UNIVERSIDADE CATÓLICA PORTUGUESA

The Central Banks' Approach to Digital Currencies

A Literature Review

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A Literature Review

Final Work in Academic Context presented to Universidade Católica Portuguesa in order to obtain the master's degree in Finance

by

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Resumo

Considerando a relevância crescente das moedas digitais e a constante especulação relativamente ao seu futuro, este trabalho procura analisar a literatura existente relativa ao tratamento dado pelos bancos centrais a moedas digitais. Através de uma revisão de literatura sistemática, o foco está nas moedas digitais emitidas por bancos centrais, nos seus prós e contras, e no debate relativamente à forma como estas devem ser desenhadas. Assim, conseguimos perceber que há um domínio dos prós relativamente aos contras e que os autores demonstram uma clara preferência por uma moeda digital de retalho disponível para todos os intervenientes.

Número de palavras: 9 357

Palavras-chave: Moedas Digitais Emitidas por Bancos Centrais. CBDC. Bancos Centrais. Inovação. Desintermediação. CBDC Design. Inclusão Financeira.

Abstract

Considering the growing relevance of digital currencies and the constant speculation regarding their future, this work aims to analyze the existing literature on the treatment given by central banks to digital currencies. Adopting the form of a systematic literature review, we focus on central bank digital currencies, debating their pros and cons, and elaborating on how they should be designed. We find that the pros seem to outcome the cons, and that there is a clear preference from the authors for a retail digital currency.

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Keywords: Central Bank Digital Currencies (CBDC). Central Banks. Innovation. Disintermediation. CBDC design. Financial Inclusion.

Index

Figure Index

Table Index

1. Introduction

The constant development and innovation in technology leads to the necessity of modernization and change. The financial and the payment systems are not immune to this phenomenon. According to a World Bank report, 76% of the adult population had an account either at a bank, other financial institution or with a mobile money provider in 2021, opposed to 68% and 51% in 2017 and 2011, respectively. Furthermore, the Covid-19 pandemic and the limitations it brought in terms of movement and consumption have inevitably led to an increase in the use of digital means of payment, with over 40% of the adult population in low and middle-income economies making payments using a card, phone, or the internet for the first time since the start of the pandemic (Demirgüç-Kunt et al., 2021).

It is this context of digital transformation that led to the growth of alternative virtual means of payment provided by the private sector, as well as to the introduction of innovations such as digital currencies. A digital currency is a medium of exchange that is generated, stored, and transferred electronically, capable of operating independently of a central bank and that does not have physical representation. As stated by the Bank for International Settlements (BIS), digital currencies represent an innovative solution that can have an impact on financial markets and the wider economy (BIS, 2015).

Currently, cryptocurrencies based on the blockchain system appear as the better-known form of digital currencies. The use of Bitcoin and other

decentralized cryptocurrencies such as Ethereum and Ripple as a means of payment is a reality that is increasingly presented as unavoidable despite its remaining challenges and pressing need for adjustments to the reality. Thus, the existence of a Central Bank Digital Currency (CBDC), a digital currency issued by a Central Bank, appears as a way in which Central Banks can guarantee the continuity of robustness of the financial system, as well as the security, transparency, and trust of users.

Moreover, especially in developed countries, the constant reduction in the use of physical money has been seen as a threat to the role of Central Banks since it can affect the way in which they conduct monetary policy to achieve price stability and to help guide the economy.

Central Banks are now faced with the question of whether they want to be part of this evolution or not. There is a growing belief that they will only be harmed if they opt for a spectator position rather than acting as one of the precursors of change. Furthermore, taking a part in the digital currency world through CBDC may be necessary to preserve its credibility and to guarantee that there is an objective and regulated access to this new technology. However, there are still too many questions that remain unanswered regarding the characteristics that a CBDC will offer and that seems to be the main reason creating disagreements.

Motivated by the growing relevance of digital currencies and the speculation regarding their future, this dissertation consists in a systematic literature review on the potential issuance of a CBDC and the main challenges behind it. Through this analysis, we aim to understand the existing lines of thought, the reported advantages and disadvantages and major challenges that may be encountered throughout the implementation of a CBDC. With this literature review, we intend to discuss the most relevant information and opinions on this CBDC topic, mapping what seem to be the next steps to take and future research avenues.

The rest of this dissertation is structured as follows. Section 2 presents the conceptual framework for CBDC. Section 3 presents the disadvantages and drawbacks of issuing CBDC. Conversely, in section 4 are presented the motivations for and the benefits of issuing CBDC. Section 5 discusses the design of CBDC. Section 6 suggests avenues for future research. Lastly, section 7 concludes.

2. Central Bank Digital Currency

A survey on CBDC was performed in 2020 by the Bank of International Settlements on 65 central banks, representing 72% of the world population and 91% of the world output. Boar & Wehrli (2021) analysed the results and found that 86% of these central banks are engaging in work regarding CBDC; 60% have already started experiences related to CBDC; and 14% have progressed to development and pilot arrangements.

While there is a consensus around the fact that CBDC is a digital form of central bank money, from that point on, everything becomes debatable and the authors in this field of study tend to have different views on what CBDC represents.

The Committee on Payments and Market Infrastructures along with the Markets Committee define CBDC as a new variant of central bank money that differs from physical cash, central bank reserves and settlement balances held by commercial banks at central banks (BIS, 2018).

Schilling et al. (2021) see CBDC as the possibility of holding a bank account directly with the central bank, meaning that it has the capability of substituting physical cash. Nevertheless, they also see CBDC as a tool that allows central banks to engage in large-scale intermediation by competing with financial intermediaries for deposits. Furthermore, CBDC is also promoted as a "vehicle for financial inclusion of a previously unbanked population as well as a safer alternative to commercial bank accounts". Thus, from their point of view, CBDC is seen as a mechanism that can facilitate financial inclusion, allowing people to

have access to features that are usually not available for them. This definition is in accordance with the one proposed by Andolfatto (2021) that suggests that CBDC is a proposal that aims to make central bank deposit accounts available to everyone and with Agur et al. (2022) that define CBDC as a new type of fiat money that rather than restricting digital access to central bank reserves to commercial banks, expands it to the public at large.

A slightly different rationale from Schilling et al. (2021) is that of Chiu et al. (2019) that define CBDC as a digital form of central bank money that can be used for retail payment and that competes with bank deposits as a payment instrument. What distinguishes them is the fact that the first aims to compete with physical currency whilst the latter aims to compete with bank deposits.

