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Abstract

This document reviews the potential macroeconomic effects of issuing a central bank digital currency (CBDC) for the use of individuals and businesses. A careful selection of the architecture, and the economic and technological design aspects of this digital form of central bank money that best suit the needs of Colombian economy is made to frame the analytical approach used to study these issues. The most salient results of the related literature are reviewed to establish the consequences of undertaking this initiative. For the set of selected assumptions, we find that the expected macroeconomic consequences are negligible.

Keywords: CBDC, macroeconomic effects, digital money, financial intermediation

JEL: E42; E51; E44; E52; E41; G21

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Efectos Macroeconómicos Esperados de Emitir una CBDC al por menor

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Resumen

Este documento revisa los potenciales efectos macroeconómicos de emitir una moneda digital de banco central (CBDC) para uso de las personas y negocios. Se realiza una selección cuidadosa de la arquitectura, y de los aspectos de diseño económico y tecnológico de esta forma de dinero digital que mejor se ajustarían a las necesidades de la economía colombiana, para enmarcar la aproximación analítica que se usa para estudiar estos temas. Se revisan los resultados más destacados de la literatura relacionada para establecer las consecuencias esperadas de adelantar esta iniciativa. Para el conjunto de supuestos seleccionados, encontramos que los efectos macroeconómicos esperados son muy pequeños.

Palabras clave: CBDC, efectos macroeconómicos, dinero digital, intermediación financiera

JEL: E42; E51; E44; E52; E41; G21

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Introduction

The rise and popularization of new payment technologies have widened the range of alternatives that consumers and firms can use to make payments and store value. These new payment technologies have led several central banks to study the possible issuance of their currencies in digital form. This is the case of countries like Sweden where people prefer to pay with digital payment solutions provided by the private sector, but it is also the case of countries like Japan where cash is the most used payment instrument in retail transactions (see Riksbank, 2021; Bank of Japan, 2022). A general-purpose central bank digital currency—retail CBDC hereafter—is a digital form of fiat money that will allow transactions in person and online and will enable merchants to receive the payments for their sales immediately. This form of central bank money will have the same unit of account as cash and could be used as a medium of exchange and to store value (Bank of Canada et al., 2020).

Most central banks studying this topic face the difficult task of deciding what would be the main reason for introducing this new type of money in the economy. In some countries like the Bahamas, the motivation behind this decision seems to be very clear (i.e., solve the logistical issues for the proper supply of cash across its islands and cays (Balz, 2022)), while in others, the motivation is less obvious.

Several idiosyncratic aspects can influence the central bank's decision to issue a retail CBDC, one of which is the current state of payment patterns in the economy. In Colombia, cash provision to the private sector has been conducted through a public-private partnership in which this money is issued by Banco de la República (Banrep) and is distributed mainly through commercial banks branches and automated teller machines (92.7%).¹ This distribution model allows its users to easily convert their deposits (commercial bank money) into cash immediately and at par. However, this situation may change if the emergence of digital payment solutions makes individuals and private firms use digital money much more than cash. If that situation reaches a point where the use of cash is about to disappear, central bank money could lose its role as a monetary anchor for deposits and other forms of private money. Such a situation seems to be very far from occurring in Colombia at the present,

¹ The remaining percentage (7.3%) is distributed through Treasury branches of the central bank (see Banco de la República, 2020).

where close to 75% of retail transactions are settled in cash.² However, if this situation changes, issuing a CBDC would be a possible solution as it could widen the use and access to (electronic) central bank money.

Banrep has not yet taken a decision about issuing a retail CBDC, but it has set an agenda with different initiatives where economic, technological, and legal aspects are being carefully studied. Several arguments have been explored in the related literature to examine whether central banks should offer currency in digital form (i.e., developing the digital economy, improving efficiency and safety in retail payments, forestalling wide adoption of stablecoins, and fostering financial inclusion – all of these are developed in Section 2). One argument in favor of this initiative would be the goal to make payments more efficient, represented in this case by reductions in the time required to settle them. Fast payment systems can alternatively help to achieve this goal by allowing payments in real time. Indeed, there is a fast payment system administered by the private sector that has been operating since February of 2020 (Transfiya); however, it is not yet fully interoperable, and it is focused on peer-to-peer services only. To tackle this issue, the central bank is currently conducting a project to design its own fast payment system, which is expected to start operating in 2025. Although none of the reasons considered in this report are convincing cases for the public provision of digital money, it is recommended to continue monitoring these aspects because one of these might justify the issuance of the retail CBDC in the future.

Before deciding on the issuance of a central bank digital currency, two critical questions should be considered: which potential macroeconomic effects it may bring and how these impacts may vary according to distinctive CBDC design features. With regard to these questions, the present paper describes and analyzes different design features (Section 3) and reviews some potential effects, mostly based on the still incipient but growing theoretical literature, and some policy papers specifically related to financial stability, monetary policy, and financial inclusion (Section 5). Other aspects of this initiative such as technological and legal requirements will not be covered in this document.

² For the remaining percentage, people used electronic funds transfers (15.4%), debit cards (8.5%), and credit cards (1.5%) (Banco de la República, 2022b).

After revising several aspects of the retail CBDC, it is established that the more convenient design for the Colombian economy should be based on a tiered architecture (either the hybrid or intermediated by commercial banks), contain holding and spending limits, be resilient to a wide range of incidents, and be non-interest bearing. By considering these design aspects as the elements that define this new form of central bank currency, it is concluded that the potential macroeconomic effects of introducing this form of digital money would be limited.

Regardless of the central bank's decision about issuing or not the retail CBDC, a policy recommendation points to the need that supervisory authorities develop regulatory standards and frameworks that strengthen the resilience of the domestic financial system to the emergence and popularization of backed cryptoassets, like stablecoins.³

The first section of the report briefly describes some forms of (either privately or publicly issued) digital money. Section 2 explains some of the motivations that a central bank might have to issue a retail CBDC. Section 3 describes some design issues that would be relevant in the issuance of a retail CBDC especially for the Colombian case. The next two sections are devoted to describing some microeconomic aspects required for a wide adoption of the central bank digital currency (Section 4) and potential macroeconomic effects (Section 5) of its issuance. The last section concludes and briefly presents some policy recommendations.

1. Different forms of Digital Money

Before examining the expected macroeconomic effects of issuing a retail CBDC (presented in Section 5), this Section briefly describes the existing forms of digital money offered by the private sector, in terms of their main characteristics and the services offered to their users. This description is intended to provide a general context for the CBDC in the current state of digital payments. The macro effects caused by these other forms of digital money will not be considered since they are out of the scope of this paper.

³ As recommended by the President's Working Group on Financial Markets, the Federal Deposit Insurance Company, and the Office of the Comptroller of the Currency for the US case (PWG, 2021), and in general by the BIS (BIS, 2022d).

Nowadays, payments are ordinarily made via the use of either cash (publicly provided) or deposits held in commercial banks (privately provided). However, recent innovations have brought new forms of digital money (some proposed, some currently in operation) which intend to increase the speed and lower costs in the payment system. In this section we describe different forms of privately issued digital money: bank deposits, cryptoassets, and within this general group a special sub-category known as stablecoins. We also describe publicly issued forms of digital money, represented in this case by central bank digital currencies (CBDCs).

Bank deposits are still the most popular form of digital money, usually denominated in the national unit of account and bearing low or no interest. This form of digital money, issued by commercial banks, is redeemable upon demand at face value and has a redemption guarantee that is backstopped by the government through the financial regulator and/or the central bank. Supervision and regulation of issuers ensures the safety of deposits as store of value. If banks lack enough liquidity to attend customers' withdrawals, they can obtain short-term liquidity from the central bank. In some countries, the deposits' function as store of value is strengthened through a deposit insurance scheme that protects, up to a certain limit, amounts held at commercial banks (Adrian and Mancini-Griffolli, 2021).

Cryptoassets, also referred to as cryptocurrencies, are digital elements, privately issued, usually denominated in their own unit of account, and capable of being acquired, preserved, and transferred electronically (Parra et al., 2019). The first known cryptoasset, Bitcoin, was created more than a decade ago with the purpose of achieving more independence from governments and from the traditional payment and financial systems. In this sense, cryptoassets represent an attempt to provide money in a private and decentralized manner, as opposed to publicly issued money which is provided by a central bank.⁴

Those digital elements or tokens are mostly issued by decentralized processes determined by computational algorithms. Transactions are recorded by means of distributed ledger technologies (DLT), mainly in a particular form known as 'blockchain'. In this specific DLT

⁴ As of August 2022, private figures (investing.com) reveal that there exist around 11,000 cryptocurrencies with a total market capitalization of US \$1 trillion. However, only four of them (i.e., Bitcoin, Ethereum, Tether, and USD Coin) represent almost 70% of such a market cap.

form, new transactions are bundled and verified in blocks and linked to previous ones in such a way that potential criminals would need to attack the entire chain in a highly decentralized system, making the probability of a successful attack very low, and hence offering highly secure transactions. Nevertheless, it is important to remark that this feature corresponds to the ledger and hence it does not guarantee the same level of security for crypto exchange platforms (i.e., intermediaries that facilitate cryptoassets transactions to their customers).

Most of the cryptoassets (Bitcoin and Ethereum among them) do not have an anchor: they are neither backed by other assets nor there is an institution committed to preserve their value stability. Consequently, they tend to exhibit very high value volatility which makes it difficult for them to adequately fulfil the money function of store of value. This in turn increases their demand for speculative purposes rather than as payment instruments.

