Digitalization, retail payments and Central Bank Digital Currency

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Abstract

Facing the challenges and leveraging the opportunities from digitalization may require changes to the traditional business model of central banks. This paper focuses on retail payments, where changes are being rapid and highly demanded by customers worldwide. Considering competition and financial stability arguments, it provides a rationale for central banks to have a deeper involvement in retail payment systems by building and keeping control of core components of these systems. Central Bank Digital Currency and Fast Payment Systems are assessed as alternative tools serving central banks to foster efficiency, resilience and security in retail payments, as well as to preserve financial stability.

1 Introduction

Digitalization of everyday activities is happening rapidly. In the case of payments, we assist to an era where improvement via digitalization is also highly demanded by customers at a worldwide scale. Nowadays, most consumers expect payments to be fully digital, (near) instant and mobile-first, whether online or at the point of sale, and providing a seamless user experience [BIS (2020)]. New technological advances make it feasible for private sector parties to develop payment systems that add value to final users and bypass settlement by central banks. In some jurisdictions cash circulation is falling rapidly, in others private-owned payment infrastructures are concentrating most operations, and stablecoins are emerging with the potential to enhance efficiency in the provision of financial services, although they are also raising concerns regarding integrity and financial stability.

Digital innovation is radically changing payment services. If adopted in a significant scale, some of the developments may challenge the ability of central banks to effectively fulfill their mandates towards price and financial stability. Others, or even the very same technological developments that are challenging central banks, would entail opportunities to profit from efficiency gains in payments services and set the basis for innovation from the financial system to spills over to the general public. Facing challenges and leveraging opportunities may require strategic decisions, confront new risks, change the traditional central banking business model, and maybe revise central banks' objectives in the digital era. Since one size may not fit all needs, it is prudent to carefully study the motives that justify central banks' action, possible strategies and their potential implications in order to inform policymakers.

The contribution of this paper is twofold. First, it aims to contribute to the ongoing discussion by presenting a conceptual perspective on the challenges and opportunities that central banks are facing in the new digital era. Second, to discuss how Central Bank Digital Currency (CBDC) and alternatively Fast Payment Systems (FPS) may serve central banks to continue playing a pivotal role in maintaining the safety and integrity of the payment system, fostering competition among payment services providers (PSP), and providing a basis for sound innovation in the financial system. Recently, CBDC and FPS have been topical issues; the strands of literature to which this paper contributes have been growing as rapidly as digitalization. See, for instance, Kiff et al. (2020) for a survey of research on retail CBDC and Bech et al. (2020) for a recent description of advances regarding FPS.

The focus of this paper is on retail, as opposed to wholesale, payment systems. A payment system is a set of instruments, procedures and rules for the transfer of funds among participants. Retail payments typically relate to the purchase of goods and services by consumers and businesses. Each of these payments tends to be for relatively low amounts, but volumes are large. In contrast, wholesale payments are typically large-value payments between financial institutions. Given their systemic importance, wholesale payment systems are generally owned and operated by central banks; differently from retail payment systems that are traditionally in the hands of the private sector.[1]

I would argue that digitalization may provide a rationale for central banks to have a deeper involvement in retail payment systems. In the digital era, the importance of network effects and relatively large investments in payments may imply market failures, so that market equilibrium may show extreme outcomes with either underdevelopment or severe threats to financial stability. Since payment systems are built on trust, a common good that is hard to construct and easy to lose, central banks may play and important role in balancing efficiency gains in normal times against potential loss of confidence in stress times. While this applies either to wholesale and retail payment systems, digitalization makes market failures more important for the retail segment, justifying a deeper involvement by central banks. To fulfill this task, central banks need appropriate tools, which reasonably must be digital. One of these tools may be building and keeping control of core components of either a CBDC or a FPS with a tiered architecture where private-sector PSP compete for customers by innovating and offering new products and overlay services.[2]

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1 Generally, cash is provided by central banks acting as a monopolist, but its distribution and the operation of retail payment systems are done by the private sector. In some cases where the use of cash diminished dramatically, the concentration of power by the private sector may justify central bank intervention as we will argue through the text.

2 The platform model proposed in a recent discussion paper by the Bank of England (2020), as well as the e-Peso pilot in Uruguay and the Sand Dollar pilot in The Bahamas (that are revised in Section 4), have this feature in common.

The term CBCD is not well-defined yet, and it is commonly used to refer to several related concepts. By focusing on its key features, a CBDC could be best defined as a (new) form, i.e. digital, of central bank money: it is a liability of the central bank that serves as a unit of account, medium of exchange and store of value. Through the years, coins and banknotes, the most usual forms of physical cash, have provided support for these three functions of money, representing central bank currency that is accessible to the general public. Central banks have also experienced with some forms of electronic money and digital payment systems, in particular for wholesale transactions, where commercial banks generally make reserve deposits at central banks. In the digital era, one may think that a direct step would be that central banks offer retail CBDC that may be used by the general public as a complement, or even a substitute, for physical cash. As far as the central bank is truthful, the CBDC system is robust and attractive, and a large population holds and uses it, then the CBDC may serve the core functions of money. Hence, a retail CBDC would constitute a third form of central bank money, along with cash (physical) and reserves (digital, but whose access is limited to commercial banks).

Indeed, the list of central banks declaring interest in researching CBDC, launching pilots and proofs of concept, and even concluding experimentation has nothing but increased in the last years. In practice, however, the adoption of CBDC is, at least, in slow motion. Possible explanations for this low speed adoption of CBDC may stem from the requirements and the consequences of digitizing central bank money. Differently from physical cash, exchanging digital money between two parties necessarily requires third-party involvement in the form of an infrastructure, system or mechanism supporting the transfers. Hence, the discussion about CBDC is necessarily linked to an assessment about the payment infrastructure underlying it; so that issuing digital money does not follow directly from the fact that central banks issue physical cash [Kahn et al. (2019)].

On top of technological uncertainty, cybersecurity, security of information and other related risks that are inherent to any digital payment infrastructure, the case of a CBDC raises other important concerns that central banks should consider. For instance, exchange of information would be substantial in a CBDC system. While this information may be socially useful to enhance security in payments, users may have a legitimate concern about privacy, in particular anonymity, and even about the possibility that the information could be used with other purposes than the transaction in which it was generated.[3] In addition to that, a retail CBDC would require a close relationship of the central bank with final users; but traditionally central banks have followed a business model far away from the general public. Anonymity concerns and lack of comparative advantages of central banks to satisfy final users' needs

3 Cybersecurity, security of information and the fact that public authorities may have access to large volumes of agents' information are characteristics mostly related to digitalization. Hence, they will be present in CBDC and in alternative digital retail payment systems.

may endanger users' experience and thus a broad adoption of the CBDC by the general public, which is needed for the success of a retail payment system given the network effects in payment infrastructures.

If the introduction of a CBDC is successful, then the concerns refer to the possible negative impact that a rapid adoption of CBDC may cause on financial intermediation via massive withdrawals of commercial bank deposits, its effects on the structure of the banking industry and the stability of the financial system. Related to this, other concerns refer to the possibility that a CBDC would facilitate bank runs, and thus challenge the capacity of the central bank to act as lender of last resort. Finally, the impact of a CBDC on the conduct of monetary policy is also a matter of concern.

Interestingly, most of the trade-offs could be balanced and the associated risks mitigated by properly designing the CBDC system. Indeed, great part of today's discussion among central banks assessing CBDC is related to design and implementation issues. Moreover, since there is not one-size-fit-all solution, different designs may better adapt to the specificities of each jurisdiction and policy objectives. It could also be the case that alternative arrangements, like the fast retail payment systems that recently have been adopted in more than 50 jurisdictions or the proposed "synthetic" forms of CBDC [see Adrian and Mancini-Griffoli (2019)], better fulfill the objectives of providing a fast, efficient, innovative, competitive, resilient and stable payment system. More research and evaluation of alternatives is necessary in order to inform these decisions. This paper aims to contribute in this line.

