

IN-DEPTH ANALYSIS

Requested by the ECON committee

Monetary Dialogue Papers, December 2019



The Impact of Digitalisation on the Monetary System



Policy Department for Economic, Scientific and Quality of Life Policies
Directorate-General for Internal Policies

Authors: Salomon FIEDLER, Klaus-Jürgen GERN, Ulrich STOLZENBURG
PE 642.361 - November 2019

EN

The Impact of Digitalisation on the Monetary System

Monetary Dialogue Papers,
December 2019

Abstract

Against the backdrop of a trend towards a cashless society and the emergence of private electronic monies, the paper discusses properties of digital currencies and implications for currency competition, describes benefits and risks of digitalisation of money for the society, explains the concept and implications of a CBDC, and discusses implications of digital money for monetary policy. The upshot is that the trend towards digitalisation will probably continue, but has to be closely monitored and accompanied with an appropriate regulatory framework.

This document was provided by Policy Department A at the request of the Economic and Monetary Affairs (ECON) Committee.

This document was requested by the European Parliament's Committee on Economic and Monetary Affairs.

AUTHORS

Salomon FIEDLER, Kiel Institute for the World Economy
Klaus-Jürgen GERN, Kiel Institute for the World Economy
Ulrich STOLZENBURG, Kiel Institute for the World Economy

ADMINISTRATOR RESPONSIBLE

Dario PATERNOSTER
Drazen RAKIC

EDITORIAL ASSISTANT

Janetta CUJKOVA

LINGUISTIC VERSIONS

Original: EN

ABOUT THE EDITOR

Policy departments provide in-house and external expertise to support EP committees and other parliamentary bodies in shaping legislation and exercising democratic scrutiny over EU internal policies.

To contact the Policy Department or to subscribe for updates, please write to:

Policy Department for Economic, Scientific and Quality of Life Policies
European Parliament
L-2929 - Luxembourg
Email: Poldep-Economy-Science@ep.europa.eu

Manuscript completed: November 2019

Date of publication: November 2019

© European Union, 2019

This document is available on the internet at:

<http://www.europarl.europa.eu/supporting-analyses>

DISCLAIMER AND COPYRIGHT

The opinions expressed in this document are the sole responsibility of the authors and do not necessarily represent the official position of the European Parliament.

Reproduction and translation for non-commercial purposes are authorised, provided the source is acknowledged and the European Parliament is given prior notice and sent a copy.

For citation purposes, the study should be referenced as: Fiedler, S., Gern, K.-J. and Stolzenburg, U., *The Impact of Digitalisation on the Monetary System*, Study for the Committee on Economic and Monetary Affairs, Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg, 2019.

CONTENTS

LIST OF ABBREVIATIONS	4
LIST OF FIGURES	5
LIST OF TABLES	5
EXECUTIVE SUMMARY	6
1. INTRODUCTION	7
2. THE MONETARY SYSTEM AND THE IMPACT OF DIGITALISATION	8
2.1. Money	8
2.2. Currency competition	9
3. POTENTIAL BENEFITS AND COSTS FOR SOCIETY FROM INCREASED DIGITALISATION OF MONEY	11
3.1. Advantages and concerns with a cashless society	11
3.2. Advantages and concerns with digital currencies	12
4. CENTRAL BANK DIGITAL CURRENCIES (CBDC)	14
4.1. Main idea	14
4.2. Possible consequences for the fractional reserve system	15
4.3. Would a CBDC relax the zero lower bound?	17
4.4. Why would central banks issue digital money?	17
4.5. Will any central bank actually launch a CBDC?	19
5. IMPLICATIONS OF DIGITAL MONEY FOR MONETARY POLICY	20
5.1. Abolishment of cash	20
5.2. Competition from other digital currencies	20
5.3. What is the optimal rate of inflation?	21
6. CONCLUSION	24
QUESTIONS FOR MEPS	25
REFERENCES	26

LIST OF ABBREVIATIONS

CBDC Central Bank Digital Currency

DCA Digital Currency Area

LIST OF FIGURES

Figure 1:	A taxonomy of money	14
Figure 2:	Current monetary system (fractional reserve system)	15
Figure 3:	Monetary system with a CBDC	16
Figure 4:	Optimal Inflation Rate	21

LIST OF TABLES

Table 1:	Reductions in Cash Use in Selected Countries, 2006 to 2016	11
----------	--	----

EXECUTIVE SUMMARY

- Digital money can take different forms representing inside or outside money, account-based or token money, and may be an independent currency or part of a traditional currency domain.
- Currency competition has been limited historically due to strong network externalities in the usage of money. By unbundling the properties of money, digitalisation substantially raises the potential for currency competition. Re-bundling of digital money along large social or commercial platforms works in the opposite direction.
- The decline in the relative importance of cash in most economies is mainly driven by the convenience and efficiency gains offered by electronic payment methods in combination with mobile devices. In the transition to a cashless society, a major social challenge is to prevent parts of the population from being left behind.
- Introduction of digital currency has the potential to be welfare enhancing by exploiting the potential of linkages and exchange in a network's ecosystem and by providing users with the possibility of direct, peer-to-peer transfers of money. However, a plethora of legal and regulatory challenges will have to be addressed before the launch of stablecoins with global scale and scope. Different regulatory regimes in different countries may ultimately lead to an increasingly fragmented international financial system. A serious concern is the possibility that the association of a widely used electronic currency with a large social or commercial electronic platform will reinforce monopolistic tendencies already inherent in network industries.
- A digital currency issued by a central bank (CBDC) can be disruptive for the fractional reserve system, because money users would have the option to hold direct claims against the central bank. Commercial banks would increasingly have to replace deposits with more reliable sources of funding.
- There are plenty of reasons why central banks may actually decide to launch a CBDC, independently or jointly: Installation of a backup payment system, higher revenue, financial inclusion, efficiency of the payment system, traceability of illegal transactions, surveillance, upholding the public monopoly of money while satisfying the need for digital money, and countering competition from private currencies as well as from foreign CBDCs.
- It is unclear if and when a major central bank will actually introduce a CBDC of global relevance. Intuition suggests that CBDCs will be realised at some point in time, and that today's leading currencies will rather not be the frontrunners of such a move.
- The implications of digital money for monetary policy are not straightforward. If digitalisation means the replacement of cash with central bank derived digital money, then the central bank's ability to produce inflation will increase because the effective lower bound on interest rates will loosen. However, if digitalisation raises the possibility of the introduction of (private or foreign) competing currencies, the ability of central banks to inflate their currencies would be constrained by the threat of people switching to these competing currencies.
- The welfare implications from digital currencies thus depend on the optimal rate of inflation. If the optimal inflation rate is high, then constraints on the central bank's ability to increase inflation could pose a problem. If, however, optimal inflation is low, then the reverse is true.
- There is considerable disagreement on the optimal rate of inflation. The choice of the targets of around 2 percent used by many central banks today are to a considerable degree arbitrary.

1. INTRODUCTION

Digitalisation has changed the way monetary systems work for many years already, but recently it has started to change its structure more fundamentally. Developed economies rapidly reduce the importance of cash, and in some cases envisage becoming cashless entirely in the foreseeable future. At the same time digital currencies have appeared. The first wave of cryptocurrencies such as Bitcoin, Ethereum or Ripple have failed to gain relevance in terms of their share in monetary transactions. This was due to systemic deficiencies leading to extreme volatility, limited capacity, unpredictable transaction costs and limited transparency, which have reduced their ability to fulfil the basic functions of money and hence their attractiveness as a medium of exchange.¹ More recently, stablecoins have entered the scene which were specifically designed to deal with the issue of volatility by tying the digital currency to an underlying set of assets. Another important difference to the first generation of cryptocurrencies is that they rely on third-party institutions to some extent and may be issued by a central entity.

The potential for a widespread adoption of stablecoins, which so far also failed to materialise, has hugely increased with the announcement of Facebook to introduce Libra, a stablecoin based on the blockchain technology and backed by a basket of reserve assets (bank deposits and short-term government securities denominated in major currencies) to give the currency intrinsic value (Libra Association 2019). The huge number of billions of users on Facebook's various platforms (including Facebook, Whatsapp, Instagram) that Libra can potentially capitalise upon raises the probability that this project will successfully reach global scale in a relatively short period of time. Meanwhile, the discussion around the introduction of central bank digital currencies (CBDC) as a possible response has continued.