In contrast stablecoins are designed not to suffer from high volatility, since their values are anchored to other assets. Stablecoins are a specific subset of cryptoassets that normally peg their value to traditional (fiat) currencies. Some are fully backed by a legal tender to which their values are pegged, while others are only partially backed and part of this backing may correspond to other types of liquid assets (e.g., commercial papers, precious metal, or even other cryptoassets). As long as the promise of a stable value remains credible, stablecoins may serve well the functions of store of value and medium of exchange, and therefore may represent a sound alternative to the traditional forms of money. Accordingly, some stablecoins have developed as the main medium of exchange inside the crypto sphere (Brunnermeier and Landau, 2022). On the one hand, the stability of stablecoins is not fully guaranteed, especially if they are partially collateralized. On the other hand, challenges to the effectiveness of both monetary policy and payment system regulation may arise if a stablecoin is widely adopted with billions of potential users across the world, i.e., a so-called global stablecoin.⁵

Another form of digital money is the central bank digital currency (CBDC), which is a digital form of fiat currency that will be denominated in the national unit of account and will be a

⁵ For instance, Diem, formerly known as Libra, was a project by Facebook (now Meta) -and hence with billions of potential users- intending to implement a global stablecoin. It was abandoned at the beginning of 2022.

direct liability of the issuing central bank (BIS, 2022b). Thus, it is natural to expect that this digital form of fiat currency will be traded at par with other forms of central bank money. A retail CBDC is intended to allow consumers and firms to make payments and store value. As regards the first function, this form of money will allow retail transactions in person (i.e., person-to-person, person-to-business, and person-to-government transactions) and online, while the second function could be used to the extent permitted by the central bank, given that this latter may impose holding limits.⁶

Diagram 1 presents a schematic summary of the above-mentioned digital forms of money. The payment solutions offered by the private sector (bank and non-bank institutions) are located at the left-hand side of the diagram. This group includes bank deposits and stablecoins (local and global). The retail CBDC is located at the right-hand side of the diagram, where two possible transfer mechanisms (or access technologies) are identified: account based, and token based. The central bank’s decision on whether to provide deposits accounts to the general public will be given by economic and technological reasons. More details on the design aspects of the retail CBDC will be presented in Section 3.

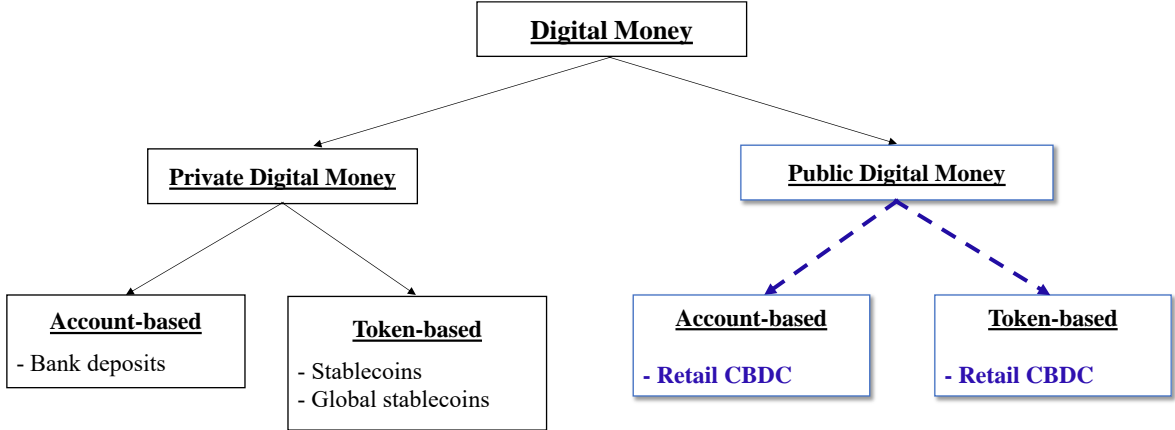


Diagram 1. Digital forms of money

Note: this diagram is a modified version of the Money Tree designed by Orr (2022).

⁶ A retail CBDC could also be used to fulfil the programmability function of digital money (i.e., recordkeeping of transactions), define the conditions under which units of value are being transferred (i.e., smart contracts), and enable decentralized transactions (see Lee, 2021; Allen, Gu, and Yaghtani, 2022).

An alternative dimension of CBDC is related to cross-border payments (i.e., those coming from international trade, foreign investments, and remittances), which currently rely on correspondent banks who operate as intermediaries in these transactions. These payments suffer from some limitations related to their lack of efficiency, high cost, low speed, and limited transparency. These features led the Financial Stability Board to highlight enhancement of cross-border payments as one of its most relevant goals for the coming years (see FSB, 2020). When considering the use of CBDC to improve cross-border functionality attention has focused primarily on wholesale CBDC, which would be available to financial institutions that participate in these transactions. Some central banks and international agencies have argued that wholesale CBDC would allow a more efficient transfer and settlement of transactions across jurisdictions.⁷ The international dimension of CBDCs will not be considered in the remainder of this document since its main purpose is to study the retail payments landscape at the local level.

2. Motivations that could make Banco de la República consider the issuance of its retail CBDC

A relevant part of studying a retail CBDC consists in identifying the gains it would bring compared to existing payment solutions. Some arguments in favor of this initiative claim that it could foster competition and innovation in payment services, while others contend that it can help with political economy concerns such as the low levels of access to financial services observed in some countries.⁸ There is also a skeptical view on this subject that argues that retail CBDC is a solution in search of a problem (see Waller, 2021; Eichengreen, 2022).

⁷ Wholesale CBDC models for cross-border payments may either rely on coordinating standards, interlinking bilateral systems, or sharing a common multi-CBDC platform (see BIS et al., 2021, and Auer, Haene, and Holden, 2021a).

⁸ Previous literature has also considered the CBDC remuneration (i.e., bearing an interest rate) as a possible motivation for its issuance, regarding the potential use of this remuneration as a monetary and even as a fiscal policy tool (see, for instance, Bjerg, 2017). However, to our knowledge neither recent central bank documents nor academic papers present it as the relevant motivation for issuing CBDC. In Section 5.3 of the present paper, we mention some details related to the effect of an interest-bearing CBDC on the transmission of monetary policy.

Although Banrep has no plans in the short term to develop a CBDC project, this section considers problems retail CBDC can solve, and whether any of these would lead the Colombian central bank to undertake its issuance.

2.1. Developing the digital economy

The digitalization of economic activities, i.e., online commerce, online payments, and new representations of value, has structural implications in several areas of the economy, including the payments landscape and the concept of money itself (Auer, et al., 2021b). Technological innovations have allowed the emergence of new digital means of exchanging assets, goods, and services and the rise of electronic payments, a trend that in some countries has accelerated in recent years, in part due to the COVID-19 pandemic.

According to Usher, Reshidi, Rivadeneyra, and Hendry (2021), issuing a retail CBDC could be part of the central bank's reaction to a situation in which it wants to support the continuous development of the digital economy by trying to solve some market failures or foster the competition and innovation in digital payments markets.⁹ A retail CBDC could enhance existing payment services and benefit a larger portion of individuals by providing digital payment services at low cost.

The digital economy also enables new functionalities like programable money and smart contracts, which initiate payments when certain conditions, previously specified by the end user, are met.¹⁰ These functionalities could open the financial industry to many possibilities in payment innovation and could be useful for transactions in capital markets, benefitting both wholesale and retail investors. Cost savings and enhanced efficiency are particularly relevant in the parts of the finance industry where the cost of intermediation is high and its efficiency is low (see Usher et al., 2021). On the other hand, these new functionalities can

⁹ Usher et al. (2021) also developed an alternative scenario that evaluates a cashless digital economy or a situation in which a cryptocurrency or a stablecoin substantially gains popularity in the country as a payment instrument.

¹⁰ A programable CBDC is one in which a program can be stored. A smart contract is a computerized transaction protocol that executes the terms of a contract; these may depend on events, identities, states or time, and their execution is enforced without relying on a trusted authority.

also involve some risks arising from the dependency of smart contracts on external data sources for their execution or from malicious attacks that may result in financial losses.

In Colombia, the National Development Plan 2022-2026 states that the government maintains its commitment to promote “a digital transformation as the engine of opportunities and equality”, supported by the promotion of competition in the provision of digital services (DNP, 2023). Although the digital transformation is an explicit goal for the Central government, fostering the digital economy is not among the policy objectives of Banrep. Therefore, this goal by itself would not be enough to consider the introduction of a retail CBDC in the economy.

2.2. Improving the efficiency and safety of retail payments

One of the most relevant mandates of central banks is to support safe, reliable, and efficient payments (Usher, et al., 2021).¹¹ To fulfil this mandate, Banrep has been continuously reviewing and implementing technological solutions aimed at improving access to payment services. A recent project built with the specific purpose of enhancing payment transfers between consumers and businesses is the creation of a fast payment system, which will be launched in 2025. The purpose of this project is to allow payment transfers in real time, in a safe and efficient way. There is a fast payment system administered by the private sector that has been operating since February of 2020 (Transfiya), but it is not yet fully interoperable. To solve this issue, the central bank decided to step in and develop its own instant payments infrastructure to offer immediate payment services at low cost.

Another type of payments innovation is retail CBDC, which could also facilitate payments in real time. However, since this goal (real-time payments) could also be achieved with a well-developed fast payment system, this property that would be obtained with the retail CBDC could not be considered a compelling reason to issue central bank money in digital form. Indeed, a fully operational fast payment system is among the goals that Banrep plans to achieve in the medium term. Therefore, providing real-time payment services through a retail CBDC would not be a strong reason to issue this new form of central bank money.

¹¹ Usher et al. (2021) explain other actions taken by central banks to fulfil this mandate.

A further dimension of providing secure and efficient payment services relates to the potential of the retail CBDC to promote competition for financial services and reduce transactions costs for end users (BIS, 2022b). The provision of safe payments also requires specific actions to prevent cyber-attacks on the infrastructure, payment service providers (PSPs), and end users. However, all these issues could also be solved with an adequate regulation. Therefore, it can be said that for the Colombian case, safety and efficiency considerations would not be the main reasons for issuing the retail CBDC.

2.3. Forestalling wide adoption of unregulated stablecoins

As explained in Section one, cryptoassets are part of the new attempts to develop privately issued digital money and thereby increase speed and lower costs in the payment system. However, since they are neither anchored nor backed by a central party, their values are highly volatile and do not satisfactorily fulfil the basic functions of money. Stablecoins are a special subset of cryptoassets intended to fix this problem by pegging its values to other assets (although they may vary widely in other design characteristics). By incorporating value stability, stablecoins try to become a sound alternative to traditional forms of money, as a store of value and as a medium of exchange.