The rest of the paper is organized as follows. Section 2 reviews the potential impact that digitalization may have in the business model of central banks, provides a rationale for a deeper involvement of them in the financial infrastructures for retail payments, and argues that the participation of the private sector is essential in no-core components of the payment infrastructure. Section 3 revises CBDC basic arrangements, i.e. account- and token-based, and discusses how different concerns may be mitigated by an appropriate design of the CBDC system. This section also explains how FPS and "synthetic" CBDC may constitute alternatives to CBDC. In Section 4 two recent CBDC pilots are revised: the Uruguayan e-Peso and the Sand Dollar in The Bahamas; as well as the experience with the TARGET Instant Payment Settlement (TIPS), a fast payment system in Europe. Section 5 offers some final remarks.

2 Digitalization and central banking

Digitalization is driving the world in a direction where the incorporation of digital technologies to everyday activities is rapid, at a worldwide scale, and highly demanded by customers who nowadays attach more value to immediacy and users' experience. Some of these developments may challenge the ability of central banks

to effectively fulfill their mandates towards price and financial stability, as well as to provide safe and efficient payment systems. Others, however, will represent opportunities to profit from efficiency gains and set the basis for innovation in financial services that spills over to the general public. Facing challenges and leveraging opportunities may require strategic decisions, address new risks and change the traditional objectives and business model of central banking.

Doing things the same way as before in this new digital era may be riskier for central banks than taking a proactive approach. Past experiences from other industries may help to illustrate this point. Think for instance that the use of physical letters and postcards has been substituted by emails and digital photos, with the estimated number of letter-like items sent worldwide in one year roughly equal to the number of emails sent in a single day. Paradoxically, Kodak invented the digital photo camera and went bankrupt. The company misunderstood customers' needs and their demand for better experiences taking pictures to the point that maintained its business model based on paper pictures for too long. There has been a high development and penetration of information and communication technologies. For example, companies that today are categorized as BigTechs (e.g. Google, Facebook and Amazon) did not exist 30 years ago. Today, digitalization is being prominent in the financial system. In payments, it is going even further, with a high demand for speed, better users' experiences and mobility. And looking ahead, the so-called "stablecoins" (i.e. cryptocurrencies designed to minimize the volatility of its price relative to some "stable" asset), like other crypto-assets, have the potential to enhance efficiency in the provision of financial services, but they may also generate risks to financial stability [FSB (2020)]. These developments imply challenges to the traditional business model of central banking.

In this digital era, the sole play of market forces may determine extreme-outcome equilibria in the payment system with either underdevelopment or severe threats to financial stability. On the one hand, network effects in the payment system may imply coordination problems among market participants, leading to fragmented and non-competitive payment infrastructures. On the other hand, in a retail payment system that is fully controlled by private banks, a banking problem could translate in loss of confidence in the payment system, challenging its robustness and resilience. Hence, these market failures provide a rationale for central banks' intervention in order to balance efficiency gains in normal times against potential technological vulnerabilities and loss of confidence in times o stress. Since payment systems are built on trust, a common good which is hard to construct and easy to lose, central banks have a rationale to protect efficiency and security in the payment system by acting as operators, regulators and catalysts. Hence, central banks need to be part of the new digital paradigm. They should be prepared to fulfill their mandates and ready to exploit new technologies in favor of the common good. Moreover, central banks need to be proactive in order not to arrive too late to the new digital revolution that is taking place at a global scale, to be able to continue fulfilling their mandates

on behalf of society, and to contribute to a healthy development of the financial system.

An active role of central banks towards financial digitalization would be of particular importance in jurisdictions where the private sector does not take a leading role on technological innovation. In these cases, the payment system will remain underdeveloped without the intervention of the central bank to foster competition and efficiency, as well as to facilitate financial inclusion. The central bank would also pursue an objective of increasing safety in retail payments by countering risky digital currencies that are not backed by a trusted government, as well as other private initiatives with the potential to affect the security of the payment system. These objectives could be achieved through Central Bank Digital Currency (CBDC) or alternatively with fast payment systems (FPS) that are made available for the general public. Since there is no one-size-fits-all solution, it is key for policymakers to understand the features of each arrangement and the specificities of their design. These issues are discussed in Section 3. In the rest of this section, I will dig deeper on the reasons justifying the argument that central banks should seriously consider to build and keep control of core components of retail payment infrastructures.

To start with, although commercial banks would already have in place the technology to provide a fast and efficient retail payment infrastructure, they may choose, as it happens in several jurisdictions, not to do so. Moreover, they would have the means to block access to other market participants that intend to enter the market, leading to inefficiencies in the payment system and high costs for final users. Several reasons may be behind this kind of behavior. First, non-bank retail payment providers would compete with banks' deposit-taking business and reduce their income from fees in interbank transfers and other payment arrangements that are under their control. Second, commercial banks are in a privileged situation to have a dominant position in the payment system because they have access to customers' accounts. Third, a payment system infrastructure exhibits large network effects, requires a relatively large investment and careful risk management. These features may hinder the necessary coordination among market participants for an efficient payment infrastructure to emerge as a decentralized equilibrium, leading to fragmented and inefficient payment systems. Fourth, given the importance of network effects, the rents from access to data and the sunk costs required to enter, the market equilibria could be characterized by international firms operating as nearly natural monopolies in domestic markets.

Central bank action may help to overcome these problems. For instance, a CBDC could solve the coordination problem by offering a centralized solution. It could also tame a monopolistic payment services provider by making the market for payments contestable. In turn, efficiency gains will come by lowering barriers to entry, solving interoperability problems and spurring innovation. In this regard, interoperability appears essential to level the playing field between market participants. A CBDC

may facilitate a prolific field for startups developing new products and services, e.g. digital wallets with enhanced customers' experience, and provide incentives to existing financial institutions to offer better payment products and services. Fast payment systems and synthetic CBDC[4] may also serve to achieve this target as we will discuss in Section 3.

Interestingly, as argued by Kahn et al. (2019) economic history suggests that unless there is a competitive threat or underlying demand from the general public, traditional financial institutions will not have incentives to adopt the infrastructure that is provided by the central bank. Hence, it is crucial to generate access conditions for non-traditional financial institutions in order to generate competitive pressure to traditional financial intermediaries. In the case of a CBDC, these non-traditional institutions could be non-bank PSPs.

CBDC would only have social benefits if it is broadly used. Hence, some disintermediation would be inevitable because some switch of funds from commercial bank deposits into central bank money in the form of CBDC will occur. However, the significant and rapid movement of deposit balances from commercial banks into CBDC could have implications for their balance sheets and affect the amount of credit provided by banks to the wider economy with an impact on economic activity and, possibly, financial stability. Nonetheless, CBDC can be designed to manage the trade-off between benefits and risks; and, central banks could provide liquidity to the financial system in order to ameliorate the negative effects. Moreover, according to Adrian and Mancini-Griffoli (2019) a massive migration of deposits to CBDC seems unlikely in an environment in which bank deposits and the banking system function properly, so that the banking model as such is unlikely to disappear. Commercial banks will feel pressure from CBDC, but they should be able to respond by offering more attractive services and products.

In the other extreme of the spectrum, i.e. when the private sector has been able to solve the coordination problem and is offering digital payment solutions to the general public, intervention by the central bank may also be deemed necessary. Consider, for instance, the case of Sweden. During the last decade, the Swedish banking system developed a very efficient payment system. The success has been of such magnitude that most people today are using it through their computers and mobile phones. The use of physical cash, on the other hand, has been falling dramatically during the last years. Today, more and more retail stores are not accepting cash as a mean of payment, which is possible because cash is not legal tender. Moreover, forecasts predict that people will completely stop using physical

4 Fast payment systems are infrastructures where "the transmission of the payment messages and the availability of 'final' funds to the payee occur in real-time or near real-time on as near to a 24/7 basis" [see CPMI (2016)]. Broadly speaking, a synthetic CBDC may be achieve by opening central bank reserves to non-traditional financial institutions [see Adrian and Mancini-Griffoli (2019) and Section 4.2].

cash by 2025. In scenarios like this, the central bank will face tremendous challenges to fulfill its mandates. Since the retail payment system relies completely on an infrastructure owned by private banks, any banking problem would automatically convert into a problem to the payment system, challenging its resilience and stability. Similarly, cryptocurrencies (and in particular stablecoins) would be rapidly adopted if they manage to offer a stable value and to integrate as a mean of payment in electronic trade. In this case, stablecoins could threaten cash, the payment system, consumer protection and even the stability of a financial system [Ayuso and Conesa (2020)]. Adrian and Mancini-Griffoli (2019) make the concern extensive to other forms of electronic money that are offered with private backstop. While electronic money may be more convenient than cash as a means of payment, it raises questions about the stability of the system.