Against this backdrop, this paper discusses some of the specific properties of digital currencies and implications for the monetary system in terms of currency competition (Section 2), describes benefits and risks of digitalisation of money for the society (Section 3), explains the concept and implications of a CBDC and assesses the probability of its introduction (Section 4), and discusses implications of digital money for monetary policy (Section 5). Section 6 briefly concludes.

¹ See Fiedler et al 2018 for a discussion of technical aspects and different use cases of virtual currencies.

2. THE MONETARY SYSTEM AND THE IMPACT OF DIGITALISATION

When discussing the impact of digitalisation on the monetary system it is useful to distinguish between architecture and technology of a monetary system. While digital money and electronic payment systems have become increasingly important elements of the monetary system for many years already, they so far have not substantially changed the architecture of the traditional two-tiered monetary system based on central bank money and deposits in commercial banks. New developments such as private money in the form of cryptocurrencies and the prospect of digital currencies issued by the government or private entities have the potential to radically alter the way the monetary system works.

2.1. Money

Money is traditionally defined as a financial instrument that fulfils three main functions:

- (1) Facilitate the indirect trade of goods and services as a generally accepted medium of exchange,
- (2) serve as a store of value, and
- (3) provide a common unit of account to accurately compare the value of goods and services.²

Irrespective of its concrete form, being the generally accepted medium of exchange is arguably the identifying characteristic of money, with the other two functions being of subordinate nature (Fiedler et al. 2018). As the most pervasive good, money constitutes a category of its own as it is neither an object of consumption (it does not directly satisfy human needs) nor a means of production (the usefulness of money to allow for increasingly complex production processes does not depend on its quantity).

In order to promote broad acceptance and safeguard its value, money was historically linked to a commodity such as gold as an anchor, i.e. the issuers of money made a legally binding commitment to convert their instrument on demand to the anchor. Today the anchor is government-issued fiat currency. Issuers of money that is used for payments are typically banks, which commit to converting deposits into an equal quantity of government-issued fiat currency. But also private non-bank money designed to circulate in a designated, limited economic sphere abound, including regional money which has become popular in Germany (with the “Chiemgauer” being a prominent example) or company debit cards (such as the Starbucks Gift Card).

An important distinction is between inside and outside money. Inside money is created by simultaneously producing a claim on the private issuing entity. Outside money by contrast is not a claim on anything, although the issuer may promote the value and acceptance of the money by promising to maintain a certain (although in principle adjustable) exchange rate to another financial instrument and support this commitment by backing it with a collection of assets. Along these lines, traditional electronic payment systems such as credit cards are examples of inside money, whereas the vast number of cryptocurrencies as well as stable coins such as the projected Libra are representing outside money.

Another important distinction is between account-based money and token money. Account-based money is related to a specific person (or company) – the account holder – that needs to prove its identity to verify authenticity of a transaction. In a token system, it is central to verify the authenticity of item (the token) irrespective of the identity of the agents. Cash is the (so far) most familiar example

² In its original version introduced by Stanley Jevons in 1876, being a standard of deferred payment was identified as a fourth distinctive function of money, which in modern textbooks is usually subsumed in the other three functional categories.

of token money, but modern e-money (e.g. Alipay and WeChat in China) and cryptocurrencies such as Bitcoin are also token money. Account-based money is typically related to the provision of credit, token-based money is typically not.

An independent currency can be defined as payment instruments that are (1) denominated in the same unit of account and where (2) each payment instrument within the currency is mutually convertible (Brunnermeier et al. 2019: 5). Put differently, the constitutive criterion for belonging to the same currency is denomination in the same unit of account irrespective of the specific medium of exchange (cash, reserves, bank deposits) and a legally binding fixed exchange rate among the different financial instruments. According to this definition, many of the recent forms of digital money are independent currencies. This includes fiat cryptocurrencies, such as Bitcoin or Ether to name the two largest, but also some stable coins, including Libra, which would be denominated in its own unit of account, have fluctuating exchange rates to individual official currencies, and retain the possibility of adjusting its initially fixed exchange rate to the underlying basket of official currencies.

2.2. Currency competition

Currency competition has been advocated as a possibility to discipline governments in managing government-issued currencies for many years, starting with Hayek (1976). Currency competition in the sense of Hayek does not necessarily imply the actual simultaneous existence of several currencies in the same economy, but may even work through the mere potential for competition, thereby restricting the room to manoeuvre for monetary policy. While governments often made competition with privately issued currencies impossible by legal restrictions, a certain amount of competition remained due to the existence of large internationally traded currencies such as the US-Dollar or the euro. In some cases, this competition from relatively stable major currencies resulted in a substantial loss of relevance of the domestic currency in the process of “dollarization” of an economy.

In general, however, currency competition is inhibited by the existence of strong network externalities (Dowd and Greenaway 1993). Historically, competing currencies needed to satisfy all three properties of money to a sufficient degree, raising high bars for a newcomer to establish sufficient prominence in terms of unit of account and acceptance as a medium of exchange even if credibility as a store of value was achieved. Moreover, switching costs (such as exchange fees) used to be relatively high, giving an incentive to stick to an incumbent official currency. In terms of the possibility to fulfil all money functions from the start, large commercial and social digital networks (such as Facebook, Amazon or Alibaba) have changed the potential for diffusing information among a large number of users at very low cost. These networks are international and allow for access to a huge number of potential counterparties beyond national boundaries. Accordingly, such digital ecosystems facilitate the successful introduction of a new (own) currency, and this explains to some extent the nervous reaction of some major central banks in response to the announcement of Libra, with billions of users on the various platforms involved – including Facebook. With regard to switching costs between currencies, in the modern digital environment they can become relatively low, with peer-to-peer exchange within networks without a third party involved and mobile devices that enable on-the-spot execution of currency exchanges. The reduction of switching costs contributes to a possible unbundling of the roles of money. The incentive to use the same currency to fulfil all functions of money (medium of exchange, unit of account, and store of value) at the same time is reduced, as soon as switching the currency is easy and cheap. For example, one currency may be particularly strong in the role as medium of exchange due to its prevalence in a large social or commercial networks, so it is used for payments, while another currency can be strong in the role as store of value, so it is used to hold money.

While the existence of network effects in the digital economy contributes to the potential unbundling of the functions of money and thus promotes currency competition, an opposite effect originates from the role of electronic platforms. Platforms are digital market places bringing together consumers, merchants and service providers facilitating exchange (of goods, services, capital, ideas...). If digital currencies are associated with platforms, they will effectively combine the functionalities and data of the platform, resulting in a re-bundling of money along the demarcation line between different platforms, which tends to weaken competition among currencies.

In the presence of large network externalities produced by transnational social or commercial platforms, new "digital currency areas" (DCA) may arise when payments and transactions are made by a digital currency that is specific to the network (Brunnermeier et al. 2019 : 19). A currency specific to a DCA could be an independent currency representing an own unit of account distinct from currencies already existing, such as Facebook's Libra. Its unit of account is derived from a basket of official currencies but remains different from any of the incorporated individual currencies. A DCA specific currency may also continue to use an official currency's unit of account (which implies that it is no independent currency according to the definition above), but would be restricted to transactions and exchanges inside the network. Major examples of this type of digital currency area can currently be found in China, with two large networks (Tencent and Ant Financial) entertaining payment systems without interoperability.

3. POTENTIAL BENEFITS AND COSTS FOR SOCIETY FROM INCREASED DIGITALISATION OF MONEY

3.1. Advantages of and concerns with a cashless society

One manifestation of digitalisation of money is a trend towards a reduction in the use of cash in transactions. This trend is indeed almost universal, although it differs substantially across countries. According to a recent IMF study, the share of cash in “cash-like transactions”, as measured by the amount of cash withdrawals plus the amount of transactions using two of the closest substitutes (card and e-money) has been falling significantly in almost all countries covered by the analysis, with India being the sole exception (Khianonarang and Humphrey 2019). On average, the share of cash in the economy declined at an average annual rate of change of 6 percent between 2006 and 2016, from 49 percent to 29 percent (Table 1).