Widespread adoption of stablecoins as a payment instrument could give rise to a variety of risks, related to higher difficulty in the prevention of illegal activities, loss of monetary sovereignty (and hence monetary policy effectiveness), fragmentation of the payment system, and possible operational and financial failures. Like other cryptoassets, stablecoins allow for a high level of anonymity in transactions. While this may be a useful feature to protect users' privacy, in the absence of supervision and regulation this feature also facilitates tax evasion and increases the difficulty of preventing money laundering and fighting the financing of terrorism and other illicit activities.

Another concern that may arise from a widespread use of unregulated stablecoins relates to monetary sovereignty. If a stablecoin denominated in a foreign currency became widely used in a country, the effects would be similar to dollarization: the monetary authority would lose control over a significant part of money supply in the economy and hence its monetary policy

actions would become less effective i.e., a significant substitution of the local fiat currency for stablecoins would limit the transmission of monetary policy. This currency substitution will be more likely if the central bank is not able to fulfil the demand of the population for digital financial and payment services (see Araujo, 2022).

Regarding fragmentation, and as highlighted by Brunnermeier and Landau (2022), money digitalization implemented by private issuers naturally works against the uniformity of currency and in favor of closed systems, dominant positions, and inefficiencies. Each issuer has incentives to maximize her own benefits by creating differentiated and special-purpose money and setting up barriers to interoperability with other systems. In a fragmented system, different types of currency become imperfect substitutes, generating uncertainty on the value of money. Furthermore, a system of competing platforms that are not interoperable facilitates hacking and theft: market share is prioritized at the expense of security (BIS, 2022c).

As noted earlier, stablecoins may be fully or partially backed by other legal tender or liquid assets. However, a stablecoin may be unable to guarantee stability, due to sudden loss of confidence or, as noted by the Bank of England (2020), because of characteristics such as the nature of the backing assets or the way they are held. In turn, uncertainty about a stablecoin's value or large fluctuations in it may pose significant risks to financial stability (e.g., liquidity or non-payment risk). Currently, the crypto universe still has significant limits to its technical capacity to scale without compromising security, facing congestion and/or imposing exorbitant fees (BIS, 2022c).

Stablecoins face many of the same basic risks as traditional payment systems, including credit risk, liquidity risk, operational risk, and settlement risk, which can undermine the redemption guarantees of the nominal value of these digital currencies. The effects that such a situation could cause in an economy could be amplified since private firms that provide this type of digital money lack access to central bank liquidity (Adrian and Mancini-Griffoli, 2021).

All the aforementioned potential risks might be mitigated by the issuance of a CBDC that prevents the expansion of the use of stablecoins by offering a competitive and safer alternative to proposed private digital moneys. As explained in the next section, some desirable properties in the design of a CBDC (e.g., high interoperability, inexpensive and fast

transactions) may easily deter the potential expansion of stablecoins and other cryptoassets (regarding their demand as a means of payment; nevertheless, the speculative motive will remain—which may be very relevant in the case of the other cryptoassets).

However, as pointed out by Kahn (2022), the fact that the issuance of a CBDC may mitigate those stablecoin-related risks does not mean that it is the best or unique solution. Alternative solutions must be also assessed. For instance, the US President’s Working Group on Financial Markets released in 2021 a report (PWG, 2021) in which it makes several recommendations to the Congress to address potential risks of stablecoins, in terms of supervision and regulation (e.g., legislation should require stablecoin issuers to be insured depository institutions and the corresponding custodial wallet providers to be subject to federal oversight). It is also possible that a credible, low inflation and flexible exchange rate regime may be sufficient to minimize the risk of expansion of stablecoins if it also offers an efficient and fast payment system highly interoperable between private and public payment services with no need of CBDC issuance.

2.4. Fostering Financial Inclusion

Several definitions of financial inclusion have been proposed in the related literature. Perhaps one of the most complete is that of the World Bank (2022), which states that this concept measures the portion of individuals and businesses that have access to affordable financial products and services that meet their needs, including transactions, payments, savings, credit, and insurance, delivered in a responsible and sustainable way.

This definition leads us to examine the current criteria used to measure financial inclusion. The most known, unbanked population refers to the percentage of individuals or households that lack access to deposit accounts. An alternative measure, underbanked population, refers to individuals and firms that have deposit accounts at an insured institution and use alternative financial services (i.e. payday loans) to obtain funds outside the banking system (see FDIC, 2017). When comparing these measures, considering the World Bank’s definition, the latter seems to better reflect the degree of access of the population to formal financial services because it contains information on deposits and credit. But such a measure

is not available for the Colombian case, which forces us to work only with an imperfect measure of financial inclusion.

In Colombia, the national government program, Banca de las Oportunidades, states that financial inclusion has gone from having 57.3% of adults with at least one formal savings or credit financial service in 2009 to 91.8% in June 2022. But as mentioned in World Bank (2022), access to formal financial products is a necessary but not sufficient condition for improving financial inclusion since the effective use of these services is required. In terms of use (*Indicador de uso*, Banca de las Oportunidades), the percentage of adults with any active or valid financial product was 76.9% in June 2022. In fact, the situation is slightly different when analyzing the effective use of the financial services indicator, which shows lower levels, mainly in rural (54.8%) and dispersed rural (42.8%) areas, individuals over 65 years of age (57.7%), and in women (74.7%) by June 2022 (Ministerio de Agricultura de Colombia, 2020; Acosta and Londoño, 2022). These last results are in line with those reported by the last survey of Banco de la República on payments instruments usage, which reveals that the use of any financial product (i.e., deposits accounts, debit or credit cards, checkbooks, electronic deposits, or credits) was 56.9% in 2022.

Access to traditional forms of money (cash and deposits) implies, in some cases, a cost for its users. In fact, the costs associated with the use of some financial services is one of the reasons why some people are still unbanked (BIS, 2020). Both consumers and merchants incur some costs for using/accepting banking cards. Merchants must assume a cost for accepting debit and credit cards at the point of sale (POS), which are not negligible, and vary according to the size of the transaction (Kosse et al., 2017). Debit and credit card holders also assume costs, in the form of periodic fees, in the first case for the management of deposits account and in the second case for the right to finance their payments with credit (Kosse et al., 2017). Since these costs tend to limit the access of the unbanked population to these payment services, it is not surprising that lower banking costs are positively correlated with a greater financial inclusion. In short, the latter would allow better access to formal financial services (Allen et al., 2012).

In the past several years, FinTech innovations have driven impressive progress in financial inclusion, especially in emerging markets and developing economies. Most of this progress

has been fueled by new digital technologies, often supported by government and central bank policies. These strategies have ensured that households and businesses have access to safe and efficient payment options (BIS, 2020). These new technologies (e.g., payment applications and mobile money) have improved access and use of digital transactions, and the ability to pay and save in the formal financial system. They have been key drivers of progress in access to deposit accounts. For instance, increasing mobile phone ownership has helped users access different financial products without going to a bank branch, resulting in lower cost and higher efficiency.

The latest report from the Ministry of Telecommunications (second quarter of 2022) reveals that in Colombia the total number of mobile phones is 77.9 million, of which only 37.9 million allow internet access. That is, although most of these devices are smartphones, a considerable part are regular mobile phones (MINTIC, 2022). Thus, given that the total country's population is 52.2 million inhabitants, internet access through these devices is close to 72.6%. These figures explain that while access to mobile phones has increased over time, this has not necessarily translated into more effective use of digital payment services.

Many people remain outside the formal financial system due to persistent barriers to inclusion, such as high cost, low financial literacy, and low connectivity access in remote areas (Demirgüç-Kunt et al., 2018; Boakye-Adjei et al., 2022). The limited competition and concentrated market structures in the financial sector give rise to high transactional costs and poor services, which tend to limit access for low-income users. Another relevant barrier is geographic, and it is mainly related to rural and remote areas that have connectivity problems. In these areas, cash is still the best option, more convenient than a bank account or digital payments that require a bank branch, computer, or mobile phone (Rueda et al., 2015; Demirgüç-Kunt et al., 2018; Ozili, 2020).

While retail CBDC could address many barriers to financial inclusion, the question that remains is whether financial exclusion would be a sufficient reason for Banrep to issue a retail CBDC, especially when financial inclusion is a policy under the responsibility of the national government and the Central Bank does not have a specific mandate on this issue. Alternative solutions include introducing regulation that promotes competition among deposit institutions, reducing bank fees, and continuing to support financial education

programs that help individuals handle different financial products (i.e., savings or credit), compare different financial offers, and improve their confidence in formal financial institutions (see OECD, 2014).

2.5. Conclusions to Section 2

As discussed throughout this section, presumably none of the arguments considered are convincing cases for the public provision of digital money under the current conditions of the economy. However, this finding does not exclude the possibility that one of these might justify the issuance of the retail CBDC in the future. That would be the case of a sudden popularization of unregulated stablecoins which, as explained above, could reduce the transmission of monetary policy, lead to a fragmentation of the payment system, and represent potential risks to financial stability mainly related to the risk of redemption.¹² While this last issue could be lessened by implementing a proper regulation for stablecoins, the former two could lead the central bank to consider introducing retail CBDC in the economy.

3. Possible design aspects and properties of a retail CBDC for the Colombian case

While it is true that the motivations reviewed in Section 2 do not support the immediate issuance of a retail CBDC for the Colombian case, it is not at odds with the emergence of a strong argument that would support this initiative in the future. This Section selects some design aspects that could meet the needs of the country, which will define the main framework used to discuss the expected macroeconomic effects of a retail CBDC.

3.1. Retail CBDC architectures

The design of a retail CBDC critically depends on the technical architecture that defines its provision and payment related services. In the *direct CBDC*, the central bank performs all functions, from its issuance, distribution, and transfer to its redemption in other forms of

¹² Redemption risk may arise when the underlying asset(s) are insufficient to allow the stablecoin to be redeemable by its reference value. As a result, the peg value does not hold (see BIS, 2022d).

central bank money, like cash. In the *indirect CBDC*, which is also known as *synthetic CBDC*, this form of digital money will be a direct liability of commercial banks fully backed by their reserves at the central bank (see Adrian and Mancini-Griffoli, 2021). In contrast with these two extreme cases, the *hybrid* and *intermediated* architectures are in a better position to meet the needs of the Colombian economy than the other alternatives, since both rely on a public-private collaboration between the central bank and private entities providing payment services (PSPs).¹³ In these last two architectures, the retail CBDC will be a direct liability of the central bank which will be the exclusive issuer of this form of digital money, but commercial banks will be in charge of distributing it, in the same way it currently works with cash. These two-tier architectures only differ in that the central bank keeps the central ledger with all transaction's information in the hybrid model, while in the intermediated model it only maintains the wholesale ledger (Auer, Cornelli, and Frost, 2020; Auer and Böhme, 2021).