Several authors, however, advocate for a CBDC that beyond these general characteristics is also interest-bearing. Barrdear and Kumhof (2021) propose a CBDC that works as a tool that allows central banks to grant universal, electronic, 24x7, national-currency-denominated and interest-bearing access to its balance sheets. Williamson (2022) sees CBDC as based on a system that involves wider access to central bank deposits and that has potential advantages over physical currency since it can be designed to be used in transactions in which privacy is desired, as well as in digital transactions in which privacy is not a priority.

Another suggestion that we will not discuss in depth comes from Adrian and Mancini-Griffoli (2021) through a Synthetic CBDC (sCBDC) that emerges as a result of an established public-private partnership in which the central bank merely offers settlement services, including access to central bank reserves, to e-money providers. The remaining functions would be guaranteed by private e-money providers under regulation. To the authors, sCBDC presents itself as a cheaper and less risky alternative to the CBDC we have previously referred to. Furthermore, sCBDC preserves the capacity of innovating and interacting with customers that is characteristic of the private sector and, simultaneously, the

capacity of central banks to provide trust and efficiency. This version of CBDC allows for more flexibility and combines the advantages of both the private sector and the central banks. Nevertheless, these characteristics also mean that it moves away from the commonly accepted definition of CBDC.

3. Disadvantages and Major Drawbacks

As innovative and useful as CBDC might look, it urges to debate the possible downsides that it can bring as well as the challenges that it will undoubtedly have to face before its adoption can be considered. Having this in mind, Alonso et al. (2020) put together a comparative study that gathers the reasons for not establishing CBDC. The most frequently mentioned ones were preference for private virtual currencies, lack of demand or inability to function, failed tests or need for more security and investigation, and the fact that there is no advantage over electronic payments. But we can still delve deeper into this matter.

One commonly mentioned disadvantage is the disintermediation effect that results from issuing CBDC. Keister & Sanches (2022), for example, show that this can happen since the substitution of CBDC for private bank liabilities can lead to a reduction in productive investment and welfare. Nevertheless, they also found that, while CBDC always crowds out bank intermediation, social welfare can still improve when financial frictions are not very severe.

Furthermore, Williamson (2022) highlights that the implementation of CBDC can only reach full potential under certain conditions. The author admits that under the assumption that the central bank is excluded from holding private assets, an increase in CBDC issuance implies that government debt is more restrained. This finding limits the potential for CBDC issuance when government debt is limited.

Another pressing question is related to the costs and increased responsibility that CBDC would input to central banks. Adrian and Mancini-Griffoli (2021) emphasize that since central banks are the main drivers of CBDC, they are responsible for performing customer due diligence, offering or vetting wallets, developing or selecting the underlying technology, offering a settlement platform, managing customer data, monitoring transactions, and interacting with customer requests, complaints, and questions. Each of these steps raises risks of glitches and cyberattacks, entails significant costs, and puts the central banks' reputation at risk.

Another commonly used argument as a disadvantage associated to CBDC is that it may crowd out private bank deposits, leading to disintermediation in the banking system (e.g., Keister and Sanches (2022)) . Additionally, the shift of funds from private bank deposits to CBDC, would probably raise bank funding costs while also leading to a decline in bank lending and investment.

Popescu (2022) introduces new considerations to this discussion related to the possible existence of cross-border CBDCs. In this study, CBDC is account based, interest-bearing and available to non-residents of the issuing country. The author studies the impacts that it can have on capital flows and the financial economy and finds that the presence of a foreign CBDC that acts as an international safe asset may increment the risk of financial intermediation in the domestic banking sector. This increase in risk can also lead to higher and more volatile capital flows. This working paper also mentions that CBDC would make central banks compete with private financial institutions for deposits, which could lead to negative consequences for the availability of bank credit, economic activity, and financial stability. Furthermore, it also refers other perturbations such as operational risks related to cyber-security, risks to financial integrity, privacy, and governance.

Moreover, the joint report of the Committee on Payments and Market Infrastructures and the Markets Committee alerts that CBDC could raise issues

that not only impact the payment systems and the monetary policy transmission and implementation, but also lead to a wider weight of central banks in financial systems. This might not sound as a problem, but it could become one in the case where central banks prove to be less efficient than the private sector in allocating resources. During challenging times, the existence of a digital currency that is seen as a safer alternative would increase the pressure over central banks, oblige commercial banks and central banks to manage adversities, and even lead to greater political interference (BIS, 2018).

From a more comprehensive point of view, Ferrari Minesso et al. (2022) developed a two-country DSGE model with CBDC to analyse the open-economy implications of CBDC for the transmission of shocks, optimal monetary policy, and welfare. The authors conclude that CBDC intensifies the international spill overs of shocks, increasing international linkages. This happens since CBDC creates an arbitrage condition that links together interest rates, the exchange rate, and the remuneration of the CBDC.

Furthermore, the issuance of CBDC may bring about consequences not only to the banking sector, but also to other sectors of the economy (Castrén et al., 2022). This spillover can happen through channels such as corporate bonds, household funding and macro-network. A drop in prices of corporate bonds may occur because of the liquidation of debt securities and can lead to funding difficulties for non-financial enterprises. As for the household funding, it can suffer constraints if commercial banks decide to redeem loans. Finally, the introduction of CBDC has the power to change the current configuration of the network, affecting the stability we are accustomed to.

Even though Williamson (2021) recognizes that CBDC can contribute to the efficiency of the payments system, the author argues that it happens at a cost of greater financial instability. Thus, he advocates that CBDC has a greater tendency to foment panics under conventional policy. Since the author believes that CBDC

would be more effective in transactions than physical currencies, it would be less disrupting for retail payments under stress. Therefore, economic agents that mainly use bank deposits would shift to CBDC even during a banking panic.

Dong and Xiao (2021) built a model based on an interest-bearing CBDC to investigate the impacts it can have on banking and the macroeconomy. Their results suggest that, in a situation where cash and banking are complements, a higher CBDC interest rate does lead to financial disintermediation since entrepreneurs switch from cash to CBDC and less cash holdings reduce bank lending.

As a new alternative that has yet to be implemented and tested in most central banks' jurisdictions, this context of uncertainty and setbacks is more than expected. Nevertheless, some of the issues that are raised in the literature may be overcame through design choices, the ripening of the CBDC project of each central bank over time and further investigation of the prejudicial effects.

