regain a part of monetary sovereignty currently enjoyed by commercial banks. So, it would be able to exert a higher control on the financial sys-

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<sup>21</sup> There is no full agreement on the meaning of these two concepts, but we can broadly define them as follows. Programmable money is money that carries an inherent logic, while programmable payments are payments that are automatically performed after some precise conditions are met.

<sup>22</sup> Smart contracts are computer protocols that facilitate, verify or enforce the negotiation or the execution of a contract or of a part of it.

tem. At that point, it could establish forms of collaboration with private financial intermediaries from a position of strength, also because of the increased competition caused by unbundling.

On the other hand, re-bundling further increases such opportunity of new synergies with the private sector.

Hence, overall CBDC can enhance collaboration of the central bank with private intermediaries, but the intensity of such partnership would be a political choice, not merely an economic one.

An intense form of collaboration with the private sector could be the private-run provision of additional services, which however could be possible only in hybrid design frameworks. Third parties would be allowed to build services on top of a CBDC system (e.g. through use of application programming interfaces, APIs). This private-led effort would be a way of integrating user experience into a CBDC and would allow competition, which could bring about continuous improvement.

However, there is also the possibility that the central bank wants to directly provide an articulate digital wallet, without outsourcing it to the private sector. This design tradeoff (control vs competition) can be in effect irreducibly traced back to a policy choice.

## 4.4 Effects on the payments system

Payments are an economy's circulatory system. The payments system is likely to be the sector of economic activity most affected by the introduction of a CBDC. This is the most crucial area of the economy with regards to the potential effects of a CBDC.

Introducing an innovation in the payments sector requires a strong user case, as a new payment method without clear advantages over existing alternatives is highly unlikely to succeed (Jiang, 2020).

### *The case for a hybrid infrastructure*

If we consider the whole payments ecosystem, the hybrid solution seems to have the highest advantages:

- It would be more efficient with respect to a direct CBDC, because it would put to use the know-how of financial intermediaries and the existing infrastructures, without the need of building *ex nihilo* a central bank-owned system.
- It would also be more effective with regards to a direct CBDC, because competition among financial intermediaries involved in a hybrid infrastructure would foster innovation
- It would be more effective with respect to an indirect CBDC, because it would allow innovations that are not possible with a narrow-bank system

### *Complementarity with other means of payment*

CBDC, as a payment instrument, enters in a market that already exists: the market of payments. Therefore, a CBDC should be devised so as to be widely accepted and used, but without displacing private forms of payments.

On the contrary, CBDC can be complementary to other means of payment. Complementarity and coexistence can be ensured by allowing interoperability with private digital payment systems. This means that interaction mechanisms between CBDC and private digital solutions must be offered to allow smooth flow of funds between different platforms. This can involve:

- reduction of membership barriers of the involved systems (e.g. through common data standards, like ISO 20022, and overlapping operating times),
- common business arrangements (e.g. designating an inter-platform settlement agent for certain payments),
- integration through "an interoperable link where the infrastructures combine their functions" (Bank of Canada et al., 2020).

### *Effects of the introduction of a CBDC on the overall payments system*

If we consider the overall payments system (formed by the central bank, intermediaries and final users), the effects of a CBDC would be positive, even if some minor risks would still be present.

The main positive effects of a CBDC would be:

- Lower costs of supplying physical cash
- Fostering financial inclusion
- Maintaining and strengthening the role of central bank money in the economy
- Higher resilience
- Guaranteeing safety
- Protecting privacy, or on the other hand helping collecting data

Other payment solutions as well could provide some of these benefits, but a CBDC would include all of them with minor shortcomings.

#### Central bank's costs and benefits

First of all, if CBDC decreased the use of physical cash (working as a form of digital cash), the cost of supplying central bank money to the public would be reduced, ensuring a cost-effective means of payment from a public policy perspective. However, the expense of setting up new central bank deposit accounts or tokens could be significant, especially if the CBDC had a direct architecture. Nevertheless, the cost of a direct CBDC could be offset by the convenience of the central bank's direct control on CBDC circulation.

#### Financial inclusion

Many authors argue that CBDC could help ensure equal access to an electronic means of payment for all citizens, encouraging financial inclusion (Mancini-Griffoli et al., 2018; CPMI-MC, 2018; Pfister, 2020). Indeed, the introduction of a CBDC would make equal access to a digital form of payment a paramount policy objective, which could help a wider public digitalization strategy in partnership with private actors.

#### Maintaining and strengthening the role of central bank money in the economy

If cash use declined significantly or even disappeared, citizens' direct access to sovereign money would be at risk (see for example Berentsen and Schar, 2018). This would be a problem, because trusted money provided by the central bank to the public is a public good. Such a role is explicitly acknowledged by the central banks themselves (Bank of Canada et al., 2020).

Moreover, with a decline of cash, banks could lose some of the incentives to manage well their solvency and liquidity risks (moral hazard). Thus, trust in the currency would entirely depend on trust in financial intermediaries issuing and managing commercial bank money. This hypothetical situation would resemble the free banking system in the United States before the creation of the Federal Reserve. As at the time, there would be no guarantee that the legal tender money of the country (dollar, euro or other) has the same value when it is deposited in two different banks.

A CBDC would solve this problem by allowing households to access central bank currency in a new form and ensuring universal access to efficient, secure and modern central bank money (especially in countries without high-quality electronic commercial bank money, and/or without a secure and efficient payment system). A CBDC would be a safe central bank instrument and may help to maintain a direct link between the central bank and citizens.

Moreover, it would avoid that private digital tokens displace central bank money in transactions and would slow the growth of crypto-assets. Such strategy would safeguard monetary sovereignty and challenge the role of private digital currencies. One should bear in mind that not issuing a CBDC would allow private tokens to replace more and more central bank money in economic activity.

Finally, targeted forms of CBDC could fulfil special functions in the payments system, which are deemed desirable from a public policy perspective.

#### Effects on retail payments

A CBDC would lower transaction costs and offer a risk-free payment network (Bindseil,

2019). It could provide more efficiency with respect to traditional cash because it would not need to be physically stored and protected. Moreover, an adequate technological customization of a CBDC would increase convenience and safety, lower overall costs and further improve resilience of the payments system (CPMI-MC, 2018). Indeed, some argue that if payments in private sector infrastructures were disrupted (e.g. due to a financial crisis and subsequent failures), households and firms could still make digital payments via CBDC. This would be even more important if cash use decreased substantially.

A CBDC could reduce the frictions that block some transactions, because it would allow households and firms to have direct access to efficient and instantaneous retail payment systems in the form of central bank money (Claeys & Demertzis, 2019).

Another notable advantage would be promoting competition and innovation in payment services, as the CBDC would become the baseline digital payment instrument. If private actors wanted their digital tokens to be accepted, they would have to make them more efficient and offer additional services.

As an additional payment method, CBDC would increase operational resilience and work as a common means of transferring funds between the other payment systems, overcoming fragmentation risk (Bank of Canada et al, 2020).

Overall, availability, resilience, efficiency and contestability of retail payments would be improved. This would be even more true in economies in which banknote demand disappears and private electronic payments solutions lack competition.

However, some authors (e.g. Mancini-Grifoli et al., 2018) suggest that alternative solu-

tions (like fast payments and regulation) already exist and currently may be more efficient.

Indeed, among the drawbacks of a CBDC are operational risks arising from disruptions and cyberattacks, which however are present as well in the case of private means of payment. The public guarantee on CBDC would probably prove more effective in avoiding these risks.

Then, costs related to “know-your-customer” function would fall on the central bank, which is not used to fulfilling this task (CPMI-MC, 2018), which is an argument that plays in favour of a hybrid CBDC. Instead, in a direct architecture the central bank would have to deal with many requests and customers (including some now excluded), for which it could be not well equipped.

The benefits for retail payments must not lead us to overlook the connected risks. Policy considerations also come into play: the growth of private digital tokens poses some threats to the role of central bank money and to competition in the financial industry. If one thinks that the central bank should preserve its traditional functions, a CBDC can be the right answer.

#### *Privacy and data collection*

Different possible technological features of a CBDC allow customization for what regards privacy, according to policy preferences.

CBDC can be set at three different levels of privacy:

- anonymous: if user’s information (regarding personal details and transactions) is not visible to other parties
- pseudonymous: if the user’s digital identity is not automatically attributable to her real identity

- transparent: if user's data are visible to the central bank (and possibly to financial intermediaries involved in the system)

If anonymity is preferred, a tokenized, DLT-based CBDC can satisfy demand for anonymous transactions. However, central bank's concrete experiments seem to rule out full anonymity in payments (see for example work by the ECB and the Bank of Canada) and are more inclined towards the other two levels of privacy.

In any case, DLT is easily adaptable to all these levels. Hence, it could be able to satisfy demand for pseudonymity in transactions better than a centralized infrastructure.

On the other hand, a CBDC which collects information on transactions may allow for better real-time data on economic activity. Moreover, it may improve the application of rules aimed at anti-money laundering and countering the financing of terrorism (AML/CFT), and possibly help reduce informal economic activities.

Data collection could be facilitated both by an account-based access, a centralized infrastructure and by a positive interest rate remuneration, which would incentivize CBDC use and discourage other payment instruments.

#### Other advantages

A CBDC without a limit on possible holdings would allow hoarding, strengthening the role of money as a store of value. Moreover, it would reduce the concentration of liquidity risk and credit risk in payment systems, as some of this risk would be taken by the central bank. Indeed, thanks to CBDC a part of digital payments would move from private platforms to the central bank infrastructure.

