AN INTRODUCTION TO THE CURRENT DEBATE ON CENTRAL BANK DIGITAL CURRENCY (CBDC)

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Abstract

This paper provides an overview of the concept of central bank digital currency (CBDC) that may serve as a basis for an ordered discussion and an in-depth analysis of the different relevant aspects in the ongoing debate about this digital financial asset. The primary objective is to review the grounds that could warrant issuing CBDC and undertake a preliminary analysis of its main implications, especially those linked to the CBDC models that seem most likely to be adopted, judging by the motivations of the central banks whose issuance plans are currently most advanced.

Keywords: central bank digital currency, stablecoins, cryptocurrencies, cryptoassets.

JEL classification: E42, E52, E58.

Resumen

Este documento ofrece una visión general sobre el significado de una *central bank digital currency* (CBDC) que pueda servir de base para una discusión ordenada que permita profundizar en los diferentes aspectos relevantes del debate actualmente abierto sobre este activo financiero digital. El objetivo fundamental es revisar las motivaciones que pueden justificar la emisión de CBDC y llevar a cabo un análisis preliminar de sus principales implicaciones, especialmente de las vinculadas a los modelos de CBDC que parecen más probables, a tenor de las motivaciones de los bancos centrales que, en estos momentos, han avanzado más seriamente hacia su emisión.

Palabras clave: moneda digital de banco central, *stablecoins,* criptomonedas, criptoactivos.

Códigos JEL: E42, E52, E58.

Contents

1 Introduction

When bitcoin began to capture the attention of the financial sector and the general public around 2013,[1] it raised a question that until then had been primarily theoretical:[2] should central banks issue digital money that is accessible to the general public? At that time, many considered that new technological capabilities (specifically, blockchain) would enable central banks to issue a digital asset with similar characteristics to cash, in competition with the new cryptocurrencies. This new digital asset (a liability of the central bank of issue) was termed "central bank digital currency" (CBDC).

Little headway was made in this early stage of the debate, chiefly because, as is well known, cryptocurrencies such as bitcoin have severe limitations that make it difficult for them to become an alternative to cash or bank deposits: their value is highly unstable; the intermediaries responsible for their distribution and custody have proven to be unsafe; their legal basis is not clear; they are not user-friendly; and the scalability of the solution (i.e. the capacity to achieve large volumes) is limited.[3] Because of these shortcomings, bitcoin-type cryptocurrencies have not received widespread acceptance. Indeed, their marginal use explains why they have not been explicitly regulated in many countries.

Although the debate about CBDC lost its urgency, the possibility of issuing this type of asset continued to be explored in countries facing specific challenges. Included here are the significant decline in cash usage (Sweden), the existence of sections of the population with insufficient access to financial services (as is the case of a large number of developing economies) and countries with high cash distribution costs (such as Uruguay, the Philippines, the Bahamas and Cambodia).

More recently, the emergence of a second generation of crypto-assets (so-called "stablecoins") and the development of projects capable of swiftly gaining a wide reach, such as Libra, have brought CBDC analysis back into the spotlight. A stablecoin can be defined as a crypto-asset, but one with the aim of maintaining a stable value relative to another asset or basket of assets, thus overcoming one of the main weaknesses of first-generation crypto-assets.[4] Libra, the main stablecoin proposal, is also backed by Facebook, one of the largest global BigTech firms. Consequently, the initiative has a very broad base of potential users and the support of firms with extensive expertise in designing an attractive user experience. Given these ingredients, many authorities[5] have highlighted the threat that Libra and other similar stablecoins pose to the smooth functioning of payment systems, the prevention of

1 See https://elpais.com/tecnologia/2013/11/19/actualidad/1384847076_655593.html.

2 See Tobin (1985).

3 See Conesa (2019).

4 Although it is not the main aim of this paper, Annex 1 briefly describes stablecoins.

5 See "Money and private currencies: reflections on Libra", speech by Yves Mersch, September 2019, (available at https://www.ecb.europa.eu/press/key/date/2019/html/ecb.sp190902~aedded9219.en.html) and "The future of the Capital Markets Union – Towards an Investment and Savings Union", speech by Bruno Le Maire, September 2019 (available at https://www.gouvernement.fr/sites/default/files/locale/piece-jointe/2019/09/discours_de_bruno_le_maire_lors_de_leurofi_financial_forum_2019.pdf). The authorities' overall position on this matter can be found in G7 Working Group on Stablecoins (2019).

money laundering and terrorist financing, consumer protection, financial stability and even states' monetary autonomy. In this situation, there have been constant calls for regulation of this type of initiative, and central banks are being urged to study the issuance of CBDC in response.[6]

Naturally, the threat of stablecoins is not in itself reason enough to issue CBDC. CBDC issuance has potentially far-reaching implications, requiring a detailed analysis in order to appropriately assess the pros and cons of any decision in this respect. In any event, the current context and the need to be ready for possible future developments necessitate that some urgency be given to such an analysis. Testifying to this are recent initiatives such as the creation of a group of central banks to share experiences and assess potential use cases.[7]

It is also worth remembering that the very concept of CBDC is relatively broad, and many of the studies conducted to date are partial, insofar as they focus on initiatives with very concrete characteristics or on CBDC's impact on very specific areas. Further, important operational aspects tend to be left out of discussions and at the same time mixed with concepts not necessarily related to CBDC, such as the possibility of extending access to accounts at central banks and changing the role of commercial banks.

