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The Digital Euro and the Role of DLT for Central Bank Digital Currencies

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Digitization has reached the monetary system. The advent of crypto assets, such as Bitcoin and Ether, revealed numerous advantages these digital assets based on distributed ledger technologies (DLTs) can bring: Using DLT can enhance the security of sensitive financial transaction data, increase transaction speed through faster processing and settlement and automate numerous business processes through smart contracts. These advantages ought to be realized in the conventional monetary system as well — not only in the "crypto industry". DLT can be used both to digitally represent bank deposits and to tokenize central bank money via central bank digital currencies (CBDCs). Current DLT-based CBDC projects and prototypes among others by the Chinese and Swedish central banks, but also initiatives by the European Central Bank (ECB), show that DLT will be an essential pillar of the digitization of the monetary system in particular and the financial system in general in the future.

Introduction[1]

The emergence of digital crypto assets, such as Bitcoin in 2008, and the underlying distributed ledger technology (DLT) have led central banks around the world to think intensively about the digitization of the monetary system and the introduction of central bank digital currencies (CBDCs). The Bank of England pioneered this movement and started to analyze the introduction of its own CBDC already in 2014. Over the last years, the topic has reached global scale — at the latest with the announcement by Facebook

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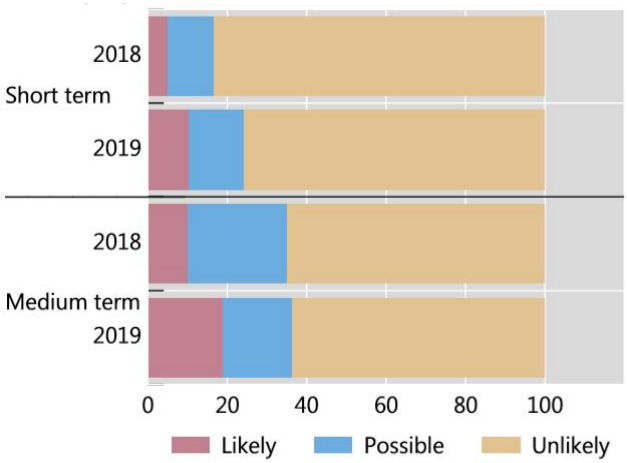
in the summer of 2019 to launch a digital DLT-based, global crypto asset "Libra" that will be backed by several fiat currencies and government bonds.

An in January 2020 published study by the Bank for International Settlements (BIS) shows that 70% of all global central banks are currently analyzing the issuance of their own digital central bank currency (see Boar, Holden, and Wadsworth, 2020). 10% of the participating central banks said that they are *likely to* introduce such digital currency in the short-run (up to three years) and 20% in the medium-term (up to six years) (see Figure 1). Further, 15% of central banks consider the introduction of a CBDC *possible in the* next three years (an additional 18% in the next six years). The direction is clear: more and more central banks are researching CBDCs and are planning to introduce own digital currencies in the upcoming years. It is, therefore, only a matter of time before the first CBDCs will be introduced.

Figure 1

Likelihood of CBDC introduction according to central banks



Source: Boar, Holden, and Wadsworth (2020).

In the public debate, DLTs, e.g., blockchain technology as a subcategory of DLTs, are often assumed to be the technological basis for the digitization of the monetary system and the introduction of a CBDC. This technological choice is not necessarily obligatory. However, the discussion is mainly driven by the emergence of this new technology and the new technological features it entails. Since there are different possibilities for introducing a CBDC old economic ideas about the design of the monetary system are brought back to

the center of the scientific debate.[2] DLT enables us to rethink all the different types of money in today's monetary system and to materialize the advantages of DLTs in different ways. One strong argument in favor of using DLT is that delivery and payments of assets can be organized on integrated platforms. A DLT makes this possible and would enable real-time settlement, e.g., in the settlement of financial securities.

In order to put the current developments into perspective, this article first explains the existing monetary system and discusses the forms and advantages of a DLT-based digital Euro. The focus will then be put on showing the possibilities to digitize the different types of money and, especially, on CBDCs. We analyze current CBDC projects and explain the intentions behind the respective CBDC introduction. In addition, possible threats for the financial system caused by a CBDC introduction, such as financial stability and data protection concerns, are discussed, and possible solutions are outlined.

The current monetary system

The anchor of the current monetary system is physical cash. Cash is the only legal tender and can solely be printed by central banks. Since the abolition of the gold standard in the early 1970s, cash is no longer backed by gold but is generated by central banks through lending activities or by purchasing assets such as government bonds. The term *fiat money* — derived from the Latin phrase for "*Let there be money*" — thus accurately describes that cash can be created at will by central banks. However, central banks issue cash not proactively but reactively in response to the expansion of commercial bank money and driven by the demand of bank clients.

Physical cash represents only a small fraction of the money supply in the existing monetary system. The vast majority of the money supply in circulation — around 87% of the Euro area money supply, according to the Statistical Data Warehouse of the European Central Bank (ECB) — is commercial bank money, which is used for payments, e.g., via debit or credit cards. Commercial bank money is recorded in the current accounts of citizens at the respective banks. Bank money is created whenever banks grant loans or purchase assets such as shares, bonds, etc. (see Deutsche Bundesbank,

2017). Commercial banks do not require central bank money or savings deposits before lending, as the theory of the money creation multiplier or the bank intermediation theory suggests. Instead, the necessary liquidity is obtained retrospectively on the money markets or from the central bank (see McLeay, Radia, and Thomas, 2014). In the existing monetary system, the proactive generation of money is thus the responsibility of commercial banks.

