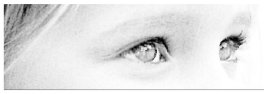

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CASH FOR THE DIGITAL AGE

Opportunities, risks and impacts of central bank digital currencies

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ABSTRACT

In the context of the rise of private digital currencies and the development of distributed ledger technology (DLT), this report investigates the changing role of money in retail payments and the question as to whether the introduction of central bank digital currencies (CBDCs) would be an appropriate policy response. It evaluates key issues ranging from the motivations and benefits for central banks, the various design and implementation schemes and the potential impact on banks and financial stability. It concludes that the effects would not be disruptive for banks and that there could be important social benefits from central banks to issue CBDCs at the individual (micro-), institutional (meso-) and systemic (macro-) levels.

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Introduction

Monetary reform in an age of digital currencies

The recent debate about monetary reform has taken on a new turn with the rise of private digital currencies and the development of new digital payments. By granting peer-to-peer payment facilities and the fluidity of electronic transactions, digital currencies may provide competition for traditional payment instruments and thus have important implications for central banks. Therefore, public authorities and central banks around the world are closely monitoring these developments and studying their implications for the economy, the financial system and central banks.

Against this background, one key policy issue for central banks is whether they should or not issue their own digital currency that could be accessed by the public to make payments. The prospect of CBDC raises, however, a number of key questions related to the benefits and risks for central banks and the economy, the design and possible schemes for implementation, and the impact – positive or negative - on banks and financial stability.

The current report provides an overview of a selected number of these aspects from an interdisciplinary perspective. It poses the question of the issuance of a CBDC not merely as technical but also as a socioeconomic and political question. This means that the design of CBDC is assessed not only from the viewpoint of its benefits for the monetary and economic system, but also from the viewpoint of its advantages for the public and society at large.

Structure of the report

The report is structured in four different chapters. **Chapter 1** describes how recent technological innovation has increasingly challenged central banks' prerogatives in the areas of payment system, monetary policy, and financial stability and integrity, while introducing the concept of CBDCs in relation with existing forms of money.

In **chapter 2**, we analyse some of the reasons *why* central banks may wish to issue an electronic form of central bank money for the public, stressing the fact that CBDCs offer opportunities that may drive at least four kinds of motivations:

- to ensure adequate central bank money for the public;
- to improve the overall efficiency of the payment system;
- to expand financial inclusion in emerging economies;
- to reinforce the effectiveness and widen the scope of monetary policy.

The question of the motivations of a central bank to issue its own digital currency has implications on the question of *how* central banks may design it. **Chapter 3** describes the different approaches that could be adopted to design the institutional and technological infrastructure necessary for the issuance and distribution of a CBDC.

Finally, **chapter 4** addresses some of the issues and challenges related to the issuance of CBDC. It begins by clarifying a confusion that is often made between the issuance of CBDC and proposals of narrow banking or full-reserve money. It also addresses the risks and implications of having two competing forms of electronic money for banks and financial stability.

1. Central banking in an age of digital currencies

1.1 New challenges and opportunities

Central banks are facing a wide range of new technological challenges that affect their role in many ways. The growth of cashless payments and the rise of digital currencies are challenging their monetary prerogatives while posing new threats to the stability and integrity of the financial system. One way of addressing these challenges is to evaluate the development of a central bank digital currency (CBDC).

The role of central banks in a changing environment

Central banks are responsible for (i) providing safe and efficient means of payment, (ii) conducting monetary policy to ensure price stability and (iii) overseeing the financial system to preserve financial stability.

In the last decades, private technological innovation has opened the door to new electronic instruments that have the potential to challenge central banks' prerogatives in the areas of payment system, monetary policy, and financial stability and integrity. Thus, central banks are actively debating about their role in an increasingly digitized economy. One key issue in this debate is to determine whether central banks should issue digital currencies of their own, namely a central bank digital currency (CBDC).

The growing interest of central banks for CBDCs has been motivated by a number of technological developments that are challenging their sovereign monetary prerogatives, in particular: 1). the trend toward cashless payment; 2). the rise of cryptocurrencies; 3). and the threats that these two trends pose to the stability and integrity of the financial system.

The trend toward cashless payment

The current wave of innovations in the means of payment accelerates an old trend: since the middle of the last century, the share of banknotes and coins in transactions has been declining in favour of commercial bank money. It should be recalled that in Europe at the beginning of the 20th century, the distribution between cash and overnight deposits (the two components of monetary aggregate M1) averaged 60%-40%, compared to 15%-85% in the euro zone today (ECB, 2018).

Today, the novelty lies in the widening of the range of means of payment beyond the traditional banking network. Traditional cash is bound to lose ground with the rise of contactless payment cards and mobile phone payment applications, although the trend is more or less pronounced depending on the country. In Europe, it seems much stronger, for example in the Scandinavian countries than in Germany or Switzerland, where the cultural attachment of the population to cash remains strong[1].

The decline in the use of cash reduces the significance of central banks in the payment system by marginalising central bank money. If the use of cash vanishes entirely because of technological innovation or is restricted for political reasons, the only form of money used in the economy would be privately issued and central banks would lose their prerogative in issuing cash. **As a result, the situation could arise where households and firms would lose access to legal tender.** By offering a central bank digital currency, central banks would ensure adequate central

[1] In Switzerland, cash is the most common method of payment for households. Of the payments recorded, 70% were processed with cash. When measured in terms of value, by contrast, cash accounted for just 45% of the recorded expenditure. This difference is attributable to the fact that cash is a particularly popular payment method for small amounts (SNB, 2017). By contrast, mobile payments remain marginal, accounting for 0.5% of the total volume of transactions (including cash) (Le Temps, 2018).

bank money for the public by enabling him to hold legal tender in electronic form (Berensten and Schär, 2018: p. 101).

The rise of cryptocurrencies

The rise of private cryptocurrencies based on blockchain technology poses several challenges to the sovereign monetary prerogatives of central banks. Indeed, private cryptocurrencies are often designed to operate outside the regulatory framework and outside the oversight authority of the central bank. If they were widely adopted for making payments, which is however, a rather unlikely scenario, they could significantly reduce the demand for central bank money and erode the transmission mechanisms of monetary policy. The growth of private cryptocurrencies could affect the size of the central banks' balance sheet to the point of reducing its ability to influence interest rates. The central bank would be no more than an issuer of payment means among others and its function of public regulator would be reduced to ensure the integrity of the system and to propose a unit of account with no effects on the level of absolute prices.

The underlying technology could present an even more radical challenge to central banks. According to the Bank of International Settlements (BIS), **the distributed ledger technology (DLT) reduces the functions of a central body and may even, in an extreme scenario, eliminate the need for a central body entirely**. For example, settlement might no longer require a central ledger held by a central institution if banks could agree on changes to a common ledger. In a similar way, the necessity of a central body issuing a sovereign currency could be put into question by protocols for issuing non-sovereign currencies that are not the liability of any central institutions (BIS, 2015: 17).

This shows that the introduction of DLT is not just a change in technology, but it implies a change in market structure affecting the relationship between public authorities and private actors. Thus, the question may be raised of how central banks could respond to an increasing use of distributed ledger technology to settle transactions. One option is to consider using the technology itself to issue digital currencies. Indeed, **an increasing number of central banks are engaging in research and active dialogue to explore a combination of the "best of both worlds": the issuance of a digital currency with legal tender and all the advantages of digitization, while avoiding the risks of private non-legal digital currencies**. As staff members from the IMF note, a central bank digital currency "may forestall such private currencies or relegate them to a secondary role in the payment system" (He *et al.*, 2017: 44).

Threats to the stability and integrity of the financial system

The rise of cryptocurrencies may also challenge central banks by putting financial stability at risk. To date, many financial authorities judge that, given their small size and limited connection to the real economy, private cryptocurrencies do not jeopardise financial stability. However, a major incident involving private cryptocurrencies could result in significant losses to users, a loss of confidence in these schemes, a disruption of retail payment systems and potential adverse economic effects. In addition, the reputation of central banks could be at risk, since they are seen as being responsible for oversight of the payment systems. Therefore, **if authorities do not act pre-emptively, cryptocurrencies could become more interconnected with the financial system and the economy and become a threat to financial stability** (Carstens, 2018: p. 9).

According to the European Central Bank (ECB), private cryptocurrencies could start endangering financial stability under the following conditions: a wider use of cryptocurrencies in regular payments; greater links to the real economy; and no structural developments to make cryptocurrencies more stable (ECB, 2015: p. 26). A central bank digital currency would be one way of preventing a wider use of private cryptocurrencies and therefore to preserve financial stability.

Another aspect of private cryptocurrencies that may affect the prerogatives of central banks is the risk that they serve illegal purposes (terrorist financing and money laundering). Indeed, private cryptocurrencies are vulnerable to illicit use since they have a global reach, are accessible through internet and allow greater anonymity than traditional payment methods (ECB, 2015: p. 28).

More precisely, they reinforce risks related to money laundering and the financing of terrorism because of the following factors:

- Given the decentralized nature of most cryptocurrencies, there is no single entity to be held accountable for their integrity and to enforce the rules of functioning. In the case of Bitcoin, the protocol does not require any identification or verification of the users, nor does it generate historical records of transactions that are associable with persons in the real world.
- It is difficult to apply and enforce anti-money laundering and regulations, as well as those countering the financing of terrorism (AML/CFT), in the presence of complex infrastructures to transfer funds involving several entities (not always identifiable) that are often spread across several countries.
- Issuers of private cryptocurrencies or their related service providers (e.g. wallet providers, exchanges) can be located in jurisdictions that do not have effective AML/CFT controls in place.

Adopting a central bank digital currency could be an appropriate policy response to curb the risks that private cryptocurrencies pose to the integrity of the financial system.

1.2 Defining central bank digital currency

The prospect of central banks issuing digital currency raises the question of the definition of this new form of money and its relation with existing forms of money. A central bank digital currency (CBDC) can potentially uphold the four major features of cash: universality, anonymity, peer-to-peer exchangeability and a constant nominal value. In practice, however, central banks are assessing CBDC schemes that retain only some of these features. Consequently, it is possible to identify four possible main schemes of CBDC.

Three types of money

In order to understand the nature of a CBDC and its possible implications, it is essential to first examine the existing forms of money in our payment and banking system. In this system, we find three different types of money: physical cash (notes and coins), commercial bank deposits and central bank reserve money[2]. These three kinds of money can be distinguished from the viewpoint of their particular material *form*, *accessibility* and *supply*.

Cash includes (physical) banknotes and coins in circulation in the economy. It is accessible to all users including private households, commercial banks, central banks and governments. Cash is a claim on the central bank that is usually responsible for printing, minting and supplying it. The central bank supplies cash in response to demands from citizens, who want to exchange their bank deposits for cash. This transaction is mediated by commercial banks that purchase cash to accommodate the demand from citizens.