This paper provides an overview of the concept of CBDC that may serve as a basis for an ordered discussion and an in-depth analysis of the different relevant aspects in the ongoing debate about this financial asset. The primary objective is to review the grounds that could warrant issuing CBDC and undertake a preliminary analysis of its main implications, especially those linked to the CBDC models that seem most likely to be adopted, judging by the motivations of the central banks whose issuance plans are currently most advanced.

The paper has the following layout: after this introduction, Section 2 sets out a simple definition of CBDC encompassing a broad range of models. Section 3 presents the main motivations prompting some central banks to consider the possible issuance of CBDC, with some examples provided. Section 4 describes three concrete CBDC models that could respond to the main motivations described in Section 3. Section 5 outlines a framework for analysing the possible impact of CBDC issuance on the financial system, especially as regards the possible replacement of deposits by CBDC and the effect of CBDC on bank crises. Finally, Section 6 summarises the main conclusions. Attached to this paper are various annexes analysing in greater detail some of the aspects discussed in the main body of the text.

6 See, for example, Landau (2019).

7 The group comprises the Bank of Canada, the Bank of England, the Bank of Japan, Sveriges Riksbank, the Swiss National Bank, the European Central Bank and the Bank for International Settlements. See https://www.bis.org/press/p200121.htm.

2 What is CBDC? A simple definition

Part of the confusion surrounding the debate about CBDC probably stems from the fact that it is a very broad concept encompassing manifold variants with different implications. Traditionally, two core aspects define CBDC: its digital nature (enabling it to have features that are not usually included in the traditional concept of currency)[8] and the possibility of a broader range of agents having access to central bank liabilities. Thus, CBDC would constitute a third form of central bank money, together with cash (physical, non-digital) and reserves (digital, but with access restricted to credit institutions). The economy's money supply is completed by commercial bank money, chiefly in the form of bank deposits, representing the bulk of what we consider money.[9]

The simple definition given in the previous paragraph covers multiple types of CBDCs. Any one CBDC initiative will require defining numerous aspects that vary among the different models. For instance, it will be necessary to determine whether or not it will be remunerated, the degree of privacy afforded, and the method of its distribution among users. Annex 2 includes some features that may vary among different CBDC models. However, not all combinations are possible; in particular, it does not appear feasible to simultaneously set the parity, the remuneration and the amount issued.

An additional element hampering the debate about CBDCs stems from their dual nature as a financial asset and as a means and system of payment. While discussions about the nature of assets and their related exchange mechanisms are more clearly separate in other areas, in the debate about CBDCs, it is normally assumed that a new asset is issued together with its own payment mechanism, thereby entwining the two discussions.[10]

8 See, for example, IBM Institute for Business Value (2019).

9 For a brief explanation of the different forms of money, see, for example, CPSS (2003) or CPMI (2015).

10 For example, commercial bank money in an economy mainly comprises households' and non-financial corporations' deposits. This money supply is used as a store of value and as a medium of exchange through the payment system. The discussion about the security and efficiency of payment systems is usually separate from debates about the amount of deposits and their appeal as an investment instrument. In the debate about CBDC, however, the two aspects are intertwined, as it is assumed that CBDC, by its very nature, requires a specific payment system that is separate from the usual systems.

3 Why issue a CBDC?

Although the concept of CBDC may be clarified with a precise definition, one key question remains unanswered: why should a central bank consider issuing a CBDC? As mentioned in the introduction, the mere technical possibility of its issuance and the existence of private stablecoins may spur discussion, but these factors should not by themselves be considered sufficient reason for issuing a CBDC.

Some theories envisage the possibility of issuing a universally accessible CBDC (i.e. available to the general public) as an alternative to bank deposits, with the ultimate aim of eliminating the existing fractional (and frictional) banking model and, with it, the possibility of banking crises. Banks would not be able to issue commercial money (in other words, deposits would have to be 100% backed by reserves) and they could only extend credit if it were supported by their retained earnings or specific funding. Although interesting from a theoretical standpoint and for long-standing debates such as the Chicago Plan,[11] this type of proposition would entail a complete overhaul of the financial system as we know it today, with numerous unanswered questions as to the final equilibrium situation and the transition thereto. At present, such propositions are not officially being considered by any central bank or other authority and are therefore not discussed here.

In more practical terms, there are three areas where some serious consideration is being given to issuing CBDC in certain jurisdictions. Specifically, as a way to resolve problems relating to cash usage, financial inclusion and certain limitations in payment systems.

— **Cash:** In some economies, such as Sweden and Norway, cash usage is declining at great speed (as a percentage of GDP and in nominal terms) and it is no longer accepted by many retailers as a means of payment. Part of the population runs the risk of losing access to this instrument, and alternative retail payment systems (mainly cards) are private in nature, as well as having foreign capital. Faced with this situation, the central bank could consider issuing a universally accessible CBDC, similar to cash, so that the population continues having access to a risk-free, publicly-provided medium of exchange. The CBDC would also have a separate exchange system, enabling it to be used should the private systems fail for whatever reason.