Table 1: Reductions in Cash Use in Selected Countries, 2006 to 2016

	Cash Share, Level 2006	Cash Share, Level 2016	Annual reduction of cash share in Percent
Australia	37	21	6
China	54	18	10
Denmark	47	22	7
Germany	84	70	2
India	45	45	0
Japan	64	23	9
Netherlands	49	31	5
Norway	22	10	8
Singapore	61	30	7
UK	39	24	5
US	40	29	3
Average	49	29	6

Source: [Khianonarang and Humphrey \(2019\)](#).

The lowest level of cash use in 2016 is found in Norway at 10 percent (down from an already low level of 22 percent in 2006), the highest level remains prevalent in Germany at 70 percent (2006 : 84

percent). East Asian economies seem to experience an especially rapid decline (-10 percent annual change of cash use in China and -9 percent in Japan). The government of South Korea actively nudges its population to reduce the use of cash further and reportedly plans to phase out cash by 2020, although the parting from bills and coins will probably be more gradual. Sweden is inquiring the possibility of complementing cash with an e-krona, a digital central bank money (see discussion in section 4).

The decline in the relative importance of cash is partly driven by the convenience and efficiency gains offered by electronic payment methods in combination with mobile devices. Other arguments in favour of a cashless society include an expected reduction of crime, as absence of physical money implies that theft and robbery of cash are eliminated as well as counterfeiting. Moreover, funding of illegal activities, money laundering and tax evasion is more difficult without cash, particularly in electronic payment systems that rely on a central counterparty that records all transactions. Clearly, the use of digital money that allows for quasi-anonymous peer-to-peer transactions – such as cryptocurrencies like Bitcoin – reduces this advantage, which is why the crypto market is heavily regulated in a number of countries. With respect to monetary policy, abolishing cash would increase the scope of monetary policy to introduce negative interest rates, as the effective lower bound to nominal interest rates depends on the possibility to switch to cash as an interest free alternative to deposits (see section 4 for further discussion).

At the same time, giving up cash altogether comes with a number of problems and concerns. These include privacy issues. As far as payments made are traceable, private companies as well as governments are able to track individual transactions (and actions) in order to compile an individual profile or engage in widespread surveillance. The potential for digital crime, including fraud, unauthorised access and data breaches may rise with a rising share of electronic payments. A serious risk is the complete reliance on a functioning electronic infrastructure in a cashless society, making the economy even more vulnerable to cyberattacks. Another challenging issue is to ensure that those currently relying on cash as a means of payments are included. These tend to be concentrated in the poorer parts of the population and in the elderly population, which are generally less accustomed to the use of electronic payment systems, and includes illegal migrants, homeless people as well as children. Finally, there is the concern that electronic payment systems make it more difficult for people to control their budgets and may lead to a problematic increase of consumer debt.

3.2. Advantages of and concerns with digital currencies

Traditional currency areas are usually defined along national boundaries and evaluated according to the theory of optimal currency areas, according to their ability to smoothen economic shocks and to improve risk sharing. This situation basically remains unchanged with the potential introduction of a central bank digital currency. Digital currency areas based on a (national or international) digital network, by contrast, aim to exploit the linkages and exchanges in a network's ecosystem by providing users with the possibility of direct, peer-to-peer transfers of money. This could in principle increase economic welfare. The introduction of private independent digital currencies, especially if they promise to deliver the functions of traditional money as in the case of stablecoins, can also serve as an additional insurance against irresponsible monetary policy with respect to the official currency. The drawback, however, could be a reduced scope for monetary policy response in the case of an adverse macroeconomic shock (see section 5).

There are a number of severe additional concerns related to the introduction of stablecoins with global scale and scope like Libra (Brainard 2019). A number of legal and regulatory challenges will have to be addressed in advance. These include compliance with rules and regulations introduced to counter the use of digital currencies for illegal activities and illicit finance, and compliance with

national jurisdictions' anti-money laundering laws, which may differ across countries. In the case of transnational networks it has to be determined which jurisdiction is responsible for which financial activity conducted by the various players in the system, and whether the respective regulatory environment is appropriate. Consumer protection is an important issue as well. It is unclear to which extent consumer protection of Libra users is comparable to those delivered by statutory regulation in many countries. At the very least, differences with respect to the risks of digital currencies in comparison with traditional deposits should be made sufficiently transparent. Finally, there is the issue of data security, given the large number of data breaches that have become public in recent years.

A serious concern is the possibility that the association of a widely used electronic currency with a large social or commercial electronic platform will lead to an unprecedented aggregation of personal data, which may strengthen the competitive advantage of the supplier of that platform and currency over potential competitors, thereby reinforcing monopolistic tendencies that are already inherent in network industries.

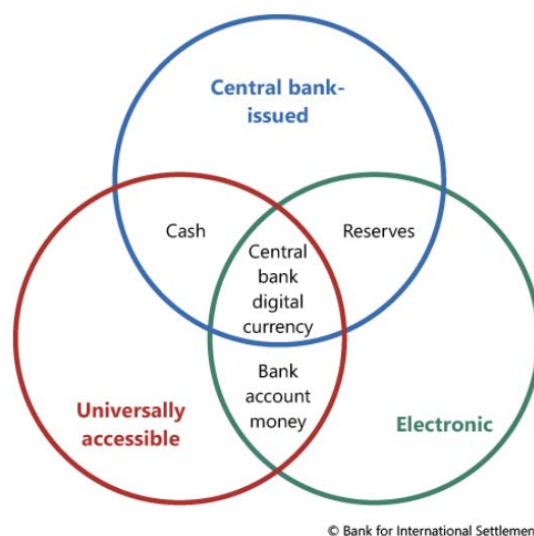
In their pursuit to allow for an evolution of the financial system while at the same time guarding against the above mentioned risks, national governments can be expected to employ different regulatory regimes, for instance to take account for different priorities with respect to the prevention of illicit transactions or privacy issues. As a result, it may become impossible to easily use a single digital currency on a global scale. Thus, despite the potential of digitalisation to facilitate transnational transactions, the outcome could ultimately be an increasingly fragmented international financial system.

4. CENTRAL BANK DIGITAL CURRENCIES (CBDC)

4.1. Main idea

In today's banking system, money issued by the central bank is available as either cash or reserves. The former (cash) is accessible to anyone; the latter (holding reserves) is only accessible to banks. If non-banks intend to hold non-tangible money, they have to rely on deposits at commercial banks. In essence, these deposits represent claims against commercial banks, instead of claims against the central bank. Put differently: It is a mere promise of the bank to pay out cash. With a central bank digital currency (CBDC), households and businesses can actually choose to hold non-tangible central bank money, i.e. direct claims against the central bank ("digital cash"). Base money is extended beyond cash and reserves to a third aggregate state – unless reserves are simply merged with CBDC units by granting unrestricted access to reserve accounts. In any case, the central bank guarantees at-par convertibility between all sorts of central bank money. The Venn diagram below visualizes former arguments, with CBDC being the intersection of all three subsets of electronic, central-bank-issued and universally accessible types of money (Figure 1).

Figure 1: A taxonomy of money



Source: Bjerg (2017).

Another way to consider CBDCs is that they are "light" versions of a full reserve system. In June 2018, there was a referendum in Switzerland on "Vollgeld", which would have radically transformed the Swiss banking system into a full reserve system. Banks would have been prohibited to create money "out of thin air" in a credit contract and to offer deposit accounts on a fractional reserve basis. The referendum spurred a vivid debate on the foundations of our monetary system in Switzerland and abroad. International newspapers followed the election campaign closely. In the end, the initiative was voted down by a large margin. It is no coincidence, however, that many proponents of a full reserve system are attracted to the concept of a CBDC, because this effectively provides the option to hold liquidity on a full-reserve account (100% money). At the same time, banks can still to offer accounts on fractional reserve basis. Therefore, a CBDC simply introduces an additional option for money users, without any radical changes to banks' balance sheets on the day of introduction,

without prohibiting fractional reserve deposits and without forcing banks to change their long-standing business practices from one day to the next. Basically, a CBDC is “Vollgeld light”.