Commercial bank money refers to electronically recorded deposit account liabilities on the ledgers of commercial banks. They are accessible to all users in the economy in so far as they have a bank account. Commercial bank money is a claim on the commercial bank in which the customer holds an account. It is supplied into the economy when commercial banks credit the deposit accounts of their customers. This happens notably when banks grant loans to borrowers or when they make payments of salaries to employees. When deposit account holders make debt repayments or interest payments to the bank, commercial bank money is destroyed.

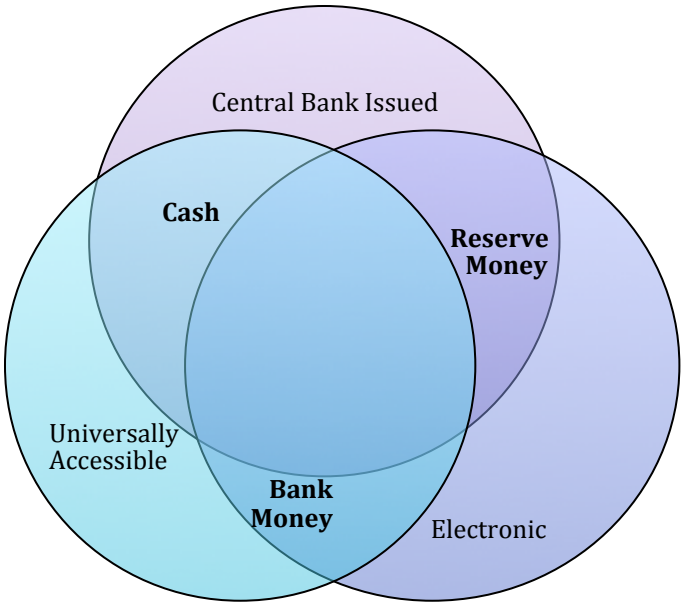
Central bank reserve money is central bank money but in electronic form, that is electronically recorded current account liabilities on the ledgers of central banks. It is accessible only to users that hold an account with the central bank, namely commercial banks, the treasury and foreign central banks. Central bank reserve money is supplied in many different ways, but mainly by being credited to commercial banks' current accounts as part of the purchase of governments bonds or when commercial banks borrow central bank reserve money from the central bank. It is electronic central bank money that banks use when they are making large payments to one another.

As highlighted by Bjerg (2017), these three types of money can be grouped in three pairs each sharing a particular feature that the third type lacks (see Figure 1):

- Commercial bank money and central bank reserve money are both electronic, which cash is not.
- Cash and commercial bank money are both universally accessible, which central bank reserve money is not.
- Cash and central bank reserve money are both supplied by the central bank, which commercial bank money is not.

[2] Private cryptocurrencies are not considered as money since they are unable to perform the three functions of a fiat money: medium of exchange, unit of account and store of value. We do not deal here with the question of the nature of money, which has given rise to endless debates between economists, considering that this is not absolutely necessary for our purpose.

Figure 1: the features of existing types of money:



A new type of money

A central bank digital currency (CBDC) would be a new type of money, potentially co-existing with cash, bank deposits and central bank reserve money. In order to define CBDC, it is useful to compare its features with the three existing forms of money from the viewpoint of its form, accessibility and supply.

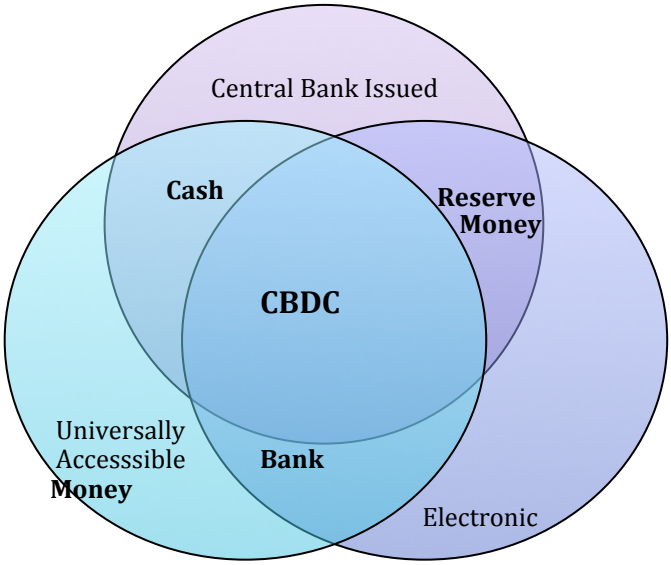
A CBDC refers to deposit liabilities that are electronically registered on the central bank balance sheet. The access to these deposits is universal, in the sense that all money users can potentially hold and use CBDC. It is the central bank that issues CBDC by crediting the accounts of money users. In sum, **CBDC is electronic**, **universally accessible** and **central bank issued money**.

The fact that CBDC is a claim on the central bank means that it is risk free, like cash. This is an important difference with bank deposits that bear credit risk. If their bank becomes insolvent, customers' claims to commercial banks can be redeemed only up to the maximum amount covered by the deposit guarantee scheme[3]. It is in mainly in times of crisis that the public becomes aware of this risk. However, credit risk is compensated by a number of advantages such as services with payment transactions and interest income (Jordan, 2018).

This definition allows us to situate CBDC into the Venn diagram of the three existing forms of money (see figure 2). As highlighted by Bjerg (2017), the diagram (below) shows that **CBDC combines all the three features of cash, bank deposit money and central bank reserve money**.

[3] Currently: £ 100'000 in the EU and CHF 100'000 in Switzerland.

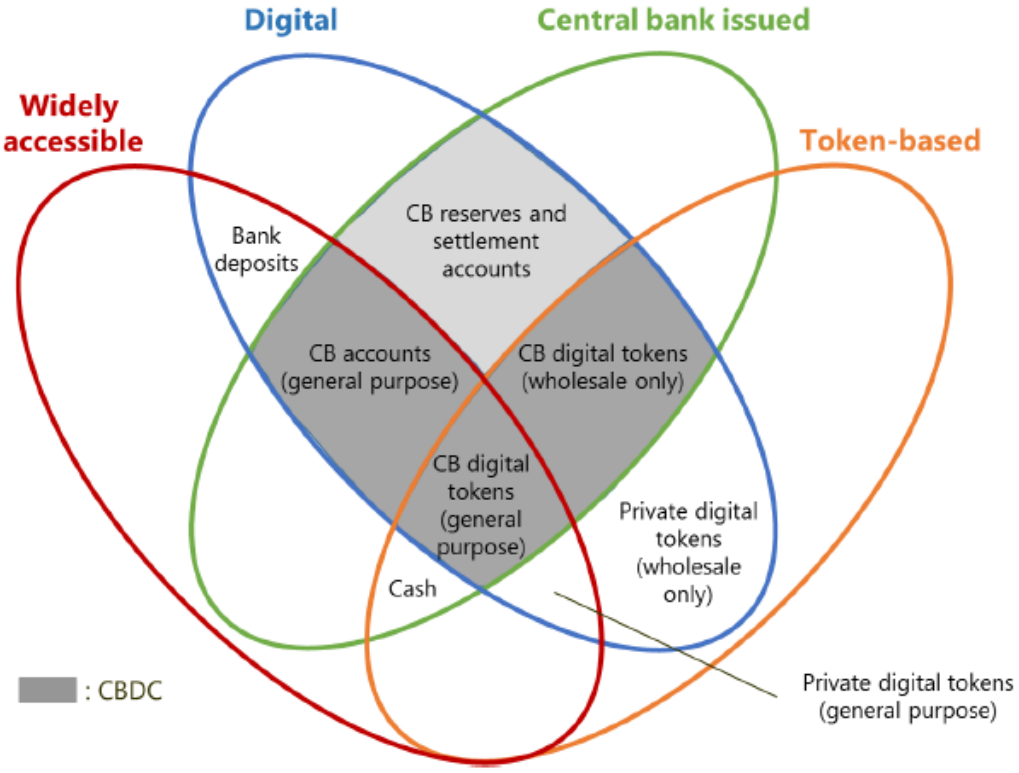
Figure 2: the features of CBDC:



In the public debate, CBDC is often associated to cryptocurrencies such as Bitcoin. However, CBDC and private cryptocurrencies have very different, if not opposite, characteristics. This linkage probably stems from the fact that CBDC is associated to the blockchain technology on which private cryptocurrencies are based. Yet CBDC does not need to be based on blockchain technology but can be created using existing technology. Indeed, in its current form, blockchain technology is not suitable for CBDC (see section 4.2).

It has to be acknowledged that the BIS proposed a slightly more complex definition of the concept of CBDC by combining the above classification of Bjerg with the properties of cryptocurrencies (CPMI, 2015). The primary difference with the above model is the introduction of a fourth attribute of money related to its transfer mechanism (token-based). The result is the so-called "money flower" that is now widely acknowledged in the literature on CBDCs (see below).

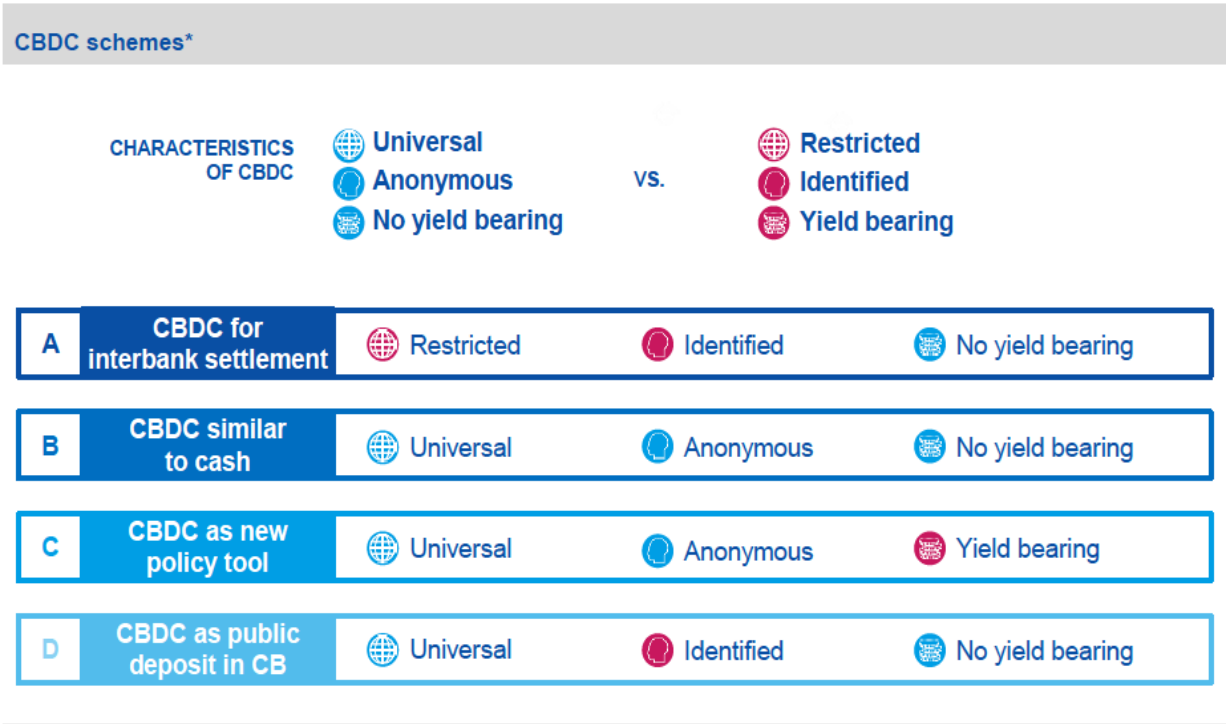
The money flower: a taxonomy of money Graph 1



Source : BIS CPMI (2018)

Variants of CBDCs

As highlighted by the Banco Bilbao Vizcaya Argentaria (2017), a CBDC has the potential to preserve the four main attributes of cash: peer-to-peer exchangeability, universality, anonymity and no yield interest bearing. Despite this technical feasibility, central banks examine CBDC schemes that retain only some of these four characteristics. Thus, it is possible to identify four main relevant variants of CBDCs, ordered below from less to more disruptive. These are some of the possible variants and other combinations can be defined as necessary to meet the needs of the government or the interests of society.