4. Motivations and Benefits

However, CBDC does not only present obstacles. In the previously mentioned comparative study carried out by Alonso et al. (2020), the arguments that endorse the establishment for CBDC are based on geographic dispersion and access to financial services, increased bank penetration rate and access to financial services, financial sector contemporaneity, security reasons such as avoiding money laundering and terrorist financing, consumer protection, maintaining control over monetary and macroeconomic policy, decrease in the use of cash, and lower costs and greater efficiency of the banking system.

Indeed, one of the most defended arguments in favour of CBDC is that it can work as a driver of financial inclusion. This is especially true when we are

referring to unbanked populations to whom the existence of CBDC would allow access to an account even without the physical presence of a commercial bank in the proximities. Nevertheless, there is also a lot of debate regarding this topic and many studies are being carried out.

Schilling et al. (2021) developed a model that relies on the canonical banking model matured by Diamond & Dybvig (1983) that focuses on the role of banks as maturity transformation providers while investigating how a CBDC affects financial intermediation and the occurrence of bank runs. The model proposed by Fernández-Villaverde et al. (2021) builds on the canonical model developed by Diamond & Dybvig (1983) since it distinguishes between commercial and investment banks, and because the authors added a government-controlled central bank to accommodate the issuance of CBDC.

Fernández-Villaverde et al. (2021) show that the introduction of a CBDC allows central banks to engage in large-scale intermediation by competing with private financial intermediaries for deposits and that, absent a banking panic, the set of allocations that can be achieved through private financial intermediation, can also be achieved through a CBDC. Thus, the authors found that central banks are more reliable than commercial banks during a panic, which ensures that CBDC can be a viable and reliable option even in times of stress.

Williamson (2022) advocates that when consumers substitute CBDC for private bank liabilities as a means of payment, safe assets drift from the private sector to the asset side of the central bank's balance sheet, thus increasing the effective stock of collateral in the economy, and potentially increasing welfare. This leads to a disintermediation effect that, in this case, is seen as beneficial and means that, in the absence of a monopoly, CBDC can discipline private banks. In his model, it is conjectured that private transactions can only be guaranteed by the central bank, either through CBDC or physical currency and that issuing

CBDC can be relevant and even improve welfare under the condition that CBDC intermediation activity is limited to narrow banking.

Brunnermeier and Niepelt (2019) built a general model of money, liquidity, and financial frictions that found that, contrary to common belief, CBDC does not necessarily threaten financial stability. Furthermore, their findings propose that the issuance of CBDC does not necessarily reduce credit or crowd out investment. They advocate that the issuance of CBDC would only highlight the central bank's lender-of-last-resort role. Therefore, a switch between CBDC and deposits would not reduce bank funding, it would just change the present composition of bank funding. That is, the central bank would provide substitute funding for banks, becoming an intermediate between non-banks and banks. In addition, their results entail that the introduction of a CBDC supported by a pass-through policy would not affect macroeconomic outcomes and that with pass-through funding, the introduction of a CBDC could even strengthen financial stability rather than threaten it since CBDC and pass-through funding could turn the central bank into a large depositor.

Chiu et al. (2019) developed a micro-founded equilibrium model of payments aiming to study the impact of a CBDC on the intermediation of private banks. The authors argue that if banks have market power in the deposit market, a CBDC can reinforce competition, raising the deposit rate, expanding intermediation, and increasing output. Furthermore, they argue that the mere existence of a CBDC as an alternative compels banks to pair the CBDC rate and generate more deposits and loans. This affects policy since it implies that the effectiveness of CBDC should be measured based on its equilibrium effect on deposits or on the deposit rates rather than its usage. Basing their model on the United States, the authors found that CBDC can expand bank intermediation if its interest rate is between 0.30% and 1.49%. Thus, at its maximum, it can boost loans and deposits by 1.96% and the total output by 0.21%. Nevertheless, they

also found that CBDC can lead to disintermediation if its interest rate surpasses 1.49%. Even in the case where the CBDC is non-interest-bearing, the authors argue that it has the capability of curbing banks' market power and improve intermediation if the use of cash maintains its tendency of declining. All these options are still an improvement from the situation where CBDC does not exist, and banks would limit intermediation and pay negative deposit rates.

Furthermore, their findings suggest that some key motivations behind the issuance of a CBDC include the fact that CBDC can discipline bank's market power in providing transaction deposit balances and improve payment efficiency and that the interest carried by a CBDC can act as a new policy tool since it can bear a negative nominal interest rate and thus relax the limit on the interest rates on reserves and deposits. Regardless, there are still other motivations referred to as relevant by the authors such as safety and resilience of the payment system, financial inclusion, monetary policy sovereignty and data privacy.

Andolfatto (2021) goes even further and elaborates on how private financial intermediaries could be disciplined in a beneficial way by CBDC issue, when there is monopoly power in the banking system. Furthermore, the author shows that a CBDC could oblige banks to increase the deposit rate, generating an increase in bank deposits and financial inclusion. He argues that the presence of an interest-bearing CBDC places even greater discipline on the monopoly deposit rate, increasing the cost of deposit funding for the bank. His model delivers several different results. First, it finds that if the interest rate on CBDC is set independently of the interest-on-reserve (IOR) rate, then the introduction of a CBDC in no way discourages bank lending. Second, if the CBDC rate is set below the IOR rate, the monopoly bank has every incentive to match the CBDC rate for the purpose of retaining deposits. Third, because the threat of CBDC induces more favourable contractual terms for depositors, it increases the supply of

deposits. Fourth, if a regulatory liquidity constraint is binding for the bank, the increase in deposits resulting from CBDC competition induces an expansion in bank lending. Lastly, it finds the hardly surprising result that CBDC unambiguously reduces monopoly bank profit.

All things considered, it becomes clear that the existence of those advantages associated with CBDC is clearly conditional on the characteristics that CBDC will offer and on the environment in which it will be made available, making the design of CBDC a crucial point of this discussion. This is done in the next section.