## 1.2 Fiscal policy and crisis management

A CBDC system could act as an efficient facility for the government to easily transfer money to the public and businesses, especially in the event of a crisis. In this case, CBDC could be issued without buying a corresponding asset, namely recording a loss for the central bank, as we have seen before.

This system could create the scope both for "helicopter money" and for targeted forms of money, like special relief programs during a crisis. The latter type of program would not be proper "helicopter money", because it would be directed to specific economic agents and/or specific economic transactions. We could call it "drone money" (Amato et al., 2020; Nerozzi & Ricchiuti, 2020).

The incremental benefit of CBDC over transfers to bank accounts, for example, would depend on design choices. For example, in such a system CBDC could be linked to a national digital identity scheme. Furthermore, the division between monetary and fiscal policy would be questioned, raising important political issues.

## 4.5 Effects on final users

Final users can access different forms of money. They will seek one that maximizes benefits and minimizes associated costs. In order to analyze the potential effects of CBDC on such a choice, we need to know which the competing forms of money and the choice criteria are, and we need to study the interaction between them. We will focus on retail payments.

Competitors to CBDC as means of exchange for retail payments fall into four categories (Mancini-Griffoli et al., 2018):

1. cash,
2. commercial bank deposits,
3. narrow finance,
4. cryptocurrencies.

They can be ranked according to the following criteria: scalability, extra services, interest returns, acceptance, settlement risk, theft and loss risk, default risk, transaction costs, anonymity costs (ibidem).

- Cash has high transaction costs, risk of theft and lack of remuneration. However, it offers immediate settlement, no default/cyber risk and full anonymity.
- Commercial bank deposits have become more attractive thanks to recent innovations.
- Private e-moneys enjoy a high ranking on several fronts. Narrow banking could improve them further.
- Cryptocurrencies seem to be not very attractive for the final user, at least for the moment. Their main advantage is anonymity.

CBDC would not strictly dominate any of these alternative forms of money:

- CBDC has two sets of features: fixed (not discretionary for the central bank) and flexible. Demand for CBDC will depend on its design with respect to the latter type of feature.
- CBDC would closely compete with improved bank deposits and e-money for all criteria, except for anonymity and default risk, where it would stand out. In particular, a big benefit of a CBDC in relation to default risk would be to satisfy “the population’s need for virtual money without facing counterparty risk” (Berentsen and Schar, 2018).<sup>23</sup>

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<sup>23</sup> According to Berentsen and Schar (2018), cash represents for now the only liquid asset for saving outside of the private financial system. However, one could argue that also government bonds are a solution that meets the need for a safe public asset. If we

- The specific implementation of a CBDC’s modality of use would matter as well. A possibility is to create a digital cash card issued by the central bank (Khiaonarong and Humphrey, 2019), or to use mobile applications on smartphones.
  - In general, digital cash in the form of a CBDC can have positive welfare effects, as it would work as an alternative payment network in case of a natural disaster and would reduce the market power of the providers of cards and other substitutes for cash (ibid.). This would foster competition in the market for digital substitutes of cash and could lead to more innovation and differentiation of services. Indeed, CBDC would work as the baseline digital payments instrument.
  - In such a situation, private actors face two business choices (which are not mutually exclusive *per se*). They could create a partnership with the central bank to manage CBDC (in the case of a “hybrid architecture”) and/or develop their own digital payment instruments. In the latter case, they would need to provide additional services with re-

restrict our focus to money and exclude non-monetary assets, their reasoning is more coherent with the current economic reality. Indeed, private monies are subject to default risk.

spect to CBDC to create demand for their financial products.

- If users have heterogeneous preferences with regards to payments, social welfare can be increased by the introduction of a CBDC. Indeed, CBDC can increase welfare if it mixes features of cash and deposits and introduces additional features. At the same time, however, it can have welfare costs if it crowds out demand for cash and deposits.
- Finally, targeted forms of CBDC can increase the welfare of some groups of final users (e.g. students that get a bonus denominated in CBDC which can be only spent on education-related goods and services).

### **BOX. The relationship between CBDC and stablecoins**

Central banks' research on CBDC has been speeded up by the perceived threat represented by stablecoins (especially Facebook's Libra), pushing them to seriously weigh the issuance of a public digital currency and the introduction of new regulations.

The attitude which is growing more and more common among central banks, governments and practitioners is that big technological companies are going to pose a threat to monetary sovereignty by issuing and controlling the supply of digital "stable" currencies.

There are also related concerns about safety, privacy, financial stability and monetary policy transmission.

Another relevant issue is the possibility of cheaper and faster cross-currency money transactions, one of Libra's most appealing promises.

Some central bankers and governments explicitly took a critical stance towards stablecoins: According to the ECB's Crypto-Assets Task Force<sup>24</sup> the term stablecoins may indeed be misleading. Stability is a word with positive connotations, even more so in relationship with money. However, the problem is that such positive connotations evoked by the word are not intrinsic of stablecoins. The special ECB's task force underlines that stability is much more dependent on the actual design and risk management of the currency, rather than on the basic characteristics of stablecoins. For these reasons, they suggest that regulatory action should be taken to change the term "stablecoins" with something less ambiguous and less focused on the "issuer's promise of stability".

In September 2020 five European governments asked the EU Commission to draw up regulation for stablecoins in order to preserve monetary sovereignty<sup>25</sup>.

Similar is the view of Banque de France's governor François Villeroy de Galhau, according to whom stablecoins could impact "financial sovereignty for decades".

In a speech in August 2019 Mark Carney, governor of the Bank of England, hinted at the possibility of creating a "synthetic" global currency, provided "through a network of central bank digital currencies" rather than a private issuer like Facebook.

#### ***Comparison between CBDC and stable coins***

**Safety and privacy.** According to CBDC proponents, CBDCs would be a safer alternative to stablecoins because they would be a direct liability of the central bank. In the former case data would be stored, at least partly, by the State, while in the latter they would be completely held by a private company. This raises issues about privacy in both cases.

**Financial stability.** It can be impaired by stablecoins, but also by a badly designed CBDC, as we have seen before.

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<sup>24</sup> "Stablecoins: Implications for monetary policy, financial stability, market infrastructure and payments, and banking supervision in the euro area", <https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op247~fe3df92991.en.pdf>

<sup>25</sup> Christian Kraemer and Michael Nienaber, "Big European states call for cryptocurrency curbs to protect consumers", <https://www.reuters.com/article/us-eu-economy-cryptoassets/european-countries-call-for-eu-stablecoin-regulation-idUSKBN26219G>

**Effects on holdings of different digital currencies.** Implications of different digital monies on financial accounts are similar with regards to stable coins, narrow banking digital currencies (NBDC) and CBDC (Bindseil, 2019, pp.31-32)<sup>26</sup>.

**Countering effects of stablecoins.** However, CBDC could be an instrument to counter perverse effects of stablecoins on monetary policy and sovereignty:

First, if private issuers of digital currency gain the ability to conduct monetary policy, there is the risk that “it would be tailored to benefit the firm rather than the public” (Brunnermeier et al., 2019).

Secondly, dominance of private digital platforms may cause agents to begin writing contracts in a unit of account different from the central bank’s one. This could undermine monetary sovereignty and the central bank’s ability to control the risks in the financial system. Moreover, it could weaken the monetary policy transmission mechanism with adverse effects on the economy and the provision of credit.

CBDC may help both enhance central bank’s ability to conduct monetary policy and preserve the role of central bank money as unit of account. This feature is paramount, because it “gives the central bank power even when its liabilities are not used as a medium of exchange or a store of value [...] As long as transactions are made using that unit of account, the central bank will keep its power in all circumstances” (ibidem).

As a matter of fact, a system where all money is convertible to CBDC would defend the role of public money.

***Is contamination between CBDC and stable coins a good idea?***

From Adrian & Mancini-Griffoli (2019)<sup>27</sup> comes a proposal that combines CBDC and stablecoins. In this version of CBDC, called “synthetic CBDC”, private e-money providers are allowed to hold central bank reserves. In this way, the e-money becomes a stablecoin fully backed by central bank reserves. This is, in fact, what we called before an “indirect” CBDC.

Thus, the proposal is to implement CBDC through a private-public partnership. The central bank would merely offer settlement services to e-money providers, leaving the management of the infrastructure to the private issuers. One major advantage is to let the market do what it does best, i.e. to design a product in line with customers’ tastes.

However, a paper issued jointly by some major central banks and the Bank for International Settlements (Bank of Canada et al., 2020) reads that a “synthetic CBDC is not a CBDC”. The reason is that, even if a stablecoin fully backed by central bank reserves can share some features of the latter, it is not a direct claim on a central bank liability. The arrangement is essentially a form of narrow bank. Moreover, private money issuers have profit objectives which can enter in conflict with the public policy priorities of central banks (e.g. creation of monopolies or fragmentation). Finally, there is the issue of liquidity: while central banks can expand their balance at will, private money providers not: this makes a proper CBDC more liquid than a synthetic CBDC.

<sup>26</sup> However, in practice, effects will not necessarily be identical. Indeed, they could vary depending on some factors: relative confidence of households into stable coins and NBDC, efficiency of stable coins and NBDC, remuneration of digital currencies, regulatory treatment, willingness of the central bank to grant the issuer of stable coins access to central bank deposits. Some of these are market-related issues, others hinge strongly on policy choices.

<sup>27</sup> Adrian & Mancini-Griffoli (2019): “The rise of digital money”, IMF Fintech Note

## 5 Central banks' experiments

So far, we have analyzed CBDC's theoretical aspects and possible practical configurations. This knowledge will prove useful for understanding central banks' experiments and research.