* P2P is a feature of CBDC in each of the four schemes
Source: BBVA Research

A. CBDC for interbank settlement

In the short term, some central banks have focused on the use of distributed ledger technology or other technological solutions only for wholesale payment systems. Under this scheme, the CBDC would be held by banks and other participants in wholesale payment systems, but not by the general public. It would be identified (as opposed to anonymous[4]) and non-interest bearing. This scenario might improve the efficiency of wholesale payment systems and have few drawbacks for the public. A number of central banks, including the Bank of Canada (Project Jasper), the European central bank (ECB), the Bank of Japan (Project Stella) and the Monetary Authority of Singapore (Project Ubin) have already experimented with CBDC for interbank settlement. The Utility Settlement Coin (USC) is another attempt by the private sector[5] to provide a wholesale cryptocurrency. It is intended to be a collateralized digital coin that banks could use to pay one another or to buy securities more quickly. The value of each country's USC on the distributed ledger would be backed by an equivalent value of domestic currency held in a segregated (reserve) account at the central bank. These early projects are still being evaluated and, in some cases, the preliminary results indicate that DLT solutions remain too immature to adopt as CBDC yet (Chapman *et al*., 2017: 10).

B. CBDC similar to cash

This option opens the CBDC to the public and can preserve all four key attributes of cash. Depending on the specific design of this version of CBDC, the efficiency gains could be superior to those of option A, since money transfers could be processed bilaterally between private users

[4] In practice, it is not possible to make CBDC completely anonymous (like cash), since all use of information technology leaves tracks. In addition, traceability of transactions is required by national regulations, e.g. Anti-Money Laundering and Know Your Customer and privacy laws (see section 4.1).
[5] The Utility Settlement Coin was developed originally by the Swiss bank UBS in collaboration with the UK-based blockchain company Clearmatics. They were later joined (2016) by BNY Mellon, Deutsche Bank, ICAP and Santander and the financial services firm NEX. New additions (2017) have included Barclays, Credit Suisse, Canadian Imperial Bank of Commerce, HSBC, MUFG and State Street.

using new technological solutions without requiring the central bank to keep track and adjust balances (see section 4.2). The payment and credit business of banks might be affected because of the partial substitution of CBDC for deposits (see section 5.2). In Sweden, the Riksbank is investigating whether an e-krona would provide the general public with continued access to central bank money as a complement to cash (Skingsley (2016) and Sveriges Riksbank (2017, 2018)). In Uruguay, the Banco Central del Uruguay started a pilot programme in November 2017 to issue, circulate and test an e-Peso as a complement to cash. Digital banknotes in several denominations were issued for distribution to an "e-note manager platform", without using DLT[6]. The pilot programme was successful and closed in April 2018, and is now in an evaluation phase (BIS, 2019: 5).

C. CBDC as a new policy tool

This version introduces the possibility of (positive or negative) interest rates. Such a CDBC could contribute to relax the zero lower bound (ZLB) on nominal interest rates, which would enable central banks to implement negative policy rates when required by economic circumstances. Alternatively, a CDBC could be used as an instrument to support unconventional monetary policy in times of crisis, such as "helicopter money" (see section 3.4). The advantages of broader policy making should, however, be balanced against the legitimacy issues that central banks would face as a result of potentially implementing financial repression.

D. CBDC as a deposit in the central bank

This scenario proposes a non-anonymous and universal CBDC that would be equivalent to a deposit at the central bank. The security of the system would be increased while policy makers would enjoy more surveillance power to fight illicit activities and tax evasion. Central banks would be in direct competition with retail banking and a type of narrow banking model would probably emerge (see section 5.1). Such a CBDC was experimented by the Central Bank of Ecuador with the "Dinero Electronico", but the system is now closed (see section 4.1).

This typology is useful to identify and understand the various models of CBDCs that are most relevant in the current debate. It has to be stressed, however, that there is no rigid frontier between the different models and other variants of CBDCs could be designed. For example, a CBDC similar to cash could include the option to be interest bearing – at least temporarily - in order to support unconventional monetary policy in times of financial crisis (see section 3.4). Another example for CBDC similar to cash is one which does not offer anonymity, except or perhaps in very restricted limits and conditions. For countries most concerned about controlling corruption and illicit commerce CBDC can be a powerful tool.

[6] The concept was elaborated by a Swiss company – the Roberto Giori Company – which developed a technology, called the Global Solutions for Money Technology (GSMT), to provide a token-based digital form of banknotes as legal tender for the public (Giori, 2016: 1).

2. Motivations for central banks to adopt digital currency

2.1 Ensuring adequate central bank money for the public

Digital innovation has transformed the financial landscape and the payments ecosystem. Securities and contracts are dematerialized and traded electronically, payments are made with smartphones and investment advice is provided with computers. Thus, the question may be raised, why should cash be only physical? The issuance of a CBDC could be seen as a natural adaptation of cash to the broader process of digitization. By offering a CBDC, central banks would address the decline of physical cash and ensure adequate central bank money for the public by enabling them to hold legal tender in electronic form. This would also contribute to preserve central bank seigniorage revenue for those countries which make use of this.

Guarantee access to legal tender in electronic form

Although the total amount of physical cash in circulation continues to rise, its use as a means of payment is declining, while the use of credit and debit cards to make purchases is rising. Indeed, the use of bank notes relative to other payment methods has declined consistently for the past 25 years, which has led some observers to predict the advent of a "cashless society".

Each form of money has its advantages and drawbacks, which is why several forms of money coexist. The relative decline of physical cash is led by market forces and not by public authorities. In situations where the market is not able to supply basic payment services such as cash, the question may be raised whether the central bank should ensure that citizens have access to such services. This is reinforced by the fact that cash has unique advantages for society as a whole.

This question is particularly acute in Sweden, where cash in relation to GDP has declined substantially since 1950, when it represented almost 10% of GDP, compared with around 1.5 % in 2016. So far, it has not created major problems, but as more and more bank branches are going cashless, it becomes increasingly difficult for the Swedish public to gain access to central bank money and to use it (Skingsley, 2016: p. 7). Therefore, as highlighted by Stefan Ingves, Governor of the Riksbank, physical cash should be adapted to the new technological context of digitization:

> "I believe that the arguments that once led to the central banks being allowed to issue money are still relevant, it is only the technology that has changed. This is why we at the Riksbank have decided to build a pilot version of a new type of Riksbank money – a digital krona, or e-krona". (Ingves, 2018: 1).

A **CBDC could be a way for the government to guarantee access to legal tender in electronic form when the use of physical cash is declining**. This would contribute to the modernisation of central banks' payment system in line with the broader process of digitization in all sectors of society.

The advantages of cash for the population

But what are the advantages of cash for the population? Cash can be used without the buyer providing information about his identity. As a result, cash payments are anonymous, which protects the privacy of users. A payment in cash is censorship-resistant, which means that there is no way for any third party to prevent anyone who wants to accept cash or spend cash from doing so. Cash is also useful where banking infrastructure is poorly developed or in situations of emergencies, when electricity is temporarily disabled (Koning, 2016: pp. 11-12).

In addition, cash is the only fully liquid[7] asset enabling people to save outside of the private financial system. For example, in Switzerland, the demand for cash increased rapidly after 2008 because cash was used as an insurance against the insolvency of financial institutions and the risk of negative interest rates. In other words, cash fulfils an important social function as a store of value. Last but not least, cash is central bank money and does not involve any credit risk for the holder. In contrast, private electronic money involves counterparty risk, since bank deposits are a liability of the issuer and bank customers are offering a credit to their respective banks (Berensten and Schär, 2018: pp. 100-101).

A CBDC could mimic all these characteristics. It would be superior to some current payment methods when security or privacy is a particular concern for the purchaser. It would respond to the population's need for electronic money without facing **counterparty risk**[8]. And it would also be less costly for consumers to use than debit and credit cards. This would be particularly beneficial for low-income households who tend to rely heavily on cash, and for small businesses that have to pay high costs when handling cash or interchange fees when making payments with debit or credit cards. At a macroeconomic level, researchers at the Bank of England have estimated that the productivity gains from adopting CBDC would be similar to those of a substantial reduction in distortionary taxes (Barrdear and Kumhof 2016). On a more socio-political level, a CBDC would allow central banks to maintain "people's only direct link to central bank money" (Mersch, 2017). Indeed, cash is the only direct claim that citizens hold against the central bank and can therefore be considered as a means for central banks to keep some visibility in society and maintain or gain legitimacy in the monetary system.

Another concern for some central banks arising from the decline of cash is the question of their seigniorage revenue[9]. Currently, it is earned only on the issuance of physical cash. Therefore, seigniorage would diminish with the decline of cash and it would be especially affected if higher denominations notes disappeared since they generate more revenue than smaller notes. The introduction of a CDBC could allow the state to get back some of the seigniorage that indirectly accrued to the banking sector when it issues bank deposits. Indeed, the advantages of cash described above would generate additional demand for CBDC. As a result, the sum of the value of bank notes in circulation and CBDC would probably be larger than the value of physical cash currently. Other things being equal, this would increase seigniorage revenue (Engert and Fung, 2017, p. 14).

[7] Liquid means that it can be directly exchanged for goods and services.