5. The Design

It is this clear dependence that guides so many authors to further investigate the characteristics of CBDC that can make it a beneficial tool for central banks while also appealing for its possible users. Regarding these users' preferences, Agur et al. (2022) argue that, optimally, households are categorized into different types of money according to their preferences, the network effects that result from the relationship between the convenience of using a payment instrument and the number of its users, and the interest rates offered on deposits and, in this case, on the CBDC. Further, the authors advocate that, in an economy where the bank's role is limited, a CBDC is optimally designed in a way that is as divergent from existing payment instruments as possible. On the contrary, in an economy with a greater focus on the maintenance of bank intermediation, an optimal CBDC would be more similar to cash, even if just up to a point. After that, the authors also believe that central banks may limit the extent to which CBDC competes against cash since cash may be negatively subject to network effects. As for an economy where the focus is on preserving the bank's deposit base, the

central bank gives up on cash and the optimal policy starts to indicate that a cash-like CBDC is a better fit.

A possibility of design is a benchmark CBDC, as the one presented by Engert and Fung (2017), that behaves in an identical way to central bank reserves, is accessible to the general public and is not restrained to major participants in the payments system. Issuing such a CBDC does not change the fact that bank notes and central bank reserves carry on being issued. Nevertheless, this CBDC would practically perform as bank notes, aiming at minimizing disruptions. According to the authors, this benchmark CBDC would be denominated in the sovereign currency, work as legal tender, lead to par exchange of bank notes and CBDC among the general public, not bear interest, not bear interest fees for distributing, exchanging, storing or making payments, would be accessible to everyone that has access to the necessary technology, and be available 24/7. Furthermore, its transactions would be untraceable, supply would be demand-determined and perfectly elastic, meaning that the central bank would supply as much CBDC as the public is willing to hold, households and firms would have to resort to a regulated financial institution to obtain, store or return this digital currency, its transactions would need to be confirmed nearly instantaneously, and the underlying transactions need to be settled irrevocably as quickly as possible, and its payment network structure would be distributed, bilateral and not tiered.

Notwithstanding, this benchmark version of CBDC is only one of the alternatives that is currently being discussed in the literature. The debate around its design revolves around different dimensions. For instance, for Williamson (2022) there are three possible designs for a CBDC. The first one consists of a CBDC that completely replaces physical currency once it is withdrawn from circulation, and this CBDC is provided by the central bank although it is issued through withdrawals from private bank accounts. Such an alternative works as an illustration that if CBDC is not allowed to compete effectively with private

means of payment, then it is not capable of improving macroeconomic performance. Under the second version, CBDC is issued by the central bank through its own narrow banking facility, and it can be used in transactions where individuals need privacy and do not. If this option prevails, the author expects that an increase in the interest rate on CBDC will cause a shift from private banking to the central bank's narrow banking facility, and that it can be welfare-improving, regardless of a decline in investment and in the private capital stock. Finally, the third alternative consists of the central bank providing a richer bundle of CBDC means-of-payment, which are issued through the central bank's narrow banking facility and designed to replicate the deposit contract of private banks. According to the author, under this regime, an account based CBDC can be converted into a CBDC that can be used essentially in a digital wallet that permits privacy, protection, and the two types of CBDC can bear interest at different rates, which increases flexibility for the policymaker. Furthermore, welfare can be improved, and, in this regime, the author establishes conditions under which CBDC issue is irrelevant for the equilibrium allocation, illustrating the importance of private bank incentive problems for the efficacy of CBDC issue.

Although extremely pertinent, this is not the discussion that we will focus on regarding CBDC design. Instead, we will depart from the questions of physical currency substitution and anonymity and focus on three other aspects: the technology behind CBDC, the possibility that it bears interest, and its degree of availability. We will do so since this is the more urgent and debated topic currently in the literature.

5.1 Account based CBDC versus Token based CBDC

Figure 1. The possible technology designs for CBDC.

An account based CBDC is one that is closer to the definition of a deposit, since it functions based on transferable account balances held at the central bank. Paradoxically, a token based CBDC is a digital version of physical currency, representing a liability of the central bank that is issued in a digital token form. The main aspects that distinguish them are the use or not of a distributed ledger technology and the verification that is performed when the transactions are realized.

Bordo and Levin (2017) discuss the main divergences between these two types of CBDC. For example, a token based CBDC would imply that the central bank would be the one ruling the supply of CBDC tokens that would be fixed in nominal value and serve as legal tender. Furthermore, CBDC tokens would demand distributed ledger technology to be able to verify the chain of ownership of each token and to validate payment transactions, without requesting the direct participance of the central bank since the tokens would circulate electronically among private individuals and firms. Thus, CBDC tokens might only rarely be redeposited at the central bank. On the other side, an account-based alternative would allow users to hold funds electronically in CBDC accounts that are located at the central bank. Hence, it would be much easier for the central bank to process and validate transactions since it would only be necessary to debit and credit the respective accounts.

Nevertheless, the authors advocate that for a CBDC to be well designed and preserve the basic functions of any public currency, it must be an account based one. Under such a system, CBDC payments could be practically instantaneous and costless as well as secure, whilst the central bank would have the capability to monitor unusual activities and perform additional anti-fraud safeguards when needed. Hence, opting for an account based rather than a token based CBDC would allow for significant efficiency gains, since these accounts could be held directly at the central bank or rather made available through partnerships with commercial banks.

According to Keister and Monnet (2022), providing an account based CBDC allows the central bank to acquire information on the status of banks when the traditional channels of communication are not properly functioning. Furthermore, the authors argue that an account based CBDC allows the central bank to recognize information regarding the funds and its owner, whilst a token-based CBDC may difficult the acquisition of such information. Nevertheless, they also recognize that a token based CBDC allows for anonymity on the contrary of an account based one. However, the authors recognize that in times of market stress, users are usually willing to waive some degree of anonymity for increased safety.

If, for example, users are looking for the level of anonymity that cash guarantees, they can only achieve it through a token based CBDC that is accessible through user accounts that are not independently verified, or a nameless payment card that can be purchased at stores or online. If, however, they value the features of security and traceability that bank deposits offer, they would go for an account based CBDC accessible through an account at the central bank that can be opened using official identification. However, Agur et al. (2022) show that CBDC can be designed to blend both characteristics in intermediate amounts, unlike cash and deposits which represents a valuable difference.

Polski and Beniak (2019) state that the adoption of an account based CBDC means that any transaction performed by an individual causes a change in the central bank balance sheet, complicating the central bank balance sheet management policy. As for a token based CBDC, the authors believe that it represents a solution that is very similar to the ones that are already available and that it would not implicate any changes in monetary policy. Moreover, they recognize that most central banks that are considering the introduction of a CBDC are inclined towards a token based CBDC.