Another form of central bank money, the so-called central bank reserves, is used to transfer liquidity between banks. In most countries, only banks and a few selected (financial) institutions have access to central bank reserves and, thus, to the central bank's balance sheet. Central banks (usually) only react reactively and as a response to banks' creation of bank deposits by increasing cash and central bank reserves (see ECB, 2012). Since the 2007/2008 financial crisis, however, central banks have increasingly abandoned a purely reactive approach: In the context of unconventional monetary policy measures such as quantitative easing, central banks have proactively generated central bank reserves on a large scale through extensive asset purchase programs.

The three existing types of money can be distinguished as follows:

- **Cash** is the only legal tender and is issued by the central bank. It is peer-to-peer transferable, i.e., without an intermediary, it is not digital and is accessible to the general public. In contrast to the two other types of money, cash allows anonymous transactions. Cash does not bear interest, which means that cash creates an effective lower bound for monetary policy. Since bank money can be exchanged for cash, rational bank customers would exchange their bank deposits into cash if the interest rates on bank accounts became (strongly) negative. Cash is generated reactively by the central bank, and the quantity is based on the cash demanded by banks and ultimately by their customers.
- **Bank money** is issued proactively by commercial banks and represents a claim on the commercial bank for the payout of cash. The account balance of a bank client indicates that cash in the amount shown can be withdrawn by the client from the respective bank account. According to the ECB, however, the Euro area's bank

money is only covered by around 13% of cash. The remaining assets are claims on borrowers and other assets the bank holds. This makes holding bank money risky: bank customers are exposed to liquidity risks, creditor risks, and market risks. Nevertheless, bank money is tied 1:1 to the value of cash and reserves and can be withdrawn at the same nominal value as cash. The interest rate on bank deposits is set by the individual bank but other interest rates, such as interest paid on bonds, interbank rates, and ultimately the refinancing rate of central bank reserves represent upper bounds.

- **Central bank reserves** are issued by the central bank but are not available to the general public. Since reserves are a form of central bank money, the holder of the reserves is not exposed to liquidity or creditor risk, as it is the case with bank money. By definition, central banks, unlike private banks, cannot go bankrupt because they are the only institutions that generate legal tender and could, in theory, even operate with negative equity (see Bunea et al., 2016). Central bank reserves — like cash — are, therefore, a risk-free form of money. However, unlike cash, they are transferable digitally. Reserves are interest-bearing and are remunerated at the central bank deposit rate.

If trust in the banking sector – and, therefore, in the money issued by banks — declines, so-called *bank runs* can emerge. In case of a bank run, bank customers withdraw their money from their checking accounts and convert it into cash in large quantities. Such bank runs can lead to massive liquidity shortages for banks, as banks have to convert large amounts of their digital reserves into cash. Depending on the extent and duration of the bank run, banks are dependent on emergency loans from the central bank to meet the demand for cash when they cannot sell other assets to generate more liquidity.

The example of Cyprus shows that bank runs are not only a theoretical construct, but that mistrust in the banking system can indeed not be ruled out. In 2013, bank customers feared that their deposits would no longer be safe and withdrew more than 40% of their funds within one year. In the

financial crisis of 2007/2008, bank runs also affected many banks in the Euro area — e.g., Northern Rock in Ireland.

After discussing the existing monetary system, we now address the digitization of fiat currencies — in the case of the Euro area, the Euro. The debate on the digitization of the monetary system includes, above all, the discussion of whether distributed ledger technologies (DLTs), such as blockchain technology, could or should be used for issuing digital money.

Advantages of a blockchain-based Euro

The issuance of a digital Euro via a DLT system could bring considerable advantages:

1. **Security:** In the current financial system, data is typically stored centrally on the servers of a third party, for example, the servers of a (central) bank. By using DLT, however, transaction data is stored simultaneously on a large number of computers. Decentralized storage of data would make the system more resistant to hacker attacks, as there would no longer be a single point of failure.
2. **Resistance to manipulation:** Since transactions are stored on several computers simultaneously, it is not possible to manipulate or subsequently change transaction data. Such resistance to manipulation offers considerable advantages, especially in applications where all participants must have the same level of knowledge, but do not necessarily know and trust each other.
3. **Automation and programmability of money:** Technological innovations such as smart contracts and peer-to-peer (micro) payments, e.g., between machines, can be realized in Euros and would not have to be processed in volatile and/or unregulated crypto assets. Smart contracts would enable internet of Things (IoT) devices connected to the DLT, such as machines, cars, and sensors, to offer services on a pay-per-use basis. A DLT-based payment system is, therefore, particularly promising in the context of the machine economy. IoT Analytics estimates that by 2025 more than 20 billion devices will be connected to the internet — three times as

many devices as there are people on earth today (see IoT Analytics, 2018). Many of these devices will also be integrated into a payment network so that in a few years, this network will comprise hundreds of millions of devices. DLT is best suited for equipping millions of devices with a computer chip and, thus, also with their own digital wallet. Devices could transfer digital Euros directly from wallet to wallet, and a device would be able to receive payments and transfer money autonomously.

4. **Efficiency gains:** Furthermore, in the case of a peer-to-peer DLT Euro system, significant efficiency gains could be achieved. The payment system could be greatly simplified, and many intermediaries would no longer be needed (e.g., clearinghouses). This would significantly reduce the costs of the payment system and process transactions faster. Significant efficiency gains would be the result, especially for cross-border payments. Nowadays, international transfers from Germany to Argentina, for example, take up to ten days and often cost up to 10% of the transfer amount in fees. The use of DLT systems could enable immediate settlement at very low transaction costs even between different currency areas.