[8] A holder of electronic central bank money bears no counterparty risk because a central bank has the ability to print its own liabilities. In contrast, private electronic money is a promise to pay out cash on demand and that promise might not be fulfilled. However, central bank money may also lead to financial disaster. Historically, hyperinflation has impoverished people holding a part of their wealth in the form of central bank currency.

[9] "Seigniorage" refers to the profit that comes from being able to issue money.

2.2 Improving the efficiency of the payment system

Central banks are responsible for issuing bank notes and promoting safety and efficiency of payment systems. As such, they are interested in exploring ways to improve the efficiency of the retail payment system and in particular reduce the cost of cash. In the past, the evolution from paper bank notes to polymer bank notes has enhanced the security and durability of bank notes. Moving forward, it is important for central banks to examine whether they could further improve efficiency by issuing cash in a digital form.

Reducing the cost of cash

Every innovation has costs and benefits. Efficiency is improved when the benefits to society are greater than the costs. How would a CBDC improve the retail payment system efficiency? Fung and Halaburda (2016) argue that a CBDC would benefit the efficiency of the retail payment system in at least two ways. First, it would reduce the cost of transactions conducted with existing payment methods, notably cash. This could encourage substitution from cash to CBDC for retail payments. Second, a CBDC would facilitate transactions that are foregone[10] at present because existing payment instruments do not allow to overcome frictions in the marketplace.

The costs to society of providing retail payment services are considerable. Schmiedel, Kostova and Ruttenberg (2012) find that the social cost[11] of retail payment instruments across a sample of 13 European countries amount to €45 billion, which equals approximately 1% of GDP. When extrapolated to the 27 EU Member States, these costs are comparable to the 13 sample countries, being close to 1% of GDP or €130 billion. The social cost of cash payments represents nearly half of the total social costs, which equals to 0,5 % of GDP[12]. In the United States, the cost of cash has been estimated at $200 billion annually (Chakravorti & Mazzotta, 2013).

Three categories of actors could potentially benefit from significant savings with the introduction of a CBDC: central banks, commercial banks and business and end-users. As highlighted by Panetta (2018), the introduction of a CBDC has the potential to reduce drastically the costs of cash for **central banks**, in terms of producing, issuing, managing, storing, counting and destroying physical cash. These cost savings would be particularly important for cash-based economies such as those in the developing world. Overall, the costs of managing a CBDC would be a fraction of the costs of physical cash. These efficiency gains would increase with the gradual development and diffusion of the CBDC.

Commercial banks and businesses would also benefit from saving costs related to cash management, distribution and logistics. A recent study by Raskin and Yermack (2016) estimates savings relating to bookkeeping and operational processing to amount to between 50% and 80% of total operational costs. In addition, commercial banks and businesses may also benefit from lower costs associated with cash-in transit robberies and the risks involved for their security personal. This cost may be substantial in some developing countries such as South Africa, where an increase in cash-in-transit heists by at least 104% has been observed between 2016 and 2017 (BBC, 2017).

Finally, **end users** are likely to benefit from the most substantial savings as a result of reducing costs faced by both commercial and central banks. Indeed, the use of CBDC will enable bank customers to avoid ATM cash withdrawal fees that range from 2% to 5% of the withdrawal value (Bordo and Levin, 2017:7). These cost savings could also apply to online transactions fees,

[10] Foregone transactions are those that are economically beneficial (improving the welfare of both parties) but do not occur because of various frictions.

[11] Social costs measure the sum of the pure costs of producing payment instruments incurred by the different stakeholders in the payment market.

[12] These figures are somehow underestimated since they do not include households' costs, such as the time it takes to find and walk to a cash provider to get banknotes (so called "shoe-leather costs").

which may be lowered with the removal of layers of electronic settlement from payment procedures. Non-monetary costs[13], such as households' shoe-leather costs, would also be eliminated if cash could be accessed at a distance, for example via smartphones. By contrast, hardware and software costs would increase, but new technological solutions promise efficiency gains (see section 4.2).

Potential efficiency gains of issuing a CBDC

In addition, a CBDC would facilitate transactions that are foregone at present because existing payment instruments do not allow to overcome frictions in the marketplace. Various frictions could preclude beneficial transactions such as concerns about security, and monetary and non-monetary transaction costs. These frictions vary according to the different types of transactions. Table 1 below summarizes the main transaction types – online, at point of sale (POS), peer to peer (P2P) and remittances – and gives examples of related frictions.

Table 1: Categorization of foregone transactions

	Security/privacy	Non-monetary costs	Fees
Online	- Worries about the safety of Internet transactions. - Worries about information storage and transfer.	- Cost of setting up online account such as Paypal. - Cost of entering credit/debit card information.	- Credit card fees.
POS/ATM	- Lack of trust in certain merchants.	- Cash only merchant. - Cost of going to ATM.	- Withdrawal fees at ATM
P2P		- Cost of going to ATM. - Cost of downloading and learning new app.	- Price of new apps (e.g. Venmo, Interac). - Fees for using electronic P2P payment methods.
Remittances	- Mailing cash or passing it through travellers is unsafe and unreliable.	- Cost of going to the remittance agent	- Western Union or MoneyGram fees.

Source: (adapted from) Fung and Halaburda, 2016.

For example, some consumers tend to avoid online purchases because of security and privacy concerns when using their credit card. Depending on its design, a CBDC could facilitate such online transactions by providing an enhanced level of privacy and safety. Another example is fees on credit and debit cards that tend to deter some consumers from purchasing online or small merchants from selling online. Charging fees lower than credit and debit cards or suppressing fees altogether would reduce such frictions and decrease the number of foregone transactions.

[13] These costs refer to the time and effort that would have been spent on travelling to ATMs to withdraw cash, to remit money across borders through informal means such as bus drivers and to transfer money electronically when requirements exist for the acquisition and input of counterparty banking details before payments can be initiated (Fung and Halaburda, 2016).

In this respect, it should be pointed out that the European Central Bank (ECB) has just launched a new market infrastructure service in November 2018, called TARGET Instant Payment Settlement (TIPS). TIPS enables payment service providers (commercial banks) to offer fund transfers to their customers in real time and every day of the year. It settles payments in central bank money, thereby eliminating credit risk for users. The price per instant payment transaction is fixed at 0.20 eurocent (€0.002) until at least November 2020 (Les Echos, 2018).

However, commercial banks that decide to invest in TIPS will add their own fees to this price. Therefore, the final cost per transaction for end users is not known with precision yet but it seems reasonable to argue that it may end up to be higher than the cost per transaction processed through a value-based CBDC that does not require the use of bank accounts (and related costs). Therefore, even if payments through the TIPS infrastructure develop in the future, CBDC, at least in its value-based version, may still bring efficiency gains by charging lower fees or suppressing fees altogether.

Another source of frictions is the non-monetary cost of downloading and learning to use new applications. Thus, an easy-to-use interface would contribute to lower such non-monetary cost and improve the system's efficiency and increase adoption. The range of devices enabling access to the CBDC is another issue to consider. Allowing a CBDC to be used on wide variety of devices (computers, smartphones and potential offline schemes) could alleviate frictions related to online transactions and increase efficiency (Fung and Halaburda: 2016).

Other considerations

In addition to efficiency gains, CBDCs could come with other benefits. Since transactions made in CBDC will leave a digital trail, it would make it possible to effectively fight money laundering, the financing of terrorism and any form of tax and social fraud or evasion which have an impact not only on state budgets, but also on criminal activities. A digital currency would also make it possible to embed automated tax collection at transaction level, enabling governments to decrease public spending and increase efficiency. These benefits would be particularly relevant in developing countries, where an important fraction of the economic activity is informal and still conducted through the use of cash.

Money laundering and the financing of terrorism

As highlighted by the BIS, given that a CBDC can allow for digital records and traces, it could 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 (BIS, 2018). CBDCs can be designed to facilitate identity authentication and tracking of payments and transfers. Identities would be authenticated through customer due diligence procedures, and transactions recorded. However, unless required by law, users' information would be protected from disclosure to third parties and governments, while criminals could be discouraged by the risk of investigation and prosecution (Mancini-Griffoli *et al.*, 2018: 20).

Under specific circumstances, CBDCs could enable central banks to collect a substantial amount of data on financial transactions which can be traceable including date and time-stamps. This level of information would provide central banks and public authorities with greater powers of control, which would allow more efficient investigations into illicit flows and money laundering. As explained by Burgos and Batavia, a CBDC would make it possible to track a suspect's financial movements, provided the suspect's bank secrecy be broken by court order. If necessary, also by court order, the CBDC digital account or wallet could be blocked to prevent the use of its electronic money as means of payment. Other investigative tools may be used to fight illicit activities such as the addition of a "special marker" to the CBDC account that will provide extra information about the location and activities of the criminal (Burgos and Batavia, 2018: 19).

Overall, as stated by Cooper and Allen, "the consequence of deeper insights into transactional level data is an improved speed of forensic accounting and auditing which underpins an

enhanced supervisory capability of a central bank to protect the value of its fiat currency." (Cooper and Allen, 2018 : 11). This capability may, in turn, increase the resilience of the financial system and the real economy and enhance social trust in CBDCs.

Tax and social fraud or evasion

A CBDC could be particularly useful for the collection of VAT that is the largest contribution to states' budgets. Indeed, tax authorities look for ways of more effective VAT collection in order to gain revenue and reduce the budget gap. A recent study shows that the EU Member States lose billions of euros in VAT revenues every year because of fraud and inadequate tax collection systems. According to a report on the VAT gap[14], the VAT gap for the year 2016 amounted to EUR 147.1 billion (Lamensch and Ceci : 2018 : 10).

One of the main problems allowing VAT fraudulent behaviours is the «cash for profit» that a fraudster can make, which raises the question of whether cash movements could be avoided or reduced while keeping an audit trail. This is where new technological solutions supporting digital currencies – in particular CBDC - become relevant because they have the potential to reduce the administrative burden imposed on companies and other organisations to collect and pay VAT, increase transparency of real-time transactions throughout the economy and reduce risks of fraud and mistakes (Walport, 2015, 71).

[14] The loss is referred to as the "VAT gap", which is defined as the difference between expected VAT revenues and VAT actually collected.

2.3 Expanding financial inclusion

Exclusion from the financial system has increasingly been identified as one of the barriers to fight poverty. Therefore, the development of innovations to extend financial services to the poor has become an urgent challenge. While mobile financial services have contributed to expand financial inclusion, they present some challenges that limit their capacity to fulfil their promise. By contrast, a CBDC allows to combine the best attributes of mobile technology with the features of an established fiat currency under the sponsorship of a central bank, which represents a unique opportunity to contribute to financial inclusion.

Financial exclusion in emerging economies

Globally, about 1.7 billion adults remain unbanked - without an account at a financial institution or through a mobile money provider. Because account ownership is nearly universal in high-income economies, virtually all these unbanked adults live in the developing world. The share is higher in Africa, the Middle East, Southeast Asia, and South Asia, and is particularly high among poor people, women, and those living in rural areas, but many middle-class people are also affected. The main reasons explaining this lack of financial inclusion[15] in emerging economies, are the cost of bank accounts, excessive distance of banks and lack of trust in the banking system (World Bank, 2017).