— **Financial inclusion:** In other countries, a substantial part of the population does not have access to banking services and, therefore, relies crucially on cash, the production and distribution of which pose cost and security problems. Issuance of a universally accessible CBDC could, in these cases, complement the use of cash and represent a first step towards providing financial services to a larger

11 See Fisher (1935). More recently, this discussion was once again raised by Benes and Kujmhoff (2012).

portion of the population. Access to CBDC would allow for the identification of users through basic "know your customer" (KYC) processes which, together with their transaction history, could then pave the way for access to and use of banking services. The project to issue CBDC in the Bahamas, for instance, fits this model.[12]

— **Payment systems**: Assuming that CBDC issuance entails creating a specific mechanism of exchange, the possibility of issuing CBDC could also be considered to improve the efficiency or overcome the limitations of current payment systems. To this end, it is important to distinguish three different cases, each potentially giving rise to different proposals:

  – Retail payment systems: If the domestic payment system is inefficient or a monopoly, a CBDC whose associated payment system is more efficient or provided by a public entity could be a solution. Nevertheless, broadly speaking, domestic payment systems are highly efficient and there are therefore few concrete examples of this category. Although the Bahamas project points towards financial inclusion, the efficiency of the domestic payment system is also mentioned among its objectives.

  – Wholesale payment systems:[13] Some private institutions have called for the creation of a wholesale CBDC through which central bank money can be used in a controlled environment, enabling tokenised securities and funds to be exchanged using smart contracts. Indeed, new technologies allow for functionalities that are not possible in traditional wholesale payment systems (based on the exchange of banks' reserve balances in the RTGS). The JPM Coin and Fnality proposals, among others, point in this direction, envisaging the issuance of private digital money backed by collateral. Some participants in these initiatives make repeated requests to central banks to consider issuing CBDCs as a more efficient solution than private tokens to form the basis for novel and potentially more efficient proposals. Some central banks (for example, the Bank of Canada with its Jasper project) have carried out trials to test blockchain technologies in this field.

  – Cross-border payment systems: Most payment transactions between different currency areas are performed through correspondent banking mechanisms. These systems are slow,

12 In some developing countries without their own currency, in addition to financial inclusion, there is the possibility of fostering a national currency to tackle dollarisation. This is the case, for example, of the CBDC initiative in the Marshall Islands.

13 Normally, a real-time gross settlement (RTGS) system.

costly and not very transparent, although projects aimed at enhancing the efficiency of this type of payment are under way (such as SWIFT gpi). The alternatives to correspondent payments, for example international card schemes and entities such as Western Union and Moneygram, offer faster services but do not always cover every use case, and their cost is not always low. The creation of a supranational CBDC could resolve these problems. The International Monetary Fund's proposal to issue a synthetic global CBDC (backed by a basket of assets denominated in different currencies) is one example pointing in this direction.

Although some central banks are considering the possibility of issuing CBDC to resolve problems such as those described, it is important to mention that it is not the only possible solution. Inefficiencies in cross-border payment systems, for example, could be resolved by interconnecting domestic systems. This is a complex problem that goes far beyond a simple technical interconnection; however, in principle, it is not unresolvable and does not necessarily require the creation of a CBDC.[14] The existence of alternatives therefore requires consideration be given not only to the CBDC's capacity for resolving a potential issue, but also to its degree of efficiency in doing so.

Other motivations for issuing CBDC can also be found in the literature.[15] However, at least for the time being, these are less important in most debates and the most advanced case studies. In particular, these include motivations related to monetary policy, enabling the reduction (and potentially, elimination) of the so-called zero lower bound (i.e. the existence of a floor for the setting of negative rates by monetary authorities). Nor are the possible loss of seigniorage income or potential improvements to financial stability currently considered to be significant motivations by central banks.[16] Nevertheless, it should be highlighted that, although the improvement of monetary policy and financial stability is not at present sufficient reason to consider issuing CBDC, its issuance could naturally have important effects on these areas, and they will need to be taken into account in any cost-benefit analysis.

14 This is one of the conclusions of the G7 Working Group on Stablecoins (2019). Going forward, a technical debate is expected to commence for conducting a cost-benefit analysis of an improvement in cross-border payment systems (with and without issuing CBDC).

15 See, for example, Bordo and Levin (2017).

16 A comprehensive list of the different motivations and a preliminary assessment of them from a central bank standpoint are provided in Engert and Fung (2017).

4 Three CBDC models

The main motivations currently driving some central banks to consider the possibility of issuing CBDC are described in the previous section. This section gives an outline of three CBDC models, with very different characteristics, which could be adapted to the problems described. These are (i) cash-like CBDC, as a complement to cash in places where its usage is on the decline, or to foster financial inclusion; (ii) wholesale CBDC, to improve wholesale payment systems; and (iii) cross-border CBDC, to improve cross-border systems. Table 1 sets out the main features that these models could have, together with a comparison with cash and reserves.

— **Cash-like CBDC:** This type of CBDC would be the form closest to cash, but in a digital format. It would be universally available, although the central bank would most probably rely on private institutions for its distribution. It would not be remunerated and, although full anonymity cannot be guaranteed in an electronic system, it could be implemented with a high degree of privacy. It could also be designed so as to be traceable and provide extensive information on its usage to the issuing or managing entity. This type of CBDC could be a complement to cash, improve financial inclusion and (potentially) provide an alternative to private payment systems. If the associated exchange system were efficient, it could even improve the functioning of local payment systems.

— **Wholesale CBDC:** Use of this type of CBDC would be restricted to specific institutions, as in the case of reserves, but it would be tokenised central bank money. It could therefore be used in distributed ledger technologies (DLTs) and as a payment method in smart contracts. Using central bank money in these environments could enhance the efficiency of certain processes, such as trade finance. As this asset would be very similar to reserves, it would presumably have an equivalent remuneration (negative in the current European context).