While digitalization challenges central banks, it may also provide new tools to face the challenges. For example, introducing a CBDC in a cashless economy may help building an instrument that is accepted by the public and allows the central bank to offer a resilient and stable payment system that may serve as backup during a financial crisis. This strategy may have a rationale in a financial stability concern. According to Rochet (2009), public intervention needs to focus in maintaining the integrity of some parts of the financial infrastructure that are deemed "vital" to the economy. Retail payment systems may be considered to belong to this category.[5] Hence, protecting financial infrastructure, e.g. the one behind retail payments, becomes fundamental to make the financial system more resilient and also to reduce the need for future government intervention.

Even if central banks assume a prominent role in retail payment systems, an approach where a central bank does everything, with no private sector involvement, is unlikely to work. Both central bank and private sector involvement will be necessary to develop an efficient and safe digital payment system for retail purposes. The central bank would provide and closely oversee the strategic parts of the systems, i.e. those that are vital for its well-functioning and stability. This is the case of several FPS around the world and should be the case with CBDC. The private sector would find a level playing field to compete in the provision of welfare improving services to customers. The design principles for retail payments elaborated by the Bank of England (2020) provide a basis to achieve this type of design which is reliable and resilient, fast and efficient, and innovative and open to competition.

Overall, central bank digital currency would serve central banks as a strategic tool in order to foster efficiency and security in retail payments, as well as to preserve financial stability. They may also imply additional challenges. In several cases, these challenges would be solved via an adequate design of the CBDC system. In other

5 For instance, the recent COVID-19 pandemic has shown the importance of having retail payment infrastructures that are resilient and continue operating under extreme circumstances.

cases, however, a CBDC could not be the best solution to achieve a central bank's objectives and other fast retail payment system would provide a better balance between pros and cons. The next section will analyze design features of CBDC and alternative retail payment systems.

3 CBDC and alternative payment systems

A CBDC could serve central banks to achieve the objectives discussed in Section 2. Other payment arrangements may do as well. This section revises the basic mechanics and implications of different types of CBDCs and alternative payment systems.

3.1 Central Bank Digital Currency

3.1.1 Introducing CBDC

The term CBDC is commonly used to refer to several concepts; it is not well-defined yet. However, it is envisioned by most as a new form, i.e. digital, of central bank money: it is a liability of the central bank that serves as unit of account, medium of exchange and store of value. A critical difference with existing forms of universally accessible central bank money, e.g. cash, is that CBDC does not have a physical but a digital form. And this simple difference is key to explain both the interest and the low speed of adoption of CBDC by central banks. Differently from cash, transferring digital money between two parties necessarily requires the involvement of a third-party. Kahn et al. (2019) argue that for this reason a digital version of cash cannot be equivalent to physical cash. Ayuso and Conesa (2020) highlight that the discussion about CBDC is complicated by the fact that the term CBDC commonly refers to both the digital representation of central bank money and its payment mechanism. Hence, an assessment of CBDC needs to be closely related to a discussion about payment infrastructures.

However, electronic representations of central bank money are already used in practice. Central banks offer digital money in the form of reserves or settlement accounts held by commercial banks, and less frequently by other financial institutions. In turn, reserves facilitated the emergence of real-time gross settlement (RTGS) systems in the 1980s to speed up wholesale payments that are now the standard around the world. Hence, central bank digital currency for wholesale purposes is not new.

The innovation would be that central banks offer digital representations of their money for general purposes, i.e. to retail users. Bech and Garratt (2017) propose a taxonomy of money, known as "the money flower", as the intersection of four key

properties: issuer, form, accessibility and type.[6] In this section, I will focus on the petal where the issuer is the central bank, the form is digital and the central bank digital money is widely accessible. The fourth property, i.e. type, refers to whether the CBDC is token- or account-based. The latter is alike the categories of object- or claim-based money in Adrian and Mancini-Griffoli (2019), who add more properties to complete what they call "the money tree" taxonomy: value, backstop and technology. Value refers to whether money serves as unit of account, a characteristic of central bank money, or its redemption is at a fixed or variable value. Fixed value redemption characterized money provided by commercial banks, e.g. payments that entail the transfer of funds from one bank account to another, and money provided by new players in the payments landscape, e.g. e-money[7] issued by Alipay and WeChat Pay in China, and by M-Pesa in East Africa. Backstop refers to whether the redemption guarantee is backstopped by the government, as in the case of commercial banks money, or relies on prudent business practices put in place by the issuer, as in the cases of e-money referred before. Finally, the technology may be centralized, i.e. transactions going through a central proprietary server, or decentralized by making use of decentralized ledger technologies (DLT). Choices around technology would have a major impact on the extent to which CBDC meets the overall objectives. In principle, it is not presumed that any CBDC must be built using DLT, and there is no inherent reason it could not be built using conventional centralized technology.

It is worth to remember the main characteristics of physical cash, the most recognizable form of central bank money, before going deeper into the analysis of its digital form. Cash, the notes and coins that have been in the wallets of people for centuries, are objects or tokens serving as visible and tangible representations of the liability of the central bank towards holders. As far as the central bank is truthful and large population uses the tokens, they may serve as store of value, medium of exchange and unit of account, i.e. the core functions of money. Cash has security embedded in order to prevent duplication and falsification. If those easily recognizable security features are hard to replicate, they increase the cost of generating counterfeiting tokens and reduce the cost of verification. In general, verification by the receiver of a payment in cash is cheap and instantaneous, and the physical exchange of cash is evidence of acceptance of authenticity. Therefore, cash appears to be an efficient and low risk medium of payment for transactions of relatively low value.

An important difference between physical and digital cash is the cost of counterfeiting. Therefore, according to Kahn et al. (2019), issuing digital money in token form does not follow immediately from the fact that central banks issue cash. Counterfeiting of digital tokens may happen because a valid token may be attempted to be spent

6 Bech and Garratt (2017) call to the last category "technology", which I have changed to "type" in order to avoid confusion with the categories proposed by Adrian and Mancini-Griffoli (2019).

7 e-money refers to electronically stored monetary value denominated in, and pegged to, a common unit of account such as the euro, dollar, or renminbi, or a basket thereof.

more than once, a problem known as double spending. It may also occur because hackers may use unexplored vulnerabilities on cybersecurity to generate new tokens at a marginal cost close to zero. Another important difference between physical and digital cash stems from their nature. While physical cash embeds tangible and easily recognizable security features and can be transferred from hand to hand, digital cash in the form of tokens embeds non-tangible security features and need a third party, either centralized or decentralized, in order to verify the tokens and make transactions.

In turn, the need for a third party to transfer digital tokens between two parties has important implications. Apart from the threats to cybersecurity and the protection of final users' information, two risks that are present in almost all digital activities, the choice of the technology underlying the payment systems for the digital currency and the impossibility of replicating exactly all features of physical cash become crucial to make the case for a CBDC.

Regarding technology, centralized solutions that are available today may be too costly or slow to adopt compared with physical cash. This may represent a constraint to scale up a CBDC payment system. Decentralized technologies may not be a cost-effective substitute [see, for instance, Chapman et al. (2017)]. Additionally, they are still in a developing stage that could question their resilience to support a CBDC, where the reputation of central banks is at stake. Moreover, interoperability of DLT or blockchain technologies with other technologies may face important challenges and require large investments. In turn, these problems may question their capacity to foster innovation and competition in some segments of the payment system where it may be desirable. Moreover, given the importance of network economies in a payment system, it could diminish the attractiveness of this type of technologies for CBDC. Auer and Böhme (2020) provide an overview of underlying trade-offs and the related hierarchy of technical design choices.