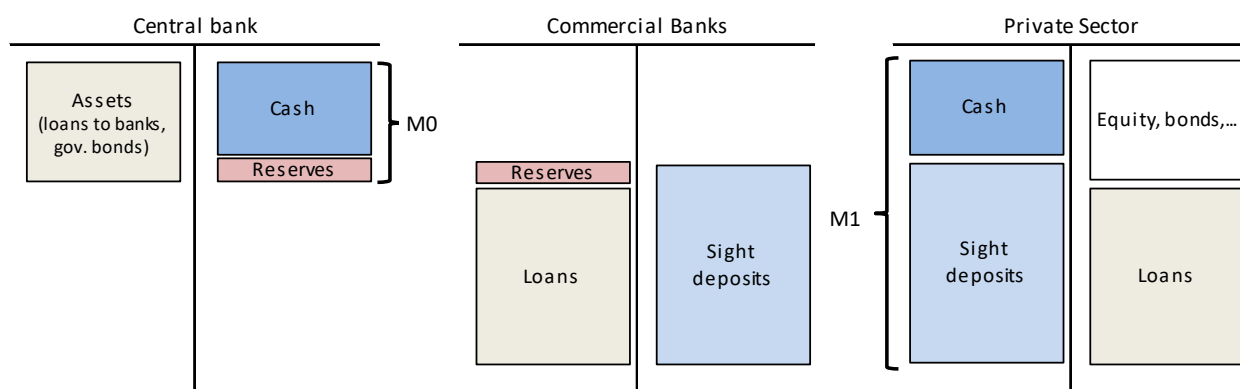
An additional distinction is whether payment systems are account-based (like bank deposits) or token-based (like cash). In an account-based payment system, authentication of a transaction requires the payer to prove his or her identity. In a token-based system, the payer does not have to reveal his or her identity, but authentication requires proof that the transferred amount of money is valid – like a banknote (Brunnermaier et al 2019). Therefore, a token-based CBDC allows for anonymous payments between peer-to-peer users. A more complex Venn diagram with four ellipses incorporates this distinction between account-based and token-based payment systems (“money flower” by Bech and Garratt 2017). However, the economic interpretation of a CBDC is not affected, but the distinction is rather a matter of technology, of feasibility of anonymous peer-to-peer transactions, of cryptographic and computing power requirements. Therefore, the remainder of this article deals with economic implications rather than applied technologies.

The easiest way to introduce a CBDC is an account-based version administered by the central bank as trusted counterparty. This implies a “permissioned” instead of a “permissionless” blockchain, by which the need for computer-intensive algorithms to prove authenticity of transactions through a distributed network of users largely vanishes. Granting digital access to CBDC accounts is possible without any retail infrastructure – a few high-performance servers to handle hundreds of millions of additional users would do, combined with software to allow for fast, secure and convenient transactions.

4.2. Possible consequences for the fractional reserve system

Currently, non-banks hold liquidity largely in the form of sight deposits. Recently, the share of deposits in the monetary aggregate M1 was more than 80% in the Euro area. For commercial banks, deposits are a cheap way to refinance. In fact, an integral part of the business model of banks consists of collecting short-run deposits and granting long-run loans (maturity transformation). Indeed, the sum of deposits in the Euro area is approximately half of the entire sum of credit to non-banks. In a balance sheet representation of the monetary system, the central bank issues cash and a small amount of reserves, which sum up to base money M0. Commercial banks, on the other hand, “issue” the bulk of money that is actually used for payments (namely sight deposits) and are required to hold only a small fraction of it as minimum reserves (Figure 2). Put differently, the quantity of money M1 that is actually used for retail payments is created in a public-private partnership, where private banks contribute by far the larger part of it.

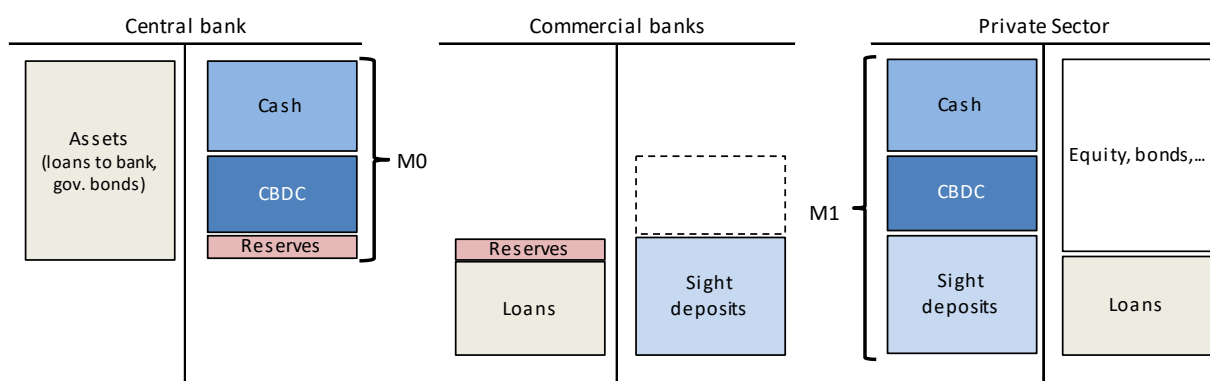
Figure 2: Current monetary system (fractional reserve system)



Source: Own representation.

A digital currency issued by the central bank is direct competition for bank deposits and can potentially substitute them as the main form of money holding. As soon as holding and transferring money on CBDC accounts is convenient and safe, a growing number of people and businesses will probably prefer to hold liquidity there. CBDC is legal tender, so no counterparty risk and no bank run risk is involved, thereby rendering this option superior to bank deposits. As a result, commercial banks will at least in part lose the ability to attract deposits. In the balance sheet representation, CBDC is both part of base money M0, as well as part of monetary aggregate M1. As non-tangible money, CBDC will replace a part of today's sight deposits (Figure 3). The "lost" deposits would cease to contribute to commercial bank's funding, and bank credit currently refinanced with deposits would require a new source of funding.

Figure 3: Monetary system with a CBDC



Source: Own representation.

Commercial banks may still retain attractiveness of deposit accounts to some extent, (1) if the payment infrastructure is more convenient or superior, (2) if they are able to bundle the deposit account with essential financial services, or (3) if they offer higher interest rates than the rate imposed on CBDC accounts. The third argument implies that the policy rate imposed on CBDC accounts is the lower bound to bank for the interest rate on bank deposits. To offset the counterparty risk associated with fractional reserve accounts, banks will have to offer a risk premium dependent on their own credit rating: In normal times, this premium is probably close to zero; at times of financial stress it could suddenly increase to prohibitively high levels. A pro-cyclical in- and outflow of liquidity into and out of the banking system is a possible outcome.

Sudden transfers of bank deposits to CBDC accounts, however, affect the financial sector in the same way as a bank run. In order to withdraw liquidity from a bank, people do not even have to line up in front of ATMs, but instead simply use online banking tools to transfer it to CBDC accounts. The impact on the banks' balance sheet is identical to a bank run, with liquidity flowing out at an alarming rate. In that situation, banks have to replace withdrawn liquidity with new sources of (re)financing. In the end, the central bank in its function as lender of last resort will flexibly provide sufficient liquidity (Riksbank 2017).

A CBDC still disrupts the traditional business model of commercial banks, even if they manage to retain attractiveness to some money users. The mere option of a full reserve account clearly implies the loss of some of today's depositors. Banks will have to offer additional benefits and services to the remaining customers, and they will be even more vulnerable to financial stress if they keep on relying on deposits to refinance credit. Therefore, a digital currency issued by the central bank can be

disruptive to the fractional reserve system, since deposits will become a less reliable source of funding (Gern et al. 2018).

4.3. Would a CBDC relax the zero lower bound?

So far, central banks are subject to an effective zero lower bound on nominal interest rates due to the option of withdrawing cash and still “receiving” a nominal return of zero percent. With subdued inflation and low potential growth, this restriction to monetary policy becomes binding more often, so central banks tend to switch to extraordinary measures which themselves are increasingly inefficient and have unwanted side effects (Fiedler et al. 2018). With a digital currency, the central bank could impose positive as well as negative interest rates on CBDC units. However, only if cash is abolished simultaneously, there will be “no way out” of the banking system, and people will be forced to accept even negative interest rates (Rogoff 2016).

