Digital currencies: Threats and opportunities for monetary policy

A. Stevens (*)

Introduction

Ever since its introduction in 2009, bitcoin and its underlying technology have spurred interest in so-called digital currencies. At first sight, a digital currency is nothing more than an electronic variety of money, just like deposited money in bank accounts or in electronic wallets such as Apple Pay and PayPal. However, its central innovation compared with existing forms of electronic money is that it can be exchanged peer-to-peer, much like cash (Camera, 2017; Raskin and Yermack, 2016). The settlement of cash transactions is completed by the simple physical transfer of, for example, coins and banknotes. By contrast, electronic money instruments are non-tangible and thus do not permit such a physical transfer. As a result, a ledger must be in place to record property rights over and transactions in these instruments. Conventional electronic money systems rely on several layers of trusted institutions, such as central banks or credit card issuers, to process transactions and to update the ledger. The involvement of third parties implies that such systems are basically centralised and likely more expensive than systems that grant some decentralisation, such as cash systems (Camera, 2017). Digital currency schemes aim to avoid the involvement of middlemen and hence intermediation costs by managing their ledger through so-called "distributed ledger technology" (DLT). This technology offers the possibility of a decentralised book-keeping system – called a distributed ledger as it is shared among the users of the system – that works in a self-verifying fashion. In fact, all actions in the ledger need to be verified by users of the system. The settlement mechanism for digital currency transactions is therefore not intermediated but direct: the transaction is settled as soon as enough system participants agree that it is valid.

By granting, at the same time, peer-to-peer payment facilities and the convenience of electronic transactions, digital currencies could provide significant competition for traditional monetary instruments and, hence, may have important implications for central banks, the financial system and the economy more generally. This article focuses on both the challenges and opportunities that digital currencies present to a central bank's monetary policy. For instance, private digital currencies, if widely adopted, could lead to significant financial and monetary stability risks. For one thing, privately issued digital currencies are traditionally not denominated or tied to a sovereign currency, but rather denominated in their own units of value. Hence, exchange rate risks are inherent and might impair financial stability and monetary policy transmission. Moreover, by substituting for regular money – here defined as monetary instruments with legal tender status, such as coins, banknotes and transferable deposits –, widely adopted private digital currencies could significantly reduce a central bank's control over monetary conditions. This would not only restrict a central bank's ability to steer interest rates but also its capacity to act as a lender of last resort.

However, it has recently been increasingly suggested that digital currencies could also entail opportunities for monetary policy. More specifically, their underlying distributed ledger technology could provide central banks with a platform to develop and issue their own electronic form of banknotes – a so-called central bank

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digital currency (CBDC)[1]. Different arguments can be cited as to why a central bank might consider issuing such a CBDC. For instance, adopting a sovereign digital currency could be an appropriate policy response to curb the risks of private initiatives mentioned above; at least to the extent that there are reasons to presume that such risks would be relevant. Another often stated argument is that a CBDC could help to relax the effective lower bound constraint on nominal interest rates, permitting the central bank to implement negative policy rates if that were warranted by economic circumstances. Such arguments, however, should be set against the implications of sovereign digital currencies for the banking system – and these appear to be highly uncertain. On the one hand, by providing competition for bank deposits, the adoption of a CBDC could limit the practice of fractional reserve banking, making for a safer financial system, with less scope for impairment in monetary policy transmission. Yet on the other, too widespread a substitution of bank deposits by CBDC could lead to a significant de-funding of the banking sector, with negative spillover effects on credit creation and monetary policy.

The article proceeds as follows. Section 1 sets the stage, briefly sketching out the language we will use to describe non-physical types of money. Subsequently, section 2 discusses the potential challenges imposed by privately issued digital currencies for the conduct of monetary policy. The opportunities for monetary policy associated with a potential adoption of sovereign digital money are discussed in section 3. The final section sets out our conclusions.

1. Some definitions

As noted by Camera (2017), no clear consensus exists on the language used to describe money components that lack the physical structure of cash. For instance, throughout the literature, different interpretations are given to the concepts "e-money", "digital money", "cryptocurrency" and "virtual currency". Sometimes these terms are used interchangeably (as, for instance, in Fung and Halaburda, 2016). In other publications, they refer to rather distinct forms of money, depending on the criteria applied to classify non-physical types of money instruments.

In this article, we adopt the definitions proposed by Barrdear and Kumhof (2016), which largely correspond to the official terminology used by the Bank of England[2]. Their classification basically depends on the technology underpinning the currency instrument. Against this background, "electronic money" (e-money) is broadly defined as monetary value stored in an electronic device that can be used to make payments – much in line with the definition used by the Bank for International Settlements (BIS, 2015); in brief: any intangible type of money that is based on computer technology. Note that this definition is broader than the legal definition of e-money as specified in EU legislation[3]. The term "digital currency" is used to refer to any electronic form of money that features a distributed ledger and a decentralised payment system. "Cryptocurrencies" are defined as a separate sub-class of digital currencies, with their distinguishing feature depending on the consensus mechanism applied for updating the ledger (for more details, see Barrdear and Kumhof, 2016). To simplify matters, we ignore the role that specific technical modalities of the distributed ledger technology – such as the consensus mechanism – might play for the economics of digital currencies. In what follows, we therefore only make reference to the more general notion of digital currencies.