Maybe the hardest feature of physical cash to be replicated by digital cash is anonymity. In a transaction with physical cash nothing else is needed than the exchange of banknotes or coins. In transactions with digital money, however, a third party may collect information that identifies, for instance, the tokens and the identity of the payer and the payee. This information may be socially useful to enhance security in the payment system, e.g. through reversals of fraudulent transactions, and to fight money laundering and the financing of illegal activities. From an individual point of view, however, the social gains are traded off with the loss in privacy and the possibility that the information may be used for other purposes than the specific transaction in which it was generated. This trade-off may be particularly relevant for low-value transactions.

Together, the technology supporting a CBDC, the design of the payment infrastructure underlying it, and key features helping to favorably solve trade-offs like security-

anonymity, will influence the willingness of customers to use a CBDC. And this opens another front in which generally central banks do not have neither advantages nor expertise: users' experience is important but central banks traditionally do not have direct connection with the general public. Hence, private sector involvement would be deemed necessary. The design of the CBDC will also have crucial implications for innovation and the development of the payment system, its efficiency and level of competition. In addition, it will also impact other financial activities, e.g. financial intermediation. In what follows, I will analyze basic arrangements for CBDC, selected design issues and their possible implications.

3.1.2 Basic CBDC arrangements

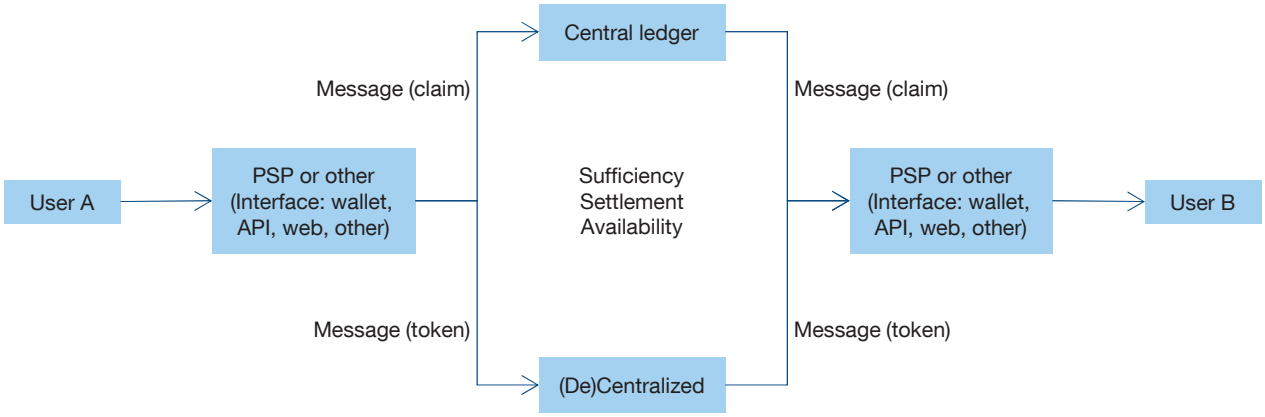
Figure 1 describes the basics for User A to transfer digital money to User B in a simple CBDC system.

One possible arrangement consists of a CBDC based on accounts (represented as a central ledger at the top in Figure 1). The basic idea is not new and can be traced back to the proposal of "deposited currency" by Tobin (1985). A transaction in an account-based CBDC would resemble today's transactions between commercial bank accounts, except for the fact that accounts would be held with the central bank. In this case, the central ledger at the central bank would receive a message from User A asking to transfer the claim she has with the central bank to User B. The central ledger would check the validity of the message and the sufficiency of funds in User's A account, settle the transfer, make the funds available in the account of User B and send a message to User B confirming her claim with the central bank. As highlighted by Mancini-Griffoli et al. (2018), the exchange of information would therefore be substantial. The central bank would ensure settlement but only after verification of the identity and authority of User A to use the account, sufficiency of funds, and authenticity of User B's account.

The idea that the general public could have access to accounts at the central bank is interesting. However, it has been feasible for long time, even before the emergence of technological advances like DLT and blockchain, but central banks have not implemented it; differently from the case of wholesale deposits where commercial banks reserves at the central bank is an extended practice and generally support high value payment systems, e.g. RTGS.

Several reasons would justify that opening accounts to the general public will not be the preferred choice of central bankers. To start with, the central bank would need to directly interact with the general public, where it does not have a comparative advantage. The cost of verifying the identities of a large number of users and of managing their accounts would make the system too expensive to operate. Second, an account-based CBDC would put the central bank in a position of direct competition

Figure 1
CBDC: BASIC ARRANGEMENTS



SOURCE: Own elaboration.

with commercial banks. This would imply undesirable effects on financial disintermediation with consequences on the development, competition and stability of the financial system, and in turn economic activity. Third, when dealing with final users, central banks would be relatively less customer-oriented than private companies. In addition to that, an account-based CBDC would make available to the central bank a large volume of information about financial transactions of individuals. These factors could discourage potential customers because they may assign high value to their experience using the CBDC and have concerns about their privacy.

Another CBDC arrangement involves digital tokens. In this case, and depending on the design of the system, User A will send a message requesting to transfer a token of her own to User B or alternatively will directly transfer the token itself. In the first case, tokens are stored and secured in a central repository, as in the Uruguayan e-Peso pilot described in Section 4. In the second case, tokens are stored in users' devices, alike physical banknotes in wallets. In this case the central bank issues tokens and maintains the list of outstanding tokens. When a transaction occurs, the central bank authenticates the tokens against the list, destroys the old token and issues a new one that is transferred to the recipient, as in the case of Sand Dollar in The Bahamas. The first case is representative of a centralized system and the second case of a decentralized token-based CBDC.

Technological options to develop a centralized system are larger than those to develop a decentralized one, which for the moment is restricted to DLT and blockchain technologies. A centralized system would be developed either in DLT or blockchain, possibly as a private and permissioned platform, but also in proprietary software. Differently from cryptocurrencies like Bitcoin, in the case of a CBDC there is a central

authority, the central bank, with the authority to verify the authenticity of tokens as nowadays happens with counterfeit banknotes and, even more importantly, with the authority to control the quantity of money in circulation. Therefore, the key advantage of DLT or blockchain technologies, i.e. the possibility of validating tokens and then transactions without the intervention of a central authority, is of second order for the case of a CBDC. Hence, other features of the technology like cybersecurity, cost, speed and delay in verification of transactions, scalability and interoperability with other systems would gain power at the time of choosing the underlying technology for the CBDC.

It seems prudent that the core of a CBDC system is under the control of the central bank because of its importance and the risks that are involved. It is possible that some activities, like for instance maintenance, could be outsourced; but it seems crucial that the central bank keeps control not only of the minting of digital currency, but also of the central ledger in an account-based system or the technology underlying transactions in a token-based one. As discussed in Section 2, these activities are strategic to fulfill the objectives of central banking. In addition to that, central banks would also fulfill roles as regulator and catalyzer in the retail payment system.

Central banks, however, do not have any advantage in dealing directly with final users. It may be very challenging for central banks to perform know-your-customer and identification of customers, to provide support 24/7 and to offer customer-oriented services. Private sector companies, however, are more efficient in doing these activities. They could provide the interface of the CBDC system to final users. Interfaces could range from digital wallets to API and web services. They could be provided by payment service providers (PSP), including banks and other institutions with access to the payment system, or other type of institutions offering CBDC's related solutions and overly services. These institutions need to be authorized by the central bank to access the CBDC system after confirming that they fulfill interconnectivity and security of information required standards, as well as other regulatory requirements. Opening this tier of a CBDC system to market competition would foster FinTech development and innovation, increasing the efficiency of the system and improving the offer of products that are closer to users' needs.