Even those with financial accounts lack access to the broad range of financial services, such as savings accounts, loans, and insurance products. As a result, most people make transactions exclusively in cash, have no adequate instruments to save or invest, and do not have access to credit beyond informal and personal networks. Therefore, a considerable amount of wealth stays outside the financial system and credit remains scarce and expensive. This prevents people from developing economic activities that could improve their lives (McKinsey Global Institute, 2016).

The prevalence of cash remains high despite new payment technologies. According to the G4S World Cash Report, 75% of the countries under study report cash is used in over 50% of transactions (G4S, 2018: 14). In emerging economies, this ratio is sometimes much higher, like in India where it reached 95% in 2016. For governments, the **predominance of cash** creates leaks in public finance and can enhance corruption. Social programs based on cash payments and subsidized goods such as fuel and food staples also limit governments' capacity to target aid and subsidies effectively. In addition, cash payments reinforce large informal economies that inhibit competition and deprive governments of tax revenue (McKinsey Global Institute, 2016).

The rise of digital payments

In many high-income economies, debit and credit cards used at point-of-sale (POS) terminals dominate the digital payments landscape. By contrast, in most emerging economies, few people have such cards since many remain unbanked. But many have a mobile phone, which could allow these economies to leapfrog formal banking services, moving directly to mobile payments. Indeed, globally, about 1.1 billion unbanked adults - about two-thirds of all those without an account - have a mobile phone that could enable them to access financial services (World Bank, 2017: p. 92).

[15] Financial Inclusion is the process of ensuring access to appropriate financial products and services needed by vulnerable groups at an affordable cost in a fair and transparent manner by mainstream institutional players.

Mobile finance[16] has an opportunity to flourish in emerging economies because network coverage is almost ubiquitous and rapidly increasing in quality. Moreover, the use of mobile phones is growing quickly: in 2014, nearly 80% of adults in emerging countries had mobile subscriptions; by 2020, this share is expected to reach over 90%. This means that a large number of people who currently do not have financial accounts, could gain access to finance through their mobile phone (McKinsey Global Institute, 2016).

But how does mobile finance contribute to financial inclusion? The *World Bank's Global Financial Development Report 2014 on Financial Inclusion* indicates that people on low incomes are the first to benefit from technological innovation in mobile payment or mobile banking services. These innovations make banking services less expensive and more accessible for the poor, especially those living in remote, scarcely populated rural areas where there are no or few retail banking services. Mobile phones can eliminate the need to travel long distances to a financial institution. And by lowering the cost of providing financial services, digital technology might increase their affordability.

In addition, the familiarity of a mobile phone can help individuals to overcome the stress they may feel when using a formal financial account. Indeed, poor people can be intimidated by the prospect of visiting a bank but are used to sending SMS texts or trading prepaid minutes with family members. Another aspect to take into consideration is the fact that access to traditional financial accounts increases slowly as national income levels rise. By contrast, the use of mobile money accounts shows no correlation with income: the highest penetration today is in some of the world's poorest countries. A critical mass of individuals needs to use the system for it to get started; once a network of active digital users is established, growing numbers will want to join (McKinsey, 2016).

Challenges with mobile payments

Despite the strong potential of mobile payments to expand financial inclusion, their development has also revealed some limitations. As highlighted in a study by UNCTAD, the expansion of mobile money poses a number of challenges in terms of **financial regulation**[17], in particular concerning the issuing of mobile money, transaction limits, agency banking and anti-money laundering (UNCTAD, 2012: 21).

Of particular importance for users is the fact that mobile money from different operators is not always interoperable to the extent that cash is. Because of this **lack of interoperability**, individuals are obliged to transfer money to those who are using the same mobile network operator within a specific country, which tends to restrict reach and make transactions cumbersome. This problem is likely to persist, since mobile money operators are themselves reluctant to allow interoperability because they do not want to make it easy for customers to move their money to competitors (Donovan, 2012). There are, however, some projects in recent years among private enterprises to implement local solutions for at least limited interoperability. These solutions can be expensive, since they require capital investments and do not involve the central bank. The intent is a relationship between the private institutions to support transactions that remain based on commercial bank money.

Another key issue is the fact that many mobile money initiatives are partially - in some cases wholly - led by non-bank institutions - that are situated outside the scope of financial regulation. This has led to concerns amongst regulators who have been reluctant to license non-bank operators offering mobile services, on the ground that they are legally not subject to **prudential oversight**. In many countries, this objection has been surmounted by central banks requiring a

[16] Mobile finance is the provision of financial services through a mobile device.

[17] Financial regulation aims to maintain the integrity of the financial system through oversight, reporting, and enforcement mechanisms. Specific goals include the prevention of market manipulation and investor fraud, provider competence assurance, consumer protection, and maintaining investor confidence in the financial system as a whole.

partnership between the mobile network operator (MNO) and a prudentially regulated bank, where the electronic value in the customer's mobile money accounts is fully or partially backed up in bank accounts. However, linking mobile payments to the formal banking system, for example by requiring a bank account to enable mobile money transactions, may compromise the objective of financial inclusion (Aron, 2017).

However, some countries are now issuing payment service provider (PSP) licenses that are required for mobile operators to operate mobile payment systems. These are limited licenses that do not allow for paying interest or issuing credit but are only intended for financial transaction management.

Benefits of a central bank digital currency

By contrast, a CBDC does not require to own a bank account and thus represents a significant advantage for consumers in countries with large numbers of unbanked, or in countries with underdeveloped or unreliable banking systems. Indeed, **a CBDC offers the opportunity to leapfrog the banking system, moving directly to fully digital solutions without the requirement of bank accounts.** This would facilitate financial inclusion by providing access to those individuals and firms that are excluded from traditional banks and by making financial services more affordable and accessible. **All citizens will enjoy the universality of legal tender combined with the fluidity of electronic transactions, without differences based on socioeconomic, ethnic, or class boundaries.**

This will make it easier for governments to reach citizens without bank accounts, to pay them subsidies or salaries. In turn, recipients will be able to use the CBDC immediately to pay bills, without having to convert in and out of a private e-money system. A CBDC will also offer a new way to save efficiently, since users will be able to receive, store and transact digitally with minimal frictions.

In addition, the fact that digital money as legal tender is ultimately guaranteed by the central bank, will enhance the **confidence** of the public in the security of the system and reinforce its acceptance and widespread use. The confidence of the public will be reinforced by the fact that, as underlined previously (see section 3.1), a CBDC is central bank money and therefore does not involve any **credit risk** for the holder. This is in contrast to private electronic money that involves counterparty risk, since bank deposits are a liability of the issuer and bank customers are offering a credit to their respective banks.

Another important feature of a CBDC that will contribute to financial inclusion is that, contrary to mobile payments networks, a CBDC offers a fully **interoperable** and simplified system of digital currency. This means that an individual's digital money will no longer be exclusively linked to a single mobile operator. A system that is fully interoperable would enable an entity accepting a particular payment instrument to be confident that customers would be able to use this instrument, independently of their banking or partner affiliation.

2.4 Widening the scope of monetary policy instruments

The introduction of a central bank digital currency (CDBC) could reinforce the effectiveness of traditional monetary policy, while providing central banks with new monetary tools. A CDBC could contribute to relax the zero lower bound (ZLB) on nominal interest rates, which would enable central banks to implement negative policy rates when required by economic circumstances. Alternatively, a CDBC could be used as an instrument to support unconventional monetary policy in times of crisis, such as "helicopter money".

The issuance of a central bank digital currency

The introduction of a CBDC could enhance the capacity of central banks to control the quantity of CBDC circulating in the economy in real time, which could inform the formulation of monetary policy. Central banks would be able to operate faster adaptations of monetary policy to changing economic conditions. They would also have the ability to adapt to the volume of transactions and the number of users that may evolve with the development of the CBDC. This is one of the advantages of new financial technologies that would allow central banks to keep track of all transactions in a transparent and auditable way (Ahmat and Bashir, 2017: 4).

Beyond these general considerations, the introduction of a CBDC could have different types of consequences for monetary policy, the extent of which depends on the specific features of the CBDC. A key parameter relates to whether the CBDC is **interest bearing**. If the CBDC is non-interest bearing like the physical cash that central banks provide to the general public, then the implications for monetary policy would be negligible. If, on the other hand, the CBDC is interest-bearing (positive or negative), it could be used as an additional instrument of monetary policy to pursue various macroeconomic objectives (Meaning *et al*., 2018: 4).

As highlighted by Dyson and Hodgson (2016), these two options reflect two different approaches central banks may adopt when considering the issuance of digital currency. In the first approach (non-interest bearing), the central bank issues digital currency **reactively** in response to demand from the public, whereas in the second one (interest-bearing), the central bank issues digital currency **proactively** to stimulate aggregate demand and thus influence the economy.

In the reactive approach, central banks would issue digital currency in whatever quantities are needed to meet the demand from the public, exactly like physical cash in the current situation. Central banks would provide the necessary infrastructure to store and transfer CBDC but would let the public determine how to allocate their holdings of money between bank deposits and CBDC. Thus, it would be the public, rather than central banks, that would determine the quantity of CBDC to be issued.

Alternatively, by adopting a proactive stance, central banks could use CBDC as a monetary policy tool to stimulate aggregate demand and influence the economy. This could take two different policy forms: enable monetary policy to operate at negative interest rates; and support unconventional monetary policy (Dyson and Hodgson, 2016: 20). These two policies are discussed below.

Enable monetary policy to operate at negative interest rates

In the aftermath of the global financial crisis of 2007-2008, central banks attempted to stimulate bank lending and economic activity, by maintaining short-term interest rates at historically low levels. As a consequence, central banks of several countries, including Switzerland, Sweden, Japan and the European Central Bank (ECB) set negative policy interest rates.

However, the policy of lowering interest rates runs up against an obstacle known as the "Zero Lower Bound" (ZLB): the fact that monetary policy loses its effectiveness when nominal interest rates approach zero. Why? Because depositors and investors have a simple way to avoid negative interest rates: by holding cash. In other words, the existence of physical cash creates an obstacle to the implementation of negative interest rates by central banks.

This problem is not new, so why should we worry about it now more than in the past? The main reason is that low interest rates may have become a structural and therefore long lasting phenomenon. Indeed, current low interest rates are not only the result of central banks' massive stimulus measures in the aftermath of the Great Recession. They are also related to deeper socioeconomic transformations occurring over the past 30 years, such as lower trend GDP growth, worsening demographics, rising inequality and savings gluts in emerging markets (Rachel and Smith, 2015). In this new context, monetary policy has less room for maneuver to fight recessions than in previous decades and central banks may find themselves more often confronted to the lower bound constraint in the future (Stevens, 2017: 84).