The above definitions are fairly broad: they are not necessarily linked to any legal terminology and do not depend on features other than the underlying technology, such as the denomination of the currency (sovereign or another reference unit) or its issuer (public or private entity). Any reference to such additional features will be spelled out clearly. For instance, the prefixes "private" and "central bank" serve to clarify the type of issuer of a digital currency.

2. Potential risks of privately issued digital currencies to monetary policy

The potential risks of private digital currencies for monetary policy have been well described in – amongst others – a recent article by Ali *et al.* (2014). Inspired by a policy brief by Lo and Wang (2014), assessing whether bitcoin can be regarded as a currency instrument, this chapter recasts many of the arguments of Ali *et al.* (2014) by thinking about the performance of a digital currency in serving the three traditional functions of money: first, money is considered as an instrument that facilitates trade by acting as a *medium of exchange* – i.e. money can be used for buying and selling goods and services. Second, money acts as a *store of value* in that it is a convenient way to store wealth – i.e. money can be used to transfer purchasing power from the present to the future. Finally, money serves quantification purposes as a *unit of account* – i.e. money is the common standard for measuring the relative worth of goods and services.

(1) The term "central bank digital currency" was first used by Broadbent (2016).
(2) The definitions applied by the Bank of England can be found at http://www.bankofengland.co.uk/research/Pages/onebank/cbdc.aspx.
(3) See https://www.ecb.europa.eu/stats/money_credit_banking/electronic_money/html/index.en.html.

In line with the literature, this section concludes that policy challenges are likely to be limited if private digital currencies only serve as a medium of exchange. In contrast, when these currencies are additionally regarded as a good store of value and – even more importantly – are also used as a unit of account, both monetary and financial stability risks may loom larger.

2.1 Low risks if private digital currencies only serve as a medium of exchange

As long as private digital currencies are merely used as a medium of exchange and are not considered as a unit of account or as a store of value, they should not pose significant threats to monetary policy. In principle, in this case, digital currencies work in a similar fashion to prepaid types of e-money instruments (e.g. electronic wallets such as Apple Pay and PayPal). More specifically, digital currencies are only put "into circulation" when regular money is exchanged by the user who intends to use it in a transaction, and, likewise, digital currency is absorbed (withdrawn from circulation) and exchanged back to traditional money as soon as the transaction is settled.

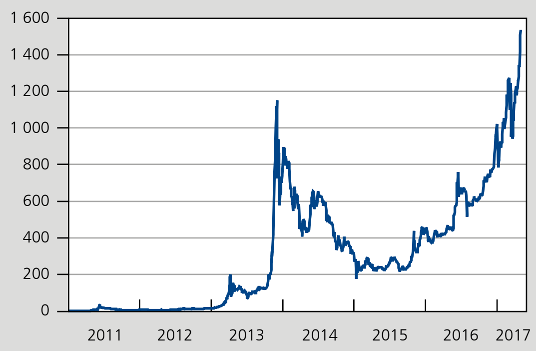
Consequently, in this scenario, a digital currency's net effect on the amount of money used for transactions should be limited, implying that the central bank maintains its ability to influence the money supply, short-term interest rates, and, hence, aggregate demand. In fact, the regular currency and the interest rate on it remain the dominant monetary guideposts, also when it comes to financing expenditure, whereas the digital currency only serves as a means of transaction. Moreover, when only used as a medium of exchange, a digital currency's price should, in theory, not be prone to too much volatility – precisely because its circulation depends on demand for it, and not on any speculation about its future price (which could be the case if the currency also served as a store of value).

The steadily growing list of merchants accepting payments in bitcoin (the most well-known private digital currency) suggests that private digital currencies have the potential to be widely accepted as payment for a sufficiently large set of goods or services (1). A 2014 study by Lo and Wang shows that retailers accepting bitcoin payments do not charge a premium and may in fact offer a discount (albeit typically a small one) on purchases made with bitcoin. This finding suggests that the peer-to-peer payment services provided by digital currencies – avoiding the fees charged by traditional payment providers – might fulfil these currencies' potential to lower transaction costs. However, at the same time, this study also suggests that digital currencies serve (so far) poorly as a store of value or as a unit of account. In fact, because the value of private digital currencies is traditionally not tied to a sovereign currency, their prices can be very volatile, as illustrated in chart 1 for bitcoin. Consequently, to avoid price volatility and associated distorted price signals, most merchants accepting bitcoin payments post their official prices in sovereign reference units (e.g. euros, dollars, etc.). Moreover, to fully reap the potential benefits of reduced payment processing costs, merchants hedge against potential exchange rate volatility. For instance, the check-out price in bitcoin is frequently updated (e.g. every ten to fifteen minutes) so as to maintain a relatively stable price when expressed in euros, whereas bitcoins paid are immediately converted back into euros (2).