The platform model proposed by Bank of England (2020) envisages the above mentioned elements. It is a token-based proposal, with a CBDC infrastructure under the control of the central bank that would process payments, providing the minimum necessary functionality for CBDC payments. Based on this basic infrastructure, private sector PSP would handle the interaction with end-users of CBDC and provide additional payments functionality through overlay services. PSP would need to meet criteria and regulation to start offering CBDC-related services. Furthermore, they should be supervised on an ongoing basis, in order to ensure consumer protection, interoperability and resilience of the CBDC system.

3.1.3 Selected design issues

Both account and token-based systems are record-keeping arrangements. There would be a large amount of information available to the central bank. Of course, it could be used for good purposes, e.g. to reverse erroneous or fraudulent operations. Nevertheless, users might have legitimate doubts about other uses that the central bank, and more generally the government, would like to do with the transactions data. There is a lawful concern for privacy and even for anonymity,[8] to the point that it would explain the prevalence of cash as a medium of exchange and the appeal of cryptocurrencies.[9] Therefore, lack of anonymity in a CBDC system would discourage users; but complete anonymity would increase the risk of serving as a vehicle for financing illegal activities.

The design of the CBDC system needs to solve the trade-off between anonymity and its risks. In so doing, there could be several elements that combined would provide an adequate balance. First, for a CBDC system to work properly it may not be necessary that the identity of users is known by the central bank when processing each single transaction. In principle, some kind of identification number for final users is needed, which need to be linked one to one with their real identities. In this case, the central bank would observe the transactions without knowing the identity of the users that are behind of them.

Second, it would be possible to track final users if necessary. For instance, the relevant information about users' identity may be encrypted, and then even if it is at the central bank, it is not directly available. Provided that the central bank is truthful and that there are clear protocols and accountability arrangements to access the information, it would reassure users about the protection of their privacy. In certain prespecified cases or under the order of a competent authority, e.g. a Court of Law prosecuting illegal activities, the files can be decrypted in order to access the necessary information.[10]

Third, it is of course necessary to do due diligence and know-your-customer actions. This task would be done by the institutions that are providing the interface and dealing directly with final users, e.g. PSP, as it is today the case with financial intermediaries in banking activities. In this case, if there are several PSP, the

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8 Garratt and Van Oordt (2019) formally show that there is a public good aspect of privacy in payments that arises because individual customers do not bear the full cost of failing to protect their privacy when are exposed to price discrimination in a dynamic framework. As a consequence, when left to market forces alone, the use of privacy-preserving means of payments may be sub-optimal.

9 It is worth noting that the feature of anonymity in cash was not intended but a consequence of the lack an adequate technology to identify the holder of each banknote and coin.

10 In practice, similar mechanisms have worked in the past for the case of commercial banks deposits in several jurisdictions under "deposit secrecy" schemes. The information about a deposit and its depositors were legally protected from the request of third parties, included government agencies. Nevertheless, the regulator (and possibly the deposit insurance scheme) maintains encrypted sensible information about commercial banks deposits, including the identity of their owners.

information about users and their transactions will be partitioned among them. Therefore, each PSP would observe the transactions that its customers do through it but remains ignorant about the identity of the senders of transfers received by its customers and of the receiver of the transactions originated by them. It also remains ignorant about transactions made by other users that are not its customers, and even of that of their customers when are done through another PSP. This partition of information will constitute an extra layer of privacy for final users.

Fourth, a combination of the previous three elements would provide a level of privacy and anonymity that may be appealing for final users. It needs, however, to be balanced with clear protocols to persecute nefarious and illegal activities. A possibility that was mentioned before is that the information about the identity of final users and their transactions can be decrypted at the request of a competent authority, e.g. a judge or a court of justice. Interestingly, the transactional information may allow to trace back transactions completely, which may be useful for instance in AML/FT cases. Moreover, it may be used to generate automatic alerts for suspicious operations that, in turn, can be investigated by the competent authority. Therefore, traceability of operations and the generation of automatic alerts are features that a CBDC systems could offer in order to strengthen the arrangement to persecute illegal activities. These features would still be possible in a design that preserve privacy of honest users and (pseudo) anonymity.

Fifth, an additional layer of security may be introduced by setting limits, for instance, to the amount of digital money that each user can hold or to the amount of transactions in a given period. This kind of caps would discourage the use of the CBDC systems for money laundering and financing of terrorism. Other potential advantages have to do with the reduction of the risk of a user losing large amounts of digital money in a hypothetical case of a security failure, as in the case of losing banknotes from our pockets. A drawback of introducing limits would be the potential for bad users' experience in those cases where the limits are too low compared with their needs. However, this could be circumvented via financial innovation. For instance, a possibility is the development of products allowing to split relatively large transactions into smaller ones as to be processed through several PSP. In addition to foster innovation and improve users' experience by allowing a variety of products that better accomodate users' needs, this kind of innovation would also increase competition among PSP.

Last but not least, the limits would reduce the disintermediation concerns that are associated to the potential of massive migration of bank deposits to CBDC. Yet, the possibility of aggregating payments for some users, possibly with higher fees than in the case of transactions below the caps, would increase contestability to financial intermediaries in the market for deposits, pushing a reaction to reach a new equilibria, possibly with the outcome of better services to customers like, for instance, the association of bank accounts with the CBDC payment system. In this case, the CBDC

system would waterfall to associated commercial bank accounts those amounts exceeding the caps in digital wallets.

Summarizing, the design of the CBDC system would have deep implications for its security and adoption by users. It would also affect the competitive behavior in the payment system but also in the market for financial intermediation. Moreover, a potential competitive disadvantage of central banks in dealing directly with the general public would be circumvented by a design that involves competition between the payment services providers offering the interface for the CBDC system. Other aspects of design would foster innovation and competition in this segment. Overall, the system should be simple and transparent.

3.2 Alternatives: Fast retail payments and synthetic CBDC

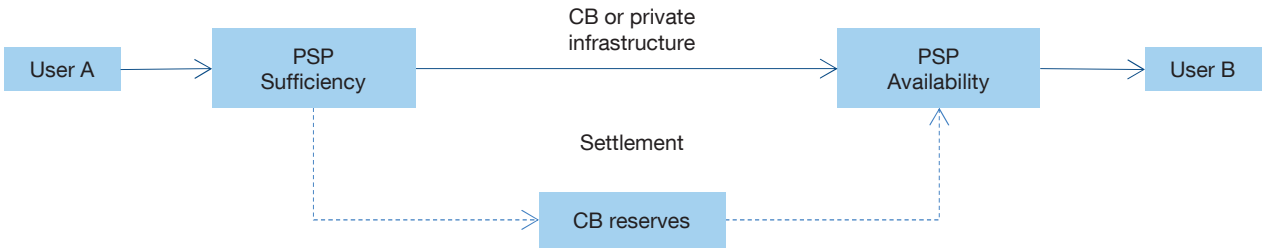
Before introducing a CBDC it is worth to evaluate other possibilities to fulfill similar objectives. Under some circumstances, fast retail payment systems (FPS) may represent a potential alternative to CBDC. These systems have been developed in many jurisdictions.[11] Bech and Hancock (2020) argue that as a result of information and communications technology improvements and (more recently) consumer demand, domestic payments are increasingly convenient, instantaneous and available 24/7. The improvements began to emerge in the 2000s and their diffusion mirrors that of the RTGS systems that emerged in the 1980s [Bech et al. (2017)]. Initially these innovations were limited to making the front end more convenient, but more recently innovations have started to address the back end and have increased the speed of retail payments.

As in the case with CBDC, in a FPS "the transmission of the payment messages and the availability of 'final' funds to the payee occur in real-time or near real-time on as near to a 24/7 basis" [see CPMI (2016)]. Also as with CBDC, FPS are payment infrastructures that facilitate payments between users at multiple PSP rather than just between the customers of the same PSP. This feature focuses on open systems, where users can access the payment system through any number of PSP; this includes, as in the case with CBDC, banks. There are, however, several differences. Maybe the most important is that a FPS does not need central bank money in digital form in order to operate.