Table 1
CASH, RESERVES AND THREE POSSIBLE CBDC MODELS

	Cash	Reserves	Cash-like CBDC	Wholesale CBDC	Cross-border CBDC
Digital format	No	Yes	Yes	Yes	Yes
Availability	Universal	Restricted to credit institutions	Universal	Restricted to financial institutions	Potentially universal
Parity (with local currency)	Yes	Yes	Yes	Yes	No
Remuneration	No	Yes	No	Yes	No (?)
Anonymity	Yes	No	No (but quasi-anonymity could be achieved in some cases)	No	No

SOURCE: Devised by authors.

— **Cross-border CBDC:** In this case, the CBDC would possibly have a specific unit of account; it could be issued by various central banks or international organisations and distributed by financial institutions. Its main purpose would be to facilitate international transfers. The value of the CBDC would probably be backed by a basket of collateral assets.

Since the most advanced CBDC initiatives tend to correspond to the first model described (cash-like CBDC), this type is discussed in the next section of this paper.

5 Some implications for central banking and the financial system

Although it is occasionally assumed that the central bank would play a key operational role in issuing CBDC, in reality there is a broad range of options, some of which envisage a residual role for central banks, limited to the issuance and, possibly, ultimate destruction of CBDC units. Central banks with the most advanced plans for issuing CBDC are considering the possibility of relying on external institutions to distribute it or to operate the mechanism of exchange. This approach is not surprising, since central banks are generally not prepared for maintaining a high number of direct relationships with customers (individuals or non-financial corporations) or for performing tasks related to managing such relationships, including those associated with the prevention of money laundering and terrorist financing. Annex 3 describes the broad characteristics of the initiatives in the Bahamas and China, two examples where the central bank will foreseeably be supported by the financial sector in issuing CBDC and managing relationships with users.

Another key concern is the impact that CBDC issuance could have on the financial system. Specifically, three scenarios are of particular concern: (i) where it replaces bank deposits; (ii) where it contributes to a deposit outflow from a specific bank when it is stressed; and (iii) where it contributes to a large-scale deposit outflow from the banking system in the event of global distrust in the financial system as a whole.

— **Replacement of deposits by CBDC:** The issuance of CBDC entails creating a new type of financial asset that competes with existing assets. In the event that CBDC is more attractive than other assets, different agents could foreseeably eschew such assets in order to acquire CBDC. Such a rebalancing of investment portfolios would alter the prices or amounts of existing assets. The impact on the financial sector would hinge both on the volume replaced and the speed of the adjustment. If the adjustment is small and slow-moving, the effects would foreseeably not be substantial. Conversely, if the adjustment happens quickly and involves large amounts, it could have destabilising effects.

  In order to determine the possible impact, it is reasonable to compare the functionalities of the CBDC to be issued with those of existing assets, including bank deposits. In the latter case, the appeal of CBDC to individuals should not be overstated. In a financially stable environment, where bank deposits are protected by a guarantee scheme and payments can be made quickly and cheaply, it is not clear that a retail CBDC can provide elements making it attractive to the average consumer. Indeed, it is even possible that the public does not clearly perceive the difference between balances held in deposits and those in CBDC. In any event, the central bank could regulate some features to make the CBDC more or less attractive than deposits (including zero or even negative remuneration) or to introduce caps on its use (for example, maximum balances). These adjustments could be used to tailor demand for CBDC and limit the possibility of a large-scale replacement of deposits. Conversely, they

could be used to ensure sufficient demand for the new asset so that it has minimal acceptance, warranting the investment made for its launch.

— **Deposit outflow from a bank:** At a time of crisis, a bank's depositors may attempt to transfer their balances to safer assets, such as those with central-bank backing. CBDC issuance could foster such a movement and therefore ultimately have undesired effects on financial stability. In response to this reasoning, two considerations must be made. First, depositors can already resort to another asset backed by the central bank: cash. Admittedly, resorting to CBDC may possibly be faster, more ubiquitous and less costly, but it does not essentially change depositors' options. As with cash, caps could be introduced on access to CBDC and, as with cash, a CBDC could be designed in which the convertibility of deposits is not unlimited, but instead depends on the amount of the bank's reserves for carrying out the conversion (see Annex 3). Second, and far more importantly, depositors can already withdraw their balances quickly and cheaply through payment systems and transfer their deposits to other banks. Again, such movements are not unlimited and depend on the reserves available to the bank experiencing the outflow. In conclusion, the introduction of CBDC does not greatly change the situation in cases of a loss of trust in one or several banks, but where confidence in the financial system as a whole holds firm.

— **Large-scale deposit outflow in the event of a general loss of trust in the financial system:** In this case, a deposit outflow could be facilitated in an environment with CBDC, as CBDC could be acquired and would have lower maintenance costs (in terms of security) than cash. However, if the CBDC conversion rules were similar to those governing cash, the central bank would not assume an unlimited commitment that is greater than at present. Instead, deposits could only be converted into CBDC insofar as the banks concerned had reserves available (as currently happens with cash). The central bank would continue to have the option (not the obligation) to provide emergency liquidity, in the same way that it can opt to provide cash today. In any event, additional caps could be imposed on the conversion of deposits into CBDC. In conclusion, CBDC issuance does not in itself entail a guarantee of unlimited conversion of bank deposits. Therefore, the possibility of deposit outflows would not necessarily have to be much higher than at present.