A DLT system designed for central banks would have a different structure than most existing DLT networks, such as the Bitcoin network. Since the central bank inherits a high level of trust, it does not need to use a fully decentralized DLT system that operates completely without mutual trust, and through a distributed consensus mechanism.[3]

The Bitcoin network, through its "proof-of-work" consensus mechanism, has managed to create a global, decentralized consensus on the conducted transactions. The proof-of-work consensus mechanism requires network participants to solve a cryptographic puzzle. The first party to correctly solve the puzzle is rewarded with a certain amount of Bitcoins from the network and acquires the right to confirm the last “block” of transactions. As a consequence, network participants do not have to rely on third parties such as (central) banks in the current financial system that decide over the validity of the conducted transactions. However, this proof-of-work consensus mechanism, which is the most secure and widespread mechanism to date, is energy-intensive and leads to a low transaction throughput in the Bitcoin

network. Currently, only seven Bitcoin transactions per second are technically feasible. Other crypto assets use alternative consensus mechanisms such as "proof-of-stake" or "proof-of-authority" to overcome the scaling issues of the Bitcoin protocol. However, none of the mechanisms has so far proven to be as secure as proof of work.

In contrast to the Bitcoin network, a central bank DLT system could consist of a large number of identified and accountable network nodes that, in line with certain rules, establish consensus on the transactions that occur (see Danezis and Meiklejohn, 2016). Blockchain-providers such as Hyperledger or Corda by R3, which partner with central banks around the world to test CBDC prototypes, also use these “permissioned” blockchains that have known and trusted validators. Such systems do not correspond to the vision and concepts of the supporters of "crypto currencies", who propagate an open monetary system that is not based on trust in third parties such as banks, the central bank, or the state. However, numerous disadvantages of "crypto currencies", such as the enormous energy consumption, the scaling issues, and the strong price fluctuations, would be overcome, and the advantages of DLT would be applied in the form of a stable and reliable digital currency.

The following section outlines possible ways how DLT can contribute to the digitization of the monetary system and how the private sector could issue a digital and “programmable” Euro.

Euro-backed stablecoins

The first possibility to use DLT to transfer Euros is to tokenize fiat money deposited at banks, e-money providers, or other financial institutions to create “stablecoins”. DLTs use so-called tokens to transfer values from A to B. Each of these stablecoin tokens must be backed by respective units of money (or other assets) deposited in the account of the client. The tokens must be fully backed by deposits, which stabilize the value of these stablecoins stable against a fiat currency such as the Euro. Holders of stablecoins must trust the issuers of the tokens that all tokens are fully backed by deposits and that they could be withdrawn even in case of 100% liquidation (see Sodhi, 2018).

Stablecoin projects already exist for several years. The most prominent (fiat-backed) stablecoin projects are Tether, TrueUSD, USDCoin, and Stasis. The projects are relatively successful in maintaining a 1:1 peg to the underlying fiat currencies. The exchange rates fluctuate only slightly around the unit of account of the fiat currency, also due to arbitrageurs that use price differentiations to yield profits.

Today, however, stablecoins are primarily used in crypto markets as vehicle currencies for the purchase or sale of other crypto assets such as Bitcoin or Ether and only rarely in "non-crypto-markets". This is mainly due to the fact that stablecoins have so far not been regulated and are not covered by statutory deposit insurance schemes. In concrete terms, this means that although stablecoins are linked to existing currencies, they are not used as means of payment due to a high degree of regulatory uncertainty. Customers are exposed to issuer and liquidity risks, for example, if a stablecoin could not maintain the peg anymore. Furthermore, many stablecoins do not have a payout guarantee on the underlying deposits. Since 2019, however, first companies have been using an e-money license to issue a fiat-backed regulated stablecoin, thereby aiming to bring the "blockchain Euro" into the real economy. These players include the German start-up Cash-on-Ledger and the Icelandic start-up Monerium.

To date, the most popular stablecoin project is certainly the Libra project, which the Libra Association around the Facebook subsidiary Calibra announced in June 2019 and which has been updated in April 2020 (see Gross, Herz, and Schiller 2019). The original plan of Libra was to issue a multi-currency stablecoin (“Libra Coin”) only which is backed by a basket of currencies consisting of not only bank deposits denominated in various fiat currencies but also short-term government bonds. As a result of intensive discussions with regulators and governments, Libra released an updated concept in April 2020, stressing that, apart from the Libra Coin that is backed by multiple currencies, also single-currency stablecoins, e.g., a Libra Euro, will be issued. These national stablecoins will be backed approximately 20% by bank deposits nominated in Euro, U.S. Dollar, Japanese Yen, etc. and 80% by government bonds of the respective government or currency union member countries. Even though the Libra tokens are not fully backed by bank deposits but also by government bonds, which entail market risk, Libra expects the coins to be stable against the tokenized currency. The Libra

project shows how easily such stablecoins can be created and stresses the advantages of using DLT for money payments. Therefore, the Libra project is widely perceived as a "game-changer".

Given the two-tier structure of the existing monetary system, fiat-backed stablecoins on DLT can be either backed by commercial bank money or by central bank money. For the end consumer, this distinction seems not to be essential at first sight as both types of money are denominated in Euro. Furthermore, bank money is secured by deposit guarantee schemes and therefore perceived as secure as central bank money. In times of banking crises, however, this can make a significant difference: Bank deposits in the Euro area are only secured by the deposit guarantee schemes up to 100,000 Euros and, as described above, only a fraction of bank deposits are backed by central bank money.