There is not a "perfect" CBDC, since each possible arrangement has advantages and drawbacks; it might favor some economic agents, while producing downsides for others. The real challenge is to first understand if a country needs a CBDC, then if it can develop one, and finally what the most feasible and adequate CBDC is for that country.

According to the surveys of the Bank for International Settlements (BIS), the number of central banks engaged in CBDC work is growing every year. In 2019 more than 80% were engaging in some kind of work and 50% were looking at both wholesale and general purpose CBDCs. Many central banks (some 40%) moved forward from theoretical research to experiments or proofs-of-concept. Finally, around 10% developed pilot projects: it is interesting to notice that all of these are from emerging market economies (EMEs). The only central banks that were not looking at CBDCs were typically from smaller jurisdictions and/or were facing more pressing issues.

### 5.1 Motivations of central banks<sup>28</sup>

Emerging market economies (EMEs) and advanced economies pursue CBDC projects for partially different reasons.

In general, EMEs have stronger motivations than advanced economies to work both on a CBDC mainly intended for retail payments ("retail CBDC") and a CBDC restricted to

wholesale actors ("wholesale CBDC"). According to the 2020 BIS' survey, EMEs consider domestic payments efficiency, payments safety and financial inclusion as "very important" motivations for issuing a "retail CBDC".

On the other hand, advanced economies deem only payments safety as "very important". According to a joint report published in 2020 by some central banks of prominent developed countries<sup>29</sup> in cooperation with the Bank for International Settlements (Bank of Canada et al., 2020), they share a common primary motivation to develop a CBDC, namely its use as a means of payment. Indeed,

"a CBDC could provide a complementary central bank money to the public, supporting a more resilient and diverse domestic payment system. It might also offer opportunities not possible with cash while supporting innovation" (ibidem).

Authors like Mancini-Griffoli et al. (2018) also add that competition with private digital currencies is a key driver in developed economies.

In general, central banks have less incentive to research "wholesale CBDC". In any case, while advanced economies are more focused on increased efficiency for cross-border payments, EMEs rank domestic payments efficiency, payments safety and financial stability as the most important reasons to look at a wholesale CBDC. This can be due to the fact that some of the smaller institutions surveyed by the BIS do not have wholesale, real-time gross settlement system for their currencies.

Swiss National Bank, Bank of England, Federal Reserve.

<sup>28</sup> Main sources; Boar et al., 2020; Bank of Canada et al., 2020

<sup>29</sup> They are: Bank of Canada, European Central Bank, Bank of Japan, Sveriges Riksbank,

## 5.2 Common principles

Central banks serve jurisdictions that heavily differ with regard to economic and financial ecosystems, societies and legal frameworks. Thus, different central banks face different motivations and risks. However, as central banks share common objectives, common principles can be agreed upon.

The central banks' joint paper by Bank of Canada et al. (2020) identified three foundational principles:

1. "Do no harm": a CBDC should not obstruct a central bank in carrying out its mandate for monetary and financial stability. This means that it should keep and strengthen the uniformity of a currency, "allowing the public to use different forms of money interchangeably" (ibidem).
2. Coexistence: different types of central bank money (CBDC, cash and reserves) should be complementary to one another and coexist with robust private money. Cash should be maintained as long as public demand for it is sufficient.
3. Innovation and efficiency: CBDC should enable innovation and competition in payments systems, so as to promote efficiency in services for end users.

These principles are intended to provide a common ground for the development of a CBDC.

In the following sections, we will analyze the main experiments and researches carried on by central banks around the world.

## 5.3 People's Bank of China (PBoC)

The Chinese CBDC project is called Digital Currency Electronic Payment (DCEP).

Motives that push China to issue a CBDC are both traditional, such as increasing efficiency and strengthening monetary policy, and country specific. Among the latter, renminbi internationalization is paramount. China aims to make its digital currency the leading one for global trade and payments settlement across continents, as digital currency can be easily used for cross-border payments.

Another country-specific reason is the enhancement of the "smart city – smart country" Chinese model. A digital currency would support the evolution of smart cities, being integrated in cashless payments and big data analysis.

### *State of the project*

The central bank of the People's Republic of China has established itself as a leader in the development of CBDC. Its work on digital currency started in 2014 and was publicly announced in January 2016.

It took a decisive turn in 2017, when the Digital Currency Research Institute (the branch of the People's Bank of China that brings forward the research on CBDC) invited state-owned commercial banks to help with the concrete design development. The PBoC managed to impress a strong impetus to the development of a State digital currency also thanks to its very centralized authority.

In April 2020, the People's Bank of China became the first central bank of a major economy to launch its own digital currency.

The Chinese central bank has developed a closed pilot scheme which is currently being tested with a so called "4+1 method". The experiment is carried on in four Chinese cities (Xiong'An, Suzhou, Chengdu and Shenzhen) and some locations of the 2022 Winter Olympic games.

On 16 April 2020 a test-interface of a digital renmimbi wallet by the Agricultural Bank of China (ABC) started circulating on media, while on 29 August China Construction Bank (CCB) included a DCEP wallet feature inside their mobile app. Some features of the closed beta version were unofficially disclosed, such as digital asset exchange, wallet management, remittances and mobile payments.

Finally, on 12 October 2020, with the aim of promoting the public usage of the digital renminbi and of further developing the pilot project, the Chinese government distributed 10-million-yuan worth of digital renminbi to its citizens in Shenzhen. This money could be spent in the Luohu District in 3,389 shops ranging from local supermarkets and pharmacies to big companies like Walmart<sup>30</sup>. The Chinese government used a lottery to allocate this bundle of digital money<sup>31</sup>.

### *Design*

DCEP is a general purpose, tokenized, hybrid CBDC, that is built on a centralized infrastructure but could incorporate some blockchain features.

Its design can be described by the motto “one coin, two repositories, three centers”, as formulated by Yao Qian, Director at the China Securities Regulatory Commission (CSRC) and former head of PBoC’s Digital Currency Research Institute.

- “One coin” refers to the Chinese State CBDC, which will be a digital form of renmimbi, guaranteed and signed by the People’s Bank of China.
- The “two repositories” (or “addresses”) are the central bank’s database and the commercial banks’ databases. They are distinct but connected. The central ledger is where the CBDC originates. Then, it is distributed to the banks and subsequently to the economy.
  - DCEP will be based on a two-tier system for issuance and redemption. On the first level, the PBoC will issue and redeem DCEP through commercial banks and, in a second phase, through payment service providers (WeChat, Alipay and Tencent). For their holdings of digital currency, financial institutions will need to maintain a 100% reserve ratio, i.e. they will need to fully back their DCEP holdings with assets of corresponding value. On the second layer, such institutions (both public and private) will distribute the DCEP to businesses and households, who will then put the currency in circulation.

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<sup>30</sup> Arjun Kharpal, “China hands out \$1.5 million of its digital currency in one of the country’s biggest public tests”, <https://www.cnbc.com/2020/10/12/china-digital-currency-trial-over-1-million-handed-out-in-lottery.html>

<sup>31</sup> Citizens had the opportunity to sign up for the lottery from the 9th day of the same month. In three days, nearly 2 million people

applied. Of those, only 50,000 people won and had the possibility to download the renminbi app. They received around 200 yuan each. The experiment had good results. In less than a week, 62,788 transactions had been carried out for a value of the 88% of the total amount distributed. In addition to this, after spending all the money won, some winners topped up their wallets, purchasing in total another 901,000 yuan.

- Importantly, transactions denominated in DCEP can happen between two DCEP wallets, independently from bank accounts. Therefore, DCEP is a form of digital cash. This technology is called “loosely coupled account links”.
- Concerning final users, limits for wallet usage are envisaged in order to respect anti-money laundering and anonymity requirements. If a user signs up with a mobile phone number, the wallet limit is at its lowest level and enables only small daily transactions. The ceiling can be raised by sharing more personal information.
- Another relevant issue is the possible incorporation of blockchain technology in the second layer of the system. China has been prioritizing blockchain technology for some years<sup>32</sup>. However, the latest information available shows that blockchain has not been concretely taken into consideration so far. Indeed, the network which is being implemented is highly centralized: a central state-owned database controls the issuance and exchange of funds. On the other hand, some key concepts of blockchain are borrowed by DCEP, such as peer-to-peer payment, traceability and tamper-proofness.
- “Three centers” are authentication, registration and data analysis centers:
  - The central bank will centralize the management of the identity information of financial institutions and users. This will allow greater security and adjustability of the anonymity design. However, in the first phase, the PBoC may only be able to authenticate and manage the identity of financial institutions.
  - The registration center will record the information related to each unit of CBDC and corresponding users. Moreover, it will record the issuance, redemption and transfer of CBDC with the objective of distributing data to nodes within the network.
  - Finally, the big-data analysis center will serve various functions, like anti-money laundering (AML), analyzing payments behavior (know-your-customer, KYC), monitoring real-time regulatory indicators, etc. Traceability of digital transactions by public authorities will make tax fraud more difficult. The central bank aims to enact a

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<sup>32</sup> For example, it launched the Blockchain Services Network (BSN), a government-supported initiative that involves both domestic and foreign businesses, being piloted along China’s Digital Silk Road routes.

Indeed, in April 2020, Yao Qian, argued that there should be competition in the distribution of digital currency and blockchain could be used with this aim.

state of “classified supervision”, which would prevent illegal activities and respect anonymity.