Conclusions

This brief paper provides basic elements for an ordered discussion on CBDCs, a debate of growing importance thanks to the spread of new technologies associated with crypto-assets (blockchain) and stablecoins such as Libra.

In order to carry out an informed analysis, the shortcomings or limitations of the current financial system that CBDC could overcome, or the improvements that it could bring, must first be identified. Once identified, and given the relative vagueness of the concept of CBDC, which encompasses multiple variants, it will be necessary to design a concrete CBDC model, assess the adverse impacts that it could have in other areas and consider the possibility of more efficient alternative solutions.

Although the debate seems to indicate the contrary, the implementation technology should not, a priori at least, be a key aspect. The main motivations currently considered by central banks that are most advanced towards the possible issuance of CBDC are enhancing financial inclusion, complementing cash in jurisdictions where its usage is falling sharply, and increasing the efficiency of domestic and cross-border payment systems.

For the time being, the efficiency of monetary policy implementation and the structure of the financial system are not among the motivations given by these central banks. However, CBDC issuance could undoubtedly have an impact on these areas, depending on the model selected; these aspects must therefore also be important for the design of a CBDC.

On the risk side, the large-scale migration from deposits to CBDC, in the event of its issuance, seems unlikely in an environment where bank deposits and the banking system function properly. Nevertheless, the design of the CBDC can include restrictions mitigating these risks.

Lastly, the cost-benefit analysis of issuing CBDC may produce very different cross-economy results. In the euro area, for example, the (dis)use of cash has not reached the levels seen in countries such as Sweden, there are no severe problems of financial exclusion, and retail and wholesale payment systems are quite efficient. That said, there is a problem of fragmentation within retail payments in the euro area, although there are also private initiatives to resolve them. Further, the problems in cross-border retail payments transcend the borders of the euro area.

All of the above considerations make it necessary to further analyse the pros and cons of the different types of CBDC and the alternatives, in order to be in a position to undertake a comprehensive cost-benefit analysis.

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Annex 1 Stablecoins

Since the emergence of the first crypto-asset over a decade ago, in late 2008, the number of initiatives has progressively increased to more than 2,300 crypto-assets. Concurrently, the ecosystem of these digital assets has gradually developed and become more complex. Examples include the launch of a bitcoin futures market and the supply of specialised crypto-asset custody services. However, the high volatility characterising the price of the main crypto-assets (see the example of bitcoin in Chart A1.1) continues to hamper their use as a medium of exchange and as a stable store of value over time.

In order to minimise this volatility, a specific category of crypto-assets, called stablecoins or "second-generation crypto-assets", began to appear from 2014 onwards.[1] The differentiating feature with respect to traditional crypto-assets is their aim to maintain a stable value in terms of another asset. This reference asset is generally a currency, such as the dollar or euro, although it may be any type of asset or commodity with a fairly stable price.

From an operational standpoint, the governance arrangements[2] of stablecoins incorporate a series of mechanisms aimed at minimising volatility vis-à-vis the reference price. Depending on the stabilisation mechanism, two broad categories of stablecoins can be identified: collateralised stablecoins and algorithmic stablecoins, which enable supply to be adjusted dynamically.[3]

Collateralised stablecoins aim to stabilise their prices through a reserve of funds or assets backing the stablecoins in circulation. Thus, the issuance of stablecoins is against the delivery of foreign currency, financial assets, physical assets and even, in the most innovative designs, other crypto-assets. The level of collateral-backing depends primarily on the volatility of the collateral used; excess collateral is usually provided when crypto-assets are deposited. There can also be secondary mechanisms to influence the supply and demand of stablecoins, thus helping to stabilise their price. Included here are the imposition of operational limits and fee charges for certain operations.

The main alternative stabilisation mechanism consists of using mathematical algorithms to adjust the supply of stablecoins to demand, dispensing with the use of collateral. To date, this stablecoin category is less common than collateralised stablecoins, owing in part to its greater technical complexity.

Despite recent advances, stablecoins continue to be in an early stage of development, and not all manage to maintain ongoing price stability over time (see Chart A1.2). Notable

1 Tether was the first example of a stablecoin and continues to be the most popular today in terms of market capitalisation.

2 Defined by the issuer or other users with voting or governance rights, depending on the configuration in each case and the existing level of decentralisation.