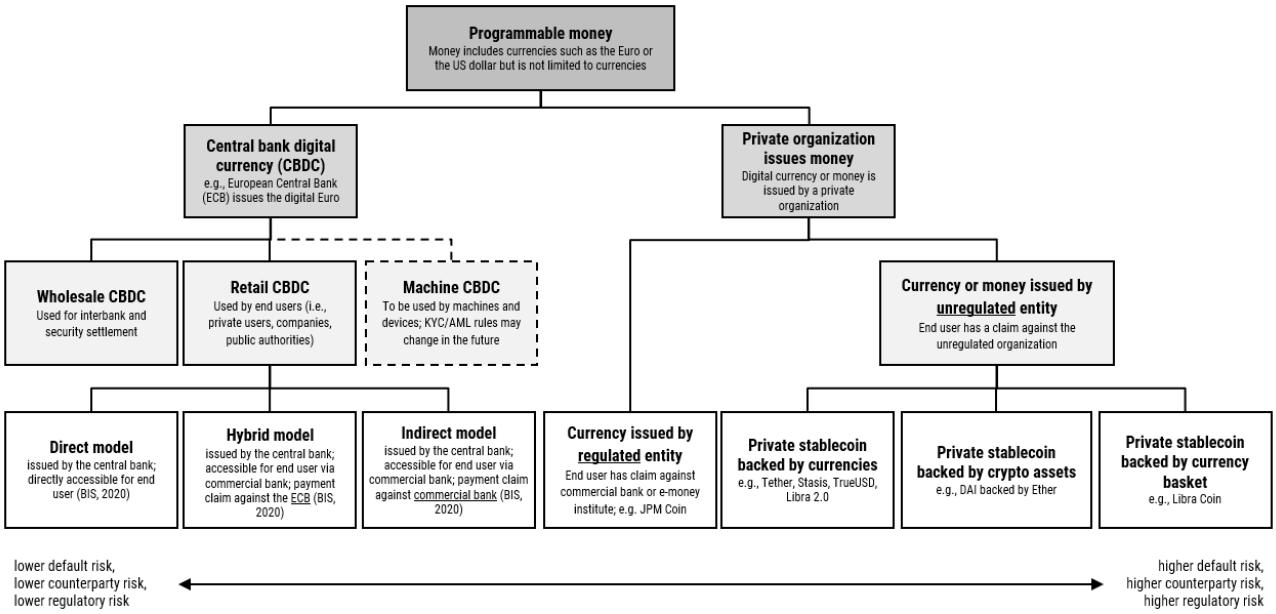
Alternatively, stablecoin projects could also keep customers' deposits in an account with an intermediary or trustee, which in turn is 100% backed by central bank money. This is possible if the cooperating bank or payment service provider backs the account balances of the customers of the stablecoin project 100 % with reserves. This variant would correspond to a deposit with the central bank secured by intermediaries or trustees, which can also be transferred via a DLT system. This type of stablecoin, therefore, indirectly accesses central bank money and is called synthetic CBDC (sCBDC) (see Adrian and Mancini-Griffoli, 2019). One difference between an sCBDC and a direct CBDC is that in the case of an sCBDC an issuer and credit risk exists, whereas a direct CBDC bears no issuer, credit, or liquidity risk.

Central bank digital currencies (CBDCs)

Driven by the developments around crypto assets and the announcement of the Libra project, a large number of central banks announced that they will take an even closer look at the possibilities of the application of DLT and therefore analyze the issuance of an own digital currency. Central banks could, therefore, also be the issuer of programmable, DLT-based money (see Figure 2, left-hand side).

Figure 2

Taxonomy of programmable money



Source: Own illustration.

There are two ways of issuing central bank digital currencies (CBDCs): wholesale and retail CBDC.

1. **Wholesale CBDC:** Central banks could change the interbank payment system from a central clearing system to a peer-to-peer system, leading to central bank reserves on a DLT. These digital tokens would only be used for interbank payments, could only be held by eligible financial institutions, and could not be used as a general means of payment. Introducing a wholesale CBDC is suspected to increase efficiency in the interbank market.
2. **Retail CBDC:** Central banks could also issue a new digital means of payment to the general public, which would coexist with bank money and cash and could be used as a general means of payment. Unlike bank deposits, it would not be a *claim* on a legal tender but would become *legal tender itself*, like cash. A retail CBDC could be designed both interest-bearing or non-interest-bearing. The challenges of an interest-bearing CBDC for monetary policy are currently intensively researched in the academic literature and go beyond the scope of this paper. The ultimate goal of a retail CBDC is to digitize physical cash

and, therefore, preserve access to the central bank balance sheet for non-banks in the digital age.

A wholesale CBDC would not fundamentally change the existing monetary system: Non-banks would continue to keep their accounts with commercial banks, and payments between customers of two different banks would continue to be made using digital central bank money — however, using DLT-based reserves. Banks would continue to create the vast majority of the money supply, and central banks would continue to have access to the non-banking sector only through physical cash. However, access to the payment system could be widened to other financial market participants easily. This could lead to further competition in the payment sector and disrupt traditional correspondent banking where smaller banks hold accounts at larger banks that manage the interbank payments in reserves for them. In addition to the development around wholesale CBDCs of central banks, there are also private sector projects such as Ripple or the planned JPM Coin project. Previous tests and prototypes of wholesale CBDC projects, for example, in Thailand and South Africa, have shown that DLT systems can increase transaction speed through fast settlement in the interbank market. The use of DLT systems is particularly advantageous if further transactions such as security transfers would also be processed via a DLT-based transaction system (see Chapman et al., 2017).[4]

A retail CBDC would make the Euro accessible to the general public as a digital currency unit and, therefore, an alternative to bank money. This could lead to significant changes in the existing monetary system as this digital form of money would be issued directly from the central bank. The holders of retail CBDCs would not be exposed to liquidity or creditor risk, as in the case of bank deposits. Thus, a retail CBDC is, like cash, a risk-free means of payment, but in a digital form.