Figure 2 shows the basic arrangement of a FPS. User A starts a transfer through the interface provided by her preferred PSP. This PSP checks the sufficiency of funds to be transferred, differently from the case with CBDC where it is the central bank that does this check. Then, the PSP sends the payment message through the payment

11 According to Bech et al. (2020) currently, 55 jurisdictions have FPS, and this number is projected to rise to 65 in the near future.

Figure 2
FAST RETAIL PAYMENTS AND sCBDC: BASIC ARRANGEMENTS



SOURCE: Own elaboration.

infrastructure. In the other extreme, the PSP of the payee receives the message and makes the funds available to User B. The payment infrastructure would be operated by the industry, generally as a consortium of PSP, or provided by the central bank. Interbank settlement would either be done immediately after receiving the payment messages or deferred, which would imply certain degree of risk assumption by participating banks. And the central bank could or could not be involved in the settlement process. I will consider these differences with CBDC in the rest of this section.

A privately owned payment infrastructure may emerge as a coordinated effort by PSP in a jurisdiction. In practice, this coordination effort generally results in the interconnection between those PSP and the existing or enhanced core clearing and settlement systems. Payment infrastructures often exhibit significant network economies, as well as economies of scale and scope. This would explain why the adoption of a fast payment system is typically not solely an individual decision. Rather, it tends to be a decision that requires coordination and collective decision-making as argued by Bech et al. (2017).

Collective decision-making by an industry consortium in order to solve the coordination problem behind the implementation of a fast payment system is often complicated and time-consuming. The involved parties would weigh the short run costs more than the potential, uncertain and difficult to quantify long term benefits, and refrain to implement the infrastructure, possibly leading to underdevelopment in the retail payment system. Therefore, getting incentives for the private implementation of a fast payment system may require a catalyst or strong outside incentives, potentially from the public sector.

Incentives could also steam from inside the private sector, for instance, as a strategic reaction to other PSP increasing competition and making the payment system contestable. In this case, part of the PSP community may find it worth to implement

a fast payment infrastructure in order to gain a competitive advantage. Since broad coverage of end users is important to realise the benefits of these payment services, which have strong network effects and require relatively large investments, private implementation by a part of the PSP community in a jurisdiction would lead to imperfect competition in fast payments. Again, public intervention will be deemed necessary. This time, in the form of competition policy to tame a monopolistic payment infrastructure, to facilitate the interconnection among infrastructures in an oligopolistic market structure, to guarantee access to third parties, e.g. new entrants like FinTech companies, to protect customers from abuse, and to foster efficiency in the payment system.

Alternatively, a fast payment system could be owned by the central bank, which is likely to consider monetary and financial stability issues. For instance, in a situation of financial stress like a banking crisis, a fast payment system under the control of the central bank would have the advantage of being easier to maintain operative than in the case that this infrastructure is operated by banks. A central bank would also be in a better position than the private sector to evaluate the potential benefits of fast payments such as the scope for improving services, to satisfy customer needs, and the prospect for future innovation. The possibility of a central bank to take such long-run factors into account, i.e. financial stability, development and innovation, could provide a rationale to consider adopting a strategic view in the implementation of fast payments. At this point, it is worth noting that the very same reasons would justify implementing a CBDC. In this regard, both CBDC and fast payment systems are alternative ways for a central bank to keep control over critical infrastructures in the digital era.

A fast payment system of a central bank would provide a fast, highly secure and resilient technology infrastructure. It may work alongside the RTGS service and provide the minimum necessary functionality. Hence, as in the case of a CBDC, this infrastructure could serve as the platform to which private sector PSP would connect in order to provide customer-facing payment services. Moreover, PSP could also build additional functionality that might be provided as a value-added service for some or all their users, increasing competition and improving users' experience. Also as in the case of a CBDC, PSP would be subject to appropriate regulation and supervision in line with any risks they might pose.

In a privately-owned fast retail payment system the transmission of the payment message and the availability of funds to the payee occur in (near) real-time. It could be the case that the system works with fund settlements among PSP in real time as well. In other words, after funds have been debited from the payer's account, an interbank settlement takes place prior to finally crediting the account of the payee. In this case, credit risk among PSP participating in the system is negligible, but there is important liquidity risk because each PSP requires sufficient liquidity to support real-time settlements of fast payments. However, fund settlement among PSPs does

not necessarily need to occur in real-time and with every payment order, but it could take place at pre-specified times during the day and in batch mode. In deferred settlement, liquidity risk is smaller, but PSP carry credit risk because in each transaction the payee's PSP advances the funds to the final user before inter-PSP settlement occurs. In practice, a variety of tools can mitigate this risk, including prefunding of positions, a maximum limit on the net position between two PSP, and collateralization of debit positions [Bech et al. (2017)].

The central bank would have a role on the settlement process of a privately-owned fast retail payment system. Nowadays commercial banks hold accounts at the central bank that allow them to settle payments by transferring perfectly safe funds in a digital form, i.e. central bank reserves. Adrian and Mancini-Griffoli (2019) propose to extend access to central bank reserves to non-bank PSPs. The ability to hold central bank reserves would allow non-bank PSPs to overcome credit and liquidity risk involved in the settlement process. It would also provide a level playing field because no single market participant has an advantage in allowing payments among customers, and interoperability in payments is ensured. Offering selected non-bank PSPs access to central bank reserves, though under strict conditions, could raise risks. Requiring non-bank PSPs to hold the totality of users' funds at the central bank in the form of reserves would mitigate them. In this case, non-bank PSPs would be financial institutions that cover hundred percent of their liabilities with central bank reserves, i.e. narrow banks that facilitate payments but do not lend to the private sector.

Adrian and Mancini-Griffoli (2019) argue that central banks in some countries could partner with PSPs to effectively provide what they call "synthetic" CBDC, or sCBDC. Differently from the full-fledged CBDC model described in Section 3.1 and the FPS provided by the central bank discussed above, under a sCBDC model the central bank would only offer the settlement platform to payment service providers other than commercial banks by providing access to central bank reserves (it is represented in dashed lines in Figure 2). Other parts of the retail payment system will be responsibility of the private sector PSP, in particular managing customer data and performing transactions in a fast payment system.

As in the case of a FPS, in a sCBDC system there is no central bank money in digital form that is made directly accessible to the general public. Central bank reserves will be made accessible to non-bank PSPs, as it is the case today with commercial banks, but it will not be accessible to the general public. Nevertheless, Adrian and Mancini-Griffoli (2019) argue that as soon as non-bank PSPs issue their digital money backed one for one with central bank reserves, then final users essentially hold and make transactions in a central bank liability.[12] Hence, the possibility of

12 From a legal point of view, however, it may be important differences on the rights that have a holder of a sCBDC with respect to those that have the non-bank PSP that is allow to make bank reserves at the central bank.

transacting in central bank reserves with a hundred percent reserve requirement, i.e. like in a narrow banking scheme, is a way to synthetize central bank digital currency.

Summarizing, fast retail payment systems and synthetic forms of central bank digital money could achieve similar objectives than a full-fledged CBDC. Selecting among the options and determining specific design issues imply to seriously consider the market failures to solve and the advantages and risks of each system in the framework of existing public policy objectives. The balance could imply the optimality of different arrangements depending on the characteristics of the payment systems.

4 CBDC pilots and FPS experiences

With regards to CBDC, there is no one-size-fits-all solution. As highlighted by CEMLA (2019), the introduction of a CBDC needs to be preceded by an in-depth analysis of the design issues that must better serve for each central bank. In this section I review two experiences with retail CBDC for domestic use in Latin America and the Caribbean: the CBDC pilots of Uruguay, called e-Peso, and of The Bahamas, called Sand Dollar. They share some design features like, for instance, a tiered architecture with the core system under the control of the central bank and third parties leading with final users. They have, however, deep differences on the underlying technology and other characteristics that we will discuss in what follows.[13] The section ends with the revision of a recent experience with a fast payment system: the TARGET Instant Payment Settlement (TIPS) offered by the Eurosystem since late 2018.