3.2. Other design aspects

The proper design of a retail CBDC would be key to determining its level of adoption by individuals and businesses. The levels of acceptance and use as a new payment instrument depend on some economic aspects, which can be adjusted to meet the central bank objectives as well as to secure the interest of potential users.

One of these aspects relates to whether the retail CBDC will be an interest-bearing asset or not. A non-interest bearing CBDC is more like a digital version of cash, while a positive interest-bearing CBDC would be a closer substitute for savings vehicles. But if the CBDC rate exceeds the rate paid by commercial banks on deposits, it could cause unwanted pressures on these latter, forcing them to use alternative liquidity sources to fulfil their intermediation function. A negative interest rate on CBDC would only be possible if cash disappears (or conversion limits are effectively imposed), since cash is the only form of

¹³ The central bank can also widen the range of institutions authorized to channel central bank money to individuals and businesses by additionally allowing payment services providers to fulfil this function. Payment services providers are private entities (banks and non-banks) that distribute the CBDC and offer payment related services.

money that guarantees the zero-lower bound of interest rates (see Bjerg, 2017). As regards this design aspect, an interest-bearing retail CBDC with a rate set below deposits rate could allow it to satisfy the store of value function better than cash, without causing disintermediation (and, in turn, negative effects on investment and economic activity) and without encouraging its use as a form of investment. However, since this design aspect can be subject to active debate, we leave it as a parameter that can take a zero or positive value in the following sections.

Data governance is another design aspect that could determine users' demand for a retail CBDC. Both the hybrid and intermediated architectures allow the central bank to set the level of privacy, by establishing rules that must be followed by the payment service providers. This requires the design of a specific regulation that will establish the appropriate treatment of the data collected, forbidding data sharing and trading. This regulation must be aligned with the current Data protection Law of Habeas Data (Law 1266 of 2008) that rules all financial transactions in the country.

Another important design consideration is the possibility of setting limits on users' holdings and/or spending of CBDC. These limits could safeguard users from cyberattacks targeting their balances or transactions and reduce the demand for retail CBDC as store of value in competition with bank accounts. Setting limits on retail CBDC holdings could also allow to deal with the tradeoff between privacy and transparency (i.e., in terms of the identification of users to fight fraud and illicit transactions (see Allen et al., 2020)). The Colombian central bank could offer digital wallets with small holding limits and a high level of privacy for people that place a high valuation to their transaction data. For those that are comfortable disclosing all their data, a wallet with high holding limits and low levels of privacy will meet their needs. No doubt, the protection of user transactions information will be key to ensuring a high level of adoption, which could be achieved by imposing reasonable limits to minimize the collection of users data.

Other technical design choices that the central bank will also need to select are the transmission mechanism or access framework (i.e., digital tokens vs digital accounts) and the technological infrastructure (centralized vs DLT -distributed ledger technology) on which this form of digital money will be based. These technical alternatives can be considered in

its due time, that is, after all the design aspects (economic and technological) have been selected.

3.3. Desirable properties in a retail CBDC

There are three technological aspects that could allow the central bank to offer a well-designed retail CBDC: interoperability, scalability, and resiliency. A fully interoperable system for all existing payment solutions would be desirable but may not be easy to achieve due to the different validation mechanisms that rule different systems (see Boissay et al., 2022). A retail CBDC interoperable with other forms of money could prevent the fragmentation of payment systems that occurs when users face costs or difficulties when paying users of other systems (Bank of Canada et al., 2020). Hence, the central bank should design the retail CBDC in a way that it would be freely exchanged with other forms of money, especially cash and bank deposits (Auer, Cornelli, and Frost, 2020). A fast payment system that is interoperable with other forms of money would be another way of avoiding the problem of fragmentation by facilitating transfers between closed-loop systems.

A second technical desirable property of retail CBDC consists of avoiding the scalability problems that have arisen in crypto assets transactions. A wide adoption and popularization of retail CBDC could provoke problems at times of peak usage. To avoid scalability problems the system requires sufficient technical capacity to handle high volumes of transactions without delays.¹⁴

Lastly, the retail CBDC must be resilient, which means having the capacity to rapidly resume operations after cyberattacks or failures in the critical infrastructure related to the functioning of the system, such as energy and internet. The latter (i.e., resilience to outages) is analyzed in the next section. With regard to cyber risk, it has become a major concern for the financial sector, primarily due to the increasing frequency and sophistication of recent cyberattacks directed to financial institutions and financial market infrastructures.

¹⁴ Project Hamilton conducted by the Boston Fed and the MIT's Digital Currency Initiative is exploring the improvement of the scalability properties of the CBDC system, among other technical challenges.

Since 2020, most central banks, and especially those in emerging market economies, have been increasing their investments in cyber security with the aim of developing a proper response to cyberattacks that could affect critical financial market infrastructures, like the large-value payment system (see Doer, et al., 2022).

With a retail CBDC in operation, intensive cyber security work would also be required to mitigate the risks that such attacks could represent to the CBDC infrastructure (either administered by the central bank or a private institution), the PSPs, and its users. Specific actions and strategies will need to be developed, with the aim of protecting the users of this form of central bank money, as well as guaranteeing the integrity and resiliency of the CBDC infrastructure and that of all its related services (e.g., issuance, distribution, and redemption). For Araujo (2022), the resilience of the CBDC system to this type of disruptions must be comparable to that adopted in other financial market infrastructures.

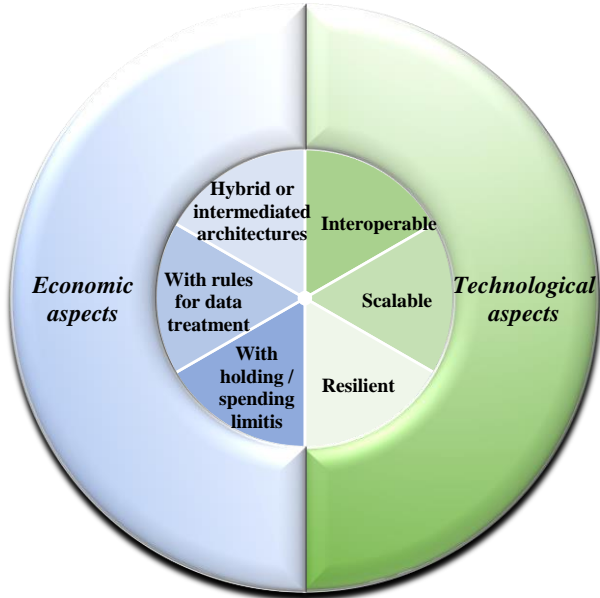


Diagram 2. Design aspects of a retail CBDC for the Colombian case

The design features of a retail CBDC that can satisfy the needs of the Colombian economy are summarized in Diagram 2. Three economic (i.e., hybrid or intermediated architectures, with rules for data governance, and holding and spending limits) and three technological (i.e., interoperable, scalable, and resilient) design aspects are selected. These design features are

used as a framework to delimit the analysis of its potential macroeconomic effects, which will be discussed in Section 5.

4. Microeconomic determinants of retail CBDC adoption

In section 2 we listed possible arguments in favor of developing a CBDC. These arguments are, however, irrelevant, if the CBDC as designed fails to generate a customer base. Payment services constitute a network, formed by a collection of users (nodes) connected by their transactions (links). An industrial organization viewpoint emphasizes the distinctive features of services provided in networks. According to Shapiro and Varian (1999), a product exhibits network externalities or network effects when its value to one user increases with the number of users. Payments services are an example of a market that exhibits network effects, to the extent that the suitability of a payment solution is strongly tied to its level of adoption (see BIS, 2022c). Thus, network effects play a crucial role in determining the demand of new users; as the number of users increases, the network effects will also increase. Because of network effects, it is difficult for a new payment method to achieve critical levels of use necessary to become viable. Some important payment instruments' characteristics that influence a consumer's choice of a means of payment are privacy, safety, and convenience (Humphrey, 2010). To achieve the required level of adoption, a new payment method needs to be sufficiently attractive in one of these dimensions to generate a critical mass of users, upon which the network effects can begin to work.

In this section we consider whether some of the features previously discussed can be used to attract an initial customer base to a retail CBDC. We focus on data privacy management, resiliency to unexpected incidents, and financial inclusion to analyze the conditions that would allow the monetary authority to have a critical mass of users for the retail CBDC. In each case, a group of clients can be evidence that particular characteristics such as certain balance between anonymity and transparency, the necessity of offline payments, or lack of access to regular financial services could represent a potential demand base for this type of digital instrument. It is essential to clarify that although there would be a potential source of demand for CBDC, these groups of people could consider other alternatives to meet their needs.

4.1. Data privacy management

In a payment ecosystem with a retail CBDC, the banked population will divide its holdings between deposits, cash, and the retail CBDC. Cash is the payment instrument that provides the highest level of anonymity to its users. Electronic and digital payment solutions (i.e., debit and credit cards, and electronic funds transfers) allow perfect traceability of transactions, as they identify both the sender and receiver of a payment, as well as the amount and time in which such payments were made. A similar level of traceability could apply to a retail CBDC, given that the central bank or PSPs will execute know-your-customers checks to prevent its use in illicit transactions. To encourage the use of CBDC by customers who value privacy, data privacy management should be governed by a specific regulation that limits recordkeeping to a minimum and inhibits its use for commercial purposes.

These issues have been examined in models with a variety of forms of money and agents with heterogeneous preferences regarding anonymity in their transactions (see Agur, Ari, and Dell’Aricia, 2022). Illicit activities usually involve transactions of high amounts and participants that seek to remain unidentified. However, not all transactions of high amounts are related to such activities, and not all individuals that place a high valuation on their privacy are engaged in illicit transactions. Hence, getting the right balance between anonymity and transparency is not straightforward. Besides, digital transactions that use regulated forms of money cannot be entirely anonymous, due to the tradeoff that exists between anonymity (privacy) and transactions transparency. Therefore, the combination of anonymity and transparency needs to be tailored to potential users.