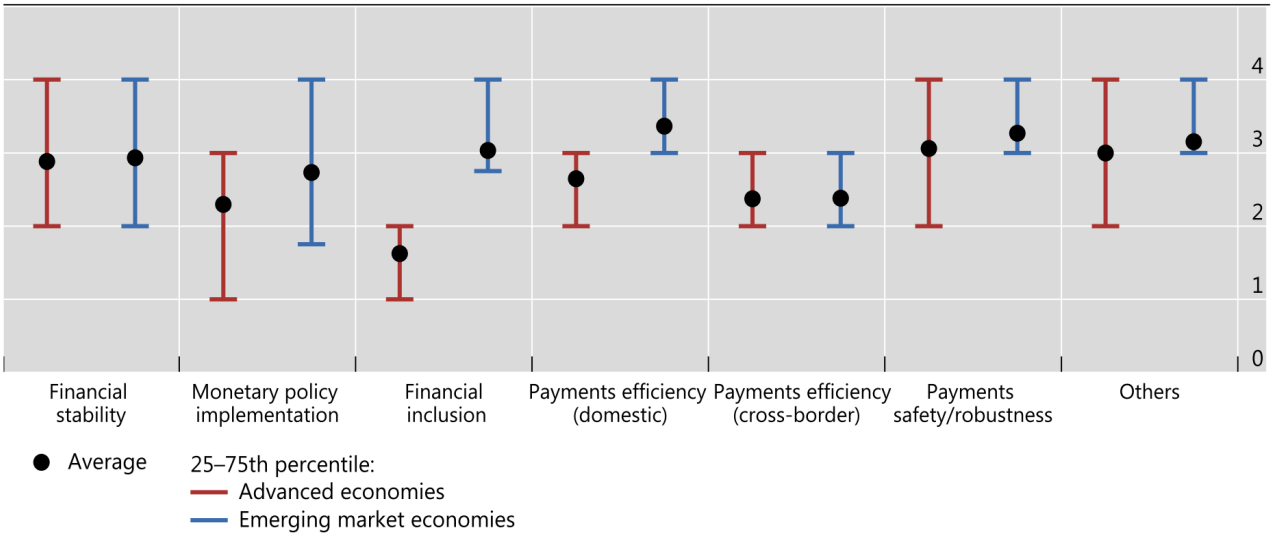
The previously mentioned study by the BIS (Boar, Holden, Wadsworth, 2020) shows that central banks are currently primarily researching *retail* CBDCs. Central banks' motives for introducing retail CBDCs are manifold (see Figure 3). The study shows that the motives differ between industrialized countries on the one hand and emerging and developing countries on the other: Industrialized countries hope to strengthen financial stability, increase the efficiency of payment transactions, i.e., by reducing transaction time and

costs, and increase the security of digital transactions. Monetary policy and financial inclusion considerations only play a minor role for central banks in industrialized countries.

Figure 3

Motives for introducing retail CBDCs

Distribution[1] Graph 3



[1] Not so important" (1); "Somewhat important" (2); "Important" (3); and "Very important" (4).

Source: Boar, Holden, and Wadsworth (2020).

Developing countries, on the other hand, aim to improve financial stability, the efficiency, and security of transactions, but above all, to reach a higher degree of financial inclusion. Financial inclusion motives have, e.g., driven the CBDC efforts in the Marshall Islands and other island groups, such as the Bahamas or Barbados. In these nations, like in many third world countries and developing countries, a large share of citizens is currently excluded from the financial system since they do not have bank accounts.

Financial stability concerns

Central bankers and economists are currently debating how such a retail CBDC system should be designed to preserve the stability of the existing monetary system. Many economists, such as the president of the German Bundesbank Jens Weidmann, see the main threat of a retail CBDC introduction in the facilitation of "digital bank runs" — numerous customers could exchange their bank deposits for the new digital central bank money

easily (see Handelsblatt, 2020). In the case of such a digital bank run, banks' liquidity holdings could be put under immense pressure and, in the worst case, lead to bank illiquidity. In addition, the direct exchange of bank money into CBDC could limit the ability of banks to create money by lending activities, as banks would have to reckon with an outflow of funds into the riskless CBDC at any time and thus would have to back the customers' deposits with a higher percentage of reserves.

Banks engage in maturity transformation and finance long-term loans through short-term deposits. The introduction of a digital form of central bank money for the non-banking sector could thus trigger risks for maturity transformation through potential and sudden withdrawal of liquidity. The process of massive outflows of reserves from the banking sector is referred to as "disintermediation" of the banking sector. An extreme scenario of this disintermediation would be that banks could become pure intermediaries and could no longer create money by granting loans. In order to provide the economy with sufficient liquidity, the central bank itself might have to generate CBDC units actively. A 2019 published study by the International Monetary Fund (IMF) discusses money creation in a retail CBDC system and sheds light on the active creation of CBDC units through lending (see Gross and Siebenbrunner, 2019). Lending could still be carried out by banks, but no additional bank deposits would be created in the lending process, as the loan would have to be refinanced 100% in CBDC.