There is still no information on the remuneration of DCEP. The direct involvement of banks could be a key factor both in creating a new role for them and in making the financial system more capable of overcoming disintermediation.

More importantly, there is no direct link between the central bank and the public. In order to be obtained, the CBDC must be created by the PBoC and given to commercial banks, which in turn will distribute it to the non-bank private sector. This makes it possible for the central bank to control the overall quantity of the CBDC, which however could be an unwise strategy. Indeed, if CBDC was not provided on demand to the public (like cash), arbitrage phenomena could arise.

## 5.4 Bank of England (BoE)

### *State of the project*

As of today, the Bank of England has not made a decision yet on whether to introduce a CBDC.

In March 2020, however, the BoE published a paper on CBDC (Bank of England, 2020) to pave the way for further research and discussion.

Motives that made the Bank start a discussion on CBDC come from the acknowledgment that, in an increasingly digital economy, banknotes are being used less and less frequently to make payments. A CBDC could efficiently mitigate this problem, while also offering a lot of new opportunities to support BoE’s objectives of monetary and financial stability.

### *Design*

In the paper the Bank clearly states that an ideal CBDC would need to meet the following design principles: to be reliable and resilient, fast and efficient, innovative and open to competition. Moreover, the Bank believes that both the public and the private sector should be involved in the project, because of the UK’s high level of financial inclusion and innovative private payments sector.

In the discussion paper (Bank of England, 2020) the Bank outlined an illustrative CBDC model. The outcome is a hybrid, centralized CBDC, with some DLT-like features.

### *Architecture and infrastructure*

- The Bank would build a “core ledger”, which would provide the minimum necessary functionality for payments. This would be a platform on which Payment Interface Providers (PIPs, i.e. private sector firms) would connect to provide users with CBDC payment functionalities as well as additional features (“overlay services”) that are not part of the core ledger and could be provided as a value added for some or all users. The Bank, of course would impose standards and regulations for these services in order to ensure security, resilience, and interoperability with the wider CBDC system. This “layered architecture” is already a common approach in payments because it facilitates competition, innovation, flexibility, and extensibility.
- To be more specific, the “core ledger” would be a database that records the CBDC values and processes the payments. Such limited range of functionalities could make it easier to

build a fast, simple, and resilient system. On the other hand, it would require most of the innovation in CBDC payments to come from the private sector through “overlay services”.

- The core ledger would be accompanied by an “Application Programming Interface” (API) that would make possible for PIPs to securely connect to the ledger for sending payment instructions and asking updates. Only the entities approved by the Bank would be able to connect to the core ledger.
- The BoE considers both the options of directly operating the core ledger and of distributing or decentralizing aspects of the maintenance and processing of transaction. The decision would come down to an analysis of the costs and benefits involved in adding degrees of decentralization to the CBDC payment system.
- PIPs, on the other hand, would manage the interactions with the users of CBDC and provide said overlay services that would improve over time the functionality of CBDC.
- Regarding settlements of payments, the model suggests that every user should have a personal account in the core ledger and that all the payments between users would be processed by the core ledger itself. An alternative model could be for each PIP to maintain a single “pooled” account in the ledger. The PIP would then record how its funds are divided between users so that payments between customer of the same PIP could be processed without the involvement of the core ledger.

### Other technological choices

- **BLOCKCHAIN AND CROSS-BORDER INTERLINKAGES.** A noteworthy project is the “Cross-Border Interbank Payments and Settlements” initiative, run jointly by the BoE, the Bank of Canada and the Monetary Authority of Singapore and concluded in 2018. This project studied blockchain in the context of cross-border interbank payments and showed how this technology enabled platforms to extend availability and payment tracking.
- **DLT FEATURES.** However, the BoE does not think that CBDC should be built using blockchain or any other type of DLT, as most of existing payments systems are run on centralized technology stacks. Nonetheless, DLT includes several highly useful innovations, which can be adopted independently of each other. This approach will allow the Bank to use the features of DLT which are most important, without having to base its CBDC only on DLT. Examples of such innovations listed by the BoE are programmable money (implemented via the use of “smart contracts”; e.g. “if X happens then pay Y to Z”), and cryptography (to improve the security of the digital currency).
- **REMUNERATION.** The Bank of England has not taken a conclusive decision. In March 2020 discussion paper (Bank of England, 2020), it analyzes various possibilities (no remuneration, constant remuneration, tiered remuneration, and so on) in relation to their effects on financial stability and to the scope of the CBDC. The conclusion is that, if re-

muneration were chosen, “soft limits” (e.g. tiered remuneration, different interest rate than reserves) would be the best choice in order to mitigate negative effects on financial stability.

- ACCESS. According to the Bank, from an operational perspective, both an account-based and a token-based approach may provide the necessary functionalities for a CBDC. However, certain applications and overlay services may be easier to realize and be better supported by one of these data structures (for example peer-to-peer payments may work better with a token-based CBDC).
- ANONYMITY. The BoE stated that both systems “can be configured with various identity solutions, ranging from pseudonymous to fully transparent” (Bank of England, 2020). Therefore, in this regard, neither option is considered a clear choice.

BoE’s senior fintech specialist Simon Scorer commented<sup>33</sup> that the Bank of England, should it ever move forward with developing a CBDC, will not negotiate with tech companies on the design principles summarized before:

“We’re clear that any choice of technology around a CBDC should be led by a set of requirements and not the other way around. We would

not let the choice of technology dictate the design; instead, what we would do is decide what functionality the CBDC requires, what our design principles are, and then we would choose what technology is most appropriate.”

## 5.5 Bank of Canada

### *State of the project*

The Bank of Canada has not decided to launch a CBDC yet. However, it is studying whether it is opportune to implement a CBDC and which would be the necessary starting conditions and the effects on the economy.

On 11 June 2020 the Bank published on its official website a job posting for a “CBDC Project Manager”<sup>34</sup>. The advertisement read that during the three-year duration of the contract the Bank would build out a “CBDC pilot system”. This move casts Canada as a serious contender in the race to develop CBDCs, even if the Bank has not officially committed to issuing a CBDC and various officials have recently downplayed the need for it.

The Bank of Canada is developing a “contingency plan” for a general-purpose, cash-like CBDC, should the need to create one arise.

The Bank will consider launching a CBDC in the future if certain scenarios materialize (Bank of Canada, 2020):

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<sup>33</sup> Paddy Baker, “Bank of England: No Compromise on Our Principles for Any Future CBDC”, <https://www.coindesk.com/bank-of-england-future-cbdc>

<sup>34</sup> Danny Nelson, “Canada’s Central Bank Is Serious About Designing a CBDC, Job Posting Reveals”, <https://www.coindesk.com/bank-of-canada-central-bank-digital-currency-project-manager>

1. if the use of banknotes continues to decline to a point where Canadians no longer have the option of using them for a wide range of transactions; or
2. if one or more digital currencies, likely issued by private sector entities, become widely used as a method of payment, store of value, and unit of account alternative to the Canadian dollar.

In these scenarios, CBDC issuance could be useful to preserve the desirable features of the payment system. In the first scenario, for instance, this would guarantee universal access to a public issued secure mean of payment, which would otherwise disappear. On the other hand, in the second scenario, widely-adopted privately-issued digital currencies would constitute a significant challenge to Canada's monetary sovereignty. In this case, the issuance of a CBDC would provide a viable way to satisfy consumers' demand of a safe digital currency and, as a consequence, to preserve Canada's monetary sovereignty. That would be even more effective if such CBDC enjoyed the status of legal tender and the Canadian government put in place "transaction policies favouring the Canadian dollar—for example, stipulating that taxes and government services must be paid in Canadian dollars" (Jiang, 2020).

### *Design*

#### *Architecture and infrastructure*

Another important factor for the Bank is the appropriate business model of the new currency. The CBDC would need to achieve policy objectives while aligning with the Bank's best practices: managing costs effectively, applying technology in innovative ways, developing and managing strategic partnerships, and maintaining agility (*ibidem*).

A business model that the Bank of Canada is open to consider is its current approach to production and distribution of banknotes (Bank of Canada, 2020): "a public-private mix involving partnerships with security features providers, banknote printers, regulated financial institutions and others".

An alternative could be a direct architecture, in which the Bank would give CBDC to users without intermediation. The Bank would provide all end-user products and services (e.g., smartphone apps and universal access devices).

A further alternative is a platform model, where the Bank develops a core system that third parties would use to build end-user products.

In any case, the Bank would keep a centralized database (a "core system") where all relevant information and operations would be recorded.

Moving on discuss the technical attributes of the potential CBDC, the Bank said that for the CBDC's core system it "will draw on cutting-edge techniques, such as new cryptographic schemes, tamper-resistant hardware and hardware security modules". The primary aim would be to ensure privacy, security and resilience.

#### *Other technological choices*

- According to the Bank of Canada, the technical design of a CBDC needs to support the following attributes (Bank of Canada, 2020):
  1. Cash-likeness with regards to peer-to-peer transfers. The Bank of Canada reported that a CBDC needs to be designed so as to limit competition with bank deposits, in order to mitigate the risk of increasing banking system fragilities. To achieve this, the Bank of Canada believes the

CBDC should be similar to cash, namely it should earn no interest. A similar design would not require banks to raise rates in order to attract households and would avoid a jump in banks' cost of funding. Thus, negative financial stability consequences would be minimized.