The situation is made more complicated by asymmetric information as regards the type of CBDC users, defined in this case by those who highly value the privacy of their data, and those who are willing to share all their transaction information. The central bank cannot identify the user type before offering its digital currency. Thus, to attend all segments of potential users, it can design a menu of contracts that meet their needs, which could be represented by a set of digital wallets with different holdings limits and distinct levels of privacy (as mentioned in Section 3.3). Two or three combinations of these arguments could serve to meet the needs of all types of end users.

4.2. Resiliency to unexpected incidents

The CBDC infrastructure and all its related services should be resilient to the occurrence of power outages and internet failures, in the sense that it must continue operating, while avoiding double spendings and protecting the system from financial crimes. Specific actions should be designed to guarantee the resiliency of the CBDC infrastructure to disruptions, especially when using the retail CBDC offline.¹⁵ This might require the implementation of special protocols that allow the successful completion (settlement finality) of offline transactions in these contingencies.

Cash represents a useful alternative to digital payments in case of a service breakdown due to a temporary suspension of electricity or the internet. However, as the use of cash declines, the resilience of the electronic payment system becomes vital. Furthermore, power supply disruption or internet connection issues may be more frequent in some specific locations, e.g., because of geographical difficulties or poor infrastructure conditions where, in addition, it is more likely to find substantial barriers to financial inclusion. As a result, operational disruptions in payment systems usually affect some population groups more than others. Thus, operational resilience can be a factor of attractiveness for an initial set of users.

As remarked by the Bank of England (2020), the issuance and the design features of a CBDC may have significant (positive and/or negative) effects on the resiliency of the payment system. A CBDC may become victim of its own success if it reduces diversity of payment options and, consequently, discourages innovation and the speed of progress in resilience and efficiency of the entire system. In the same way, negative effects would also be expected if the CBDC substitutes cash and reduces its use (and supply) substantially, leaving the economy almost without an offline payment alternative. To avoid such effects the central bank needs to provide, linked to the CBDC system, a contingency against digital network disruptions. On the other hand, by providing an additional network a CBDC contributes to

¹⁵ Project Polaris, launched by the BIS Innovation Hub's Nordic Centre in February of 2023, is intended to explore the security and resilience issues that may arise when using the retail CBDC offline.

resilience in payments since it is less likely that two different networks (including that of CBDC) suffer interruptions at the same time.

We draw on Bank of England's (2020) analysis to briefly highlight two elements that may help increase CBDC's operational resilience. The first one is decentralization. Involving multiple entities to store and process data mitigates the risk of information loss and facilitates operational continuity despite interruptions in parts of the system. Moreover, decentralization may be useful to solve the aforementioned problem related to diversity in geographical conditions and difficulties. Of course, these benefits come at a cost in terms of efficiency (e.g., data duplication) and data privacy, and new challenges related to the need of coordination and synchronization among the entities involved. It is also essential that the central bank retains overall control of the CBDC network. The second aspect is the development of offline payments. As mentioned above, it is very important to mitigate potential risks in case of the use of cash drops significantly. However, to our knowledge, the development of this type of technologies is still experimental and costly. Some central banks are studying options, as mentioned by BIS (2022c): Bank of Canada have explored the use of universal access devices in which individuals securely store and transfer CBDCs. Something similar has been explored by Bank of Ghana, linked to the existing mobile money agent networks.

In short, the resilience of the CBDC system to the different types of incidents that may impact its normal operation may require the design of a robust infrastructure, which could offer the offline functionality in its services (avoiding double spending) while allowing its users to enjoy the benefits of positive network externalities.

4.3. Financial inclusion

As mentioned in Section 2.4, the cost associated with some financial services is one of the reasons why some people are still unbanked (BIS, 2020). As a result, there is a considerable group of people that remains without financial services, using cash in all their transactions. This section only considers the costs that could explain financial exclusion.

The costs of using cash in face-to-face transactions are non-pecuniary and are mostly represented by the costs of carrying banknotes and coins to the place where the transaction occurs. These costs affect both the banked and unbanked population. In non-face-to-face transactions, like e-commerce, the unbanked population must assume pecuniary costs represented by the fees for transferring funds or non-pecuniary costs represented by the risk of entrusting someone else to deliver the money. In general, the access of the unbanked population to digital transactions is limited, unless they incur additional fees to pay in advance for the purchase or use cash-on-delivery services if these are available.

The low availability or lack of POS terminals in retail businesses also plays a role in the consumers' preference for cash. That is the case of rural and/or remote areas, where most commercial activities are made in cash. POS terminals are more commonly found in formal businesses where low-income population (mostly unbanked) are less likely to shop. As a result, cash is the only payment instrument that can be used in these specific contexts (Mazzotta and Chakravorti, 2014).

The emergence of new payment solutions, mostly based on traditional banking and FinTech services, has reached a large portion of the population, especially the unbanked. In the last decade, the financial services offered by electronic deposits and payment services (SEDPEs) like Nequi and Daviplata, have allowed the population to execute retail payments without requiring a formal nexus with the financial system. Both SEDPEs have shown a substantial growth in recent years (e.g. Daviplata has gone from 5.9 million of clients in 2019 to 15.8 million in 2022).¹⁶ Indeed, SEDPEs services have contributed to improve financial inclusion at the customer's and merchants' levels (i.e. several informal businesses are already accepting payments with Nequi and Daviplata).

A retail CBDC can reduce transaction costs, which in the case of bank deposits, usually represent a high financial burden for the low-income population (Náñez et al., 2020). This digital form of money can also extend the benefits of using central bank money in digital payments at low or no cost, which would be particularly valuable for the unbanked

¹⁶ <https://www.larepublica.co/finanzas-personales/mas-de-ocho-millones-de-personas-usan-billeteras-digitales-en-colombia-2931216>

<https://www.larepublica.co/finanzas/los-colombianos-compraron-unos-6-4-billones-mediante-daviplata-el-ano-pasado-3548561>

population. Retail CBDC would be especially relevant in countries where maintaining a high volume of low-value payments and other financial services could allow the entry of new players, due to its complexity or unattractive character for commercial banks or e-money operators (e.g. SEDPEs), keeping many people without access to such services. In this way, CBDCs can help address the problem of insufficient reach of existing payment systems (Didenko and Buckley, 2021).

In short, introducing the retail CBDC in the Colombian economy could improve financial inclusion if this form of central bank money could attract the unbanked population as a customer base. To achieve this goal, the design of the digital currency should consider the possibility of offering its services with low or no costs for the population. The retail CBDC could allow these users to enter the financial system and the online world without assuming fees for these services, as it occurs when the private sector (i.e., banks or other financial institutions) provides them.

5. Expected macroeconomic effects

Since CBDC is a very recent topic and there is not much practical experience about it (e.g., at the moment of writing this report it is not yet in place in any major economy), it is still too early to have direct evidence of its macroeconomic impact. As mentioned by the Bank of England (2020), this is one of the topics for which further research is needed.

On the one hand, there might be some indirect evidence from a case like that of mobile-phone payment systems; however, such a case mainly corresponds to low-income countries (e.g., Kenya, Nigeria) and is primarily related to financial inclusion purposes. On the other hand, and in a more general view, there are some papers that intend to analyze the impact on welfare or some other macroeconomic variables from a theoretical perspective. This section is mostly based on the latter analysis with the caveat that such research is still in its early stages. It is expected that future studies, preferably from a general equilibrium perspective and considering very different situations (e.g., very distinctive CBDC design features), will provide more robust conclusions.

This section presents some potential macroeconomic effects that could be expected if the central bank decides to issue this form of digital money, considering mainly the framework described by the following set of design aspects: a retail CBDC that relies on a two-tier architecture (either hybrid or intermediated since, like in the current payment system, these options are based on public-private collaboration), with holding and spending limits (to tackle the inherent trade-off between privacy and security), and a specific regulation that will enable a proper data management. Since there is no definitive decision about offering the CBDC as a cash-like or as an interest-bearing asset, we consider different scenarios, with zero and non-zero interest rates.

5.1. Expected effects on interest rates and (potential) financial disintermediation

A retail CBDC might have important effects on the structure of the payment system and, as a result, on the entire economy. One instance in which those effects might occur is the level of bank intermediation. If the retail CBDC pays an interest rate higher than the one paid by bank deposits, commercial banks would need to increase their rates and still some level of disintermediation may occur, i.e., a reduction in funding for banks and, consequently, in the provision of credit. But even in the case that this form of digital money pays no interest (or a very low one) there may still be some pressure for disintermediation caused, for instance, by lower transactions costs associated to CBDC payments and transfers compared to banks deposits. In any case, a permanent decline in lending supply (or an increase in its cost) would affect investment, innovation, and economic growth.