In fact, CBDCs can enable central banks to regain control over money creation and to be the sole issuer of money, like the Chicago Plan in the 1930s had foreseen (see Fisher, 1936). For years, economists, NGOs, and political parties campaigned for a modern version of Irving Fishers' "100% Money" called "Sovereign Money". Proponents of this structure of the monetary system contemplate to create money when the real economy needs additional money to grow — either via transfers from the central bank to parliament or via a citizen's dividend (see Huber, 2017). DLT could facilitate this idea by tying money creation to the development of the real economy via smart contracts that automatically create new money when certain conditions are met (see Rashkin and Yermack, 2016). The former Chief Economist of Deutsche Bank, Thomas Mayer, even believes that the introduction of such a 100%-CBDC system would provide a chance to restart the Euro as a more stable and future-oriented currency (see Mayer, 2019). Among others, the

former Governor of the Spanish central bank, Miguel Ángel Fernández Ordóñez, believes that this transition could lead to a far more stable banking and financial system. He argues that such a system could provide the reasoning for liberalization of the banking sector, which would foster competition between banks and Fintechs in the market for loans (see Ordóñez, 2020).

So far, three different approaches have been developed to prevent a digital bank run and the disintermediation of the banking sector. Economists from the Bank of England propose a parallel payment system, which would make it impossible to directly exchange and "digitally withdraw" bank money into CBDC. Consequently, bank deposits would not be directly convertible into CBDC. Central banks would actively generate new CBDC units by buying securities and, in return, create CBDC in the accounts of the sellers, both banks and the general public. In secondary markets, the exchange of CBDC and bank money between buyers and sellers could be enabled. This would leave the stock of bank money in the system unaffected and thus prevent disintermediation of banks (see Kumhof and Noone, 2018).

An ECB publication from January 2020 proposes a two-tiered CBDC system with two different interest rates on CBDC balances (see Bindseil, 2020). This two-tiered interest rate structure is expected to prevent bank disintermediation — even if direct convertibility between bank money and CBDC is given. If a certain CBDC threshold is exceeded in the central bank account, the excess CBDC amount would bear zero or negative interest rates, making it unattractive to hold CBDCs in large quantities and to use CBDCs as a store of value.

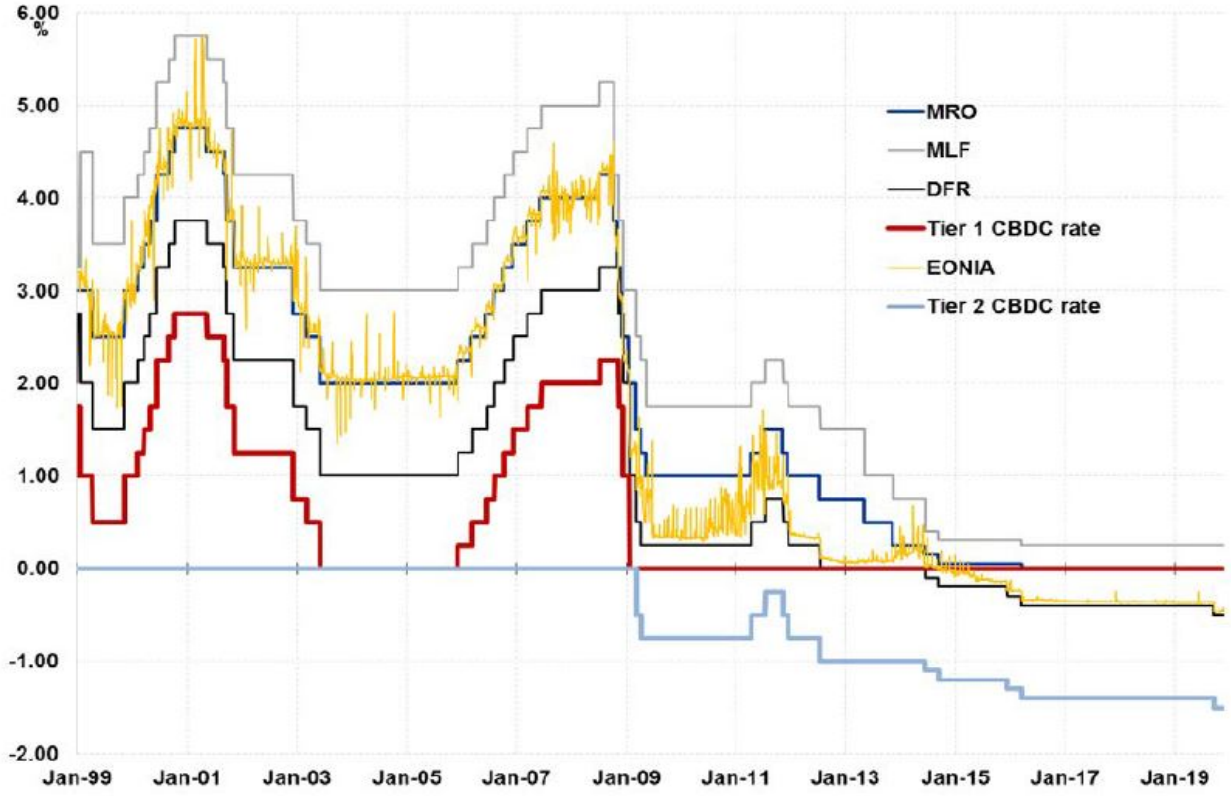
The idea of a two-tiered CBDC interest rate on central bank balances is not new: Currently, an amount of six times the minimum reserve that commercial banks must hold with the central bank as a minimum liquidity requirement is excluded from the negative deposit rate (see Deutsche Bundesbank, 2020). In the Euro area, the minimum reserve currently amounts to 1% of bank deposits. Currently, the deposit rate of -0.5% must be paid on the excess reserves that banks hold with the central bank.