Without cash, the effective lower bound is indeed relaxed, and the central bank will improve its ability to affect economic activity in low interest rate environments. With substantially negative interest rates in place, a CBDC constitutes a workable implementation of previous suggestions to add carrying costs to money in order to prevent cyclical hoarding (Gesell 1916, Fisher et al. 1933). In this setting, substantially negative interest rates incentivise economic actors either to spend money immediately or to put it to a savings account in the bank. Even with perfectly stable prices, money of this kind (“stamp scrip”) loses some of its functionality as a store of value. Therefore, this CBDC currency would likely be vulnerable to – and would probably require regulatory protection from – direct competition with currencies that are better stores of value.

In most countries, however, a CBDC will likely be introduced as a complement to cash rather than a replacement. Cash plays an important role in the life-long experience and payment habits of many people, and numerous businesses still rely on cash as a main or only accepted means of payment. Moreover, cash payments do not leave a digital trace. Therefore, availability of cash is not only desirable for criminals, but also constitutes institutionalised freedom from government control and personalised data collection. Moreover, it requires political support to abolish cash legally, which currently appears well out of reach in most countries – any attempt to do so certainly faces strong political resistance. Therefore, a more likely path to a cashless society would start with introducing a CBDC as a mere complement. Once people are used to the new and more convenient means of payment, and once the digital currency is accepted everywhere, the government can actually consider abolishing cash. Only then, the zero lower bound will be effectively relaxed.

4.4. Why would central banks issue digital money?

What is the business case for central banks to issue CBDCs, independent or jointly? In general, central bankers tend to be hesitant and careful when it comes to launching a potentially disruptive innovation to the monetary system. At least in theory, there is a considerable list of reasons to launch a CBDC:

Backup payment system: At times of financial stress, the fractional reserve system is vulnerable to systemic crises, even though there are mechanisms in place to handle this issue (financial regulation, deposit insurance, lender of last resort function). Nevertheless, if large banks are in trouble, governments tend to bail them out in a hurry to prevent bank runs from unfolding and in order to protect the payment system, which lies at the core of economic activity in societies that rely on division of labour. With a CBDC, a different payment system would be available that is not at all vulnerable to systemic crises. Financial crises can be resolved more calmly if economic actors are able to switch to a different payment system.

Higher seigniorage: The central bank can partly replace bank deposits with CBDC, so that the amount of interest-bearing assets in its balance sheet increases and thereby its ability to generate public revenue. However, generating profit is probably not a primary motive for most central banks of today.

Payment system efficiency: Potential benefits include availability of CBDC accounts on a 24/7 basis and faster settlement. However, private institutions can well introduce innovative payment methods. A CBDC issued by a national central bank will also not increase the efficiency of cross-border payments.

Cash phase-out: If people increasingly rely on digital means of payment, whereas businesses start refusing cash payments due to relatively high cost of maintaining a retail cash infrastructure, legal tender will lose relevance for money users. Issuance of a CBDC allows central bank-issued money (which defines the unit of account) to continue to play an important role in retail payments.

Financial inclusion: In particular in less-developed countries, a considerable share of the populations has no or a rather limited access to financial services. With digital money, the hurdles to access payment systems were much lower, because a physical retail bank is not necessarily required. For developed countries, however, financial exclusion is less of a problem, and in fact with a rising importance of digital payments, financial exclusion of some (elderly) people might become a problem instead as their payment habits are affected more by a potential phase-out of cash.

Surveillance: Digital payments always leave a trace, while cash allows for anonymous peer-to-peer transactions. A CBDC would improve options for preventing and tracing illegal transactions, money laundering, crime, tax evasion and so on, and would also extend possibilities for surveillance of the population. Privacy and civil liberties are key elements of western democracies, so the possibility of increasing surveillance may raise doubt and resistance there. In other countries, more possibilities for close surveillance may be an argument in favour of a CBDC.

Upholding the public monopoly of money: Private issuers of e-money certainly try to provide a currency that indeed fulfils the needs of money users – if only to reach or maintain a position as trustworthy money provider. Nevertheless, money is currently provided by public authorities (public monopoly of money), and it is debatable whether this core competence of nation states should be allowed to shift to private issuers beyond democratic control (as Hayek (1978) indeed proposed). After all, being in charge of money provision brings power and revenue, and private issuers of money may have other aims (in particular profit maximisation) that do not necessarily align in all potential situations with the provision of an indispensable public good like money. Therefore, a digital currency with central bank backing can be a credible alternative to satisfy some of the needs of potential users of private e-money. At the same time, the government will continue to regulate emerging cryptocurrencies, especially if they have the potential to reach macroeconomic relevance.

Countering competition from foreign CBDCs: If a major foreign central bank introduces a universally accessible CBDC, this innovation will considerably raise interest in – and possibly attraction of – that currency, for example as a reserve medium or even as an international currency. If this sets the international relevance of currently leading currencies on a downward trend, policymakers in these countries have to consider launching their own CBDC in order to maintain their position.

Countering competitive devaluations: A foreign central bank might not only introduce a CBDC, but also abolish cash. In that case, monetary policy authorities in the respective currency area are able to drive interest rates deep into negative territory. In the recent past, many countries entered a near-zero interest rate environment where traditional transmission channels of monetary policy like the bank lending channel lost relevance, whereas the exchange rate channel gained importance instead. As a result, some of the monetary policy decisions of major central banks in the 2010's –including quantitative easing – have been interpreted as “competitive devaluations” or even “currency wars” by

major newspapers. Against this background, a currency that replaces cash with a CBDC would allow the respective central bank to penetrate the exchange rate channel much further, so that the remaining central banks – who are restricted by the zero lower bound – would be unable to counter. To prevail in such a competitive devaluation, they would also have to replace cash with a CBDC.

Countering the challenge of Libra: Privately issued e-money like Libra, which are not restricted to a specific territory and therefore are truly international, can challenge major national currencies as global reserve media. This would divert power and seigniorage from national central banks to private institutions (probably large multinationals). If Libra is successfully introduced, it will – by construction – immediately be as stable as the major currencies it builds upon. Due to its large network (Facebook), it immediately reaches out broadly and beyond national borders. This makes a perfectly stable currency suddenly available to people in developing countries, whose home currencies often fail to provide a similar degree of stability. People would probably start to hold money in that currency (“digital dollarization”, or “liberation”?). In developed countries, on the other hand, Libra will start as a mere internet currency accepted in online shops and for services offered via internet. Frictionless convertibility to each major currency ensures that many shops actually accept Libra, as long as regulatory measures do not prevent them from doing so. Over time, people will probably start to hold money partly on Libra accounts for online purchases. On a global scale, the newly established unit of account – Libra – would gain relevance and there might even emerge a capital market to intermediate between Libra savers (in developed countries) and Libra borrowers (in developing countries) with a common risk-free interest rate. Once users continuously hold large amounts of money on Libra accounts, the Libra network can confidently reduce its 100% backing with established currencies step-by-step and still maintain full convertibility. Libra would evolve to a currency on its own that (perhaps rather temporarily) maintains a currency peg to a certain basket of traditional currencies. To prevent the affiliated loss of relevance for national currencies, authorities could impose strict regulatory measures to prevent Libra from gaining any relevance in the first place (e.g. outlaw all transactions). Another probably less likely approach to counter private international e-money from gaining much relevance is to issue a CBDC jointly with a number of major central banks – with regulatory support to ensure its dominance – in order to provide a global digital currency as an alternative (that retains power and seigniorage in public hands).