2.2 Financial stability risks if private digital currencies also serve as a store of value

Increased financial stability risks and associated impairments in monetary policy transmission could emerge if private digital currencies were widely perceived as good stores of value, as such perceptions are unfounded. In fact, private digital currencies lack the elements of traditional stores of value that would render them safe vehicles for transferring wealth from the present to the future. For instance, in contrast to commodities (such as oil and gold), private digital currencies have no intrinsic value: intrinsically, they are nothing more than lines of computer code. Neither do private digital currencies carry any legal value, in that they are not backed by a sovereign entity as is the

CHART 1 THE VALUE OF BITCOIN
(US dollar per bitcoin)



Source: www.blockchain.info

(1) See, for example, the website Coinmap for an interactive map showing all physical stores around the world accepting bitcoin as a payment instrument.
(2) Bitcoin intermediaries such as Coinbase offer such hedging services.

case for regular money. More specifically, they are not legal tender – which would give them value in terms of being accepted to, for instance, discharge tax obligations. Nor do they imply a legal right to a regular currency at par – which would grant them value in terms of future consumption.

All of this means that a private digital currency's value hinges entirely on an expectation of others' willingness to accept it later at a sufficiently greater value (Lo and Wang, 2014). Put differently, the equilibrium value of private digital currencies depends on self-fulfilling expectations. This characteristic renders private digital currencies conducive to speculation and, hence, subject to bubbles. Consequently, the price of digital currencies can be very volatile (see, for instance, the bitcoin dollar exchange rate in chart 1) and price crashes are not inconceivable. Importantly, when the effects of such crashes cannot be limited to the direct holders of the alternative currencies, they might erode financial stability, which, in turn, might impair monetary policy transmission. The financial system would be particularly prone to such contagion effects if investment in private digital currencies were to have been debt financed, or if systemically important financial institutions were to have built significant unhedged exposures to such currencies (Ali *et al.*, 2014).

So far, the total value of all digital currencies would seem to be too small to pose a systemic threat to financial stability and monetary policy in the way presented above (1). Critical voices (e.g. Krugman, 2013) argue that the current high volatility of the exchange rate of private digital currencies (rendering them a poor store of value) prohibits their widespread adoption anyway, thereby limiting any potential financial stability concerns. However, recent theoretical model simulations by Bolt and van Oordt (2016) show that, in the long run, exchange rate risks are not likely to get in the way of widespread use of private digital currencies, because such risks would be mitigated as such currencies become more established. One interpretation is that the assessment of value is to a large extent based on subjective beliefs, which can evolve over time. For instance, if private digital currencies were to achieve increasing success as a medium of exchange, they would gain value in terms of practical utility. This source of value could render exchange rates less sensitive to the impact of shocks to speculators' beliefs. Financial stability risks would in any case be limited in this scenario, as widespread adoption of privately issued digital currencies would actually contain exchange rate volatility.

(1) See, for instance, the evidence on daily bitcoin transactions presented in Ali *et al.* (2014) or more recently in Bolt and van Oordt (2016), which show that – although growing – bitcoin is still a relatively small monetary phenomenon.

2.3 Monetary and financial stability risks if private digital currencies also serve as a unit of account

The greatest hypothetical risk to monetary policy that might be posed by private digital currencies would be if they grew to a point where they were generally accepted and used as units of account. In this case, private digital currencies would substitute for the bulk of sovereign currency-denominated regular money, including central bank money. In the most extreme scenario, the economy is "bitcoinised", meaning that the alternative money would be used as the predominant form of money in the economy and euros would only be used for interactions with the government (such as to pay taxes), or even – one step further – that the government would accept private digital currencies for payment of tax obligations.

A widespread substitution of regular money by privately issued digital currency would have a number of monetary policy implications. First, monetary policy might become less effective in managing aggregate demand in order to stabilise the economy around full employment. In fact, if sovereign money no longer served as the base money in the economy, the central bank would essentially lose control over monetary conditions. In such an environment, it would become harder for monetary policy to steer the relevant interest rates in order to respond to macroeconomic demand imbalances. Volatility in prices would then ensue, causing welfare-destroying volatility in economic activity. Additionally, monetary policy would lose any discretion to adjust monetary conditions on a tactical basis as part of a stabilisation policy – for instance, to react to changing supply conditions such as technological improvements or structural changes in product and labour markets.

Second, a drain on regular money could also erode a central bank's capacity to act as lender of last resort in the event of bank liquidity shortfalls. Such an effect would increase the likelihood of bank runs and, hence, financial impairments. This would be notably the case if a fractional reserve banking system were to emerge above a private digital currency. In fact, because so far no regulatory status has been granted to private digital currency systems, such a system would lack the support of a trusted authority to provide liquidity if access to liquidity from other sources were impaired; nor would it offer the protection of a deposit insurance scheme in the event of a bank failure.

Third, given that most existing private digital currency schemes incorporate strict rules that govern their creation and follow a pre-determined path to a fixed eventual total supply, large-scale adoption of such schemes might contribute to deflation in prices of goods and services (and wages). Such deflation, when perfectly anticipated, is not problematic. However, in a rock-bottom interest rate environment, deflationary forces might induce a structural increase in real interest rates, plunging the economy into a secular stagnation trap featuring low growth and chronic deflation. Note, however, that there are no technical reasons why private digital currency schemes could not adopt "smarter" rules that seek to provide for structural inflation instead of deflation (for instance, a money supply rule tracking the number of transactions). Such alternative rules could help to curtail secular stagnation risks.

Finally, a substitution of sovereign money by private digital currencies would also lower a government's seigniorage income. This would have to be compensated by increased distortionary taxation, which in turn might impede economic activity.