2. Highest possible degree of privacy compatible with current regulation (such as AML rules). Privacy is regarded by the Bank of Canada as a core attribute of money (a feature held in high regard by literature, see: Masciandaro, 2018; Borghonovo et al., 2019). However, Bank's officials believe that it will be almost impossible for a CBDC to provide cash-like privacy. As a matter of fact, any acceptable CDBC design needs to adhere to Canadian laws, condition which rules out the possibility of full users' anonymity in digital payments.
  3. Relevance in an increasingly digital world. A necessary condition to kick-start and sustain a CBDC is to ensure it has a clear niche in the payment environment. Again, a promising route could be to design a CBDC that resembles cash in its desirable features with improved transaction capabilities. Canadians, in fact, "are served by a plethora of payment methods [...] [and] the penetration rates for bank accounts, mobile phones and internet access are very high" (ibidem). Thus, the central bank could have a comparative advantage in providing a cash-like electronic payment instrument. Ensuring wide adoption will be fundamental. This does not mean that most transactions need to occur via
- CBDC, but it requires that most Canadians are willing to hold it and use it for at least some transactions.
  4. Universal accessibility (e.g. from smartphone, computer, smart-watch...). Apart from online accessibility, another interesting feature considered by the Bank of Canada is the possibility to enable offline transfers, which would mimic one of the most desirable features of cash. Such characteristic could help promoting widespread usage and financial inclusion and complementing existing payment methods that are sensitive to power outages and internet disconnections (Jiang, 2020).
  5. Absence of remuneration.
  6. Guarantee of payments safety and resilience.
  7. Interoperability with existing payments systems.
- CBDC would raise also political questions. Indeed, support from the Canadian government would be needed, in order to provide the Bank of Canada clear legal authority to issue a CBDC. In addition, since a CBDC would be a legal novelty, it could possibly fall under legislations that apply to other assets and means of payment. For this reason, the government and the parliament should intervene to clarify in which way this could affect the feasibility of the digital currency and its possible features.
  - Finally, within the context of wholesale payments, the Bank of Canada has been doing research and experimentation and has been working with stakeholders in the area of DLT since 2016. This

has been done mainly through the Project Jasper<sup>35</sup> in collaboration with monetary authority of Singapore's Project Ubin (see also: Auer and Boehme 2020; Duong 2020; Mandeng & Velissarios, 2019). This initiative has allowed the Bank to explore risks and benefits of DLT and could have implications on how the CBDC is realized.

## 5.6 The European Central Bank (ECB)

### *State of the project*

The European Central Bank is carrying on an attentive research on CBDC.

On 12 December 2019, ECB chair Christine Lagarde said that the Bank was "ahead of the curve"<sup>36</sup>. Lagarde is very supportive of CBDC and showed this stance also during the Covid-19 crisis, when she announced a task force for exploring the project.

- For the ECB, research on CBDC is part of a wider strategy for the innovation of the payment system<sup>37</sup>. According to the ECB, time has come to provide new impetus to the European retail payments market, as it is fragmented, and no European solution has emerged for point-of-sale and online payments so far. Such situation, if not addressed, could pose a threat to the ECB's monetary sovereignty and the stability of the European payment system.

<sup>35</sup> <https://www.bankofcanada.ca/research/digital-currencies-and-fintech/projects/>

<sup>36</sup> It is remarkable that she underlined the importance of such an issue at her first official press conference as ECB President. Previously, serving as head of the IMF, she had expressed a cautious but open attitude.

<sup>37</sup> A note of December 2019 by the ECB underlined the Bank's focus on safe, efficient and inclusive payment infrastructures.

While it strongly backs private solutions, the ECB continues to assess costs and benefits of issuing a CBDC:

- The central bank wants to keep guaranteeing public access to central bank money. However, cash is still popular in the euro area, so this is not the most pressing factor behind the interest in CBDC. Moreover, Lagarde<sup>38</sup> made clear that a digital euro would not be a substitute for cash. Its main aim would be to ensure that sovereign money remains at the center of European payment systems. Therefore, a European CBDC would be meant to be an alternative to "private digital currencies" for Eurozone citizens.
- The ECB thinks that the social need for an innovative and efficient pan-European payment solution could be met by a CBDC, if the private sector fails to develop such a solution (European Central Bank, 2019). In any case, the central bank is aware of the implications for the financial system and underscores the need for further analysis.
- The attention to these issues intensified during the pandemic, when users adopted digital payments in increasing numbers and at an accelerating pace. On the 12 October 2020 the European Central Bank launched a public consulta-

Moreover, the Bank follows very carefully new developments in retail payments and shortcomings in the existing ones (<https://www.ecb.europa.eu/pub/pdf/other/ecb.other191204~f6a84c14a7.en.pdf>).

<sup>38</sup> Turner Wright, "Digital euro will not be a substitute for cash: ECB President", <https://cointelegraph.com/news/digital-euro-will-not-be-a-substitute-for-cash-ecb-president>

tion on the digital euro. Citizens, businesses, trade unions, academic organizations, and so on could take part to a digital survey.

- Due to the need to practically test design options and to explore their technical feasibility, the ECB stated that it will decide whether to start a digital euro project towards mid-2021, with the possible launch of a preemptive investigation phase.
- Involvement of European and international institutions is also needed to ensure that the digital euro will satisfy the expectations of every stakeholder.
- A CBDC would also have important implications for the EU's international relations. Indeed, an online version of the euro could facilitate to some extent a process of "euroisation" in countries with weak currencies. This could create problems for the monetary sovereignty of such countries, increasing the risk of political conflict. For this reason, some kind of coordination with international financial and political organizations is important.

### *Design*

The design of a European CBDC has been envisaged in two ECB researches: a proof of concept published in December 2019 and a report published in October 2020. They are partly different and show a maturation and evolution in ECB's attitude, if seen in perspective.

While in the first research there is a strong focus on DLT and privacy, in the second more design choices and features are considered, including a centralized infrastructure. Moreover, the technological problem is treated in detail in the 2020 report. What is still missing is a clear vision of the concrete role of a European CBDC in the economic

and financial landscape. In the box below one can find some details on the first experiment. In the following paragraphs, we will focus on the 2020 report, which summarizes the main findings of a High-Level Task Force established in January 2020 by the ECB's Governing Council.

### **BOX. ECB's Proof of Concept (December 2019)**

The ECB carried out a proof of concept (PoC) for a CBDC, which was realized by the EUROchain research network with the support of Accenture and R3 and whose results were published in December 2019.

The key purpose of the PoC was to explore the possibility to allow some degree of privacy in electronic payments, while providing a digital solution for AML/CFT procedures. The researchers developed a simplified CBDC payment system that allows users some degree of privacy for low-value transactions. Higher value transactions are subject to AML/CFT controls.

The ECB's 2019 proof of concept was built on four principles:

1. the CBDC is cash-like,
2. there is a two-tier model (where a level is represented by the central bank and the other level by commercial banks),
3. the central bank is the only issuer of CBDC,
4. there is a dedicated AML authority.

The PoC had the following characteristics.

- The chosen technology was DLT, which, in ECB's researchers' opinion, can be used to balance an individual's right to privacy with the public interest in the enforcement of AML/CFT regulations.
- Specifically, the proof of concept was developed using an open source blockchain solution called Corda, where CBDC units are represented by Corda "states" – i.e. tokens that contain information on its value, details of past and current owners, and cryptographic proof of its validity.
  - The transaction mechanism was based on the unspent transaction output (UTXO) model. Every payment "consumes" one version of a "state" and generates a new version of it that can be used in a subsequent transaction.
  - Moreover, a special node called "non-validating notary" allows intermediaries to control the validity of "states". This is done through a registry of all currently valid UTXOs.
- These were only the baseline rules. The system allowed intermediaries to apply additional norms, making CBDC a *de facto* programmable money.
- Each economic agent that wants to use CBDC has to register at an intermediary. The latter gives its clients pseudonymous identities that are used as network addresses for CBDC payments.
- Furthermore, the AML authority provides to each user a limited amount of anonymity vouchers, that a user spends if she wants to preserve the privacy of her information. Anonymity vouchers are not transferrable and are free of charge. They are simply a technical tool that limits the amount of CBDC that can be transferred anonymously. They enable the enforcing of limits on anonymous CBDC transfers without recording the amount of CBDC spent by each user. Thus, users' privacy is protected.
- The ECB's proof of concept was only the first sketch of a digital euro. Its authors made clear that it was made only for the sake of understanding concept and design issues and that there was much space for improvement.

### Architecture and infrastructure

The CBDC envisaged in the 2020 report is a central bank liability for retail payments in digital form, which would complement the current ECB's offering of reserves and cash.

The ECB considers a hybrid architecture only. As a matter of fact, the ECB makes clear that in any case there would be the need for the involvement of supervised intermediaries. They would deal with users and would possibly direct transactions to the central bank infrastructure, to limit the central bank's technical and operational challenges. In addition, intermediaries could offer new CBDC-related services.

No conclusive decision has been taken on the infrastructure (centralized or decentralized) and on the concrete setting of the relationships between the central banks and private intermediaries. Different possible combinations are outlined.

Supervised intermediaries are characterized in two ways within the report: as mere gatekeepers or as settlement agents. Gatekeepers should "authenticate end users and deal with activities such as KYC, AML and CFT requirements" (European Central Bank, 2020). Settlement agents would "in addition execute the digital transactions for their customers" (ibidem) and may provide other innovative services.

#### *1. Centralized infrastructure*

End users would hold their accounts directly at the ECB. Such accounts would have similar functionalities to bank deposits. According to the ECB, this setting would be the toughest solution for the Eurosystem's operations and organizational capacity.