A possible solution to the potential disintermediation problem would require the central bank to significantly increase lending to compensate for the reduction in commercial bank funding (Brunnermeier and Landau, 2022).¹⁷ This may imply changes such as accepting lower collateral quality from banks. If, instead, the central bank decides not to lower the collateral quality requirements, the size of the non-collateralized interbank market may increase substantially and the monetary policy rate would become less relevant for the determination

¹⁷ Brunnermeier and Niepelt (2019) maintain that with a strong commitment from the central bank to serve as lender of last resort, the issuance of CBDC there would not cause a reduction in bank funding but only a change in its composition.

of other market interest rates (i.e., a weakening of monetary policy transmission and effectiveness). The Bank of England (2021) calls attention to the fact that it is also likely that commercial banks need to borrow more frequently and unexpectedly in wholesale money markets (increasing volatility in market interest rates) and try to get additional funding from longer-term sources (which may reduce maturities mismatch in their intermediation function but will also increase their funding costs). Another form of partial mitigation of the problem would be to impose spending and/or holding limits such that large savings and transactions are still processed through commercial bank accounts.¹⁸

Vargas (2022), based on the analysis of Andolfatto (2021) (who models the case of a monopolist commercial bank), concludes that for the case of Colombia, where the banking sector exhibits high levels of concentration, there would be minimum impact on the level of intermediation and the lending rates. A monopolist bank optimally links its lending rate to the monetary policy rate and not to the CBDC interest rate. If the CBDC rate is higher than the one for deposits, the monopolist bank will increase the latter to match the former one, and hence the CBDC would substitute cash but not deposits in equilibrium. Furthermore, the monetary policy transmission to deposit rates could be weakened (if those rates match and become fixed at the CBDC rate) but then, as already mentioned, a greater fraction of bank funding would be directly linked to the policy rate and such a rate would keep being the relevant cost for bank lending, i.e., the transmission to lending rates would have very limited impact.¹⁹

5.2. Expected effects on Financial Stability

Besides financial disintermediation, other potential effects of retail CBDC on financial stability relate to bank risk taking, effects on competition, and susceptibility to bank runs. Similar effects and risks could arise from new forms of privately provided digital money (i.e., stablecoins); therefore, regulatory authorities should establish adequate regulation that limits

¹⁸ A design-related solution to the disintermediation problem would be the implementation of a hybrid (or two-level) retail CBDC in which, as explained in Section 3, the issuance is the responsibility of the central bank but the private sector (e.g., commercial banks) is in charge of the distribution.

¹⁹ Instead, under a perfectly competitive banking system, banks pass the increase in funding costs to the borrowers and therefore aggregate lending falls (Keister and Sanches, 2021).

unintended consequences on the financial system and the entire economy. These regulatory requirements for digital forms of money, whether privately or publicly provided, are out of the scope of this document.

As mentioned in the previous subsection, the introduction of a retail CBDC in the economy may influence bank funding given that it can make bank customers prefer to shift their deposit account balances into this new form of central bank money. Any loss in customer deposit funding base (i.e., if the CBDC design features — e.g., interest-rate bearing — imply the substitution of deposits rather than the substitution of cash) would require banks to consider a combination of actions to try to maintain regulatory ratios and risk-adjusted profitability.²⁰ These could include partially switching to alternative market-based funding sources that could be more expensive and less stable, increasing bank risk taking and lending rates, or leveraging its role as a retail CBDC intermediary, to reduce its assets or deleveraging. If, on aggregate, banks switch to alternative funding sources, such as issuing long-term debt, their funding costs would increase, which could reduce their profitability if they continue to lend at the same interest rates they charged before the retail CBDC was offered. If, on the other hand, banks want to keep their profitability level unchanged, they will increase interest rates on loans, which could make them more sensitive to market conditions (see BIS, 2021b).

The retail CBDC could additionally increase the level of competition in the deposit market. In this regard and under the scenario of an imperfectly competitive banking system, Chiu et al. and Andolfatto (2021) argue that if this form of digital money is remunerated (at a relatively low rate) greater allocative efficiency is achieved: higher competition induces more favorable contractual terms for depositors and hence increases the supply of deposits, which in turn expands bank lending. In other words, the introduction of the retail CBDC could limit monopoly profits of banks and induce them to offer more loans to individuals and firms. In contrast, it has been claimed that the retail CBDC could also change the structure of the banking system, especially that of small banks with little access to wholesale funding

²⁰ Canadian household survey data estimates that households could hold from 4% to 55% of their combined cash and deposit holdings in CBDC depending on the features of the CBDC (lower estimates would likely apply for more cash-like features, while higher estimates would reflect a CBDC similar to bank deposits). Bank of England considers an illustrative scenario in which about 20% of household and corporate deposits migrate to CBDC owing largely to non-financial factors such as safety and convenience (BIS, 2021b).

markets. In such a case, it could be expected a wave of mergers and acquisitions that could end up giving rise to a much more concentrated banking sector (BIS, 2021b).

Another potential impact of the retail CBDC relates to an increase in the likelihood of bank runs during periods of financial stress; however, this possibility hinges on the CBDC's design features. In a payment system where deposits and CBDC are close substitutes, e.g., with an interest-bearing CBDC, it could be expected that bank customers may be more willing to make substantial transfers of their bank deposits (into retail CBDC's accounts or digital wallets) when they perceive some signals of financial stress. In contrast, the implementation of a cash-like CBDC would not seem to increase the probability of bank runs with respect to the current scenario, since there already exists online and hence rapid access to bank transfers and withdrawals, and such a CBDC would not decrease the cost of substituting deposits. In general, the issuance of a retail CBDC would not significantly modify the main drivers of bank runs, but some potential negative effects could be mitigated, especially if it is based on an architecture administered by commercial banks (either hybrid or intermediated). Moreover, a retail CBDC that improves payment efficiency would reduce the impact of bank runs (Auer et al, 2021b).

As a result of the above reasons, commercial banks might need to adapt their own practices and adjust their regulatory parameters if the retail CBDC is issued. A clear example in this line is the liquidity coverage ratio (LCR) regulation, where outflow parameters for deposits are calibrated based on observed outflow rates during times of stress. If the issuance of the central bank digital currency or a major dominant private digital currency increases the outflow risk of such deposits, the corresponding outflow rates may need to be reassessed (BIS, 2021b). Furthermore, the central bank's lender of last resort (LOLR) framework could also be reviewed in these scenarios, to expand either the eligible collateral or the type of financial institutions with access to these facilities.

Other financial institutions could also be impacted by the issuance of a retail CBDC, since this form of money could become a substitute for investments in low risk and liquid assets, such as Money Market Funds (MMFs) and Treasury Bills. Depending on design features (e.g., ability to redeem MMF shares directly into CBDC or access to institutional use) and its remuneration, the introduction of the CBDC could be an attractive alternative for some risk-

averse holders of other cash-like instruments, even under non-stressed conditions. This would impact the demand for assets that MMFs invest in (mainly government bonds, commercial papers, and term deposit certificates), possibly affecting yields and the volume of money market transactions.²¹ However, as mentioned in Section 3.2, by imposing CBDC holding limits to end users, this, and other types of situations (i.e., the tradeoff between privacy and security) could be easily controlled.

5.3. Expected effects on other macroeconomic variables and monetary policy

Transmission of monetary policy

CBDC might enhance the transmission of monetary policy. On the one hand, and especially under the interest-bearing design, by promoting more competition in the financial sector. On the other hand, CBDC might increase the proportion of money directly linked to monetary policy decisions. This is explained by Meaning et al. (2021) who argue that a narrow version of CBDC already exists in the form of central bank reserves (a position also sustained by Niepelt, 2020) and the big change with the issuance of a retail interest-bearing CBDC would be introducing universal access (i.e., including nonfinancial business and households). It could be used for monetary policy in much the same way that central bank reserves are used now, and the monetary transmission mechanism would be stronger because of widening access to electronic central bank money.

Garratt, Jiaheng and Haoxiang (2022) show that it would be better to design a retail CBDC with a high level of convenience (e.g., speed, privacy, and access to digital markets, among others) than a remunerated CBDC. The rationale behind this finding works as follows. A remunerated CBDC (that pays an interest rate above the policy rate or the interbank interest rate) will amplify the competition on the rates offered in the deposit market and, therefore, the responses of commercial banks to changes in the policy rate. However, it may also represent a disadvantage for small banks, as they will have to offer higher deposit rates to

²¹ This is a relevant financial stability concern, since the potential impact of CBDC on money market transactions, specifically overnight unsecured deposit transactions in which MMFs are key participants, are used to determine interest rate benchmarks.

compensate for the high convenience services usually offered by large banks. In contrast, a retail CBDC that offers high levels of convenience in a universal way would level the field of such services for all banks and put some pressures on the deposits market. Through these arguments the authors support the issuance of a non-remunerated retail CBDC that, in essence, would be equivalent to digital cash.

Previous literature has also brought up the fact that a CBDC with a negative interest rate might relax the zero lower bound (ZLB) constraint (e.g., Bank of England, 2020; Brunnermeier and Landau, 2022); however, if CBDC coexists with cash it is unlikely that there might occur a significant change in the lower bound on policy rates (BIS, 2021a). If CBDC is easily convertible to cash (as it should be while both payment forms coexist), trying to impose a negative interest rate on the former will essentially cause large amounts of its holdings to shift to the latter. On the other hand, Barrdear and Kumhof (2016) assert that even without the need of negative interest rates, CBDC helps face a ZLB event because it opens the possibility of CBDC-funded asset purchases which, unlike standard quantitative easing, may involve a direct exchange with the non-bank sellers of the corresponding assets, without involvement from commercial banks (reducing the compensating effect that arises from banks partially offsetting increases in their balance sheets).

If a negative interest-bearing CBDC is possible and hence the interest rate is no longer constrained by a lower bound, Bordo and Levin (2017) assert that the need to maintain a positive “inflation buffer” is eliminated, since the ZLB is currently a key reason to target positive inflation rates. Consequently, the monetary policy strategy could ensure that the value of the CBDC remains constant over time in terms of consumer prices, achieving a price-level targeting scheme which, as demonstrated by the economic literature, corresponds to the optimal monetary policy, and provides substantial benefits to macroeconomic stability.²²

²² However, it must be clarified that targeting a constant level of prices is neither the only form of price-level targeting nor the most standard one in the corresponding literature, i.e., price-level targeting does not imply that prices must remain constant over time.

Gross domestic product and Welfare

Regarding the effects on other macroeconomic variables, the literature is just beginning to develop, and it is exclusively focused on advanced economies (e.g., US, Canada). For instance, Barrdear and Kumhof (2022) find, for the US case, that maintaining a stock of interest-bearing CBDC equal to 30% of gross domestic product (GDP) could permanently raise GDP by 3%, due to lower real interest rates (by reason of a substitution of defaultable debt by non-defaultable low-interest CBDC), lower distortionary taxes (as a result of the reduction in the cost of government financing), and lower monetary transaction costs (due to increased liquidity as the money created by the central bank, independently of the banking system, is not subject to part of the financial frictions and regulations faced by that system). Davoodalhosseini (2022) studies the cases of the US and Canada and concludes that introducing an interest-bearing CBDC is welfare improving provided that the additional cost of carrying CBDC (the need of adopting electronic devices and applications) be small. In this case the CBDC may help the economy achieve the first-best level of production.