There are reasons to doubt, however, that private sector digital currencies will ever become trusted units of account, rendering the monetary policy risks described above highly unlikely. Buiter (2009) remarks that, although authorities cannot regulate the unit of account, they can strongly encourage the use of a specific unit of account. For instance, seeking to minimise any loss of seigniorage income, sovereigns could insist that all contracts with the public sector are denominated in euros, and require taxes to be paid with the official currency. Importantly, such requirements would curb the use of private digital currencies not only in direct but also in indirect ways. More specifically, a refusal to grant private digital currencies either legal tender or regulatory status strips these types of currencies of any intrinsic value, which, in turn, makes them prone to speculative bubbles (see above). This is likely to reduce their attractiveness and limit the risk that they will become widely accepted.

A second reason why it is unlikely that private digital currencies will become widely used and substitute for regular money is that such currencies serve as a poor haven in a flight to safety. As stressed by Broadbent (2016), currency substitutions occur only in cases of profound distrust of authorities and deeply compromised sovereign currencies, for instance in the wake of a collapse in the banking sector or monetary policy failing to maintain price stability. In these cases, however, it is pretty unlikely that people will flee to entirely new currencies. Instead, it is more reasonable to assume that people will reach for an existing, trusted currency, such as established sovereign currencies. Moreover, as noted above, privately issued currencies have no intrinsic value and, therefore, serve as a bad store of value. Hence, it is very unlikely that a flight to safety would spark a drain to these types of currencies.

3. Opportunities of digital currencies for monetary policy

Digital currencies do not only present monetary policy with challenges. In fact, their underlying distributed ledger technology (DLT) includes some interesting features that might encourage central banks to co-opt this new technology.

First, according to some observers, DLT has the potential to improve the efficiency and security of existing payment systems (see, for instance, Bernanke, 2013; UK Government Office for Science, 2016). The efficiency argument relates to the direct settlement mechanism embedded in distributed ledgers: this has the potential to not only raise the speed of settlement but also to lower settlement costs compared with traditional payment systems. The security opportunity of the technology basically rests on the fact that distributed ledgers are shared among users of the system: this makes them hard to corrupt, as to do so would require deceiving all users[1]. From a monetary policy perspective, these potential efficiency and security benefits suggest that the distributed ledger technology could help to further underpin trust in the monetary system (see, for instance, Haldane, 2015; Raskin and Yermack, 2016). This is an important feature, as trust is the cornerstone on which a fiduciary money system is built. In fact, fiduciary money derives its intrinsic value solely from trust. Against this background, central banks may choose to permit interbank payment systems to run on a DLT network.

Central banks' interest in the distributed ledger technology, however, is not limited to investigating potential interbank applications. In fact, they are increasingly pondering the potential of this new technology to serve as a platform for the issuance of a digital form of banknotes – a so-called "central bank digital currency" (CBDC)[2]. Hence, from a broader economic perspective, the DLT offers a potential efficiency gain for central banks to expand their role by widening electronic access to their balance sheets – that is, beyond commercial banks[3].

(1) Note that the decentralised nature of distributed ledgers is not in itself enough to banish fraud altogether. In fact, anyone succeeding in taking control of the consensus mechanism verifying the validity of transactions could still commit fraud. To prevent such practices, digital currency schemes typically design their validation process to be computationally challenging – thereby preventing record falsification by minority coalitions.

(2) A couple of recent speeches by central bank officials testify to the growing interest in the idea of CBDC within policy circles. For instance, in March 2016, Ben Broadbent, the Bank of England's Deputy Governor for Monetary Policy, set out his views on the potential macroeconomic consequences of a CBDC (Broadbent, 2016). More recently, in January 2017, ECB Executive Board member Yves Mersch noted that these consequences depend on the exact design or modalities of what he calls "digital base money", e.g. the remuneration of sovereign digital money as well as its convertibility to traditional cash (Mersch, 2017). In Sweden, the Riksbank is pondering whether it should play a pioneering role in issuing an electronic means of payment – an "e-krona" – to complement physical cash (Skingsley, 2016).

(3) See also Broadbent (2016) on this point.

It remains a question, however, whether or not this is a desirable outcome. On the one hand, by (partially) substituting for cash, a CBDC could relax the so called "effective lower bound" constraint on nominal interest rates, which could promote macroeconomic stability. On the other hand, by providing competition for bank deposits, a CBDC could have profound implications, either positive or negative, for the banking sector. The following two sections elaborate in greater detail on these two issues.

3.1 Could a CBDC solve the problem of the effective lower bound on interest rates ?

As articulated by Haldane (2015), the fact that nominal market interest rates cannot fall much below zero arises from the fact that technological constraints hinder paying interest (both positive and negative) on physical cash. Central banks have no problem whatsoever paying negative interest rates on reserve deposits held by banks with them[(1)]. However, the transmission of such negative policy rates to other interest rates – retail bank rates in particular – can get impaired as soon as banknotes cannot be charged the same negative rate. Indeed, in this case, there is an escape route from negative rates, in that deposits can be switched for banknotes. This practice impairs the effectiveness of monetary policy in that it imposes limits on central banks' capacity to implement negative rates as a strategy to re-launch the economy, and was originally known as the "zero lower bound problem" (Ball, 2014). Today, this issue is increasingly referred to as the "effective lower bound problem", or ELB for short. This is because the effective lower bound is somewhat below zero in that carry costs for cash (i.e. costs of storage, safekeeping and insurance) are typically higher than for bank and reserve deposits.