3 Nevertheless, there may be "hybrid" models which initially use collateral and subsequently evolve to algorithms.

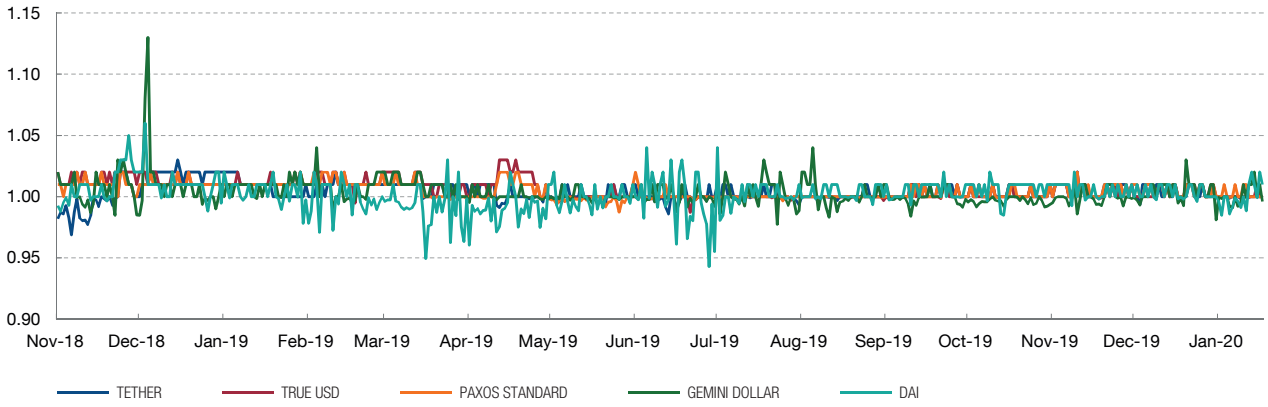
Chart A1.1

HISTORICAL VOLATILITY OF BITCOIN

SOURCES: coindesk.com and Banco de España calculations (90-day moving deviation).

Chart A1.2

PRICE OF STABLECOINS PEGGED TO $1



SOURCE: coinmarketcap.com.

among its current uses is in crypto-asset trading operations, enabling investors to protect themselves from volatility in their investments without needing to convert their positions to fiduciary money.

Annex 2 Features of the different types of CBDC

CBDC is defined by its digital nature and by being a more accessible central bank liability than reserves. These two core characteristics, however, leave many other aspects undefined, and there is therefore a wide range of potential CBDC models. When defining a concrete CBDC model, the following characteristics, among others, would need to be defined:

— **Remuneration:** CBDC could accrue fixed or floating interest, which could be positive, negative or zero.

— **Privacy:** CBDC could offer various degrees of privacy or even near-complete anonymity. In the latter case, blockchain technologies could be required, although the creation of a fully anonymous CBDC model does not seem feasible or desirable.

— **Direct or intermediated distribution and operation:** In some cases, the central bank could distribute CBDC directly to end-users and operate the system of exchange; in other cases, the central bank may prefer various intermediaries to distribute the CBDC and operate the system of exchange.

— **Rules on issuance:** It could be issued passively (on demand), or a specific issuance target could be set.

— **Rules on usage:** It could be universally available without any type of limitation, or with some type of restriction on maximum balances, transactionality (maximum number or amount of transactions within a certain timeframe) or possible users (e.g. only individuals or small enterprises).

— **Rules on convertibility:** CBDC could be exchangeable on demand for other central bank liabilities (cash or reserves) or for commercial bank deposits, or on a restricted basis, such that only some agents can perform the exchange or it can only be carried out up to certain amounts.

— **Parity with other forms of money:** In principle, it is usually assumed that the CBDC would be denominated in the same unit of account as the rest of the economy's money at an exchange of one to one. However, in certain cases, one option would be to create a new unit of account (for example, to facilitate international trade and migrants' transfers between two or more currency areas).

— **Technology:** It is not a coincidence that technology is the last point mentioned. Although the debate about stablecoins and CBDC originated in technical discussions on the possibilities opened up by DLT, it is not at all clear that CBDCs would require this type of technology. Focusing the debate on technology could

be counterproductive, as selecting a specific technology beforehand could precondition the functionalities that could be offered. Instead, it should be the other way around: selecting the desired functionalities needs to be the primary objective, and the technology chosen should match the desired model. That said, in certain cases, DLT can offer functionalities that were not possible with other, more traditional approaches.

Annex 3 Two models for the phased-in issuance of CBDC: the cases of China and the Bahamas

CBDC project of the People's Bank of China[1]

The People's Bank of China (PBoC) has announced its intention to soon begin issuing a sovereign digital currency (CBDC). This new digital money would have two of the most distinctive qualities of cash: portability and anonymity (although anonymity would not be perfect, as transactions would be traceable by the authorities). It would also be 100% backed by reserves and would not accrue interest. Thus, it would represent an enhanced version of cash, as it would be a more versatile option[2] and strengthen the fight against money laundering and the pursuit of unlawful activities. The CBDC would be a free-of-charge alternative to the private retail payment solutions that have proliferated in China in recent years; it would also enable more efficient settlement between financial institutions in a single ledger. Moreover, it could foster the use of the renminbi for cross-border payments.

The central bank itself is expected to maintain absolute control of the digital currency and infrastructure.[3] However, it would be distributed among the public in two stages. First, the PBoC would issue and redeem CBDC through commercial banks. Second, commercial banks would be responsible for its distribution among the public and firms, intervening in a similar manner to under the current model. Thus, the PBoC could replace cash without changing current distribution channels, minimising the CBDC's impact on financial stability and on the taking of deposits by commercial banks.

Central Bank of the Bahamas: Project Sand Dollar[4]

The Central Bank of the Bahamas is considering the issuance of CBDC and intends to carry out a "Project Sand Dollar" pilot in 2020. The aim of digitalising the Bahamian dollar is to modernise the country's payment infrastructure, providing all citizens and firms with access to a digital mobile payment network and resolving the logistical challenges posed by the specific features of the archipelago. At the same time, the initiative will allow for improving financial inclusion and access to financial services, as the digital currency would complement more traditional banking services. In terms of efficiency, it is expected to reduce the costs associated with cash (use of which is expected to decline) and improve transaction efficiency.