The Bank of International Settlements performed a survey on CBDC in which Barontini and Holden (2019) also distinguish between the type of technology behind this digital currency. They highlight that the genuineness of a token based CBDC can be verified by the person receiving it whilst an account based CBDC can only be verified by an intermediary. Their work focuses on two variants of CBDC that are relevant for this discussion: a "general purpose", "account based" variant that would be widely available and would be primarily targeted at retail transactions; and a "general purpose", "token based" variant that would have similar availability and functions as the previous one but would be distributed and transferred differently. This means that the first variant would be equivalent to an account at the central bank that is available for the general public while the second would be equivalent to a type of digital cash that is issued by the central bank to the general public.

Overall, every discussion around this topic considers both options under study. Different authors lean towards different choices, but that difference is justified by the characteristics and ambitions that they project on CBDC. At the end of the day, central banks will have to decide which characteristics they want to offer in a CBDC and what characteristics users value the most. If they are looking for an alternative that can either compete with or compensate the decreasing use of physical currency, and that maintains the level of anonymity

that up until now has been guaranteed by cash, they would probably prefer a token based alternative. If, on the other hand, central banks are looking for a CBDC that can compete with commercial bank's deposits and that allows the traceability of the users and the funds, then they would probably prefer an account based alternative.

5.2 Interest-bearing CBDC versus Non-interest-bearing CBDC

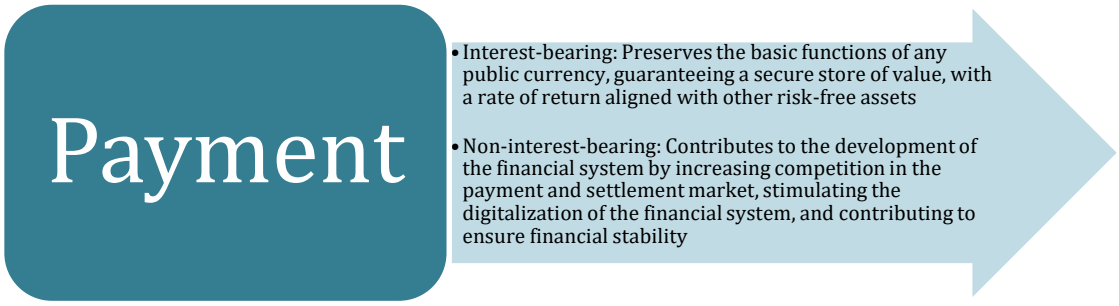

Figure 2. The possible payment designs for CBDC.

Underpinning the procedure of many central banks around the world of paying interest on reserves of commercial banks held electronically at the central bank is an argument used by Friedman (1960). The argument explains that money issued by the government should deliver the same return as other risk-free assets, in an efficient monetary system.

It is based on this argument that many authors advocate for an interest-bearing CBDC. Promptly returning to the previous discussion, it is straightforward to understand that issuing an interest-bearing CBDC is only possible when an account based CBDC is adopted which means that both topics of discussion are related.

Bordo and Levin (2017) argue that if a CBDC is to be well designed and preserve the basic functions of any public currency it should be interest-bearing. The authors believe that an interest-bearing CBDC could guarantee a secure store

of value, with a rate of return aligned with other risk-free assets. Thus, the CBDC interest rate could work as the main tool for conducting monetary policy and would not be constrained by any effective lower bound, contributing to greater macroeconomic stability. Furthermore, Bordo and Levin (2017) also claim that an interest-bearing CBDC might increase the competitiveness of the banking system.

Allowing a CBDC to pay interest would transform CBDC into a crucial tool of monetary policy, consequently mitigating the need to use other monetary tools so often.

A dispute that follows this debate regards how much interest should CBDC bear. Keister and Monnet (2022) found, through the results of their model, that the interest rate on CBDC should be set as high as the interest rate on excess reserves or the yield on treasuries (whichever is lowest), since these would give sufficient incentives for investors to use CBDC without necessarily yielding to the disintermediation of the banking sector. Furthermore, not paying any interest on CBDC may divert sophisticated investors from purchasing CBDC to purchasing higher yielding assets.

However, issuing a non-interest-bearing CBDC would still have its advantages. Leading to a higher effective lower bound, tightening the room for monetary policy is one of them, as defended by Polski and Beniak (2019). On the other hand, if central banks opt for an interest-bearing CBDC the effective lower bound could be preserved or even lowered, depending on the degree of popularity of the digital currency issued. A higher effective lower bound would then limit the central banks' power to stabilise inflation through conventional policy whilst a lower effective lower bound would have the opposite effect. That explains why authors that often advocate for less central bank influence are defenders of a non-interest-bearing CBDC.

Arguments favourable to the issuance of interest-bearing CBDC are often related to the pursuit of opportunities to improve the transmission mechanism in the conduction of monetary policy. This transmission mechanism is realised through the effective lower bound of the interest rate (Sakharov, 2021). However, it is important to guarantee that the interest-rate of the CBDC is not higher than the deposit rate of the central bank so that economic entities do not have access to arbitrage opportunities.

Nevertheless, the same authors reach the conclusion that the issuance of non-interest-bearing CBDC is preferable since it will allow reliable banks to maintain their resources if they account for the adjustment of their business models in accordance with the growing competition in the payments market.

The issuance of a non-interest-bearing CBDC will contribute to the development of the financial system by increasing competition in the payment and settlement market, stimulating digitization of the financial system, and contributing to ensure financial stability.

Moreover, paying interest creates complications regarding the anonymity of the users of CBDC, which would probably reduce the demand. However, it would also address the problems related to CBDC use for criminal activities. As a matter of fact, an interest-bearing CBDC has not been found to have material implications on monetary policy, since the interest rates paid on central bank reserves are likely to be similar to the ones paid on interest-bearing CBDC. Nevertheless, an interest-bearing CBDC might increase the risk of political interference and lead to a reduction in central bank autonomy under some conditions (Engert and Fung, 2017).

When it comes to the debate around paying interest, the questions addressed by the authors diverge even more and the argument becomes a lot more complex than when we were considering the technology behind CBDC. Beyond the question of bearing interest or not, whilst the anonymity is still relevant, authors

also account for how much interest CBDC should bear and the implications that that decision could have in the implementation of monetary policy. Therefore, central banks should consider how much flexibility they aim to have towards interest rates and monetary policy in the moment of issuing a CBDC. Nevertheless, users may tend to be more attracted to an interest-bearing option since it could provide them a higher yield while working as a secure alternative for them.