The ELB constraint is not new. In fact, it has existed for as long as banknotes have been in issue. So why should we now worry more about it than we did a decade ago ? The key factor is that there are strong reasons to believe that the likelihood of this constraint becoming binding has increased in recent years. For one thing, current low interest rates tend to be not just cyclical in nature, in that they are not only the result of central banks' massive stimulus measures in the aftermath of the great recession. Instead, some of the deep roots of the ELB constraint may be structural and, therefore, long lasting (Buiter and Rahbari, 2015). For instance, lower trend growth, worsening demographics, rising inequality and savings gluts in emerging markets have all lowered average real interest rates over the past 30 years (Rachel and Smith, 2015). In tandem with central banks' success in bringing inflation down again from its too high levels in the 1970s and 1980s, nominal interest rates have also fallen. As a result, monetary policy currently has less room for manoeuvre to fight recessions than it did a generation ago. On top of this, macroeconomic volatility has increased since the financial crisis, bidding farewell to more than two decades of "Great Moderation". This means that monetary policy's dwindled room for manoeuvre is expected to be exploited more often[(2)]. As a result, central banks may in future find themselves repeatedly bumping up against the lower bound constraint. Policy options that would loosen the ELB constraint on a durable basis therefore deserve our attention.

Various proposals for circumventing the lower bound have been put forward, ranging from raising average nominal rates by revising the inflation target upwards, to finding means to levy negative interest rates on cash – such as a stamp tax on banknotes or a managed exchange rate between cash and deposits – through to abolishing cash entirely[(3)]. To date, however, no central bank has attempted to implement any of these schemes. This is because each of these potential solutions also brings particular challenges. For instance, the main objection against raising the inflation target is that it could jeopardise central bank credibility and, thereby, the anchoring of inflation expectations. Options to levy an implicit interest rate on cash, for their part, suffer from the problem that their practical implementation is not that straightforward or – at least – requires a costly infrastructure. Finally, a ban on cash would face some major social acceptance issues. For one thing, access to publicly issued money – such as banknotes – is regarded as a social convention (Haldane, 2015). Challenging this convention could spark intense public protest. Another often stated argument against eliminating cash is that it would infringe privacy rights, as only cash allows making anonymous transactions. Moreover, the abolition of cash implies a loss of seigniorage income for the central bank.

Recently, however, it has been increasingly suggested that the technical opportunity offered by distributed ledger technology to issue a CBDC could effectively relax the lower bound constraint on interest rates (see, for instance, Haldane, 2015 ; Raskin and Yermack, 2016 ; and Camera, 2017). The reason is that a CBDC could easily support negative interest rates while at the same time providing the option to not simply abolish cash,

(1) For instance, in the euro area, banks are currently charged 40 bps on excess liquidity that they hold with the central bank.

(2) Chung *et al.* (2012), for instance, show that a re-calibration of pre-crisis models that takes the higher levels of macroeconomic risk observed during the great recession into account raises the incidence and severity of ELB events.

(3) See Haldane (2015) for a comprehensive overview of concrete proposals put forward in the literature. More specifically, see e.g. Ball (2014) and Williams (2016) for a recent plea to increase the inflation target. Proposals for levying a stamp tax on banknotes date back to Gesell (1916). More recently, the idea has been re-introduced into the policy debate by, for instance, Goodfriend (2000) and Buiter and Panigirtzoglou (2003). The idea of installing a floating exchange rate between cash and deposits has been pitched by Eisler (1932) and recently revitalised and updated by, for instance, Buiter (2009) and Goodfriend (2016).

but instead to replace it with an electronic version. This approach would preserve the ability to hold direct claims on the central bank – even if banknotes were no longer available – and it would not need to affect seigniorage income. What is more, when running on a distributed ledger network, a CBDC could – in principle – provide anonymity to its users, just like banknotes. Indeed, as evidenced by the e-cash proposal made by Danezis and Meiklejohn (2016), which they call RSCoin, the distributed ledger technology permits the monetary supply to be centralised, without the need to centrally manage the transaction ledger. For instance, designated intermediaries (such as commercial banks) could be put in charge to collect and verify the validity of transactions, avoiding the need for central banks to process the personal details of CBDC holders. Importantly, a CBDC could reduce the lower bound constraint even if it would complement or at least only partially replace physical cash. In fact, by offering an alternative sovereign monetary instrument, widespread adoption of a CBDC would create the conditions to consider abandoning the largest banknote denominations. Since the largest denominations feature the lowest cost of carry, their discontinuation would increase the average carrying cost of holding cash and, thereby, enlarge the scope for negative policy rates (Rogoff, 2016).