It has been proposed that the infrastructure supporting the CBDC be a blockchain platform that adheres to international anti-money laundering and counter-terrorism

1 *Binance Research. First Look: China's Central Bank Digital Currency* (August 2019) (available at https://info.binance.com/en/research/marketresearch/img/issue16/Binance-Research-China-Central-Bank-Digital-Currency.pdf).

2 Valid both for the retail public and for certain interbank operations.

3 The possibility of the new infrastructure being supported by blockchain technology has been assessed as part of this project. However, given the high performance that will be required (with a potential need to process 300,000 transactions per second), this technology has not been considered appropriate.

4 "The Bahamian Payment System Modernisation: Advancing Financial Inclusion Initiatives", March 2019, speech by John A. Rolle (Governor of the Central Bank of the Bahamas); "Project Sand Dollar: The Central Bank Identifies Preferred Technology Solutions Provider for Bahamas Digital Currency", March 2019, press release from the Central Bank of the Bahamas.

standards. Users will be able to access the infrastructure by setting up a mobile wallet, either with the central bank or with other financial service providers, although the central bank's role in this area is expected to gradually decrease. These wallets will not be linked to a bank account, and a ceiling is expected to be imposed on the amount of CBDC that can be held by individuals. Further, balances will not accrue interest and will be redeemable at any time. Payments made with digital Bahamian dollars will not be anonymous and KYC procedures will be implemented for accessing the infrastructure. Lastly, in order to guarantee interoperability with the rest of the financial system, the infrastructure will be connected to banks and other payment service providers.

Annex 4 Cash-like CBDC: convertibility and deposit outflows

Broadly speaking, it is assumed that convertibility between the different forms of money without significant friction is essential for maintaining the parity of one to one between its different representations.[1] Extending this reasoning to CBDC issuance, it is argued that users will be able to convert, on demand, unlimited deposits into CBDC, with the central bank being responsible for guaranteeing this convertibility in some models.[2]

Although admittedly there can be many different CBDC models, this annex analyses a CBDC with a similar functioning to cash in order to show that CBDC issuance may not substantially change current convertibility arrangements, in which the central bank has limited responsibilities.

To this end, let us begin by considering a situation before CBDC is issued, with a simple model including two commercial banks (X and Y) and a central bank, whose balance sheets appear in Figure A4.1. The banks take deposits from the public and receive loans from the central bank, which they invest in extending loans and buying securities that can be used as collateral for transactions with the central bank. They also have accounts at the central bank (reserves) enabling them to operate with other banks through the wholesale payment system (RTGS) or to buy cash. Within its liabilities, the central bank has the cash issued and the banks' accounts, which it invests in securities and loans extended to the banks. Let us assume that the cash is fully held by customers of the banks.

In this model, there are three forms of money: reserves, cash (central bank liabilities) and commercial money (deposits that are included in the banks' liabilities). The central bank only maintains relationships with the banks and does not directly operate with their customers. In these conditions, how can the banks' customers exchange their deposits for other forms of money?

First, it should be highlighted that the customers do not have access to reserves. Therefore, if the customer of a bank (X) wishes to exchange their deposits for another type of money, their only possibility is to convert these deposits into cash or to transfer them to another bank (Y). In the first case (see Figure A4.2), the customer requests the cash from their bank. The bank, which does not have cash on its balance sheet, purchases this cash from the central bank. The central bank issues cash in exchange for a debit in X's reserves and transfers the cash to the bank, which in turn delivers it to the customer. The balance

1 See, for example, "Do We Need Central Bank Digital Currency? Economics, Technology and Institutions", SUERF/BAFFI CAREFIN Centre Conference (available at https://www.suerf.org/docx/s_cf0d02ec99e61a64137b8a2c3b03e030_7025_suerf.pdf).

2 See, for example, O. Ward and S. Rochement (2019), "Understanding Central Bank Digital Currencies (CBDC)", Institute and Faculty of Actuaries (available at https://www.actuaries.org.uk/system/files/field/document/Understanding%20CBDCs%20Final%20-%20disc.pdf) or B.S.C. Fung and H. Halaburda (2016) "Central Bank Digital Currencies: A Framework for Assessing Why and How", Bank of Canada (available at https://www.bankofcanada.ca/wp-content/uploads/2016/11/sdp2016-22.pdf).

Figure A4.1

Bank X

Assets		Liabilities	
Reserves	200	Deposits	800
Loans	600	CB loans	100
Collateral	200	Capital	100

Bank Y

Assets		Liabilities	
Reserves	300	Deposits	700
Loans	550	CB loans	150
Collateral	150	Capital	150

Central bank

Assets		Liabilities	
CB loans	250	Reserves	500
Collateral	600	Cash	200
		Capital	150

SOURCE: Banco de España calculations.

Figure A4.2

Bank X

Assets		Liabilities	
Reserves	100 (-100)	Deposits	700 (-100)
Loans	600	CB loans	100
Collateral	200	Capital	100

Bank Y

Assets		Liabilities	
Reserves	300	Deposits	700
Loans	550	CB loans	150
Collateral	150	Capital	150

Central bank

Assets		Liabilities	
CB loans	250	Reserves	400 (-100)
Collateral	600	Cash	300 (+100)
		Capital	150

SOURCE: Banco de España calculations.

sheet of bank X shrinks and the stock of money held by the public (deposits and cash) does not change.