The ECB describes two models of a centralized infrastructure (which could also be combined):

- A. **DIRECT ACCESS.** The Eurosystem would be supported by supervised intermediaries as "gatekeepers" and would let end users "directly access and operate accounts on its infrastructure" (ibidem). Thus, the Eurosystem could retain full control over the digital euro: it would be able to issue and redeem any unit of it and to process transactions directly on its own infrastructure. This model, however, would raise the most significant technological challenges because the ECB would have to manage a huge number of connections and accounts. Moreover, it would put an operational burden on the central bank, as it would need to comply with payment services regulations.
- B. **INTERMEDIATED ACCESS.** Payments are initiated by end users but instructed by supervised intermediaries which manage accounts with the central bank on their behalf. Therefore, the Eurosystem would directly interact only with supervised intermediaries. The ECB would have to manage a lower number of connections. At the same time, the Eurosystem would still exert full control over the "digital euro life cycle" (ibidem) and end users would still have a direct claim on the central bank. Finally, the infrastructure design could foster competition between intermediaries in providing customer services.

#### *2. Decentralized infrastructure*

The ECB describes two possible models of a decentralized digital euro:

- a) DIRECT END-USER ACCESS TO A TOKENIZED DIGITAL EURO. This approach could be implemented in two ways:
- via distributed ledger technology (DLT) protocols
  - through local storage (e.g. using pre-paid cards or mobile phones), also available for offline payments

Payments verification would be provided by end users. Nonetheless, the involvement of supervised intermediaries as gatekeepers would be required. It is noteworthy that this solution presents, however, the biggest challenges for compliance with AML and CFT rules.

- b) HYBRID TOKENIZED DIGITAL EURO COMBINED WITH AN ACCOUNT-BASED INFRASTRUCTURE, that would allow also wholesale transactions. The last option would be structured as follows:
- the ECB would issue a token-based digital euro at the level of supervised intermediaries
  - the intermediaries would then act as settlement agents for digital euro payments (and they could use the same infrastructure also for their wholesale payments).

The ECB argues that when providing retail payment services to end users, “supervised intermediaries would be able to leverage

their account relationship but end users would still hold a direct claim on the Eurosystem” (European Central Bank, 2020)<sup>39</sup>.

Other issues connected to a decentralized approach are the following:

- It must fit central bank requirements. The central bank will “need to set the security and regulatory standards that would allow external parties to transfer central bank money” (European Central Bank, 2020), for instance by requiring some specific validation methods or cryptography.
- It would imply additional transformations.
  - First, the Eurosystem should build a new infrastructure with adequate security and processing capacity, which would require sizable efforts and resources.
  - Second, supervised intermediaries would need to adapt their internal systems.
  - However, a decentralized infrastructure would imply a smaller operational burden for the central bank.
- A decentralized infrastructure could be better suited for a token-based digital euro<sup>40</sup>.

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<sup>39</sup> The report does not provide further details. We can imagine that end users would have an account with intermediaries, which would be backed by the “real” digital euro held by the intermediaries themselves. However, it is not clear how direct claims from the public on the Eurosystem would still be possible.

If there was the possibility of leveraging holdings of digital euros, this system would resemble the functioning of the current

banking system. It would not be a significant innovation.

On the contrary, if leveraging was ruled out, the ensuing system would be an “indirect CBDC”. However, such arrangement would result in a form of money which is not considered by many central banks (including the ECB) as a CBDC.

Therefore, the ECB should rule out this latter intricate and controversial CBDC structure.

<sup>40</sup> Referred to as “bearer digital euro” in the report.

### Other technological choices

The ECB report describes also other specific design issues:

- **PRIVACY**

- For the ECB, digital euro users' privacy can be guaranteed to various degrees, depending on the trade-off between public interest and individual rights.
- Full anonymity in electronic payments is prohibited by current regulations, with which the digital euro must comply.
- Another reason to avoid full anonymity could be the need to limit the scope of users of the digital euro in case of necessity. Some examples: excluding some non-euro area users and preventing excessive capital flows; avoiding excessive use of the digital euro as a form of investment.
- Different degrees of privacy can still be granted by the Eurosystem:
  - The approach to privacy could be, for instance, selective, meaning that the system operator could permit only certain types of transactions to be executed with a certain level of privacy.
  - Another possible solution, similar to what already happens with current forms of electronic payment, is for the digital euro transactions to be completely transparent to the operator of the infrastructure, who is still obliged to guarantee data protection.

- **REMUNERATION**

- The first reason to remunerate the digital euro is to strengthen

monetary policy. Such remuneration could be fixed or variable (e.g. linked to other central bank rates). However, the stated primary purpose of the ECB's report is not to identify the precise role of the digital euro as a monetary policy tool, so the discussion about this topic is not as thorough as it could be.

- The second reason for a remuneration is related to financial and structural stability. The digital euro, in fact, should not be primarily used as an investment (store-of-value), neither by EU residents nor by foreigners. To disincentivize such behavior, remuneration could play a role. For instance, lower rates – maybe even negative – could be applied on holdings by foreign investors. Otherwise, a tiered remuneration could be introduced, with lower, or even negative, rates applied on larger holdings of CBDC, following the proposal by Bindseil (2019).
- **OFFLINE AND ONLINE AVAILABILITY**
  - Offline availability of digital euro payments is deemed as an attractive feature by the ECB. The option considered in the report to make this feature possible is to rely on “trusted hardware” modules. Such modules, increasingly available to potential CBDC users in the form of smart cards, mobile devices, and payment terminals, would permit to consider final even the payments that are not confirmed online. According to the ECB, the offline digital euro could be anonymous and could

- only be remunerated with a fixed, non-negative interest rate.
- The digital euro, however, should be usable also online. The remuneration of the online version could vary over time.
- At this point, it is possible to identify two types of digital euro that are not mutually exclusive and could be even offered together. A link between the offline version and the online one should be built in order to allow interoperability with other forms of payment and to support advanced functionalities.

Legal aspects

A European CBDC's issuance would probably need to be supported by some changes in the European laws (Pfister, 2020). This raises political issues, because support both from other European institution and from national governments will be necessary. Moreover, in the Eurozone Treaties' rules are very stringent. They do not include an express possibility for the ECB to issue a

digital currency. Such prospect would have to be integrated in the existing Treaties' provisions, either reforming them or providing a new legal interpretation.

If it were necessary to change current legislation regarding the ECB, in principle a new treaty would be needed, and this would raise many difficulties.

Regarding the possibility of interpreting the treaties in a new way, the legal basis that would give the Eurosystem the most discretion for the issuance of a digital euro with the status of legal tender would be Article 128(1) of the TFEU in conjunction with Article 16 of the Statute of the ESCB. Invoking instead the Article 127(2) of the TFEU in conjunction with Articles 17, 20 or 22 of the Statute of the ESCB would be better in case of the issuance of digital euro variants for limited uses, devoid of general legal tender status (European Central Bank, 2020).

However, the absence of legal tender laws for CBDC could be overcome if the ESCB is prompt to exchange CBDC with any holder of the currency, against other forms of currency. In this way, CBDC's security could be

Purpose and design	Legal basis
<i>instrument of monetary policy</i> , similar to central bank reserves, and only accessible to central bank counterparties	<ul style="list-style-type: none"> <li>• Article 127(2) of the TFEU</li> <li>• Article 20, first sentence, of the Statute of the European System of Central Banks (ESCB)</li> </ul>
<i>means of payment available to households and other private entities through accounts held with the Eurosystem,</i>	<ul style="list-style-type: none"> <li>• Article 127(2) of the TFEU</li> <li>• Article 17 of the Statute of the ESCB (which, however, cannot serve as the sole legal basis)</li> </ul>
<i>settlement medium for specific types of payment, processed by a dedicated payment infrastructure only accessible to eligible participants</i>	<ul style="list-style-type: none"> <li>• Article 127(2) of TFEU</li> <li>• Article 22 of the Statute of the ESCB</li> </ul>
<i>instrument equivalent to a banknote</i>	<ul style="list-style-type: none"> <li>• Article 128 of the TFEU</li> <li>• Article 16, first sentence, of the Statute of the ESCB (Such interpretation would have a restrictive impact on CBDC's characteristics, because it would imply absence of remuneration and a tokenized form)</li> </ul>

perceived as equivalent to that offered by legal tender status.

More specifically, the laws that would work as the basis for CBDC issuance depend on the design of the digital euro and on the purpose for which it is issued (European Central Bank, 2020):

## 5.7 The Federal Reserve

The United States have a history of financial innovation since the establishment of the first British colonies<sup>41</sup>. Another important feature of American economic culture is the aversion to an all-powerful central bank<sup>42</sup>.

Therefore, it is no coincidence that private monetary innovation is developing strongly in the US, while there is a more cautious approach to public financial innovation and especially to CBDC.

The Fed has adopted a wait-and-see approach to CBDC. It investigates the digital dollar, evaluating pros and cons, but it does not actively develop one. In November 2019,

Chairman Jerome Powell said that, while the Fed keeps analyzing carefully pros and cons of a CBDC, it has “not identified potential material benefits of [a] general purpose CBDC to the implementation of monetary policy relative to our existing tools”.

Fed’s officials have expressed a quite conservative attitude with respect to CBDC:

- Lael Brainard, member of the Federal Reserve Board of Governors, explicitly said in a speech held in October 2019 that “there are compelling advantages to the current system”. First, she underlined that physical cash in circulation in the US continues to rise, an issue emphasized also by Fed’s chair Jerome Powell<sup>43</sup>. Data are shown by the figure below.
- Second, Brainard highlighted the role of the dollar as the global reserve currency and the fact that maintaining public trust in the sovereign currency is fundamental.