All this renders CBDC an interesting policy option to remove the effective lower bound while still offering households and firms (i.e., non-bank economic agents) the possibility to hold claims on the central bank. The idea, however, is also subject to some caveats. Some studies suggest that there are reasons to doubt whether the effective lower bound actually reduces the effectiveness of monetary policy (see, for instance, Swanson and Williams, 2014), thereby rendering a search for solutions to the ELB problem irrelevant. The argument goes that the ELB restricts central banks' ability to cut short-term interest rates much below zero, but not their capacity to steer long-term interest rates. In fact, an array of non-standard policy instruments – among which forward guidance and asset purchases – exists to offset the effects of the ELB on long-term interest rates (on this point, see also Coeuré, 2015). Moreover, Raskin and Yermack (2016) note that imposing negative rates on households – even if justified by economic rationale – might provoke public protest and hence face political constraints. If that were the case, imposing negative interest rates on the general public as part of a strategy to support economic demand could end up undermining central bank independence and weakening monetary policy transmission. In response, one could argue that a central bank should make sure not to levy too negative an interest rate on a CBDC. However, in that case another difficulty arises: if a CBDC were to mimic too closely the uniform and zero remuneration rate of banknotes, it might actually raise rather than lower the effective lower bound. The reason is that digital banknotes are likely to have lower costs of carry than their physical counterparts. Finally, as a third potential caveat, an interest-bearing CBDC could compete not just with physical money but also with bank deposits. This competition could severely interfere with the traditional operation of the banking sector. It remains uncertain, however, what this would imply for financial stability and economic activity more generally. The next section offers some – still fairly speculative – thoughts on this.

3.2 How would a CBDC affect the banking sector, financial stability and economic activity?

Under a central bank digital currency scheme, citizens and business would be permitted to open and hold accounts with the central bank. Especially if these accounts also paid interest, there would be little to distinguish them from traditional commercial bank accounts. A CBDC, therefore, would compete directly with commercial bank deposits, likely inducing a partial shift of deposits away from commercial banks towards the central bank.

Importantly, such a drain would not be without consequence. Under the prevailing order, banks are engaged in "fractional reserve banking". This is the practice whereby a bank accepts deposits, but holds as reserves with the central bank only a fraction of these deposits. The difference between bank and reserve deposits reflects the money created by banks when they engage in lending. In fact, whenever a bank extends a loan, it simultaneously creates a matching deposit in the borrower's bank account, thereby creating new money. In other words, in a fractional reserve banking system, bank deposits are only partially backed by central bank money, with the difference used to finance investment in the economy. Fractional reserve banking thus implies a maturity transformation: short-term deposits typically fund long-term loans. This maturity mismatch makes the banking system inherently vulnerable to funding liquidity risks and hence to bank runs sparked by fear that liquidity problems might turn into solvency problems.

The foregoing suggests that, by draining deposits from commercial banks, the adoption of a CBDC would limit the practice of fractional reserve banking and its associated liquidity and solvency risks. This could make for a safer financial system, with less scope for impairment in monetary policy transmission. Importantly, as a side effect, this also implies that there is less need for deposit guarantees or for lender-of-last-resort facilities.

CHART 2 ECONOMIC IMPACT OF A CENTRAL BANK DIGITAL CURRENCY: FOUR SCENARIOS

(a) NARROW BANKING

Central bank		Commercial banks		Private sector	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
ECB refinancing	CBDC ↑ (blue) ↓ (red)	Loans	Deposits ↓ (blue)	Deposits ↓ (blue)	Loans
Other assets	Bank reserves	Bank reserves	ECB refinancing	CBDC ↑ (blue) ↓ (red)	Other liabilities
	Equity	Other assets	Other liabilities ↑ (red)	Other assets ↑ (red)	

(b) IMPAIRED LENDING

Central bank		Commercial banks		Private sector	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
ECB refinancing	CBDC ↑ (blue) ↓ (red)	Loans ↓ (red)	Deposits ↓ (blue)	Deposits ↓ (blue)	Loans ↓ (red)
Other assets	Bank reserves	Bank reserves	ECB refinancing	CBDC ↑ (blue) ↓ (red)	Other liabilities
	Equity	Other assets	Other liabilities	Other assets	

(c) INFLATED CENTRAL BANK BALANCE SHEET

Central bank		Commercial banks		Private sector	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
ECB refinancing ↑ (red)	CBDC ↑ (blue)	Loans	Deposits ↓ (blue)	Deposits ↓ (blue)	Loans
Other assets	Bank reserves	Bank reserves	ECB refinancing ↑ (red)	CBDC ↑ (blue)	Other liabilities
	Equity	Other assets	Other liabilities	Other assets	

(d) IMPAIRED FINANCIAL STABILITY

Central bank		Commercial banks		Private sector	
Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
ECB refinancing	CBDC ↑ ↓ (blue)	Loans ↓ ↑ (red)	Deposits ↓ ↑ (blue)	Deposits ↓ ↑ (blue)	Loans ↓ ↑ (red)
Other assets	Bank reserves	Bank reserves	ECB refinancing	CBDC ↑ ↓ (blue)	Other liabilities
	Equity	Other assets	Other liabilities	Other assets	

Note: Blue arrows indicate the initial impact of a CBDC introduction on the balance sheet items of the central bank, commercial banks and the private sector. Movements are judged against the counterfactual situation (no CBDC adoption), all other things being equal. For simplicity's sake, we do not include any impact of a CBDC on the number of banknotes in circulation, ignoring this factor altogether. Red arrows indicate the direction of the balance sheet items that need to adjust to preserve equilibrium under four different scenarios. "Narrow banking" refers to the scenario in which commercial banks succeed in attracting alternative funding in the private sector to help replace lost deposits. "Impaired lending" refers to the scenario in which a widespread substitution of deposits by central bank digital money leads to a de-funding of the banking sector with negative spillover effects on credit creation. "Inflated central bank balance sheet" denotes the situation in which the central bank steps in as provider of alternative bank funding. Finally, "impaired financial stability" refers to the scenario in which a CBDC acts as a vehicle for digital bank runs.