4.1 e-Peso

A digital currency issued by the Banco Central del Uruguay (BCU), called e-Peso, circulated in Uruguay between November 2017 and April 2018. e-Peso is legal tender currency issued by BCU, alike physical Uruguayan Pesos banknotes, in a digital form. This section describes the main features of the e-Peso pilot.[14]

The preparation of the pilot started several years before the first e-Peso was put in circulation in late 2017. In 2014, BCU was approached by The Roberto Giori Company, a firm specialized in money security, with a preliminary proposal to create legal tender digital money which is secure and reliable. Then, legal, information security and technological aspects were evaluated to be sure that the relevant risks were under strict control. Risks include financial and legal ones, but also reputational risk

13 This section profits from the peer review effort of CBDC pilots done the CBDC Working Group of the Forum of FINTECH Experts at CEMLA during 2019-20 (see https://www.cemla.org/fintech/english.html). I would like to thank Chaozhen B. Chen from the Central Bank of The Bahamas for fruitful exchange, as well as Raúl Morales, Pablo Picardo and José Luis Vázquez for your contribution in that effort.

14 This section is largely based on Bergara and Ponce (2018).

that was a matter of particular concern. Several measures were undertaken to reasonably mitigate cyber risk and to make sure that the system provides adequate standards regarding security of information. Other risks, e.g. financial and reputational risks, were reasonably hedged through detailed contracting with the participants.

The e-Peso system involves several participants. In addition to Banco Central del Uruguay, who mints the digital e-Peso tokens, and The Roberto Giori Company, who provides the core payment system for them (Global Solution for Money Technologies), there were four more participants in the pilot: the state-owned telecom company, Antel, provides the telecommunication network. IBM provides data storage services, management and control of e-Pesos transactions.[15] It also provides support to customers through a call center. Inswitch Solutions, a Uruguayan FinTech specialized in mobile financial services, provides the interface for the management of users, transfers and transactions. Final users need to register through Inswitch, which performs due diligence and know-your-customer. Moreover, digital wallets keep linked to the mobile phone SIM card of the owner. Finally, Redpagos (a payment service provider with branches all around the country) offers cash-in and cash-out services, i.e. exchanging physical banknotes by e-Pesos and vice versa. In addition to these participants, final users include individual customers and retail businesses.

A series of caps were incorporated in the pilot in order to generate a controlled environment for risk management. To start with, e-Peso circulated by a limited period of time: six months. The issuance of e-Peso bills was limited to 20 million Uruguayan pesos. The number of users was limited to 10,000 mobile phone users of Antel. More precisely, the first 10,000 users that install the e-Peso application and register to the pilot could make transactions. The maximum balance in e-Pesos wallets was set to 30,000 Uruguayan pesos (equivalently to 1,000 US dollars) for final individual users and to 200,000 Uruguayan pesos for retail business registered in the pilot. Finally, the system allows two kind of digital transactions: peer-to-peer transfers among final users and peer-to-business payment between final users and registered retail businesses.

The core e-Peso system has two components. First, a "digital mint" under the control of the central bank generates the e-Peso notes and uses cryptography to provide security. Digital notes are then tokens. Nevertheless, the system needs a second component to operate and e-Peso could not be transferred directly among final users without being validated in this second component: "a digital vault". This vault holds e-Pesos in individual, encrypted and anonymous digital vaults that are linked one-to-one with final users' digital wallets. Hence, e-Peso is nor purely token-based neither account-based in their classical definitions: tokens need to be centrally validated and there are not accounts but vaults. Interestingly, the partition of information allows providing (pseudo) anonymity to transactions since final users are

15 During the pilot the management of the e-Peso payment system was outsourced to IBM, but this is matter of evaluation in the aftermath of the pilot due to the importance of keeping control of it by the central bank.

just identified through their telecom provider and digital wallet, but they are anonymous in the core system. Nonetheless, transactions can be traced back and the identity of users revealed under the authorization of a competent authority, e.g. a court of justice.

Other features of the e-Peso system are as follows. First, the system provides instantaneous settlement on a 24/7 basis. Second, the e-Peso system uses internet as the principal channel and the USSD telecom protocol as secondary authentication method, enhancing security, and as a contingency channel. The e-Peso pilot did not feature off-line transactions, but without access to the internet transactions were processed on-line via the USSD protocol. Third and related to the previous point, in the e-Peso system users can make transactions without an internet connection or even without a smartphone. Fourth, e-Pesos are secured at the core system even if users lose their mobile phones or their digital wallets password. This also enhances security with respect to physical banknotes. Fifth, each e-Peso bill will have a unique serial number (through cryptography) and specific denomination. These features are aimed to improve security because they help to prevent double spending and counterfeiting. Nevertheless, they could increase the technical requirements of the system when the e-Peso denomination in a particular wallet is not appropriate to make the transaction.

The e-Peso pilot helps to evaluate many aspects of the technologies for CBDC, and central bank business models applied to the payment system. It was also useful to visualize tentative answers to relevant questions about the impact of a CBDC. For instance, a matter of concern refers to the impact of e-Peso on banks and other financial institutions. During the e-Peso pilot, banks were deliberately kept out of the pilot in order to have a firewall to keep risks under control, but several banks approached the project manager asking to be allowed to participate. Banks seem to visualize profitable business opportunities and potential for cost reduction linked to e-Peso. A very preliminary assessment indicates that there will not be major disruptive effects in the financial intermediation activities. Should a CBDC like e-Peso be put in production, then it is likely that the banking system reaches a new equilibrium. Of course, the characteristics of this equilibrium will depend on the settings of e-Peso.

A CBDC like e-Peso may contribute to a level playing field for sound competition and innovation in the financial market. It may reduce entry barriers for startups developing new products and services, e.g. digital wallets with enhanced customers' experience, and could provide incentives to incumbent financial institutions to offer better products and new e-Peso related services. For instance, during the pilot registered businesses just needed a mobile phone to operate e-Peso. Given the small scale and limited time of the pilot no other investment was needed to link existing billing systems to the e-Peso system, and existing communication technology was enough to operate the e-Peso. All these areas would need innovations and development of solutions to solve, for instance, the ways in which other payments platforms and systems (POS, for instance) will connect to the e-Peso system. Moreover, digital

wallets were just provided by one FinTech during the pilot. This segment could also be open to competition should the e-Peso goes into work. Last but not least, efficiency and security in the payment system may dramatically improve by the introduction of a CBDC. Moreover, e-Peso could contribute to the objectives of financial inclusion.

4.2 Sand Dollar

The Bahamas started in December 2019 a pilot phase with a digital version of the Bahamian dollar, called Sand Dollar. As a consequence of Hurricane Dorian, which impacted The Bahamas between the 24th of August and the 10th of September 2018, public infrastructure resulted seriously damaged. The damage extended to the payment system itself given the geography of the country, which is composed of fewer than 700 islands. In this context, the Central Bank of The Bahamas started the Sand Dollar pilot with the main targets of improving financial inclusion and access and making the domestic payment system more efficient and competitive. The Sand Dollar is aimed at addressing some of the current financial access gaps provided by both, remoteness of some communities outside of a cost-effective range of physical banking services, and onerous customer due diligence and know your customer requirements. This CBDC initiative aims to achieve universal access to digital payments and financial services, underpinning government efforts to digitize and make a more efficient spending and tax administration.

The pilot starts in two islands: Exuma in the first place, and Abaco in the second place. Exuma was chosen due to its landscape and similarity with the Bahamas' geographic landscape. Abaco was selected due to its economic recovery after Hurricane Dorian. A public relation national campaign was developed to educate the public on the use of Sand Dollar. Moreover, the main dissemination efforts are put on building user base through public outreach and authorized financial institutions. The system offers a free of charge service for final users. However, looking ahead, the operation may generate a nominal fee for the upkeep of the service which may be shared amongst all of the beneficiaries of the system.

In terms of design, Sand Dollar is a token-based CBDC, which is minted by the central bank solely. As in the e-Peso pilot, critical functions of the project are all under direct control of the central bank, i.e. minting and settlement. However, certain maintenance, penetration testing and system audits could be outsourced. Alike e-Peso, the Sand Dollar can be seen as a real-time, retail, digital cash-transactions system, featuring 24x7 availability.