This is where digital central bank money becomes relevant. Andy Haldane, Chief Economist at the Bank of England, suggests that one way to eliminate the Zero Lower Bound is to introduce digital central bank money on which **negative interest** could be levied:

> One interesting solution, then, would be to maintain the principle of a government-backed currency, but have it issued in an electronic rather than paper form. This would preserve the social convention of a state-issued unit of account and medium of exchange, albeit with currency now held in digital rather than physical wallets. But it would allow negative interest rates to be levied on currency easily and speedily, so relaxing the ZLB constraint. (Haldane, 2015: 11).

Importantly, **the introduction of a central bank digital currency could effectively reduce the zero lower bound constraint without abolishing physical cash but simply by complementing it** (Stevens, 2017: 85). In effect, the widespread adoption of a central bank digital currency would create the conditions to consider abandoning the largest banknote denominations. And since the largest denominations have the lowest cost of carry, their interruption would increase the average carrying cost of holding cash and thus enlarge the room for negative interest rates (Rogoff, 2016). This makes central bank digital currency an interesting option to remove the Zero lower bound while still offering the public the possibility to hold claims on the central bank.

Support unconventional monetary policy

Given the zero lower bound constraint and the ineffectiveness of expansionary monetary policy in the post-crisis years, some central banks resorted to "unconventional" monetary policy of Quantitative Easing (QE). A central bank implements QE by buying large amounts of financial assets, typically government bonds, thus raising the prices of those financial assets and lowering their yield, while simultaneously increasing the money supply.

There is, however, a debate on the effectiveness of QE at stimulating the real economy. Some economists argue that such policy benefits only a minority of wealthy households (bondholders and shareholders) who have a lower propensity to spend extra wealth and income than lower-income households. In other words, there would be no "trickle down" effect to the real economy.

In response to concerns that QE fails to create sufficient demand, a number of economists have called for "QE for the people" or so called "**helicopter money**". Instead of buying government bonds or other securities, they suggest that central banks could make payments directly to households and thus encourage aggregate demand. A CBDC could provide the distribution channel to facilitate a direct transfer of central bank funds to individuals and firms. This mechanism could serve as a tool of **anti-cyclical monetary expansion** by allowing the injection of liquidity directly into the economy without going through the banking sector.

3. Designing a central bank digital currency

3.1 Issuance and distribution approaches

The many advantages for central banks to issue a central bank digital currency (CBDC) are not without their challenges, especially concerning its design. Depending on their motivations, central banks need to define the features of their CDBC and collaborate with innovative software providers to understand current and future technologies. This section focuses on a CBDC designed specifically for the purpose of enabling central banks to issue a sovereign currency in digital form with the same features as cash, highlighting the different approaches for issuance and distribution.

The issuance of central bank digital currency

The issuance of a CDBC with the same features as cash is similar to the way paper currency is currently issued. The same steps are required for the production, storage and distribution of the currency, the only difference being the digitization of the process. Printing presses are replaced by a secure 'virtual State Print Works' and the digital banknotes are stored in a digital vault in the data centre of the central bank. Armoured vehicles to deliver freshly printed banknotes are substituted by digital transfers of CBDC to users' wallets. Security elements found on modern banknotes (holographic foils, precision patterns and serial numbers) are translated into digital cryptographic security elements. This makes CBDC monetary units equivalent to banknotes with a unique signature and serial number.

Given their ubiquity, mobile phones would be the most convenient way to hold and transfer such digital currency. Each transaction would be secure and validated by an operating platform. The units could also be stored in accounts or digital wallets held in remote servers. As the digital currency would circulate electronically, it could be used for both point of sale payments and remote payments. As such, it might not only serve as an equivalent to physical cash but also as a substitute to bank money. It would be perfectly fungible with other monetary instruments and, for instance, could be exchanged for physical cash at ATMs or at point of sale.

The distribution of central bank digital currency

As highlighted by Mersch (2017), there are two approaches for the central bank to provide digital money for the public: **value-based** and **account-based**. Cash is value based and no account is involved: a transfer of cash is final when the payer gives the cash to the payee. The central bank is not involved in the transfer. It only registers the issuance and the final return of cash. By contrast, current CBDC in the form of deposits of commercial banks at the central bank is account based: a transfer from one bank to another is final when the funds are debited from the account of the payer and credited to the account of the payee. The central bank is directly involved, since it registers the transfer.

Value-based model

A CBDC could be value-based like cash (also known as "token-based"[18]): the central bank creates and issues the CBDC either directly to the public or (indirectly) through existing intermediaries. The distribution of the currency and the administration of the wallets (digital deposit accounts) can be provided by the central bank itself or can be delegated to the private sector. The central

[18] Tokens are digital representation of a physical asset and can be used to verify the asset's authenticity. A "token-based" CBDC means that, once issued, units of CBDC can be transferred from one person to another without the intervention of the central bank, in the same way as physical cash. The alternative is an "account-based" CBDC in which agents had an account recorded by the central bank and transactions were made by the central bank debiting one account and crediting another.

bank or the private firms (banks or technology companies) operating the system would provide a special type of digital deposit account, which are called "Digital Wallets". The firms providing these accounts are referred to as "CBDC providers".

CBDC providers would have the responsibility for providing payment services, account information, internet and mobile banking, and customer support. A transfer of CBDC would require the funds be debited from the payer's digital wallet and credited the payee's wallet without the intervention of the central bank.

Legally, **it is important to stress that the digital money held in electronic wallets would belong to the account holders, and not the CBDC provider**. This latter would administer the digital wallets but would not own the money in the wallets. This is in contrast to what happens in traditional banks: the physical cash you deposit becomes the property of the bank and you are instead given a liability in the form of a bank deposit. As a result, CBDC providers would not be able to grant loans with their customers' CBDC and therefore be inherently as risk free as physical cash (Dyson & Hodgson, 2016). This value-based approach has several advantages:

- **administrative burden**: if operated by private firms, it minimises the administrative burden of the central bank by delegating this task to existing commercial banks and new entrants for the technology industry.
- **market-driven approach**: the administration of the system by private firms would encourage competition and innovation to improve and expand the services.
- **regulatory framework**: since CBDC providers would not put their customers' funds at risk, the system would require less intensive regulations. For instance, it would not be necessary to apply the Basel capital requirements. This could stimulate innovation by making it easier for new entrants to provide some competition to existing banks.

Account-based model

Alternatively, a CBDC accessible to the public could be account-based: the central bank would open an account for every user and provide them with sort codes, account numbers and payment cards so that they can use the money to make payments. This would require that customers be able to check their balance and transactions through Internet and mobile banking. The central bank would need to implement fraud prevention and anti-money laundering regulations on all accounts (Dyson & Hodgson, 2016). However, there are some downsides to this approach:

- **administrative burden**: the administrative capabilities to serve the public directly and provide customer and technical support would be beyond the current capacity of many central banks.
- **competition with banks**: the central bank could be perceived as trying to compete with commercial banks for the provision of payment services. This competition would likely raise questions of conflict of interest between central banks and the institutions within their oversight authority.
- **little incentive to innovate**: the central bank would not have much incentive to innovate the payment mechanism since it would be the only provider.

This approach was implemented in 2015 by the Central Bank of Ecuador (CBE) to issue Ecuadorian electronic money (*dinero electronico*) in the form of "e-money" accounts to the public. Citizens could open an account by downloading an application, registering their national identity number and answering a few security questions. However, unlike what is usually envisioned under the rubric "central bank digital currency," the BCE was not creating default-risk-free accounts denominated in its own domestic fiat money, but it was issuing claims to US dollars. In other words, it was not really a currency but a currency board with a 100% reserve in US dollars.

The system failed to attract a sufficient number of users or volume of payments and was shut down in 2018. This failure can be mainly explained by public distrust toward public authorities, nurtured by previous episodes of hyperinflation and resulting fears that the digital money would be a first step toward the de-dollarization of the economy. But it is also related to the difficulty for the Central Bank to operate an account-based system that requires to provide both hardware and software to many thousands of merchants, as well as direct customer support to the public beyond the capacities of private sector institutions (White, 2018).

Specific features of a central bank digital currency

The specific features of a CBDC depend on the original motivations of the central bank to issue it. We examine below the most important features of a CBDC similar to cash, although generalizations are difficult because of the variety of designs and specifications that account-based and value-based CBDC can have:

Denomination

A CBDC is denominated in the sovereign currency; e.g. for Switzerland, the Swiss franc.

Legal tender

Like cash, a CBDC is legal tender. This is important since end users will have more trust in a central bank than in a commercial bank or mobile network operator. Inspiring trust is the condition for the currency to be accepted by everyone and to be adopted by a sufficient critical mass, thereby reducing transaction costs in the interest of the economy and the public in general.

Convertibility

The central bank would exchange CBDC at par with financial institutions that have an account at the central banks or directly with end users. This would lead to par exchange of bank notes and CBDC among the general public.

Non interest bearing

The question of whether a CBDC could bear interests depends on its distribution model. If the CBDC is distributed through bank accounts (account-based model), it could potentially bear (positive or negative) interests. A CBDC bearing interest would be a close substitute of bank deposit and as such would compete directly with commercial bank deposits. This would induce a partial shift away from commercial banks towards CBDC wallets. Such a drain could have negative side-effects and threaten the practice of fractional reserve banking (see section 5.2).

By contrast, if the CBDC is distributed through digital wallets (value-based model), the possibility of the payment of an interest would be legally inconceivable. The contract allowing the user to have access to the distribution platform would be similar to a deposit agreement: the CBDC operator would provide the user with a dedicated area on the platform – a kind of "digital safe" - where he could deposit his digitized monetary units. The user would retain full ownership of his monetary units and could assert his ownership vis-à-vis the authorized operator and any third party. He would execute payment transactions under his own responsibility. This would be in stark contrast from what happens in traditional banks where the physical cash you deposit becomes the property of the bank and you are instead given a liability in the form of a bank deposit.

Access to CBDC

The access to CBDC is non-exclusive, which means that anyone could use it, but access to related technology is required. The CBDC is held on an account or in a digital wallet available to any person or firm through various technological devices, including mobile phones, tablets and personal computers with online capability. The digital wallets or the accounts would be provided and administered either by the central bank or by commercial banks.

Availability of CBDC

The CBDC would need to be available 24/7, like cash and other electronic payment methods.

Confidentiality of CBDC use

New technologies raise questions about the appropriate level of privacy or transparency in the financial system. A suitable technological solution would need to ensure a similar level of confidentiality to the processes in place for electronic payments, while at the same time provide the conditions for traceability that are allowed by national regulations and privacy laws. This means that the system would be private (transaction details are only visible to the counterparties of the transaction) but not anonymous (participants must be identifiable to enable applicable regulations, e.g. Anti-Money Laundering and Know Your Customer) at least above a specific threshold[19]. Depending on the legal environment, certain authorities may also require the capacity to view transactions under specific circumstances.