The potential economic and policy implications of curbing fractional reserve banking are not limited to this favourable outcome, however. In fact, account must be taken of the balance sheet effects that the adoption of a CBDC might induce. The initial impact of a shift of resources from deposits to CBDCs is clear: banks' liabilities would decline while those of the central bank would increase. It remains uncertain, however, which balance sheet items need to adjust in order to restore equilibrium. Different outcomes are conceivable, with different policy implications, but with no clear indication as to which is most likely (see chart 2 for a schematic overview).

Narrow banking: safer financial system

The most beneficial outcome would be the one that proponents of so-called "sovereign money systems" refer to as the "narrow banking" case (chart 2a). Under a narrower banking system, banks are indifferent as to whether they fund their investment by liquid deposits or less run-prone liabilities, such as equity and longer-term debt. In this case, if a CBDC dried up a bank's access to deposits, the bank would simply address private markets to step up its debt and equity financing. What makes a bank "narrow" in this case is the fact that the liquidity structure of its assets and liabilities are better matched. Under this scenario, the net impacts of a CBDC on the financial system, monetary policy and the economy more generally are positive: all that happens is that the banking sector becomes safer – strengthening the transmission of monetary policy – while credit supply is not affected as deposits are replaced by more stable funding.

Box – "Narrow banking" resembles but is not the same as "full reserve banking"

The case for narrow banking in order to ensure financial stability fits in with the long-standing idea of full reserve banking (FRB)[(1)]. After all, in both cases, the business of maturity transformation would be limited: under full reserve banking, banks would hold central bank reserves for the total amount of their deposits, whereas under narrow banking, banks would fund their loans mainly with long-term liabilities and retail clients would hold part of their deposits in accounts with the central bank. The first proposal for FRB can be traced back to David Ricardo. In his "Plan for the Establishment of a National Bank" (drafted in 1823) Ricardo (1951) argued that note issuance should be separated from commercial lending[(2)]. Because at that time paper money was the dominant means of payment, this plan essentially proposed separating money creation from lending activity, or, put another way, separating monetary policy from credit policy.

In the 1930s, and in search of policy answers to restore public confidence during the Great Depression, the FRB idea re-emerged in the famous Chicago Plan. This widely discussed academic proposal suggested extending the prohibition of private money creation to also include commercial bank deposits, thereby ending the practice of fractional reserve banking. The plan, however, did not survive legislation and the FRB idea was not included in the Banking Acts of 1933 (better known as the Glass-Steagall Act) and 1935[(3)].

Simply put, the CBDC proposal could provide the conditions for a revival of the Chicago Plan. A narrower banking sector, however, does not entail a strict prohibition of fractional reserve banking. In that sense, a narrow banking system (following the introduction of a CBDC) rather resembles James Tobin's watered-down FRB proposal. To reduce the need for deposit insurance, Tobin (1985, 1987) argued that the government should create what he called a "deposited currency". That currency would function according to the FRB principle and would be deposited in accounts with the central bank. At the same time, however, commercial banks would still be allowed to raise deposits of their own and to turn these into new loans. In other words, only a fraction of demand deposits would function according to the FRB principle, the size of which would be determined by the market.

(1) Extensive overviews of the literature on and history of full reserve banking proposals can be found in Bossone (2001), Lainà (2015) and Goodhart and Jensen (2015).
(2) According to Phillips (1992), Ricardo's plan served as a guideline for the US Bank Charter Act of 1844, which prohibited private money creation in the form of banknotes.
(3) Instead of preventing any form of private money creation, the Banking Acts separated commercial and investment banking, provided deposit insurance and improved government's control over monetary policy.

Impaired lending: safer financial system but with a structural brake on economic activity

The likelihood of this optimistic scenario depends on banks' actual willingness but also on their ability to raise the vast bulk of their funds from equity and long-term debt. Opinions differ on this. Deposits are often regarded as a cheap and reliable source of funding and therefore argued to be preferred by banks relative to alternative sources of funding. Defenders of the so-called

Modigliani-Miller (1958) theorem, on the other hand, would argue that this presumption is false. The fact that equity funding appears today as more expensive relative to deposits cannot be seen in isolation from banks' current funding structure (see, for instance, Cochrane, 2014). Indeed, the more a firm's assets are equity-funded, the more any potential losses can be spread over a greater number of shareholders, and the cheaper the average unit of capital becomes. However, market imperfections should not be disregarded : even if banks were willing to seek alternative funding, there is no guarantee that they would actually succeed. Households, for instance, might be reluctant to hold illiquid, non-deposit types of bank liabilities if they consider the practice of maturity transformation a means to solve informational asymmetries – concerning the riskiness of banks' assets and their loans, in particular (Diamond and Rajan, 2001). The argument goes that the risk of a run inherent in maturity transformation exerts a disciplinary effect on banks that discourages them from engaging in irresponsible lending.

All this implies that, instead of just narrowing the banking sector, a widespread substitution of bank deposits by CBDC might also impair banks' funding sources (chart 2b). Such an outcome would tighten the credit market, or at least increase lending rates, thereby likely putting a drag on investment and economic activity. After all, households as well as many small and young firms depend on the banking sector to satisfy their credit needs, since they barely have access to capital markets. In this second hypothetical scenario, the competition provided by CBDCs to bank deposits could come at the cost of a structural decline in economic activity due to tight credit supply.