A key difference between e-Peso and Sand Dollar is that the latter is based in a DLT-enabled core system which works as a private and permissioned platform. Regarding the validation process, the system relies on a cognizant consensus model based on

a “proof of work” protocol. In order to prevent double-spending and counterfeiting the system uses enhanced short-lived (time sensitive) one-time web tokens instead of traditional reusable tokens that are used in the case of e-Peso. The Sand Dollar system seems to deliver a technological solution that is scalable and trustable. In terms of data protection, the system seems to be able to respect and protect users’ data and anonymity, accordingly, as no personal information is ever stored on the DLT permissioned network. Nevertheless, if there is a need to investigate nefarious activity, traceability of transactions is always possible.

Interoperability is guaranteed through supervised financial institutions: commercial banks, payment service providers and money transmission businesses integrated via API connectivity to the Sand Dollar network. Currently in addition to commercial banks, there are seven payment service providers in the market. Only these supervised financial institutions are allowed to handle the distribution of Sand Dollars. For that purpose, they have accounts at the central bank. These institutions are responsible for applying due diligence and know your customer regulation. Moreover, end-user overlay services are expected to operate in a competitive environment. In this respect, innovations are expected to be developed based on the Sand Dollar system. For instance, a card-based access option has been developed to satisfy the needs of the less technological savvy demographics. Moreover, authorities are working with financial intermediaries to link the Sand Dollar system directly to bank accounts.

The wallets of final users are encrypted and secured and can only be accessed with a unique PIN number or through biometrics. Wallets can also be blocked through accessing the wallet on a secondary device, in case it is necessary (if it is stolen). All transactional data is centralized and housed in a central bank’s datacenter. Furthermore, the system has a built-in proprietary resilience network that allows users to connect to the Sand Dollar network without data and internet connectivity.

While the envisioned ecosystem provides room for the private sector to play different roles, no private-owned institution has control over the transmission and settlement of transactions, which are offered in real time by the Sand Dollar system housed at the central bank. Hence, the central bank maintains control of the most strategic parts of the system: minting, transmission, settlement and data protection. Yet, this CBDC system has the potential to generate competition in the financial market and then better products and services to final users, whilst it does not impact the stability of the financial system.

4.3 TIPS

In November 2018 the Eurosystem launched a new market infrastructure service known as TARGET Instant Payment Settlement (TIPS). This service allows final users

to make fund transfers in euros,[16] within seconds, in a 24/7 basis and with the highest standards of security against settlement risk, since the transactions are carried in central bank money. TIPS shares most of the features of a fast payments system offered by a central bank that were discussed in Section 3.2. In particular, it is offered by the Eurosystem as an extension of its real-time gross settlement system, TARGET2, uses it to settle payments in central bank money, and authorized PSP are enabled to offer individuals and firms instant payment services through the countries served by the Eurosystem, ensuring reachability and interoperability.

TIPS represents a response to the growing consumer demand for digitalization and instant payments that are accessible anywhere and at any time. In this context, several European countries were planning their own solutions and a number of national schemes appeared or were under development. Starting in a national basis, however, poses the problem that the new instant payment systems would have stopped at national borders, leading to a fragmented landscape and slowing further harmonization of payments in Europe. Hence, a challenge for the Eurosystem is to ensure that these national solutions do not promote fragmentation into the European retail payments market, a risk that TIPS aims to minimize.

To operate in TIPS, payment services providers must be eligible to access central bank money, i.e. they need to fulfill the same requirements for participating in TARGET2. In such a case, a participant PSP can open one or more dedicated TIPS account with a central bank member of the Eurosystem. These accounts are then used to settle instant payments conducted through TIPS. When a participant PSP sends a payment transaction message to TIPS, it validates and reserves the amount to be transferred in the account of the sender. Next, TIPS forwards the payment transaction for acceptance to the receiving PSP. Once a positive reply is received by TIPS, it performs the settlement and confirms the transactions to both the sending and the receiving participants. Settlement is then final and irrevocable. According to the operator, the end-to-end processing time of a transaction is 10 seconds or less. The price per instant payment transaction is fixed at 0.20 eurocent until at least November 2020, although the system intends to work with a full cost-recovery and not-for-profit principles, so that this amount could vary in the future.

Participation on the TIPS system is subject to the same rules than those applied in TARGET2, the RTGS system. In particular, there are three avenues through which a PSP could operate. First, as participant a PSP is eligible to open one or more accounts in TIPS. Moreover, participants may let other parties to instruct payments on their behalf by using the participant's account. Second, by entering into a contractual agreement with a participant, a reachable party is able to access that participant's TIPS account. In general, reachable parties adhere to the SEPA Instant Credit Transfer (SCT Inst, a scheme for pan-European instant payments aimed to

16 The system supports multi-currency technical capability as well.

favor digitalization and fast payments in Europe together with the harmonization of direct debits and credit transfers across national borders) but do not want to open a TIPS account. Instead, they send and receive payment instructions using a participant's TIPS account. In general, participants set maximum limits for the reachable party under a functionality called Credit Memorandum Balance. This functionality allows efficient risk management without splitting liquidity. A third way to participate on TIPS is to become an instructing party by entering into a contractual agreement with one or more participants or reachable parties to instruct payments on its behalf. Overall, the three forms of adhering to TIPS by a PSP provide an ample set of possibilities as to facilitate adoption and reach final users with customized payment services.

As fast payment system offered by a central bank, TIPS is based on the RTGS service to provide the minimum necessary functionality, guarantee a fast and secure process of transactions, and enable a deployment process without interruption in the service. Consequently, it is capable of instantly settling a large volume of payments at relatively low cost. Furthermore, it is compatible with the strict supervision requirements of the Eurosystem, as well as with the CPMI-IOSCO guidance on cyber resilience for financial market infrastructures.

The feature of being an extension of TARGET2, which already has an extensive network of participants across Europe, will help TIPS to achieve reachability and implementation in a short period of time. Moreover, the first 10 million payments made by each participant PSP before the end of 2019 were free of charge in order to promote adoptability. In addition to that, another feature that may help adoption of TIPS is that it is compliant with SEPA Instant Credit Transfer (SCT Inst Scheme). This scheme is expected to be used by a large number of payment service providers across Europe. Indeed, it is currently being used in 22 countries by more than half the total number of European PSP. The estimated share of SCT Inst volumes in the total has continuously growing since its start in 2018 to reach 6.47% during the second quarter of 2020.

5 Final remarks

Digitalization implies challenges to central banks and also provides new tools for them to face the challenges and better fulfill their mandates. With regards to retail payments, the digital era provides a rationale for central banks to have a deeper involvement in the core payment infrastructures. If the current market equilibrium is characterized by fragmented and inefficient payment systems, central bank intervention offering basic payment alternatives may foster innovation and competition by solving the coordination problems that are inherent to markets with large network effects, and by increasing contestability. If the (foreseeable) market equilibrium is characterized by a monopolistic infrastructure under the control of the

private sector, the central bank would provide an alternative payment infrastructure in order to tame the monopoly and to keep control of a reliable backup payment system in case of financial problems. As digitalization progresses, retail payment infrastructures acquire systemic characteristics that justify public intervention in order to maintain their integrity.

Facing challenges and leveraging opportunities may require strategic decision, face new risks and change the traditional objectives and business model of central banking. Minting central bank money in digital form, i.e. Central Bank Digital Currency (CBDC), appears as a potential avenue that is being explored by central banks around the world. Alternative Fast Payment Systems (FPS), which are currently provided by more than 50 central banks, would also serve the same purposes. In this paper different arrangements, design options and experiences are described an assessed. Overall, the design options of a CBDC system are pretty large and may be tailored to better fulfill the requirements in different jurisdictions. The topic is in a state of flux and more research and experimentation is needed in order to make informed strategic decisions. Nevertheless, an approach where the central bank does everything does not seem to be the best option. While central banks should build and keep control of the core components of either a CBDC or a FPS, private sector involvement will be optimal in a tiered architecture where payment services providers compete for customers, innovate and offer overlay services.

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