5.3 Wholesale CBDC versus Retail CBDC

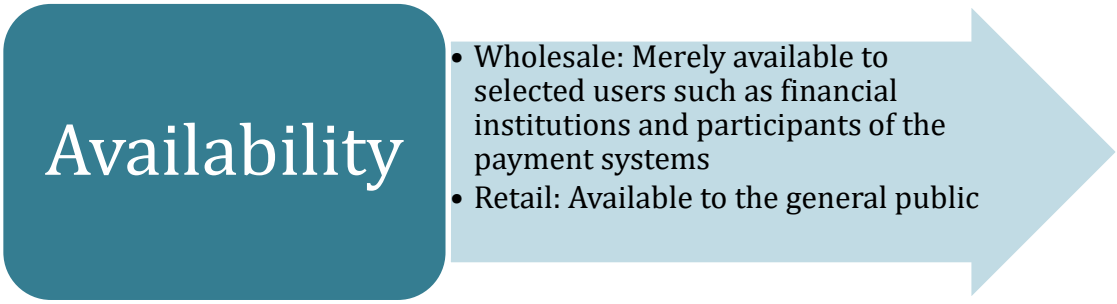

Figure 3. The possible availability designs for CBDC.

Another relevant distinction is the one between a wholesale CBDC and a retail CBDC. According to Popescu (2022), a wholesale version is one that is merely available to selected users such as financial institutions and participants of the payment systems, while a retail version is available to the general public. That explains why the author defends that a retail CBDC emerges as the most relevant design option in terms of the central bank achieving several policy objectives. In accordance, Sakharov (2021) supports that wholesale CBDCs do not have a significant impact in the current financial infrastructure and do not yield a clear competitive advantage over the payment and settlement systems that are operating. Additionally, retail CBDCs have the convenience of being issued either based on a token or on an account, becoming more flexible. Nevertheless, there are other and more complex explanations that are worth exploring.

Bech and Garratt (2017) defend that a retail CBDC would waive the high price volatility, despite them also advocating that in the case where retail CBDC completely replaces cash, it would become impossible for depositors to avoid negative interest rates while still holding central bank money. The authors alert for some possible threats that can emerge from the adoption of a retail CBDC. Among them is the fact that if the general public has the ability to easily convert commercial bank money into risk-free central bank liabilities, bank runs may occur more quickly. They also claim that it can lead to risks to the business models of commercial banks since they might be disintermediated, and thus less capable of performing essential economic functions, such as monitoring borrowers in the case where consumers choose to pass on commercial bank deposits for retail CBDCs. Nevertheless, these benefits and costs, as we have previously showed, are not unique to retail CBDCs.

As for retail CBDCs, they are often presented as an opportunity to expand digitalization processes and to allow full use of the potential of CBDCs. To Sakharov (2021), a retail CBDC can simultaneously work as a risk-free asset for the economic agents and as a new form of money that responds to the needs of the digital economy. Furthermore, during a crisis, they can be used as a mechanism to grant direct government support to citizens. Moreover, they are designed to guarantee the access of the general public to modern technologies that allow them to make payments through a digital form of money available to economic entities which is a top priority for central banks of developed countries in the face of the growing prosperity of economic entities and processes of digitalization of the economy. Thus, this paper recognizes as positive impacts of retail CBDCs the increased competition in the financial services market, the combination of advantages of physical cash and non-cash forms of money that it allows, the promotion of the processes of digitalisation of the financial system, the formation of prerequisites for ensuring financial stability, the ability to be

used as a tool for direct support of economic agents from the government, the ability to use smart contracts, the safeguard of access to high-quality financial services for economic entities that have a demand for them, and the increase in attractiveness of the national currency in the face of the intensive global foreign exchange competition. Nevertheless, the authors acknowledge a drawback. In the case where CBDCs of developed countries are available to non-residents, additional risks for developing countries can come up since payment systems based on the mentioned CBDC can create additional competition for the currencies of developing countries.

There is another argument provided by Cheng (2022) that helps us understand the reason behind the literature's preference for a retail CBDC: retail CBDC is a more comprehensive alternative since both individuals and financial institutions can use it to support their financial transactions, while wholesale CBDC is only available for specific financial operations between financial institutions and entities. Then, retail CBDC projects are naturally favoured in emerging markets and developing economies where financial inclusion and enhanced payment abilities are usually indicated as the key drivers for this innovation. Furthermore, the author innovates by introducing the distinction between direct and indirect retail CBDCs styles in which the central bank and the financial intermediaries play different operational roles. In depth, the design of a direct retail CBDC may switch the traditional two-tier monetary system to a one-tier one in which the central bank keeps all the records of transactions and directly supervises payment services for the general public. This direct version of retail CBDC eliminates the dependence on financial intermediaries. However, this kind of infrastructure entails that the responsibilities that were previously of the intermediaries, as customer due diligence, account management, and payment services, are shifted from the private sector to the central bank, which may have an impact on the stability and efficiency of the payment system. This seems to

indicate that an indirect retail CBDC is less disruptive to the prevailing payment system, since it implies a two-tier financial system, where the central bank is responsible only for the wholesale accounts of financial intermediaries, while financial intermediaries are still accountable for the public.

On the contrary, research and experiments on wholesale CBDCs or interbank CBDCs have often been focused on developed economies with relatively well-established interbank systems and financial trading markets where payment-related motivations as, for example, efficiency, safety, and robustness are of greater concern than financial inclusion (Cheng, 2022). Additionally, most of the wholesale projects are conducted in order to test the interconnection potential between different CBDC projects. This type of CBDC is less likely to influence the operational role of the central banks and financial institutions because banks already have direct access to the central banks' electronic money. Nevertheless, taking into consideration that the wholesale project ambitions to foster security and efficiency in the institutional trading process, it is not unlikely that it also grants CBDC accounts and payment services to other institutions such as securities participants and nonfinancial companies. Furthermore, to facilitate cross-border payments, cut down transaction risks and costs, and boost payment efficiency, the author also distinguishes between three different models of a cross-border CBDC program to ease transactions between central banks. The first model aims to eliminate the conventionally trusted third party in interbank settlements and conduct direct payment versus payment (PvP) services from cross-border transactions. As for the second model, it retains the third institution between two separate CBDCs systems, but it contemplates a joint institution managed by specific central banks to serve cross-border payments. Lastly, the third model proposed by the author extends CBDC cross-border payments from two banks to multiple banks through a common network.