4.5. Will any central bank actually launch a CBDC?

The concept of a CBDC is widely debated among central bankers and academics. Numerous central banks around the world currently explore the prospects of a CBDC, not only theoretically, but some of them are already in the process of developing technical solutions to implement it. Sometimes, the investigation takes place behind closed doors, whereas other central banks like the Swedish Riksbank communicate their investigation of the possibility of an “e-krona” quite openly: In 2017, there was a brainstorming phase and the publication of the first e-krona report (Riksbank 2017). In 2018, the bank engaged in a deeper analysis of prospects and challenges leading to two additional reports. The years 2019 and 2020 are dedicated to develop technical solutions, and they even hired external experts for this purpose. No decision was made so far whether the e-krona will actually be launched, however, and such a move would probably require political support. Further legislative steps towards actually introducing the “e-krona” would take additional time. Overall, it is unclear if and when a major central bank actually introduces a CBDC that has global relevance. Intuition suggests that (1) CBDCs will become a reality at some point in time, and (2) today’s leading currencies will rather not be the frontrunners of such a move.

5. IMPLICATIONS OF DIGITAL MONEY FOR MONETARY POLICY

There are a number of scenarios about how a digitalisation of money might play out, each with different implications for monetary policy. In the following, we discuss two types: digital government (or government-derived) money that potentially replaces cash and digital private (or foreign) money.

5.1. Abolishment of cash

The scenario of digital government money would be one in which the use of cash had been curtailed a lot and supplanted with digital payments based on central bank currency. This could happen for several reasons: first, there could be a straightforward abolishment of cash via fundamental changes in the relevant body of law. Second, a central bank digital currency could be issued with properties so attractive that people voluntarily shift towards it. Third, other means of digital payments, such as credit cards, Paypal, etc., crowd out cash payments (this, once again, could happen voluntarily). While these digital payment services are provided by private companies, they are still conducted on the basis of central bank money.

Regardless of whether it happens organically or is imposed via law, the upshot of a situation where people do not use cash anymore – but rather digital means of payment based on a central bank currency – will be that the effective lower bound constraint on monetary policy will loosen. Standard monetary policy theories prescribes a reduction of central bank interest rates whenever inflation threatens to fall below target. However, because people could always shift into holding zero-yielding cash, the central bank cannot reduce interest rates too much below zero; the point after which too large a shift into cash occurs is then called the effective lower bound. Insofar as cash is replaced by digital money based on central bank controlled currency, monetary policy could gain additional room for manoeuvre.

5.2. Competition from other digital currencies

A different scenario sees the introduction of currencies (including private ones) that potentially compete with central bank-issued or central bank-based money. Digitalisation may help improve competition between currencies because it can provide easier on-the-spot unit conversions and currency exchanges. If then some new money is developed that can credibly promise to keep its value (or even increase it) over time, this would directly constrain the central bank's management of its own currency: if it implements too inflationary a policy, people can abandon government money and shift to the competition's currency (a similar argument is made in Hayek 1978). This would be similar to the dollarization phenomenon observable in some countries at times of extreme inflation rates for the respective local currencies. As digitization simplifies shifting between currencies, the inflation that a central bank can produce before people abandon the money it issues will be lower (assuming the central bank is indeed able to produce inflation deliberately, which was more obvious in Hayek's time). Note that even the threat of potential competition would already be a check on inflationary policies.

In short, a shift away from cash towards a CBDC would increase the central bank's ability to produce inflation, while competition from third-party digital currencies constrains it.

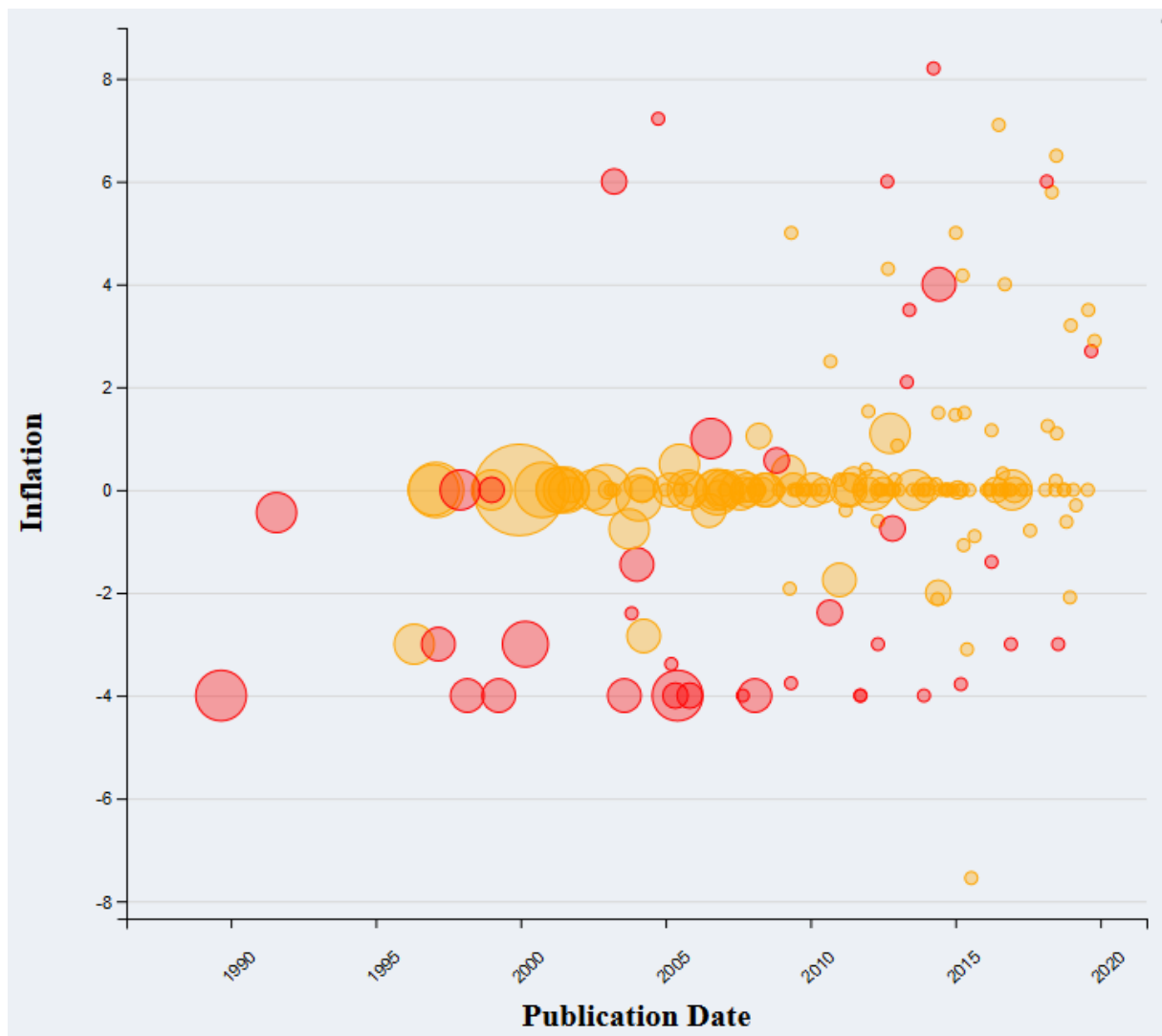
The welfare implications of such changes to the constraints faced by central banks depend on the optimal rate of inflation. If it were very important for monetary policy to be able to create sizeable price inflation, then the additional room for interest rate cuts described in the first digitalisation scenario would be quite welcome, but the availability of competing currencies as in the second scenario may prove harmful. The reverse would be true if it were more important to keep inflation low.

5.3. What is the optimal rate of inflation?

Currently, many central banks in developed economies, including the European Central Bank (ECB), try to achieve annual inflation rates of roughly two percent. But there is a certain degree of arbitrariness in the choice of the two percent figure, since, when looking at the relevant scientific literature, there is a lot of disagreement about which rate of inflation would be optimal.

Diercks (2019) looks at over 250 studies on optimal inflation published since 1988. While there is a very large cluster at zero percent, and the average optimal inflation rate found is 0.01 percent, there are also some studies that deviate markedly from this (Figure 4).

Figure 4: Optimal Inflation Rate



Note: Optimal inflation rates in percent per annum found in different papers; dots scaled by citations; red dots: paper uses flexible prices, yellow dots: paper uses sticky prices.

Source: Diercks and Langlois: [The Reader's Guide to Optimal Monetary Policy](#).