Agur et al. (2022) set up a theoretical model that incorporates payment-instrument network effects and a tradeoff between privacy and security. An interest-bearing CBDC that closely competes with bank deposits would depress credit and output but, on the other hand, a cash-like (non-interest-bearing) CBDC may lead to cash disappearance (due to network effects i.e., low use and low acceptance reinforce each other) and a welfare loss for the reduction in payment-instrument diversity. As explained in previous sections, this diversity is a positive feature for the resilience of the payment system. To avoid cash elimination, or to reduce the speed at which it happens, the central bank could implement a negative CBDC interest rate (Agur et al. 2022) although in practice such a policy may be ineffective (when both CBDC and cash coexist, as previously mentioned) or politically difficult to be accepted.

Inflation

By means of a historical perspective (data from eight advanced economies), Chen and Siklos (2022) propose to understand CBDC merely as the latest improvement in a long line of financial innovations. Using long historical time series, the authors analyze the impact of

technological changes in payment systems on the velocity of circulation and inflation.²³ They conclude that these innovations have had limited impact on inflation and so will be the case with CBDC.

5.4. More efficient transfer of subsidies to specific segments of the population

Although access to digital payment services has grown substantially in recent years, it still presents considerable barriers for some segments of the population. Within these barriers are the cost of transactions and the remote geographic areas where part of the unbanked population resides (see Subsection 2.4). The first barrier is commonly related to the high intermediation margins with which commercial banks operate, given that it can discourage them from offering their services to low-income segments of the population (Garcia et al., 2013). The second barrier is commonly attributed to the lack of adequate connectivity and infrastructure, which is much more pronounced in geographically remote locations (Banerjee, 2015).

As has been previously discussed in this document, the retail CBDC can broaden the access of the unbanked population to formal financial services, primarily through the provision of low-cost transactional services.²⁴ This feature would be key to promoting government programs designed to provide support to the underprivileged. One of these programs in Colombia is “*Ingreso Solidario*”, created by the government in April 2020 to financially support the low-income population during the COVID-19 pandemic. This program used digital wallets to deliver funds transfers to its beneficiaries through electronic deposit and payments specialized societies (i.e., *SEDPEs*).

²³ Financial innovations in the payment system are empirically proxied by two alternative and widely used measures: either the currency-money ratio (notes plus coins in circulation over a broad money measure) or the ratio of total non-bank financial assets to GDP.

²⁴ The macro effects of introducing a retail CBDC (eNaira) in Nigeria, after its first year of operation, are limited. Although eNaira has had a smooth start with operational resiliency capabilities, the project needs to go beyond the initial users. Therefore, for the second phase of this project, the central bank plans to incorporate clients without bank accounts and without Internet services. One of the expected effects of the second phase of the project is the improvement of social cash transfer programs, by enabling mobile access to faster, more manageable, and less expensive transfers through the retail CBDC (Ree, 2023).

The retail CBDC has the potential to facilitate the transfer of government subsidies to specific segments of the population and, at the same time, increase the use of formal financial services. These goals could benefit from a robust technological infrastructure that would accompany the digital currency and that should be available throughout the country, even in remote areas (Auer et al., 2022).

5.5. Conclusions to Section 5

As remarked in the introduction of this section, it is still early to have empirical evidence or theoretical consensus about the potential macroeconomic effects of issuing a retail CBDC. Besides, those effects will depend critically on the specific design features that are ultimately chosen. Although the potential benefits (i.e., enhancing monetary policy transmission and increasing efficiency of transfers) are somewhat relevant, we believe that for the discussion about whether or not issuing a retail CBDC, the central bank should pay particular attention to the possible impact on financial disintermediation (and the best policies or design features to mitigate it -e.g., imposing holding and spending limits or considering a non-remunerated CBDC), since it appears to be the main and common factor of negative macroeconomic and financial stability effects.

General Conclusions and Policy Recommendations

The emergence of new technologies in payment services has entered the policy debate, which has led central banks to consider the possibility of issuing their currencies in digital form. Some central banks are leading the research and development of a retail CBDC (the central banks of Canada, China, Sweden, and the ECB), but some of these and many others have also taken a cautious approach by studying the issue and even conducting experiments and pilots but delaying the release of an official position on that subject. To date, no major economy has issued its currency in digital form, however most central banks are engaged in studying this topic to better understand the potential benefits and risks of undertaking this initiative. Banco de la República (Banrep) is not an exception, and it has formed working

groups to study the economic, technological, and legal aspects in order to build its own position on this issue.

The first contribution of the present paper is underlining some possible considerations that Banrep might have for an eventual issuance of a retail CBDC. Nonetheless, it seems that none of the motivations considered (i.e., developing the digital economy, improving efficiency and safety in retail payments, forestalling wide adoption of stablecoins, and fostering financial inclusion) are currently convincing cases for the public provision of digital money. This is the case because of the current conditions of the Colombian economy and the fact that for most of these situations there seem to be alternative solutions (e.g., fast payment systems). However, this conclusion does not exclude the possibility that one of these might justify the issuance of the retail CBDC in the future. That could be the case under a sudden popularization of unregulated stablecoins or a retail CBDC issued by another country, which could reduce the transmission of monetary policy, lead to a fragmentation of the payment system, and represent potential risks to financial stability.

The document also contributes by studying the potential macroeconomic effects that the issuance of central bank money in digital form could cause to the Colombian economy. To this end, the paper describes and analyzes some different design features and their possible effects on the economy if the central bank decides to introduce this form of money. Based on this analysis and the previous literature, if Banrep decides to issue a retail CBDC, it seems that the most likely and convenient design would be based on a tiered architecture (either the hybrid or intermediated, as both rely on a public-private collaboration between the central bank and private entities providing payment services), with holding and spending limits to tackle the inherent trade-off between privacy and security, resilient to incidents that could affect users, providers, and the financial architecture that accompanies this digital currency, and without remuneration (to minimize potential disintermediation effects). The retail CBDC will coexist with cash and is expected to fulfil the functions of a payment instrument, thus allowing individuals and businesses to make their routine payments in digital channels and in person in a highly efficient way. Therefore, this new form of central bank money will not entirely fulfil other money properties such as unit of account and store of value functions. The unit of account will continue to be satisfied by the physical representation of the local

currency (cash), but it will also be fulfilled by the retail CBDC, both denominated in Colombian pesos. As regards the store of value function and as mentioned before, the retail CBDC would be subject to different holding limits that allow the central bank and PSPs to differentiate potential users by their identification profiles.

Considering the scenario described by the abovementioned design aspects, the expected macroeconomic effects of introducing this form of digital money into the economy would be nil, especially its potential detrimental disruptive effects on both financial intermediation and financial stability. Regarding the former (i.e., financial disintermediation), in any case the policy rate would keep being the relevant cost for bank lending. Regarding the latter (i.e., financial stability), no major changes are foreseeable to the extent that the holding limits imposed by the central bank reduce the likelihood of bank runs and financial stress. It is however recommended to keep an eye on the future developments of the related literature to have an updated and more precise analysis of the potential macroeconomic effects of choosing these or other design features. Furthermore, as remarked by Section 4, the decision of issuing a retail CBDC must consider the fact that it would also need to have enough desirable features to generate a core group of users sufficient to generate the network externalities needed to make it viable.

Even if the central bank decides to delay or not undertake for the time being this initiative, a policy recommendation would point to the need that supervisory authorities develop regulatory standards and frameworks to strengthen the resilience of the domestic financial system, by introducing general standards that accompany all forms of digital money, whether privately (stablecoins) and publicly (the retail CBDC) provided. Specific rules defining data governance will be required for both BigTech and FinTech companies providing stablecoins, and PSPs in charge of distributing and offering payment-related services for retail CBDC users.

References

Acosta, L., Londoño, F. (2022). Reporte de Inclusión Financiera Trimestral a junio de 2022. Banca de las Oportunidades.

- Adrian, T., Mancini-Griffolli, T. (2021). “The Rise of Digital Money”, *Annual Review of Financial Economics*, 13.
- Agur, I., Ari, A., Dell’Aricia G. (2022). “Designing central bank digital currencies”, *Journal of Monetary Economics*, 125, 62-79.
- Allen, F., Demirgürc-Kunt, A., Klapper, L., Martínez, M. (2012). “The Foundations of FI. Understanding Ownership and Use of Formal Accounts”, *Policy Research Working Paper, The World Bank. Development Research Group, Finance, and Private Sector Development Team*.
- Allen, S., Čapkun, S., Eyal, I., Fanti, G., Ford, B., Grimmelmann, J., Juels, A., Kostianen, K., Meiklejohn, S., Miller, A., Prasad, E., Wüst, K., Zhang, F. (2020). “Design choices for central bank digital currencies: policy and technical considerations”, NBER Working paper 27634.
- Allen, F., Gu, X., and Yagtiani, J. (2022). “FinTech cryptocurrencies and CBDC: Financial Structural Transformation in China”, *Journal of International Money and Finance*, 124.
- Andolfatto, D. (2021). “Assessing the Impact of Central Bank Digital Currency on Private Banks”, *The Economic Journal, Royal Economic Society*, 131(634), 525-540.
- Araujo, F. (2022). “Initial steps towards a central bank digital currency by the Central Bank of Brazil”, BIS paper 123.
- Auer, R., Banka, H., Boakye-Adjei, N. Y., Faragallah, A., Frost, J., Natarajan, H., & Prenio, J. (2022). Central bank digital currencies: a new tool in the financial inclusion toolkit. *World Bank Group and Bank for International Settlement Financial Stability Institute Insights on Policy Implementation*, (41).
- Auer, R., Böhme, R. (2021). “Central bank digital currency: the quest for minimally invasive technology”, BIS Working Paper 948.
- Auer, R., Cornelli, G., Frost, J. (2020). “Rise of central bank digital currencies: drivers, approaches, and technologies”, BIS Working Paper 880.
- Auer, R., Haene, P., Holden, H. (2021a). “Multi-CBDC arrangements and the future of cross-border payments”, BIS Papers 115, March.
- Auer, R., Frost J., Gambacorta, L., Monnet, C., Rice, T., Song, H. (2021b). “CBDCs: motives, economic implications and the research frontier”. BIS Working Papers, No. 976.
- Auer, R., Banka, H., Boakye-Adjei, N., Faragallah, A., Frost, J., Natarajan, H., Prenio, J. (2022). Central bank digital currencies: a new tool in the financial inclusion toolkit, FSI insights on policy implementation No 41.
- Balz, B. (2022). The Landscape in 2030: CBDCs or Private Digital Payment Solutions?, Central Banks Payments Conference, June 29.