Figure 5. Currency in circulation in the US.

<sup>41</sup> Examples are 18<sup>th</sup> century’s paper money of Virginia and 1860s’ greenbacks.

<sup>42</sup> As a matter of fact, politicians abolished the central bank for two times, before establishing the Federal Reserve in 1913. In any case, the Federal Reserve was structured in a decentralized way, so as to avoid an excessive concentration of power.

<sup>43</sup> Daniel Palmer, “Fed Reserve Evaluating Digital Dollar But Benefits Still Unclear, Says Chairman”, <https://www.coindesk.com/fed-reserve-evaluating-digital-dollar-but-benefits-still-unclear-says-chairman>

- For Brainard, another strong point of the current system is the structure of the banking system: banks are numerous, diverse and geographically dispersed.
- Furthermore, in the opinion of CBDC-skeptics, current digital payment options are widely available and ever more assorted in the US, besides building on the existing institutional framework. For example, in November 2019 Powell pointed out that a CBDC could bring substantial improvements where digital payments are slow and unreliable, but this is not the case in the US (ibid.).
- Moreover, as we stressed before, top Fed officials are concerned with the additional power that a widely accessible CBDC would give to the central bank. For example, a CBDC would require the central bank to record all related payment data, a shift defined “dramatic” by Lael Brainard.
- Some are concerned about both the authority and the operational ability of the Federal Reserve to issue a digital currency and are preoccupied with CBDC’s potential effects on financial stability.

Therefore, Fed’s stance on CBDC is very cautious. The Federal Reserve seems more focused on other initiatives, like the FedNow Service, “a new instant payment service that the Federal Reserve Banks are developing to enable financial institutions of every size, and in every community across the U.S., to provide safe and efficient instant payment services in real time”<sup>44</sup>.

However, it seems that something changed during 2020. In September 2020, Loretta Mester, president of the Federal Reserve Bank of Cleveland, revealed that the Fed has

started evaluating technical solutions for a CBDC. She said that the Board of Governors has been “building and testing a range of distributed ledger platforms to understand their potential benefits and tradeoffs” since before the pandemic. So, the Fed is not only thinking about the theoretical possibility of a CBDC, but it is also looking at possible infrastructures.

However, Fed’s initiative does not signal any conclusive decision to adopt a digital currency. Therefore, the Fed is not inactive on CBDC, but it is long behind China and far from concrete experiments.

## 5.8 Sweden (Sveriges Riksbank)

The use of banknotes and coins has been declining significantly in Sweden since several years. Indeed, in the household and retail sectors the use of cash fell from 39% in 2010 to 13% in 2018 (Duong, 2020).

### *State of the project*

No conclusive decision on e-krona issuance has been taken by the Riksbank yet. However, the Riksbank finds the marginalization of cash problematic. Thus, it has been exploring for some years the issuance of a Swedish CBDC, the e-krona.

As of 2020, the Riksbank is running a pilot project, in collaboration with Accenture, which will last until February 2021, to build a technical platform for e-krona. The stated aim of the pilot is to create and test a CBDC that is simple, user-friendly and, at the same time, complies with critical requirements for security and performance (Sveriges Riksbank, 2020a).

(<https://www.frb services.org/financial-services/fednow/what-is-fednow.html>).

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<sup>44</sup> Such project, which would be completed in 2023 or 2024, aims at supporting the existing payments infrastructure, so that everyone has access to real-time payments

Given its peculiar trend in the usage of paper money, Sweden is probably one of the countries with the highest motivation to create a public digital currency to preserve the public's direct access to central bank money. The Riksbank will probably manage to issue a CBDC before the total disappearance of cash in Sweden, and it is also well placed in the global CBDC race. It is interesting to see how this process will proceed after the pilot scheme will be completed.

### *Design*

The solution proposed in the pilot project is a hybrid, decentralized, token-based CBDC.

In the pilot, e-krona will rely on DLT. Such network validates and records all transactions and verifies that each participant in it runs one or more nodes. These nodes store e-kronor and process e-krona transactions.

The technical platform will be based on Corda, a permissioned DLT platform run by R3 consortium. Differently from cryptocurrencies, Corda is comparable, for its energy efficiency, to existing payments systems. Moreover, in each transaction, only very few nodes are involved, thus providing better scalability and robustness.

In the system each token, called e-kronor, is "portable, cannot be forged or copied (i.e. double-spent) and enables instantaneous,

peer-to-peer payments as easily as sending a text message" (Sveriges Riksbank, 2020a).

The test environment will be based on a two-tier (hybrid) architecture. In the first one, the Riksbank will issue e-kronor to financial institutions, like banks, participating in an e-krona network. In the second one, e-kronor will be distributed to end users by the involved financial institutions.

Only the Riksbank will have full control over the issuance and redemption of e-kronor. Participants in the network will be able to obtain or redeem e-kronor in exchange for reserves held directly by the participants or via a representative in the Riksbank's settlement system, RIX. Participants in the e-krona network will then have the possibility to distribute e-kronors to end users which will control them through a digital wallet that can be used with an app, either installed in a mobile phone (for consumers) or in a cash register/terminal (for merchants), or with smart cards and smart watches.

### *Other technological features*

According to the Riksbank, the envisaged e-krona network architecture is flexible and has an expandable design. In case the e-krona pilot will be extended, it will be possible to examine additional services such as automatic deposits or automatic transfers,

#### **BOX. The 2018 project**

The 2018 Riksbank's project<sup>45</sup> outlined two possible ways to realize e-krona. The first one consisted in an account-based digital currency, while the second one consisted in a value-based (i.e. tokenized) digital currency to be stored in a digital card or in a smartphone app.

Legally speaking, in Sweden, a value-based digital currency would be classified as e-money, while an account-based digital currency would be classified as a deposit. In both cases, there would be an underlying register, so that it is possible to record all transactions and keep track of who is the owner of each e-krona. As a consequence, all digital transactions with e-krona would be traceable.

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<sup>45</sup> Sveriges Riksbank, 2018

which network participants might develop and offer in the future.

## 5.9 Caribbean Islands

Caribbean islands are relatively small and dispersed. This creates challenges for their citizens, who sometimes face issues in the access to financial services, despite broad availability of digital technology. This reason has always pushed Caribbean countries to foster financial and monetary innovation. This explains why central banks in Bahamas and Eastern Caribbean islands are already at an advanced stage in CBDC projects. They are motivated mainly by the willingness to improve financial inclusion and to explore other CBDC benefits such as, for instance, know-your-customer (KYC) controls and lower cost of cash.

### Bahamas – an account-based approach

#### *State of the project*

Banking and offshore financial services are some of the most relevant sectors of the Bahamian economy. Nonetheless, financial inclusion is still a relevant problem as many citizens lack access to traditional financial services, partly because of Bahamas' geographical conformation.

For this reason, the central bank of the Bahamas started a pilot project for an account-based general purpose CBDC called "Project Sand Dollar". Its development started in 2019 and it was launched nationwide and made available to all Bahamas' inhabitants on the 20 October 2020, making it the world's first general purpose CBDC<sup>46</sup>.

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<sup>46</sup> Turner Wright, "The Bahamas launches world's first CBDC, the 'Sand Dollar'",

#### *Design*

Being an account-based CBDC, the holder of the digital currency will have a direct claim on the central bank, legally equivalent to an account. The digital currency will be available both for retail and wholesale payments. To avoid banking disintermediation, there will be limits on the amount of digital currency that can be held according to the category of user and the level of required customer due diligence. Moreover, no interest will be paid (Central Bank of the Bahamas, 2019).

The Central Bank of the Bahamas, while admitting that most of the benefits of introducing a digital currency are still unquantifiable, believes that they include a potential suppression of economic costs for businesses and users associated with cash usage (for example transaction costs), and benefits to the government from improved expenditure and tax administration systems.

### Eastern Caribbean – a token-based approach combined with DLT

#### *State of the project*

The central bank has been running a pilot for its general purpose, token-based CBDC (called DXCD) since 2019. The DXCD will be used for retail payments, in particular for financial business and peer-to-peer transactions, and it will be available through smartphone devices.

The pilot consists of two phases: first development and testing, and then rollout and implementation. The first phase was actually supposed to last only for 12 months but

<https://cointelegraph.com/news/the-bahamas-launches-world-s-first-cbdc-the-sand-dollar>

its end has been delayed to the second half of 2020.

### Design

The DXCD implementation would work as follows: through established financial institutions, which provide services to wallet-holders, the central bank will issue, redeem and verify all tokens. Such tokens will be considered as cash and represent a claim on the central bank. They will be recorded and transferred on a distributed ledger which is permissioned and private, with all parties that are identifiable.

The method of issuance and redemption of this digital currency will follow the conventional principle of creating central bank money: financial institutions will “purchase” DXCD from the ECCB (just like how other Eastern Caribbean Central Bank’s money is “purchased”) and will then make it available to their customers.

Just like in Bahamas’ project, limits on the amount of digital currency one can hold will be in place and it will bear no interest, to avoid substituting for savings or deposits.

## **5.10 Conclusions**

Projects carried on by the examined central banks have reached different stages. In the next pages, we will sum up their main features, highlighting the most important issues.