Supply by central bank

The central bank would need to supply as much digital currency as the public is willing to hold. Therefore, the supply would be demand determined and perfectly elastic.

Distribution channel used by central bank

Households and firms would purchase the CBDC either directly from the central bank, or indirectly at a regulated financial institution (e.g. bank) with their deposits or with bank notes. These regulated financial institutions would have accounts at the central bank and comply with know-your customer (KYC) and anti-money laundering (AML)/combatting the financing of terrorists (CFT) requirements for their CBDC operations.

Finality and irrevocability

A CBDC requires a technological solution enabling transactions to be confirmed instantaneously. In the case of a value-based CBDC, there would be, as with cash transactions, no need for any clearing and settlement between the two parties transacting.

[19] Indeed, an option discussed in some countries is to allow a limited wallet (or account) with strong transaction and balance restrictions that can be used anonymously or under very limited registration criteria. Above a certain threshold, full registration would be required with proof of identity. The result is a 2-tier wallet system of classes with different limitations. This tries to address the desire by some people to have access to an anonymous digital instrument.

Table 1: Features of a central bank digital currency similar to cash

Features	CBDC similar to cash
Denomination	Sovereign currency; ex: CHF, USD
Legal tender	Yes
Convertibility to cash	At par / no commission
Interest-bearing	No
Central bank fees	None
Access	Non-exclusive, but access to related technology is required
Availability	24/7
Confidentiality of use	Similar to electronic payments
Supply by central bank	Demand determined; perfectly elastic
Distribution channel	Directly through central bank or indirectly through regulated FIs that have accounts at the central bank. FIs comply with AML and KYC regulations.
Finality/irrevocability	Immediate, at time of transaction

3.2 Technological solutions for implementation

It is often assumed that consensus-based technologies such as blockchain – a specific type of distributed ledger technology (DLT) – would be required to implement a CBDC. Although these technologies have some advantages for financial record systems, they present dangers and challenges in the traditional model of sovereign currency. Instead, new technological solutions are emerging to provide a non-consensus based system to handle transaction processing. These technologies are better suited to enable central banks to issue a sovereign currency instrument in digital form.

Bitcoin and distributed ledger technology

It is now widely recognized that the key innovation in Bitcoin is not the alternative unit of account, but its underlying technology, the so-called "Distributed Ledger Technology". DLT allows a payment system to operate in a decentralised way, without any role for a trusted third party, such as a central bank. The term "distributed ledger" is used to describe a "secure database or ledger that is replicated across multiple sites, countries, or institutions with no centralized controller" (ITU, 2016: 11)).

The idea of a distributed ledger is not new. Such ledgers are used by organisations (eg. supermarket chains) that have branches across a given country or across countries. However, in a traditional distributed database, a **central administrator** performs the key functions that are necessary to maintain consistency across the multiple copies of the ledger. The easiest way to do this is for the administrator to maintain a master copy of the ledger that is periodically updated and shared with all network participants (BIS, 2017: 58).

By contrast, new systems based on DLT differ from traditional databases in that no such central administrator is needed to manage the database. New information can be provided by participants at any time and added to the database by means of a validation process. The new data are added to each participant's copy of the distributed ledger so that each participant will always have the latest version of the entire database.

The first and most well known application of DLT is the **blockchain** technology developed originally to support Bitcoin. Blockchain technology is based on a decentralized consensus mechanism that facilitates the sending of digital currency from one user to another without the need for a trusted third party.

However, as highlighted by Scorer (2017), it may not be the best solution for the implementation of a CBDC. **The environment in which a CBDC might exist would be totally different, with at least one trusted party – the central bank - needing to exert some degree of central control.** In addition, blockchain solutions require a huge amount of processing power and time and, therefore, cannot be used on a wide scale as is required for an official currency. It would be socially inefficient and technological nonsense wasting vast amounts of calculating power and energy[20]. Therefore, the features of the blockchain technology may be neither necessary nor desirable to implement a CBDC.

Some projects that are based on permissioned ledgers have been tested for interbank settlements for the public sector (OECD, 2018: 20). Projects conducted so far, and mentioned in Section 2.2, are still being evaluated, but the preliminary results indicate that DLT solutions using permissioned forms of DLT remain too immature to adopt as CBDC.

Technology requirements for a central bank digital currency

[20] The annual electricity consumption of Bitcoin is estimated to be about 73.12 (TWh) as of the end of August 2018, which is the equivalent to that of the entire country of Chile.

The initial motivations of central bank to issue CBDC are essential in determining the technological solution to implement it. In the case of a CBDC similar to cash, there are, however, a number of general requirements that would need to be addressed, among which: resilience, security, scalability, transaction processing, confidentiality, interoperability and future proofing. These requirements are technology agnostic, in the sense that they should be considered for any kind of CBDC solution.

They are discussed in greater detail below:

Resilience

A widely used CBDC would be considered as a strategic national infrastructure, necessary for a country to function and upon which daily life depends. Any disruption would have a major impact on the financial system and on the economy. Therefore, the technological solution should offer high levels of resilience and be operational across the country, 24 hours a day, 365 days a year.

Security

Security considerations are also paramount, especially in light of the increasing frequency and impact of cyber-attacks. The CDBC should be protected against unauthorised access to and alteration of data, as well as disruption to operation.

Scalability

An important technological requirement is the ability of the system to adapt to the volume of transactions and the number of users that may increase with the adoption of the CBDC.

Transaction processing

An optimal technological solution would enable transactions to be confirmed instantaneously and require no settlement. As with cash transactions, there should be no need for any clearing between the two parties transacting.

Confidentiality

New technologies raise questions about the appropriate level of privacy or transparency in the financial system. The technology underlying a CBDC should ensure a similar level of confidentiality to the processes in place for electronic payments, while at the same time offer flexibility to provide the conditions for traceability that are allowed by national regulations and privacy laws. This means that the system should be private (transaction details are only visible to the counterparties of the transaction) but not anonymous (participants must be identifiable to enable applicable regulations, e.g. Anti-Money Laundering and Know Your Customer). Depending on the legal environment, certain authorities might require the capacity to view transactions under specific circumstances.

Interoperability

A CDBC would need to coexist with the financial system. A synchronisation between the different payment systems would be required to ensure the effectiveness and coherence of payments. Therefore, the technological solution should allow full interoperability with existing payment methods. Interoperability includes the requirement for points of exchange between CBDC and commercial bank money to extend the use of CBDC in transactions with other payment systems.

Future proofing

Another technological requirement is that the CBDC would need to be able to function for a long period of time and thus to adapt to a changing environment. It might need to adapt the processing capacity to changes in demand. Also, the technological landscape is likely to evolve

rapidly in the future. Therefore, it is vital that the system has the ability to continually upgrade and increase its security features.

Requirements	Summary
Resilience	Highly operational 24/7/365
Security	Secure against cyber attacks
Scalability	Potential for several thousand transactions per second
Transaction processing	Immediate, real time, no settlement finality
Confidentiality	Similar to electronic payments
Interoperability	Full currency exchange and interoperability with existing payment systems
Future proofing	Ability to upgrade and enhance, without impacting service

4. Issues and challenges

4.1 Central bank digital currency and narrow banking

It is often argued that the issuance of CBDC raises questions that are similar to those relating to narrow banking or full-reserve money. However, such line of argument is misleading because the introduction of a CBDC does not share the same objective and does not involve the same restrictions as narrow banking or full-reserve money. Therefore, it is important to clarify the differences between the two reform proposals and their implications for the banking system.

Full reserve banking: a case of narrow banking

Full-reserve banking (also known as 100% reserve banking) is a proposed alternative to the fractional-reserve banking in which banks could no longer create new money in the form of bank deposits. In the current monetary system, almost all money is created by commercial banks via the creation of loans. By contrast, under a full-reserve banking system, private money creation would be prohibited, and every deposit would have to be backed by government money (i.e. cash, central bank reserves and government securities) to satisfy potential demand. In brief, a bank's reserve ratio must be 100% (Dow, Johnsen, Montagnoli, 2015).

"**Narrow banking**"[21] is usually presented as the modern equivalent of the "full reserve banking" principle, promoted by early economists such as David Ricardo to correct the inadequacy of money reserves against the stock of banknotes in circulation. Narrow banks specialize in deposit-taking and payment activities, they are prohibited or restricted from lending to the private sector and invest all their deposit liabilities in assets of very high quality (Bossone, 2001: 4). In a narrow-bank system, deposits do not fund lending or risky investments, but all deposits are invested in secure, liquid instruments such as central bank reserves or government paper (Norges Bank, 2018: 38).

Narrow banking resembles full reserve banking but is not exactly the same, full reserve banking representing a **specific type of narrow banking**. As explained by Laina (2015), narrow banking differs from full reserve banking in that it allows any safe asset to be the balancing item of bank deposits. The safe assets can be anything from central bank reserves to traditional bank loans such as mortgages. By contrast, full reserve banking allows only government money (cash, central bank reserves and government securities) as the balancing assets of bank deposits. Therefore, it can be considered as one type - the strictest - of narrow banking.

In the 1930s, narrow banking was proposed as a policy for monetary reform to restore confidence during the Great Depression in the USA, notably by a group of economists from the University of Chicago, such as Frank Knight, Henry Simons and Lloyd Mints. That policy was also supported by well-known monetary economists such as Irving Fisher, Milton Friedman and James Tobin. What became known as the "**Chicago Plan**" proposed notably to abolish the fractional reserve regime and to adopt a 100% reserve requirement on deposits. The plan, however, was never adopted due to strong resistance from the banking industry (Benes and Kumhof, 2012).

Central bank digital currency and full reserve banking

What is the relationship between CBDC and full reserve banking? **A CBDC payments system does not need to conform to a full reserve banking model, where banks lose their ability to create credit.** However, it is true that the introduction of CBDC could result in a situation of full reserve banking if customers were to transfer *all* of the sight deposits held at commercial

[21] The term « narrow banking » was coined by Robert Litan (1987).

banks to CBDC wallets or accounts. This extreme scenario is not very likely though, especially if CBDC wallets or accounts bear no interest rates.

More precisely, as highlighted in a study of the Bank for International Settlements (2018), CBDC and full reserve banking differ in two important ways:

- First, under CBDC residents hold direct claims on the central bank, whereas under narrow banking residents hold commercial bank money that is fully backed by central bank reserves or sovereign claims.
- Second, a CBDC could coexist with commercial bank deposits, whereas full reserve banking proposals aim to abolish the privilege of banks to create money. The idea of a CBDC is to give the public the option to choose between commercial bank deposits and central bank money, with the two coexisting side by side (Huber, 2018: 1).