However, as Bech and Garratt (2017) state, retail CBDCs remain at the conceptual stage while some central banks already have completed proofs of concept for distributed ledger technology (DLT) based applications. One of the reasons for the interest in DLT is that many central bank-operated wholesale payment systems are at the end of their technological life cycles. The systems are programmed in obsolete languages or use database designs that are no longer fit for purpose and are costly to maintain and will eventually need to be substituted to maintain efficiency. This means that there is far more evidence of performance regarding wholesale CBDCs, which becomes even more interesting now that we have gathered that most of the literature available seems to be a staunch defender of retail CBDCs.

Despite the literature clear preference for a retail digital currency in this context, central banks appear to have a predilection for a wholesale option possibly because a wholesale CBDC is more similar to the services that they are accustomed to provide while a retail CBDC would imply a significant change in their current role. It then urges to perceive the results from completed proofs of concept of this version of CBDC. Only then will we be able to understand if the central banks' position is merely due to some conservatism or rather because it really is the option that will better fit the needs of both the participants of the payments system and the system itself.

6. Future Research

Despite the recent upsurge on CBDC related literature, there are still many avenues that, in our perspective, deserve to be explored to fully understand the impact that CBDCs can have in the near future. In this section, we discuss some of them.

6.1 Finding the optimal CBDC design

As previously discussed, there is still not a consensus around the design of CBDC. The most challenging part of this debate emerges from the fact that the proposed designs of CBDC cannot meet competing objectives. For example, a CBDC that aims to increase financial inclusion usually lowers the entry requirements to increase the number of people that have access to it, increasing the difficulty of combating problems such as money laundering. Another example consists of the fact that when designing a CBDC that aims at achieving price and financial stability, it becomes extremely difficult to achieve a CBDC that, at the same time, is also efficient. This explains the reason why it is important to find a CBDC design that is capable of meeting competing objectives. Therefore, finding an optimal CBDC design that is able to fulfil the goals of the financial system as well as maintaining macroeconomic stability is of major relevance.

6.2 Discussing how CBDC should be regulated and taxed

Since we are discussing the adoption of a CBDC, we need to consider the fact that, sooner rather than later, regulation and taxation will need to be discussed. As a new form of money, a digital currency issued by a central bank will have to comply with the existing regulation and new regulations will probably have to be put into place to guarantee that CBDC is used properly and distributed fairly throughout the economy. Furthermore, and especially since central banks are considering, among others, a form of CBDC that bears interest, this new form of money will certainly have to be taxed to comply with anti-money laundering principles and to be kept away from financing undesired activities. Therefore, a relevant open research topic is the legal framework in which CBDC can be fitted and if and how it should be taxed.

6.3 Exploring case studies of specific countries and regions

Most information available regards developing and emerging countries that have performed practical experiences with CBDC. At the same time, several developed countries are also considering CBDCs and have performed studies and surveys on this subject but have not yet initiated practical experiences. Once we have access to the results from such experiences, we would be able to depict a comparative analysis between different types of CBDC and its impacts. Furthermore, if this analysis would be performed in specific regions, we would also be able to compare the different results inside the same country and readjust the characteristics of the digital currency, accordingly, making it a better fit. There is therefore scope for comparative studies focused on the attributes of CBDC between regions and countries.

6.4 Discussing the country-specific implications on financial stability and monetary policy

The discussion around the impact on financial stability and monetary policy in the literature is a broad view of the effects that might emerge. Although that is enlightening, it would be beneficial to analyse the country-specific implications to have a more concrete impression of what might really happen. The financial system, although globally connected, still bears different characteristics from country to country. Therefore, the impacts might happen at a different degree or even in an opposite way depending on the country under analysis or the degree of adoption of CBDC, for example. Future studies could aim at comparing these implications and analysing the mechanism behind them, allowing the gathering of more information.

6.5 Estimating the impact of CBDC on currency value

Assuming that CBDC implementation will be successful, a move from traditional means of payment to this digital currency would be expected. Particularly in the case where a cross-border access to CBDC is considered, it would be pertinent to analyse the impact that the adoption of this new type of money would have on trades and the functioning of the global economy. For example, if CBDCs from developed countries are available to non-residents, that might pose a risk for the currency of developing countries or if there is a significantly broad use of CBDC, domestic currencies might end up losing some of its relevance. Future studies may study the impact that the adoption of CBDCs, especially the ones with cross-border access, can have on currency value.

6.6 Exploring the effects of CBDC on different and specific sectors of the economy

Up until now, the literature has mainly focused on the payments and financial system impacts, as well as the impact on the macroeconomic stability. To fully understand the changes that CBDC can originate, it would be interesting to analyse and compare how CBDC could impact different sectors of activity. Certainly, CBDC's impact would not be confined to the financial sector of the economy if households and firms have access to it and choose to adopt it. Future studies should analyse and compare the effects that CBDC would have in different sectors of the economy, and how willing they would be to adopt CBDC as an alternative to traditional means of payment.

7. Conclusion

Undoubtedly, CBDCs have been gaining relevance in the debate around new forms of money. The constant innovation in technology and, more recently, the Covid-19 pandemic favoured a change in consuming habits, alerting us to the pressing need to modernize the way in which we have been making payments. Furthermore, the popularity growth of other digital means of payment such as cryptocurrencies forced central banks to consider the possibility of issuing their own digital currency to be able to sustain the power that they have been known to possess. These reasons motivated this literature review on central banks' approach to CBDC.

CBDC, as it is now commonly accepted, is a form of digital money that is issued by a central bank. Nevertheless, that is about it when we talk about consensus around this topic. Its functions and the means of payment that it will substitute or improve are the first reason for disagreement among authors, explaining the need for a clear conceptual framework for CBDC as well as further investigation on the subject.