In "normal times" with interest rates of > 0%, the amount of CBDC below the threshold would yield positive (or non-negative) interest. The interest rate on

this "Tier 1 CBDC" is designed to follow the movements of all other market rates but should be set, for example, 1% below the level of the deposit rate at the central bank, thus making CBDC less attractive than bank deposits. However, if the deposit rate fell below 1%, the Tier 1 CBDC interest rate would remain at 0%, thus guaranteeing CBDC holders a non-negative interest rate (see Figure 4).

Figure 4

Interest rates in the proposed two-tiered CBDC system



Source: Bindseil (2020).

The "excess" CBDC balances in the central bank account ("Tier 2 CBDC") would never be remunerated positively. If the ECB deposit rate falls below 1%, the Tier 2 interest rate would become negative. In times of crisis, the spread between the deposit rate and the Tier 2 rate could even be increased to avoid bank runs. Such a two-tiered CBDC system would thus make a CBDC unattractive as a store of value, as Tier 2 CBDC units would never bear a positive interest rate.

Lastly, a simple absolute limit of CBDC deposits per holder could be introduced to prevent large liquidity outflows from the banking system into the central bank balance sheet.

Anonymity concerns

In addition to threats for financial stability, the introduction of a CBDC could also affect the privacy of sensitive transaction data. Today, payment methods such as Apple Pay, bank transfers, or cash transactions differ in their level of data privacy and anonymity. For example, if a transaction is made via Apple's payment service Apple Pay, the transaction data can be seen and monitored by Apple. If a bank transfer is used, payment details are available to the bank. This does not hold for cash: cash is completely anonymous. With cash, transactions are carried out on a peer-to-peer basis without any intermediary that could potentially access transaction data. Thus, transaction details are only available to the participating transaction partners. Such data privacy and a certain degree of anonymity are also crucial for payments via CBDC.

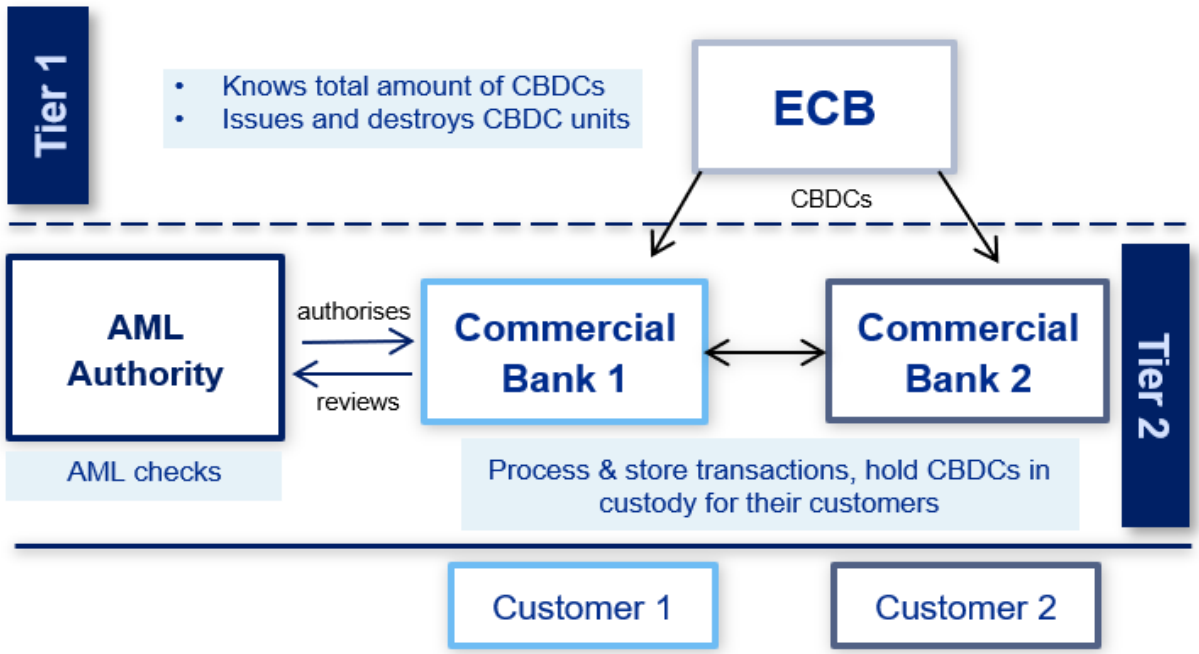
In a paper published in December 2019 (ECB, 2019), the ECB presents and discusses a concrete system for a cash-like retail CBDC in which (partially) anonymous payments are enabled. This system is based on the distributed ledger technology R3 Corda and is shown in Figure 5. The ECB's sole responsibility is to issue CBDC units. A network of banks takes over administrative tasks, e.g., validation of the transactions, conducting anti-money laundering (AML) checks, providing the necessary infrastructure, and storing the cryptographic keys for initiating payments in clients' digital wallets.