CENTRAL BANK	STATE OF THE PROJECT	ARCHITECTURE	INFRASTRUCTURE	ACCESS	REMUNERATION	OTHER FEATURES AND NOTES
People's Bank of China (DCEP)	Field test	Hybrid	Centralized	Token-based approach	Still no information	<ul style="list-style-type: none"> <li>-Involvement of State banks</li> <li>-DCEP's design can be summarized with the motto "one coin, two repositories, three centers"</li> <li>-Tested with the "4+1 method" in some big cities, using lotteries</li> <li>-First-mover advantage</li> </ul>
Bank of England	Opened a discussion with stakeholders and proposed an illustrative model	Hybrid	Centralized, with some DLT-like features. Private financial institution (PIP) can offer user services	Considering both token- and account-based approaches	No conclusive decision. In case of an interest-bearing CBDC then "soft limits" on remuneration would be put in place	<ul style="list-style-type: none"> <li>-Private financial institution (PIP) would be able to connect to the core ledger through an API</li> <li>-Innovation would happen via additional services offered by the PIPs</li> </ul>
Bank of Canada	Developed a basic plan on how to issue a CBDC	No conclusive decision. Various "business model" are considered, both hybrid (public-private mix; platform model) and direct	Centralized	Considering both token- and account-based approaches	No remuneration	<ul style="list-style-type: none"> <li>-It would be cash-like</li> <li>-Cutting edge technologies for the "core system", such as cryptography, hardware security modules, and so on</li> </ul>
European Central Bank (digital euro)	<ul style="list-style-type: none"> <li>-Carried on attentive research</li> <li>-Will decide whether or not to launch a project by mid-2021</li> </ul>	Hybrid	No conclusive decision. Both centralized and decentralized infrastructures are taken into account.	Considering both token- and account-based approaches (also a hybrid version of the two)	Interest-bearing: <ul style="list-style-type: none"> <li>-remuneration could be fixed or variable</li> <li>-tiered remuneration could be introduced</li> </ul>	<ul style="list-style-type: none"> <li>-In October 2020 the ECB launched a public consultation</li> <li>-The ECB will need further analysis and research</li> </ul>

			In the latter case: DLT or local storage		-possibility to apply different rates for foreign digital euro investors	-Need for the involvement of other European, national and international institutions
Federal Reserve	Wait-and-see approach	No information	Rumors that it is building and testing a decentralized platform (DLT)	No information	No information	
Sweden's Riksbank (e-krona)	Running a pilot project until February 2021	Hybrid	Decentralized infrastructure based on Corda (DLT) by R3 company	Token-based approach	No remuneration	-Cash usage in Sweden has been dropping, and the project motives stem from this -The envisaged CBDC would be flexible and it would be possible to examine additional features
Central bank of Bahamas (Sand Dollar)	Launched nationwide the first general purpose CBDC in October 2020	Direct	Centralized	Account-based approach	No remuneration	-Limits on maximum holdings -The central bank expects from the implementation of CBDC a reduction of cash usage costs for firms and consumers and improved government expenditures and tax administration
Eastern Caribbean Central Bank (DXCD)	First stage (development and testing) of a two-stage project	Hybrid	Decentralized, with DLT	Token-based approach	No remuneration	-Limits on maximum holdings -Second phase (rollout and implementation) expected to start in the second semester of 2020

*How to read the table:*

*First column:* red=little known research, yellow=advanced research, green=pilot scheme, light green=launched;

*Second, third and fourth column:* grey=unknown/undecided, gold=more decentralized approach, blue=more centralized approach.

## 6 Final considerations

### 6.1 The right approach to CBDC

This is a moment of great transformations with regards to money and payments systems. There is a fertile environment for innovations, both in the private and in the public sector.

Debates on CBDC matured in the last years and provided a significant common policy ground, as shown by joint works realized by central banks. The theoretical framework is now sufficiently detailed to speed up more courageous experiments by monetary authorities that have not engaged in field tests yet.

However, this does not mean that central banks should overlook controversial or problematic issues. On the contrary, they should look at them carefully so as to identify hidden opportunities which could make the monetary system more efficient, effective and fair.

In any case, one should always bear in mind that a CBDC must be issued only if it can support a central bank's public policy objectives. Therefore, any approach must be "cautious, incremental and collaborative" (Bank of Canada et al., 2020).

### 6.2 CBDCs must be country-specific, without overlooking common and overlapping issues

Our exposition also made clear that a CBDC cannot follow a "one size fits all" model. As a matter of fact, every central banks face different motivations and risks, which can result in different problems. Such problems need jurisdiction- and time-specific answers. Therefore, a CBDC must be first and foremost designed for domestic users and for the domestic payment system.

However, common principles and requirements for a CBDC can be determined, as central banks have common objectives: first of all, providing trusted money to the public.

This theoretical effort can make it possible to outline the core features that a CBDC needs to fulfill. This is precisely what major central banks did in a joint report with the BIS (Bank of Canada et al., 2020). They identified fourteen core features, which are listed below:

- instrument features:
  - convertibility,
  - convenience,
  - acceptability and availability,
  - low cost;
- system features:
  - security,
  - instant functioning,
  - resilience,
  - availability,
  - high throughput,
  - scalability,
  - interoperability,
  - flexibility and adaptability;
- institutional features:
  - robust legal framework,
  - conformity to regulatory standards.

We should also pay attention to international implications. Multilateral organizations are already active in directing the development of CBDCs. For example, the G20 outlined a roadmap on cross border payments whose "building block" 19 is explicitly related to CBDC, being named "factoring an international dimension into CBDC design".

An important issue is international interoperability: national differences should not create involuntary obstacles to cross-border payments with CBDC. This question should be tackled on various levels.

First, complementarity and coexistence with different, internationally available payment systems should be enabled.

Then, CBDC functionalities, designs and links with other platforms might need adequate international standards. Central banks of different currency areas should collaborate in their development.

Finally, coordination between different CBDCs would require harmonization of different legal frameworks, whose diversities could hinder cross-border payments.

The international dimension of CBDC also involves the risk of stronger unintended international spillovers, as a result of sizable foreign holdings of the domestic CBDC or of sizable domestic holdings of a foreign CBDC.

Possible negative effects are excessive volatility in foreign exchange rates and, in the case of dyscrasia between regulations, more tax avoidance and less effective surveillance by domestic authorities.

Another possible spillover of CBDC is represented by “digital dollarization”. By that we mean the situation where domestic users widely adopt digital forms of money not denominated in the sovereign currency (stablecoins, cryptocurrencies and foreign CBDCs) and reduce their use of the domestic sovereign currency. Such phenomenon could limit the effectiveness of monetary policy and the ability to preserve financial stability, impairing monetary sovereignty. Issuing an efficient and convenient domestic CBDC could be the answer to such problems.

### 6.3 Possible effects of a CBDC and open issues

Our exposition made clear that the most relevant benefits of a CBDC would be in the payments system. Not by chance, improving

the payments system is the main driver behind central banks’ work on CBDC.

Monetary policy would be affected in a limited way, and there are both risks and advantages. The most problematic issues arise when we turn to the financial system. They can be addressed through various technical adjustments, but “a central bank should have robust means to mitigate any risks to financial stability before any CBDC is issued” (Bank of Canada et al., 2020).

An overall evaluation must weigh payments-related benefits and financial risks. In the literature, most authors are careful in advocating openly the adoption of a CBDC, but they tend to suggest that it could have net positive effects.

In any case, the role of technological and institutional features is paramount, because design choices are not neutral. A proper design can ease many policy trade-offs, but it cannot transcend them. Indeed, some design-related decisions imply drastic choices: for example, an interest-bearing CBDC is radically different from a cash-like one.

As a matter of fact, the design of a CBDC determines its effects and its functions. Therefore, design is not simply a technological and institutional choice, but it is a policy choice. As such, it needs to be examined carefully.

#### *Other open policy issues*

The effects of CBDC on two specific public policies, namely credit and distributive policies, should be explored more in detail by scholars and central banks. In this report we have underlined that CBDC could enable credit centralization. However, it is still unclear how that would work and whether central banks want to set rules to allow or

avoid this process. We have also outlined some possible distributional effects of a CBDC. Overall, however, investigation in such fields is still scarce and needs to be deepened further.

Moreover, relationship with private monies must be further analyzed. Indeed, this issue is not only relevant with respect to the opportunity of cooperation and interoperability, but also with respect to central bank's control on new private monies, such as stablecoins. Here we will only underline that, according to some authors, "the introduction of CBDC may restore some power to the monetary authority without requiring the direct regulation of new currencies" (Brunermeier et al., 2019). Another related question is how the central bank will manage to guarantee a level playing field for all digital means of retail payment while creating its own one.

## 6.4 Conclusion

Once we agree that from a theoretical point of view a CBDC should be issued, we need to analyze real-world economies to evaluate the concrete case for a CBDC.

While developed countries have higher technical knowledge and their institutions could be readier for a CBDC, some authors point out that in countries where bank cards and e-money are in the initial stages there is higher demand for cash substitutes, which could be satisfied by CBDC (Khiaonrong and Humphrey, 2019). At the same time, however, in advanced countries there is a need for a safe means of payment that can compete with increasingly relevant private solutions.

In any case, not all emerging economies are equal, and neither are all advanced economies. In order to understand feasibility and conveniency of a CBDC it is necessary to

study the concrete economy taken into account. There is no such a thing as a "standard" CBDC that can work for every currency area.

Overall, a CBDC can be a beneficial innovation if it is well designed and if policymakers have a clear idea of the functions it needs to play and the objectives it must help to achieve. Of course, in the initial stages a CBDC would be limited, but demand (users' needs) and supply (central bank's policy objectives and possibly financial intermediaries' search for profit) will push the evolution of the system.

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