This latter point allows us to stress that, unlike full reserve banking, **the aim of a CBDC is not to replace the traditional banking system with a unique state-issued form of liquidity. Instead, the aim of a CBDC would be to complement the banking system, by offering a larger range of options to spend, store and send value.** This means that banks would remain free to continue to develop credit activities and attract deposits, but that the balances of the customers of CBDC would be operationally and legally separated from depository balances. In that sense, the introduction of a CBDC could be described as a "partial narrow-banking system", as opposed to a "full narrow-banking system" in which banks are obliged to operate as narrow-banks rather than fractional-reserve banks (Gouveia *et al.* : 2017).

4.2 Implications for banks and financial stability

The introduction of a CBDC would lead to a situation where two competing forms of electronic money are in competition: bank deposits and CBDC digital wallets. This could create movements of funds both in normal times and during a financial crisis, with different implications for banks and financial stability. Although a CBDC system could stimulate a flight of funds away from banks towards the central bank in times of financial stress, it would also have a positive effect by guaranteeing continued access to a safe payment system for the population.

The market dynamic between digital wallets and bank deposits

The introduction of CBDC would amount to a new situation where consumers have the choice between two different forms of electronic liquidity: traditional bank deposits and digital wallets. Despite their differences, these two forms of electronic liquidity would inevitably be in competition. Consumers would need to choose whether they wish to hold physical cash, electronic money issued by banks or electronic money issued by the central bank.

As already mentioned above (see section 2.2), an important difference between these two forms of electronic liquidity is that bank deposits have credit risk above the insurance threshold (currently EUR 100'000 in the EU; CHF 100'000 in Switzerland), while digital wallets would bear no credit risk whatever the amount held. This means that for individuals or institutions with large sums of money to store, digital wallets may be attractive. In times of financial stress, digital wallets could seem to be even more appealing since governments may want to "bail in" depositors, such as in the case of Cyprus in 2013.

On the other hand, however, banks are able to pay interest on account balances since they earn revenues from credit activities, unlike CBDC providers who would have to store all customer funds at the central bank. The absence of interest on CBDC wallets would tend to reduce their attractiveness in comparison to bank accounts.

Implications for financial stability

A widely expressed concern is that the implementation of a CBDC bears **financial stability risks** related to the possibility for households and companies to move their deposits back and forth between their CBDC digital wallets and their bank accounts (BIS, 2018). The extent of these substitution effects depends on two factors: the design of the CBDC and its subsequent attractiveness in comparison to bank accounts; whether the shifts of funds occur in normal times or during a financial crisis.

Implication in normal times

In normal times, bank deposits and digital wallets would be close substitutes as they both have low credit risk and are directly accessible (high liquidity). The demand for CBDC would depend on several factors such as the user-friendliness of the system, the interest rate on bank deposit in comparison to the CBDC and any usage fees. Thus, if the goal of the CBDC is to mimic cash transactions and therefore offers no interest and no services similar to bank accounts, the substitution effects between the two would remain moderate because people would probably want to keep most of their money in commercial banks (Broadbent, 2016). Only some categories of bank deposits might migrate to CBDC digital wallets, namely sight deposits offering little or no interest (Panetta, 2018). In this situation, banks can offer a deposit rate slightly above zero to continue to retain their deposits, which means that the negative effects on bank profits and financial stability would be minor (Riksbank, 2017: 29).

By contrast, if the CBDC system provides customers with interest, holding CBDC would become more attractive and could encourage a larger number of people to move their funds from their

bank accounts to digital wallets. As a result, the CBDC may become a floor for bank deposit rates and consequently banks might need to adjust their deposit rates to prevent a too large quantity outflow of bank deposits (Riksbank, 2017: 30).

In an extreme case, a high CBDC volume may lead banks to opt for wholesale funding as the primary source for their activities, which would mean in practice the introduction of a **narrow-bank system** (see section 5.1). This scenario is, however, rather unlikely as it involves that the newly introduced CBDC replaces *all* bank deposits. Overall, **the effects of the introduction of an interest-bearing CBDC should not be disruptive for banks as they can always compete by offering services that CBDC digital wallets cannot, such as access to credit and payment services** (Panetta, 2018: 7-10).

Implication in times of financial crisis

In times of financial crisis, the CDBC could function as a store of value and therefore stimulate a flight of funds away from private financial institutions towards the central bank. Indeed, when faced with systemic financial stress, agents tend to shift their deposits towards financial institutions perceived to be safer. They could flee toward the central bank by converting their bank deposits into cash, but cash is relatively inconvenient and many bank accounts have limitations on the amount that can be withdrawn.

As highlighted by the BIS, the fact that digital wallets offer the safety of physical cash and the convenience of bank deposits accounts may prompt people to move – at least temporarily - their funds to digital wallets. This could allow for "**digital runs**" towards the central bank with higher speed and scale (BIS, 2018). In this case, the banks' capacity to retain deposits with higher deposit rates would be weaker, since it is the absence of credit and liquidity risks in CBDC that would drive the demand. Even in the presence of deposit insurance, shift in deposits could be large because a risk-free CBDC provides a safer alternative (Riksbank, 2017: 31).

For banks, large flows from banks deposits to digital wallets would reduce their liquidity ratios and any subsequent shortage of reserves would need to be addressed by central banks issuing additional central bank reserves. The situation would be managed via traditional monetary operations.

This risk is often emphasized to argue against the introduction of CBDCs (see for ex. Jordan, 2018). This argument is, however, hard to support. First, it would be possible to mitigate the risk of "digital runs", for example by imposing **quantitative limits** on digital wallets to limit substitution effects. The limit could be set so as to make it possible to use CBDC for transactions, but not for savings, for example as a fixed ratio of GDP. Alternatively, an overall ceiling could be set for the amount of CBDC. These measures, however, are not without their own challenges (Danmarks Nationalbank, 2017: 17).

Second, it has to be stressed that **the existence of CBDC digital wallets in times of financial crisis may also contribute to financial stability, as it would have a positive impact on the population as it could guarantee continued access to a safe payment system** (Riksbank, 2017: 31).

Finally, and most importantly, the logic of the argument itself is questionable. Any argument against CBDCs on the ground that it would exacerbate the shift from potentially risky bank deposits to safer forms of digital money, "is logically the same as arguing that the state should not issue government bonds because it provides a safe asset for investors in stocks and corporate bonds to switch to, thereby exacerbating instability in the stock market." Similarly, the same logic could be used to argue that insurance on bank deposits increases volatility of the system because it encourages stock and bond investors to switch back in times of financial stress. In other words, the risk exists but it can be reduced (e.g. with ceilings) and, in any case, it does not constitute a coherent argument to reject the idea. If the flow of funds to digital wallets was so severe to pose a systemic risk, it would suggest a much more fundamental problem in the

banking system which has nothing to do with the existence of a CBDC (Dyson and Hodgson, 2016: 27).

Table 1. Demand for CBDC and the effect on banks

	Situation with a positive repo rate[22]	Situation with a negative repo rate	Situation of financial stress
CBDC with no interest	Holding CBDC is relatively unattractive. Banks offer a deposit rate slightly above zero to retain their deposits. The negative effects on bank profits and financial stability are negligible.	Holding CBDC is attractive. Banks need to offer a deposit rate slightly above zero to retain their deposits. The negative effects on financial stability are negligible, but the effect on the banks' profits is greater than with a positive repo rate.	It would be more attractive to hold CBDC. Assets not covered by the Deposit Guarantee would probably be exchanged for CBDC. The implications for financial stability are unclear as the access to secure payments via CBDC system is positive for the economy at the same time as the banks' funding and liquidity situation deteriorates.
CBDC with interest	Holding CBDC is attractive. Banks are forced to offer a deposit rate that is close to the repo rate to retain their deposits. Banks' profit growth is limited in times of increasing interest rates.	Holding CBDC is not attractive. The banks need to offer a deposit rate slightly above zero to retain their deposits, or just above the repo rate in a cashless society. The effects on financial stability are negligible, and the effect on the banks' profits is lower than with a positive repo rate.	It would be more attractive to hold CBDC. Assets not covered by the Deposit Guarantee would probably be exchanged for CBDC. The implications for financial stability are unclear as the access to secure payments via CBDC system is positive for the economy at the same time as the banks' funding and liquidity situation deteriorates.

Source: (adapted from) Riksbank, 2017: 30

[22] Repo rate is the rate at which the central bank of a country lends money to commercial banks in the event of any shortfall of funds.

Conclusion

The constant development of new technologies for payments and the rise of private digital currencies are reducing the significance of central banks in the payment system by marginalising central bank money. In certain countries such as Sweden, the quasi-disappearance of cash amounts to a situation where the public is on the verge of losing access to legal tender. From this perspective, CBDC appears to be the only way to preserve access to legal tender for the public in the future. As mentioned in the report, this would have several social benefits that can be summed up by distinguishing between the micro (users), meso (institutions) and macro levels (system).

At the **micro-level**, the benefits for users would be significant since this new form of money would be electronic, universally accessible and central bank issued, combining all the three features of cash, bank money and central bank money. Central bank digital currency would be risk-free and less costly for consumers than debit and credit cards, which would be particularly beneficial for low-income households and small businesses. All citizens would enjoy the universality of legal tender and the fluidity of electronic transactions, without the risks associated with private digital currencies.

In emerging economies, the benefits for users would be even more important, since a CBDC would offer the opportunity to leapfrog the banking system, moving directly to fully digital solutions without the requirement of bank accounts. This would facilitate financial inclusion by providing access to those individuals and firms that are excluded from traditional banks and by making financial services more affordable and accessible, while providing a fully interoperable system.

At the **meso-level**, central banks would be able to reduce their costs related to printing, securing, distributing, and processing physical notes and coins. Similarly, commercial banks and businesses would also benefit from savings related to cash management, distribution and logistics. In addition, central banks could leverage public trust in their institution by reaffirming a direct link with national citizens. Thus, CBDCs would allow central banks to keep some visibility in society and maintain legitimacy in the monetary system.

At the **macro-economic level**, CBDCs would contribute to the modernisation of the payment system without abolishing cash and would improve the effectiveness of conventional instruments of monetary policies, while providing central banks with new monetary tools.

At the **macro-policy level**, CBDCs would enable central banks and governments to maintain a public service of payment with access to legal tender for citizens, in the face of the decline of cash and the digitization/privatisation of money. In addition to efficiency gains, CBDCs would contribute to effectively fight money laundering, the financing of terrorism and forms of tax and social fraud or evasion.

By offering a safe and public alternative to private digital currencies, central banks would prevent a wider use of these currencies and thus contribute to preserve the stability and integrity of the financial system. Finally, although CBDCs might induce some instability by stimulating flight of funds away from private financial institution in times of financial stress, they may as well be regarded as contributing to financial stability by ensuring continued access to a safe payment system.

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