Arguments for a lower or even negative inflation target

What are the reasons behind substantially different recommendations for optimal inflation rates? One standard argument in favour of mild deflation is the Friedman rule: to eliminate the opportunity costs of holding money (which is thought to be zero-yielding and to have negligible production costs), nominal interest rates should also be zero. Aiming for nominal interest rates of zero implies that inflation must exactly offset the real interest rate. Since real interest rates are generally somewhat larger than zero, this implies a certain degree of deflation in the optimum.

Inflation rates close to zero can be supported by arguments involving so-called sticky prices. If firms adjust their prices infrequently (because changing prices may be costly) and on different schedules, both inflation and deflation will lead to additional inefficiencies. For example, if there is general inflation, firms who did not adjust their prices for a relatively long period of time will have artificially cheap prices compared to firms who did adjust recently (not least because firms would raise prices above the optimum whenever they set new prices if they expect to be overtaken by inflation again before their next adjustment date). Customers would then shift towards the artificially cheaper firms' offerings, inducing an increase in production here (and a correspondent decrease at the firms who adjusted prices more recently). These shifts in production are inefficient since they are not based on economic fundamentals (such as changes in the structure of production costs or consumer preferences). However, the progress of digitization weakens the sticky price argument. For example, Gorodnichenko and Talavera (2017) find that prices in online markets are more flexible relative to regular stores, and Cavallo (2018) reports that in conjunction prices at brick-and-mortar stores have also become more flexible.

The frictions typically introduced by tax systems also support low optimal inflation rates. For example, most countries tax nominal capital returns, which means that higher inflation rates directly increase real tax burdens. Consider a project with a pre-tax real (that is: adjusted for inflation) return of 4 percent and a tax rate of 50 percent. If inflation is 0 percent, then the tax on the real return will be 50 percent and the after-tax real return will be 2 percent. But if inflation is 2 percent, the after-tax return shrinks to 1 percent and the tax rate effectively increases to 75 percent. And if inflation is 4 percent, then the tax would take 100 percent of the real return, leaving the investor with nothing. Other difficulties can arise whenever nominal thresholds are not adjusted for inflation. For example, in progressive income taxation schemes that tax incomes past certain levels at higher rates, inflation will lead to automatic tax increases, since some unchanged real incomes will fall into higher nominal tax bands.

Arguments for slightly positive inflation targets

But there are also some arguments in favour of the slightly positive inflation targets that are set in practice. First, measured inflation is commonly thought to overstate actual inflation, for example due to the failure to sufficiently account for the introduction of new products and quality improvements for existing ones. Boskin et al. (1996) report that the US Consumer Price Index overstates inflation on average by about 1.1 percentage points (but there is considerable uncertainty and their estimated plausible range of mismeasurement reaches from 0.8 to 1.6 percentage points). Although there are some indications that the mismeasurement has decreased somewhat over time (cf. e.g. Adam and Weber 2019), an update on the Boskin report by Moulton (2018) still sees the CPI overstating actual inflation by 0.85 percentage points. Note, however, that there are also arguments for the view that measured inflation understates actual inflation. For example, Gros (2018) argues that the European Harmonised Index of Consumer Prices (HICP) is biased because it excludes owner-occupied housing.

Second, some believe that nominal wages are downwardly rigid, and that this can lead to excess unemployment. According to this theory, people have a strong aversion to nominal wage cuts such

that in a downturn, which would necessitate lower real wages to attain the new labour market equilibrium, employers would rather reduce their workforce than impose nominal wage cuts on a per employee basis. If, however, real wage growth were lower than nominal wage growth due to inflation by some margin, then simply holding wages steady would already produce real wage cuts. There is some disagreement about how relevant nominal wage rigidities are and by how much, if at all, inflation targets should be increased in response. For example, Billi and Kahn (2008) see no large role for these rigidities in shaping real world central bank targets. Kim and Ruge-Murcia (2011) estimate that nominal wage rigidities could justify an average inflation rate of roughly 0.4 percent per year. The evidence for nominal wage rigidity is also not consistent across countries and wage setting regimes. Fagan and Messina (2009) report that in some cases it may even be real wages that are rigid. They derive optimal inflation rates for four European countries as well as the US. While the estimated inflation rates range from 2 to 5 percent for the latter, they range from 0 (Belgium, Finland) to 2 percent (Portugal) in Europe (with Germany being in the middle of the range). Schmitt-Grohé and Uribe (2013) argued at the time that an increase of inflation to 4 percent for five years could restore full employment in the European periphery.

Third, there is the aforementioned effective lower bound. Higher inflation will lead to higher nominal interest rates in equilibrium such that the lower bound becomes a problem less often. Since natural real rates have most likely declined over the past decades (Fiedler et al. 2018), this buffer may currently be particularly important. For example, Andrade et al. (2019) argue that in the empirically relevant region, a reduction of the natural rate would optimally be compensated by an almost one-for-one increase in inflation.

Apart from these, there are many more factors that influence the optimal rate of inflation, such as financial frictions and collateral constraints, the possibility to extract seigniorage from foreign users of one's currency, and the implications for capital investment in the optimal portfolio choice (on the last point cf. Brunnermeier and Sannikov 2016). There are also interactions between the different factors mentioned here. For example, Amano and Gnocchi (2017) argue that the presence of wage rigidities reduces both the frequency and costs of a binding lower bound on interest rates.

Interim conclusion

All in all, there is still considerable disagreement about the optimal level of inflation, and a priori there is no strong reason to favour the current targets of roughly 2 percent. This does not necessarily mean they should be changed. Frivolous changes, especially in a situation where a central bank has failed to achieve its target for some time, could further erode the credibility of its monetary policy. Furthermore, insofar as monetary policy would actually produce markedly different inflation outcomes after the target change, distortions are introduced for all actors that made long-term plans on the basis of the previous targets (e.g. investors in fixed-rate long-term contracts would lose).

Overall, it is very unclear whether general welfare would be increased or reduced in either of the two scenarios – central banks being able to produce additional inflation after a switch from cash to central bank-derived digital money on the one hand, and constraints on inflation due to competing currencies on the other. Both the Federal Reserve as well as the European Central Bank have recently announced a review of their monetary policy strategies. Taking account of the benefits and drawbacks of different forms of digital currencies during these reviews would certainly be warranted, but the question of whether their introduction should be welcomed cannot be answered definitively without a much deeper understanding about the appropriate inflation target.

6. CONCLUSION

The process of digitalisation of money is proceeding and may even pick up further speed. The decline in the relative importance of cash in most economies is mainly driven by the convenience and efficiency gains offered by electronic payment methods in combination with mobile devices. The transition to a cashless society could already be completed in the next couple of years in some countries. However, a major challenge is to prevent that part of the population is left behind.

The chances of successfully launching a private electronic currency on a global scale have increased with Big Tech appearing on the stage. There are, however, a number of legal and regulatory challenges to be addressed, including security concerns, issues of consumer protection and the risk that the association of a widely used electronic currency with a large social or commercial electronic platform will reinforce monopolistic tendencies already inherent in network industries. On the other hand, different regulatory regimes between countries may ultimately lead to an increasingly fragmented international financial system, thus preventing full realisation of potential welfare gains from digitalisation and therefore calling for international regulatory cooperation.

A digital currency issued by a central bank (CBDC) can be disruptive for the fractional reserve system, because money users would have the option to hold direct claims against the central bank. Commercial banks would increasingly have to replace deposits with more reliable sources of funding. There are plenty of reasons why central banks may actually decide to launch a CBDC, independently or jointly: Installation of a backup payment system, higher revenue, financial inclusion, efficiency of the payment system, traceability of illegal transactions, surveillance, upholding the public monopoly of money while satisfying the need for digital money, and countering competition from private currencies as well as from foreign CBDCs. It is nevertheless unclear if and when a major central bank will actually introduce a CBDC of global relevance. Intuition suggests that CBDCs will be realised at some point in time, and that today's leading currencies will rather not be the frontrunners of such a move.