Banco de la República (2020). “Informe de la Junta Directiva al Congreso de la República”, August.

Banco de la República (2022a). “Reporte de Sistemas de Pago”, June.

Banco de la República (2022b). Resultados de la encuesta de percepción sobre el uso de los instrumentos para los pagos habituales en Colombia - 2022. DSIF.

Banerjee, S. (2016). Aadhaar: Digital inclusion and public services in India. *World Development Report*, 81-92.

Banerjee, S. S. (2015). From cash to digital transfers in India: the story so far. *CGAP Brief, Consultative Group to Assist the Poor (CGAP), Washington, DC*.

Bank of Canada, ECB, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, Board of Governors Federal Reserve System, BIS (2020). “Central bank digital currencies: foundational principles and core features”, Report 1.

Bank of England, (2020). “Central Bank Digital Currency. Opportunities, challenges and design,” Bank of England Discussion Paper, March.

Bank of England, (2021). “New Forms of Digital Money,” Bank of England Discussion Paper, June.

Bank of Japan (2022). Liaison and Coordination Committee on Central Bank Digital Currency, Interim Report.

Barrdear, J., Kumhof, M. (2016). “The macroeconomics of central bank digital currencies”, Bank of England Staff Working Paper 605. July.

Barrdear, J., Kumhof, M. (2022). “The macroeconomics of central bank digital currencies”, *Journal of Economic Dynamics and Control*, Elsevier, 142(C).

Bindseil, U. (2020). “Tiered CBDC and the financial system”, ECB Working paper 2351.

BIS (2020). “Payment aspects of financial inclusion in the fintech era” Committee on payments and market infrastructures, BIS Papers No. 191, April.

BIS (2021a). “CBDCs: an opportunity for the monetary system,” in BIS Annual Economic Report 2021, Chapter 3, Bank for International Settlements, June.

BIS (2021b). “Central Bank Digital Currencies: financial stability implications”. Report No. 4, September.

BIS (2022a). “CBDC in emerging market economies”, BIS Papers No. 123, April.

BIS (2022b). “The Future Monetary System”, BIS Annual Economic Report, June.

BIS (2022c). “The Future Monetary System”, speech by Hyun Song Shin, Economic Adviser and Head of Research, Bank for International Settlements. Basel, June 26.

BIS (2022d). “Prudential treatment of cryptoasset exposures”, December.

- Bjerg, O. (2017). “Designing new money- the policy trilemma of central bank digital currency”, CBS Working Paper, June.
- Boakye-Adjei, N., Auer, R., Frost, J., Prenio, J., Banka, H., Faragallah, A., Natarajan, H. (2022). “Central bank digital currencies: a new tool in the financial inclusion toolkit?”, FSI Insights, April.
- Boissay, F., Cornelli, G., Doerr, S., Frost, J. (2022). “Blockchain scalability and the fragmentation of crypto”, BIS Bulletin 56.
- Bordo, M., Levin, A. (2017). "Central Bank Digital Currency and the Future of Monetary Policy," NBER Working Papers 23711, National Bureau of Economic Research, Inc.
- Brunnermeier, M., Niepelt, D. (2019). “On the equivalence of private and public money”, *Journal of Monetary Economics*, 106(C), p. 27-41.
- Brunnermeier, M., James, H., and Landau, J. (2021). “The digitalization of money”, BIS Working Paper 941, May.
- Brunnermeier, M., Landau, J. (2022). “The digital euro: policy implications and perspectives.” Study requested by the committee on Economic and Monetary Affairs, European Parliament.
- Chen, H., Siklos, P. (2022). “Central bank digital currency: A review and some macro-financial implications”, *Journal of Financial Stability*, 60, pages 1-19.
- Chiu, J., Davoodalhosseini, M., Jiang, J., Zhu, Y. (2019). “Bank Market Power and Central Bank Digital Currency: Theory and Quantitative Assessment.” Bank of Canada Staff Working Paper, 2019-20, May.
- Cooper, B., Esser, A., Allen, M. (2019). “The use cases of central bank digital currency for financial inclusion: A case for mobile money”. *Cenfri*.
- Davoodalhosseini, S. (2022). “Central bank digital currency and monetary policy”, *Journal of Economic Dynamics and Control*, 142(C).
- Demirgüç-Kunt, A., Klapper, L., Singer, D. and Ansar, S. (2018). The Global Findex Database
- Didenko, A., Buckley, R. (2021). Central Bank Digital Currencies: A Potential Response to the Financial Inclusion Challenges of the Pacific. *UNSW Law Research Paper*, (21-63).
- DNP (2018). Pacto por la transformación digital de Colombia: Gobierno, empresas, universidades y hogares conectados con la Era del Conocimiento.
- Doer, S., Gambacorta, L., Leach, T., Legros, B., Whyte, D. (2022). “Cyber risk in central banking”, BIS Working paper 1039, September.
- Eichengreen, B. (2022). “Digital Currencies — More than a Passing Fad?”, *Current History*, 121 (831).

FDIC —Federal Deposits Insurance Corporation— (2017). “FDIC National Survey of Unbanked and Underbanked Households”.

FSB (2020). “Enhancing cross-border payments: stage 3 roadmap”, October.

Garcia, N., Grifoni, A., Lopez, J.C. and Mejía, D., (2013), “Financial Education in Latin America and the Caribbean: Rationale, Overview and Way Forward”, OECD Working Papers on Finance, Insurance and Private Pensions, No.33, OECD Publishing.

Garratt, R., Jiaheng, Y., Haoxiang, Z. (2022). “The case for convenience: how CBDC design choices impact monetary policy pass-through”, BIS Working Paper 1049.

Humphrey, D. (2010). “Retail payments: New contributions, empirical results, and unanswered questions”, *Journal of Banking and Finance*, 34, 1729-1737.

Kahn, Ch. (2022). “Should the US issue a Central Bank Digital Currency? Lessons from abroad. Department of Finance, University of Illinois, May.

Keister, T., Sanches, D. (2021). “Should Central Banks Issue Digital Currency?” Working Papers 21-37, Federal Reserve Bank of Philadelphia.

Kosse, A., Chen, H., Felt, M. H., Jiongo, V. D., Nield, K., Welte, A. (2017). *The costs of point-of-sale payments in Canada* (No. 2017-4). Bank of Canada Staff Discussion Paper.

Lee, A. (2021). “What is programmable money?”, FedNotes, June 23.

Mazzotta, B., Chakravorti, B. (2014). The cost of cash in Mexico. *The Institute for Business in the Global Context*.

Meaning, J., Dyson B., Barker, J., Clayton, E. (2021). “Broadening Narrow Money: Monetary Policy with a Central Bank Digital Currency”, *International Journal of Central Banking*, 17(2), 1-42, June.

Ministerio de Agricultura de Colombia (2020). Estado de la inclusión financiera de las mujeres rurales en Colombia.

<https://colombia.unwomen.org/es/biblioteca/publicaciones/2020/12/estado-inclusion-financiera-mujeres-rurales-colombia>

MINTIC – Ministerio de Tecnologías de la Información y las Telecomunicaciones (2022). Boletín trimestral de las TIC: cifras a segundo trimestre de 2022, October.

Náñez A., Echarte, S., Fernández, M., Sanz D., Kaczmarek, J. (2020). Reasons fostering or discouraging the implementation of central bank-backed digital currency: A review. *Economies*, 8(2), 41.

Niepelt, D. (2020). “Reserves for All? Central Bank Digital Currency, Deposits, and Their (Non)-Equivalence”, *International Journal of Central Banking*, 16(3), 211-238, June.

OECD (2014). “PISA 2012 Results: Students and Money: Financial Literacy Skills for the 21st Century”. (Volume VI), PISA, OECD Publishing. Chapter 1: The assessment of financial literacy in PISA 2012, 25-52.

Orr, A. (2022). “The Future of Money demands innovation”, Speech Angel Association New Zealand Summit, February

Ozili, P. (2020). Optimal financial inclusion. In *Emerging Market Finance: New Challenges and Opportunities*. Emerald Publishing Limited.

Parra, J., Arango, C., Bernal, J., Gómez, J.E, Gómez, J., León, C., Machado, C., Osorio, D., Rojas, D., Suárez, N., Yanquen, E. (2019). “Criptoactivos: análisis y revisión de literatura”, *Revista ESPE*, Banco de la República de Colombia, 92, 1-37, November.

PWG (2021). “Report on Stablecoins,” President’s Working Group on Financial Markets, the Federal Deposit Insurance Company, and the Office of the Comptroller of the Currency, November.

Ree, J. (2023). “Nigeria’s eNaira, One Year After”, IMF Working Paper WP/23/104, May.

Riksbank (2021). E-krona pilot Phase 1.

Rueda, L., García-Bohórquez, N., Esguerra-Umaña, M., Cano-Sánchez, C., Velasco-Martínez, A. (2015). *Inclusión financiera en Colombia*. Capítulo 6. Inclusión financiera en Colombia, 143-211.

Shapiro, C., Varian, H. (1999). “Information rules: a strategic guide to Network Economy”, Cambridge, Mass.

Usher, A., Reshidi, E., Rivadeneyra, F., Hendry, S. (2021). “The positive case for a CBDC”, Bank of Canada, Staff Discussion Paper 2021-11.

Vargas, H. (2022). “Some thoughts about the issuance of a retail CBDC in Colombia”, BIS Papers chapters, in: Bank for International Settlements (ed.), *CBDCs in emerging market economies*, 123, 49-64.

Waller, Ch. (2021). “CBDC – A solution in search of a problem?”, Speech at the American Enterprise Institute, Washington D.C., August 5.

World Bank (2022). Financial inclusion is a key enabler to reducing poverty and boosting prosperity. <https://www.worldbank.org/en/topic/financialinclusion/overview>