The second option is to transfer deposits from one bank to another. In this case (see Figure A4.3), bank X debits its customer's account and issues an interbank payment through the RTGS in favour of this customer's account at bank Y. That transaction is settled in the reserve accounts of the two banks at the central bank (-100 in X's account and +100 in Y's account). Upon receiving payment in its central bank account, bank Y credits its customer's deposit account. The balance sheet of bank X shrinks, the balance sheet of bank Y expands and the aggregate balance sheet of the central bank does not change. In both cases, converting deposits requires reserves.

Figure A4.3

Bank X

Assets		Liabilities	
Reserves	100 (-100)	Deposits	700 (-100)
Loans	600	CB loans	100
Collateral	200	Capital	100

Bank Y

Assets		Liabilities	
Reserves	400 (+100)	Deposits	800 (+100)
Loans	550	CB loans	150
Collateral	150	Capital	150

Central bank

Assets		Liabilities	
CB loans	250	Reserves	500 (-100X, +100Y)
Collateral	600	Cash	200
		Capital	150

SOURCE: Banco de España calculations.

Figure A4.4

Bank X

Assets		Liabilities	
Reserves	200	Deposits	800
Loans	600	CB loans	100
Collateral	200	Capital	100

Bank Y

Assets		Liabilities	
Reserves	300	Deposits	700
Loans	550	CB loans	150
Collateral	150	Capital	150

Central bank

Assets		Liabilities	
CB loans	250	Reserves	500
Collateral	750	Cash	150
		CBDC	200
		Capital	150

SOURCE: Banco de España calculations.

Large-scale deposit outflow

In the extreme case of a large-scale deposit outflow from bank X (let's assume of 700 units), the bank first uses the reserves available to convert these balances into cash or to transfer them to other banks through the RTGS. Once the reserve balance is exhausted (200), the bank uses the collateral available (200) to obtain new reserves at the central bank. Once this limit has been reached, the bank will depend on the provision of emergency liquidity by the central bank or will go into liquidation, and the deposit guarantee mechanism will possibly be activated. The central bank can provide additional liquidity, but it is not required to do so.

In conclusion, in the absence of CBDC, customers can order their deposits be converted into cash or into commercial money at other banks. Nevertheless, responsibility

for carrying out this conversion lies with the bank where the customer has an account (not the central bank), and the bank can only carry it out to the extent that it has reserves (or eligible collateral with which to access the reserves). In other words, the convertibility of deposits into cash is not guaranteed by the central bank, although in normal circumstances it can be carried out by the bank where the customer holds the account. Convertibility is not guaranteed in the event that a large-scale deposit outflow (to cash or to accounts at other banks) exceeds the bank's capacity to access reserves in order to convert them into cash or to send deposits to other banks.

Introduction of CBDC

Let us now introduce CBDC into the foregoing model. This is a central bank liability that is digital in nature and accessible to bank customers (unlike reserves, which remain restricted to banks). As with cash, let us assume, for the sake of simplicity, that the balances of CBDC are fully held by the public.[3] The revised balance sheets are presented in Figure A4.4. The convertibility of deposits into cash or into balances at other banks does not change. However, the introduction of CBDC would enable users to exchange cash and deposits for this new asset. A crucial aspect of the model (which could hold unchanged following the introduction of CBDC) is that the central bank does not directly operate with end-users and it therefore only guarantees convertibility between reserves, cash and CBDC for banks. In other words, the operating procedure for CBDC would be similar to that for cash.

In this situation, cash would be converted into CBDC, and vice versa, with the banks as intermediaries. The customer of bank X would transfer the cash to their bank, which in turn would send it to the central bank. The central bank would remove the cash and issue CBDC, which would be sent to the customer through their bank. The bank's balance sheet would not change, nor would the aggregate balance sheet of the central bank. Banks could hold cash and CBDC balances on their balance sheets to facilitate this conversion in normal circumstances, without changing the basic mechanics of the conversion process.

The conversion of deposits into CBDC would be similar to that for cash. A customer of bank X wishing to convert their deposits into CBDC would go to their bank, which would buy the required balance of CBDC from the central bank in exchange for reserves, and subsequently deliver the CBDC balance to the end customer. The outcome is presented in Figure A4.5.

In this model, and despite the introduction of a new asset, the central bank does not assume automatic and unlimited convertibility of deposits into CBDC. The conversion would be carried out in a similar manner to that for cash at present as, in order to access the balances in CBDC (or in cash) required by customers, banks need to have reserves available. The convertibility between deposits and CBDC would not be guaranteed by the

3 The model can be made more complicated by introducing small cash or CBDC balances on banks' balance sheets to facilitate the conversion of customer deposits, but the basic working and conclusions do not change.

Figure A4.5

Bank X

Assets		Liabilities	
Reserves	100 (-100)	Deposits	700 (-100)
Loans	600	CB loans	100
Collateral	200	Capital	100

Bank Y

Assets		Liabilities	
Reserves	300	Deposits	700
Loans	550	CB loans	150
Collateral	150	Capital	150

Central bank

Assets		Liabilities	
CB loans	250	Reserves	400 (-100)
Collateral	550	Cash	150
		CBDC	300 (+100)
		Capital	150

SOURCE: Banco de España calculations.

central bank. Although in normal circumstances it could be carried out by the bank where the customer has their account, it may not be possible in the event of a large-scale deposit outflow exceeding the bank's capacity to access reserves to convert them into cash or CBDC or to send the deposits to other banks.

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