The implications of digital money for monetary policy are not straightforward. If digitalisation means the replacement of cash with central bank derived digital money, then the central bank's ability to produce inflation will increase because the effective lower bound on interest rates will loosen. However, if digitalisation raises the possibility of the introduction of (private or foreign) competing currencies, the ability of central banks to inflate their currencies would be constrained by the threat of people switching to these competing currencies. The welfare implications from digital currencies thus depend on the optimal rate of inflation. If the optimal inflation rate is high, then constraints on the central bank's ability to increase inflation could pose a problem. If, however, optimal inflation is low, then the reverse is true. There is considerable disagreement on the optimal rate of inflation. The choice of the targets of around 2 percent used by many central banks today are to a considerable degree arbitrary.

In short, our conclusion is that the trend towards digitalisation will probably continue, but has to be closely monitored and accompanied with an appropriate regulatory framework.

QUESTIONS FOR MEPS

1. How does the ECB assess the euro area's position in terms of evolution towards a cashless society? Does she actively promote progress in terms of digitalization of transactions and, if so, by which measures?
2. What is the ECB's stance with respect to the introduction private digital currencies with the potential to actually replace national currencies in a substantial way? What would be minimum regulatory requirements to allow a construct like Libra to become fully operative in the euro area?
3. Does the ECB actively investigate the prospects of a central bank digital currency? Do you already consider specific technical solutions to implement it?

REFERENCES

- Adam, K. and H. Weber (2019): Optimal Trend Inflation. *American Economic Review*, 109(2). Available at: <https://doi.org/10.1257/aer.20171066>.
- Amano, R. and S. Gnocchi (2017): Downward nominal wage rigidity meets the zero lower bound. Bank of Canada Staff Working Paper 2017-16. Available at: <https://www.econstor.eu/handle/10419/197941>.
- Andrade, P., J. Galí, H. Le Bihan, and J. Mathéron (2019): The Optimal Inflation Target and the Natural Rate of Interest. BPEA Conference Drafts, September, 2019.
- Bech, M.L., R. Garatt (2017). Central Bank Cryptocurrencies. *BIS Quarterly Review* Sept. 2017. https://www.bis.org/publ/qtrpdf/r_qt1709f.htm.
- Billi, R. and G. Kahn (2008): What is the Optimal Inflation Rate? Federal Reserve Bank of Kansas City, *Economic Review*, Second Quarter of 2008. Available at: https://www.researchgate.net/profile/Roberto_Billi/publication/5044062_What_Is_the_Optimal_Inflation_Rate/links/0deec533414f34ab4d000000/What-Is-the-Optimal-Inflation-Rate.pdf.
- Bjerg, O (2017): "Designing new money - the policy trilemma of central bank digital currency", Copenhagen Business School (CBS) Working Paper, June.
- Boskin, M., E. Dulberger, R. Gordon, Z. Griliches, and D. Jorgenson (1996): Final Report of the Advisory Commission to Study the Consumer Price Index. Committee on Finance, US Senate. Available at: <https://www.finance.senate.gov/imo/media/doc/Prt104-72.pdf>.
- Brainard, L. (2019). Digital Currencies, Stablecoins and the Evolving Payments Landscape. <https://www.federalreserve.gov/newsevents/speech/brainard20191016a.htm>.
- Brunnermeier, M. and Y. Sannikov (2016): On the Optimal Inflation Rate. *American Economic Review*, 106 (5). Available at: <https://www.aeaweb.org/articles?id=10.1257/aer.p20161076>.
- Brunnermeier, M. K., H. James and J.-P. Landau (2019). The Digitalization of Money. https://scholar.princeton.edu/sites/default/files/markus/files/02c_digitalmoney.pdf.
- Cavallo, A. (2018): More Amazon Effects: Online Competition and Pricing Behaviors. NBER Working Paper No. 25138. Available at: <https://www.nber.org/papers/w25138>.
- Diercks, A. (2019): The Reader's Guide to Optimal Monetary Policy. Available at: <https://ssrn.com/abstract=2989237>.
- Fagan, G. and J. Messina (2009): Downward Wage Rigidity and Optimal Steady-State Inflation. ECB Working Paper No. 1048. Available at: <https://ssrn.com/abstract=1386926>.
- Dowd, K, and D. Greenaway (1983). Currency Competition, Network Externalities and Switching costs: towards an Alternative View of Optimum Currency Areas. *The Economic Journal* 103(420): 1180-1189.
- Fisher, I., H.R.L. Cohn, H. Wescott (1933). *Stamp scrip*. Adelphi Company, New York 1933.
- Fiedler, S., S. Kooths and U. Stolzenburg (2017) Extending QE: Additional risks for financial stability? In-depth analysis for European Parliament's Committee on Economic and Monetary Affairs. Available at: <http://www.europarl.europa.eu/committees/en/econ/monetary-dialogue.html>.

- Fiedler, S., K.-J. Gern, D. Herle, S. Kooths, U. Stolzenburg and L. Stoppok (2018). Virtual Currencies. In-depth analysis for European Parliament's Committee on Economic and Monetary Affairs. Available at: <http://www.europarl.europa.eu/committees/en/econ/monetary-dialogue.html>.
- Fiedler, S., K. Gern, N. Janssen, and M. Wolters (2018): Growth prospects, the natural interest rate, and monetary policy. In-depth analysis for European Parliament's Committee on Economic and Monetary Affairs. Available at: <http://www.europarl.europa.eu/committees/en/econ/monetary-dialogue.html>.
- Gesell, S. (1916). The Natural Economic Order. Translation by Philip Pye 1958. London: Peter Owen Ltd.
- Gorodnichenko, Y. and O. Talavera (2017): Price Setting in Online Markets: Basic Facts, International Comparisons, and Cross-Border Integration. American Economic Review, 107 (1). Available at: <https://www.aeaweb.org/articles?id=10.1257/aer.20141127>.
- Gros, D. (2018): Persistent low inflation in the euro area: Mismeasurement rather than a cause for concern? In-depth analysis for European Parliament's Committee on Economic and Monetary Affairs. Available at: <http://www.europarl.europa.eu/committees/en/econ/monetary-dialogue.html>.
- Hayek, F. (1978): Denationalisation of Money: The Argument Refined. An Analysis of the Theory and Practice of Concurrent Currencies. Hobart Papers (Special), The Institute of Economic Affairs.
- Hayek, F. A. (1976). Denationalisation of Money: An Analysis of the Theory and Practice of Concurrent Currencies. London.
- Khianonarong, T., and D. Humphrey (2019). Cash Use across Countries and the Demand for Central Bank Digital Money. IMF Working Paper 19/46.
- Kim, J. and F. Ruge-Murcia (2011): Monetary policy when wages are downwardly rigid: Friedman meets Tobin. Journal of Economic Dynamics and Control, Volume 35, Issue 12. Available at: <https://www.sciencedirect.com/science/article/pii/S0165188911001527>.
- Libra association (2019). An Introduction to Libra. Available at: https://libra.org/en-US/wp-content/uploads/sites/23/2019/06/LibraWhitePaper_en_US.pdf.
- Moulton, B. (2018): The Measurement of Output, Prices, and Productivity: What's Changed Since the Boskin Commission? Available at: <https://www.brookings.edu/wp-content/uploads/2018/07/Moulton-report-v2.pdf>.
- Rogoff, K. (2016). The Curse of Cash. Princeton University Press.
- Riksbank (2017). The Riksbank's e-krona project. Report 1, September 2017. URL: <https://www.riksbank.se/en-gb/financial-stability/payments/e-krona/the-e-krona-projects-first-interim-report/>.
- Schmitt-Grohé, S., and M. Uribe (2013): Downward Nominal Wage Rigidity and the Case for Temporary Inflation in the Eurozone. Journal of Economic Perspectives, 27 (3). Available at: <https://www.aeaweb.org/articles?id=10.1257/jep.27.3.193>.

Against the backdrop of a trend towards a cashless society and the emergence of private electronic monies, the paper discusses properties of digital currencies and implications for currency competition, describes benefits and risks of digitalisation of money for the society, explains the concept and implications of a CBDC, and discusses implications of digital money for monetary policy. The upshot is that the trend towards digitalisation will probably continue, but has to be carefully monitored and accompanied with an appropriate regulatory framework.

This document was provided by Policy Department A at the request of the Economic and Monetary Affairs (ECON) Committee.