Inflated central bank balance sheet : safer financial system but with a threat to central bank independence

It remains a question for discussion whether the central bank should step in to preserve the downward pressure on bank credit availability which CBDC may cause. It could do that as a provider of alternative bank funding (e.g. by stepping up its refinancing operations) or even by directly providing credit to the non-bank sector (chart 2c). In either case, the central bank balance sheet could be severely expanded – depending on the degree of competition that a CBDC might represent to bank deposits. Proponents might argue that such an expansion could induce significant seigniorage gains for the government [1].

Moreover, by expanding its balance sheets, the central bank would obtain greater discretion over broad financial conditions, allowing it to better safeguard macroeconomic stability. Critical voices, by contrast, might argue that an inflated central bank balance sheet threatens central bank independence, thereby damaging trust in the commitment of the central bank to its stated objectives. In fact, by expanding its assets to such large extent, the central bank could challenge the boundaries of its mandate by acting not only as a guardian of price stability, but also by playing an increasing role in allocating resources. Doing so might provoke both political and public protest, as such policies with clear distributional aspects pertain to elected politicians in democratic societies.

Impaired financial stability : increased risk of bank runs, volatile credit supply and a rise in shadow banking

The analysis so far shows that, by curbing fractional reserve banking, a substitution of bank deposits by CBDC could strengthen financial and macroeconomic stability but it could also weigh on growth prospects if it compromised bank lending activity. Moreover, there is also reason for concern that draining deposits from commercial banks might impose a threat to financial stability, hampering, rather than supporting, monetary policy transmission.

First, even if banks were both willing and able to attract alternative funding, the adoption of a CBDC could make credit supply more volatile. In fact, by offering the economy an additional and very easily accessible safe asset, a CBDC might facilitate flights to safety (as discussed by Broadbent, 2016, and Dommerholt and Van Tilburg, 2016) [2]. One would thus be likely to see resources flowing out of commercial banks during times of financial stress, and back towards them when risk aversion is low. In such an environment, the central bank would be forced more – rather than less – often to take up its role as lender of last resort.

Second, the de-funding risks of banks associated with a CBDC might push the private sector into shadow banking activities. This would specifically be the case when maturity transformation is considered as a necessary feature of a market economy (for instance, as discussed above, to discipline bank behaviour). More specifically, in this case, one could expect to find financial intermediaries developing so-called near-money instruments as alternative liquid sources of funding (see, for instance, Goodhart and Jensen, 2015). Such practice would mitigate any negative impact on

(1) Such seigniorage gains would in fact present a transfer of seigniorage income from the private to the public sector, addressing the claim of full-reserve-banking advocates that money creation should be a state monopoly (see, for instance, Goodhart and Jensen, 2015, and the references therein for a discussion of this claim).

(2) See also Goodhart (1987 and 1993) for an earlier discussion of this argument in the context of full reserve banking.

lending activity, but it would also lack the benefits of prudential supervision, thereby increasing risks to financial stability.

Conclusion

Technological innovations have opened the door to the development of cash-like instruments that permit electronic transactions, much like deposits but without the involvement of financial intermediaries to settle the transaction, similar to cash. Combining the best of two worlds, these so-called digital currencies could provide significant competition for traditional monetary instruments. Such competition would present monetary policy with challenges but also with opportunities.

Digital currencies have so far been issued by private players. Such private initiatives have been closely monitored as they carry the risk of impairing monetary policy transmission if they were to become generally accepted as a valuable monetary instrument not only serving as a medium of exchange but also as a store of value and a unit of account. For instance, by substituting for regular money, such as banknotes and transferable deposits, widely adopted private digital currencies could significantly reduce a central bank's control over monetary conditions. This would not only restrict a central bank's ability to steer interest rates, but also its capacity to act as a lender of last resort. Such monetary policy risks are likely to be limited, however, as there are reasons to doubt that privately issued digital currencies would ever become widespread: not only does the current high volatility of such currencies' exchange rates stand in the way of that happening, they also lack fundamental value as long as authorities do not grant them regulatory status.

Digital currencies do not just present monetary policy with challenges. In fact, the technology underlying private digital currencies is increasingly studied for possible application in the issuing of a digital cash substitute by central banks – a so-called central bank digital currency (CBDC). One promising opportunity for monetary policy is that a CBDC could help relax the effective lower bound constraint on nominal interest rates, which could promote macroeconomic stability. It remains uncertain, however, to what extent and in what direction a sovereign digital currency would impact the banking sector and financial stability. On the one hand, by providing competition for bank deposits, the adoption of a CBDC could limit the practice of fractional reserve banking, thereby strengthening financial stability. On the other, too widespread a substitution of bank deposits by CBDC could lead to a significant de-funding of the banking sector, with negative spillover effects on credit creation and economic activity. Moreover, by offering the economy an additional and very easily accessible safe asset, a CBDC might act as a vehicle for digital bank runs, undermining – rather than promoting – financial stability and the effectiveness of monetary policy. More research should hence be devoted to better understanding and assessing the opportunities and risks associated with the possibility of issuing a sovereign digital currency. Only then can balanced policy decisions be made.

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