Despite its early stage of development, different disadvantages and drawbacks are already pointed out such as preference for virtual currencies, lack of demand or inability to function, failed tests or need for more security and investigation. Moreover, there is a constant worry in literature that the adoption of CBDC can lead to problems such as financial disintermediation and instability. Nevertheless, benefits are already recognised and can be easily summed up to

financial inclusion, increased bank penetration and access to financial services, financial sector contemporaneity, security reasons, consumer protection, maintaining control over monetary and macroeconomic policy, and lower cost and greater efficiency of the banking system. In the next table, this set of disadvantages and advantages are summarized:

CBDC Disadvantages	CBDC Advantages
• Lack of demand or inability to function (Alonso et al., 2020) • Failed tests or need for more security and investigation (Alonso et al., 2020) • No advantage over electronic payments (Alonso et al., 2020) • Disintermediation effect (Keister & Sanches, 2022; Williamson, 2022) • Can only reach full potential under certain conditions (Williamson, 2022) • Increased costs, responsibility, and risks for central banks (Adrian & Mancini-Griffoli, 2021; Andolfatto, 2021; Engert & Fung, 2017)	• Combats geographic dispersion (Alonso et al., 2020) • Increases access to financial services (Alonso et al., 2020) • Increases banks' penetration rate (Alonso et al., 2020) • Promotes financial sector contemporaneity (Alonso et al., 2020) • Increases security (Alonso et al., 2020) • Promotes consumer protection (Alonso et al., 2020) • Allows for control over monetary and macroeconomic policy (Alonso et al., 2020; Chiu et al., 2019) • Decreases the use of cash (Alonso et al., 2020)

• Decline in bank lending and investment (Keister & Sanches, 2022) • Higher and more volatile capital flows (Popescu, 2022) • Impact on the availability of bank credit, economic activity, and financial stability (Popescu, 2022) • Operational risks (Popescu, 2022) • Wider weight of central banks (BIS, 2018) • Adversities for central and commercial banks (BIS, 2018) • Greater political interference (BIS, 2018; Engert & Fung, 2017) • Intensifies international spill overs of shocks (Ferrari Minesso et al., 2022) • Affects other sectors of the economy (Castrén et al., 2022) • Changes the current configuration of the network (Castrén et al., 2022)	• Lowers costs of the banking system (Alonso et al., 2020; Bordo & Levin, 2017) • Greater efficiency of the banking system (Alonso et al., 2020) • Driver of financial inclusion (Andolfatto, 2021; Cheng, 2022; Chiu et al., 2019; Schilling et al., 2021) • Large-scale intermediation (Fernández-Villaverde et al., 2021; Schilling et al., 2021) • Viable and reliable option in times of stress (Fernández-Villaverde et al., 2021) • Can improve welfare (Williamson, 2022) • Highlights the central bank's lender-of-last-resort role (Brunnermeier & Niepelt, 2019) • Strengthens financial stability (Brunnermeier & Niepelt, 2019; Sakharov, 2021) • Reinforces competition (Chiu et al., 2019) • Disciplines banks' market power (Andolfatto, 2021; Chiu et al., 2019)

• Greater tendency to foment panics under conventional policy (Williamson, 2021) • Higher CBDC interest rate when cash and banking are complements (Dong & Xiao, 2021)	• Improves payment efficiency (Cheng, 2022; Chiu et al., 2019) • New policy tool (Chiu et al., 2019) • Safety and resilience of the payment system (Chiu et al., 2019) • Guarantees monetary policy sovereignty (Chiu et al., 2019) • Ensures data privacy (Chiu et al., 2019) • Disciplines private financial intermediaries (Andolfatto, 2021; Fernández-Villaverde et al., 2021) • Increases bank deposits (Andolfatto, 2021; Williamson, 2022) • Reduces monopoly bank profits (Andolfatto, 2021)

Table 1. A summary of CBDC's main disadvantages and advantages

Currently, one of the hot topics around CBDC regards its design. As we have documented through this literature review, most authors have been focusing on aspects such as the technology behind CBDC, the possibility that it bears interest, and its degree of availability. Although there is a lot more that must be considered, these are the options that have gained more recognition since the debate started. A tendency can already be identified among the literature, but there remains the need for further studies and proofs of concept to reach an

optimal CBDC design that can be widely adopted and that satisfies the needs of central banks and its future users, whether they are just financial institutions and participants of the payments system or households, firms, financial institutions, and participants of the payments system.

Although already quite extensive, the research on CBDC is still ongoing and, in our perspective, there are interesting research avenues. Matters such as the optimal CBDC design, the regulation and taxation of CBDC, the specifics of CBDC for each country and region, the country-specific implications on financial stability and monetary policy, the impact of CBDC on currency value, and the effects of CBDC on different and specific sectors of activity are still relatively under investigated and require more thorough insight. Nevertheless, in this new context where private digital currencies exist and its demand has been growing, the issuance of CBDC seems to be a question of when and how rather than if.

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Glossary

Term	Definition
Blockchain	A system in which a record of transactions made in bitcoin, or another cryptocurrency is maintained across several computers that are linked in a peer-to-peer network.
Disintermediation	A reduction in the use of intermediaries between producers and consumers, for example by investing directly in the securities market rather than through a bank.
Distributed Ledger Technology	Refers to the technical infrastructure and protocols that allows simultaneous access, validation, and record updating in an immutable manner across a network that is spread across multiple entities or locations.
Due Diligence	An investigation, audit, or review that is performed to confirm facts or details of a matter under consideration.
Effective Lower Bound	Refers to the point at which further cuts in the main monetary policy interest rate no longer provide stimulus to aggregate demand and gross domestic product or at which adverse effects, such as in the financial sector, can arise.
Interest-on-reserve	An interest rate that central banks pay on funds that are statutory reserve requirements as well as the reserves that are in excess of the required reserves.
Lender-of-last-resort	An institution, usually a country's central bank, that offers loans to banks or other eligible institutions that are experiencing financial difficulty or are considered highly risky or near collapse.
Pass-through Funding	Represents the situation where money is appropriated by a state agency which includes ongoing or one-time money and is designated as general funds, dedicated credits, or any combination

	of state funding sources, that is intended to be passed through the state agency to a local government entity, private organisation, including not-for-profit organisations or persons in the form of a loan or a grant.
Payment versus Payment	A settlement mechanism that ensures that the final transfer of a payment in one currency occurs if and only if the final transfer of a payment in another currency or currencies takes place.
Token	Represents a fungible and tradable assets or utilities that reside on their own blockchains. These tokens are usually created, distributed, sold, and circulated through the standard initial coin offering process, which involves a crowdfunding exercise to fund project development.
Two-tier Monetary System	A system where there is one type of money that is used when transacting with central banks and between commercial banks (reserves), while another type of money is used when transacting with everyone else (bank deposits).