Within this two-tiered system, (partially) anonymous payments are guaranteed, which are compliant with AML regulations. A possible solution for AML compliance would be that the identity and transaction history of the sender would not be revealed to the central bank and an AML authority. In the paper, the ECB addresses an essential trade-off between the possibility of anonymous payments and the use of digital money for illegal activities. It is, of course, desirable for the society that illegal activities such as terrorist financing and money laundering are prevented. At the same time, however,

from the citizens' perspective, it is desirable that anonymous payments, at least to a certain extent, would be possible.[5]

Figure 5

Two-tiered CBDC system: Division of labor between the ECB and banks



Source: Andersch, Gross, and Schiller (2020).

Technically, this (partial) anonymity is ensured by not disclosing the identity of the user to the central bank and the AML authority when so-called *anonymity vouchers* are attached to the transaction. These vouchers allow anonymous transfers of funds for a limited CBDC amount over a predefined period of time. Every citizen is equipped with a certain number of anonymity vouchers with which anonymous transactions can be carried out. As soon as all vouchers have been redeemed, the transactions are no longer carried out anonymously. One disadvantage of the model is that the transactions are visible for the processing banks and, therefore, not completely anonymous. In this respect, anonymity is only given between the transaction participants and the central bank and AML authority. This is a clear disadvantage of the prototype and should be considered in future prototypes and publications.[6]

Nevertheless, this paper is a good starting point to further analyze anonymity in retail CBDCs in connection with DLT.

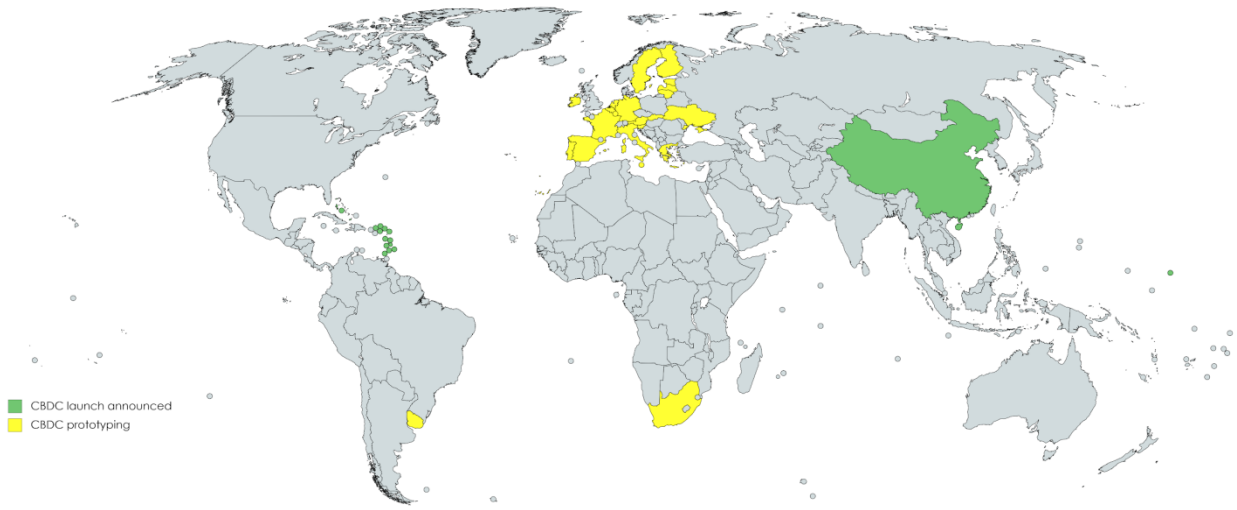
Will there soon be a (central bank-issued) blockchain Euro?

Stablecoin projects have already tokenized Euros and other fiat currencies by using DLT infrastructures. However, these tokens are currently mainly used in crypto markets to "park" liquidity before investing in other crypto assets. The Icelandic startup Monerium and the German startup Cash-on-Ledger are the first startups that use an e-money license to conduct regulated transactions in Icelandic krona, and Euro via the Ethereum blockchain and therefore offer a blockchain-based Euro. Non-DLT-based synthetic CBDCs, i.e., bank deposits or e-money 100% backed by central bank reserves, already exist in China and El Salvador, where e-money licensed companies must hold 100% of the funds in central bank reserves.[7] In addition, in recent years, England and Lithuania, among others, have relaxed their e-money regulations and now also allow e-money-licensed payment service providers to access the central bank balance sheet and thus to back their deposits with central bank reserves.

Current retail CBDC projects are shown in Figure 6. China is likely to be the first developed economy to issue a retail CBDC. In April 2020, a test run of the Chinese CBDC has been started in several cities where government salaries were paid out in CBDC into the wallets of the public official. The Swedish central bank (Riksbank) has been studying the issuance of a digital version of the Swedish Krona (E-Krona) since 2017 to respond to the strong decline in the usage of physical cash in the society. It is currently testing a DLT-based E-Krona prototype (see Riksbank, 2020). In the Caribbean, the Blockchain company Bitt has entered a partnership with the Eastern Caribbean Central Bank. Both parties are jointly investigating the applicability of DLT for an Eastern Caribbean Digital Dollar. A CBDC is intended to increase financial inclusion for the inhabitants of the seven Caribbean member islands by providing an easily accessible digital means of payment. The Sand Dollar of the Bahamas pursues a similar goal and has already been available to Bahamian citizens in a pilot phase since December 2019 (see Central Bank of Bahamas, 2020). The SOV, a crypto asset emitted by the Central Bank of the Marshall Islands, is also expected to be issued in the next few months.

Figure 6

Overview of current retail CBDC projects



Source: Own depiction (Created via mapchart.net).

At the end of 2019, the ECB has intensified its CBDC efforts. Christine Lagarde stressed at her first press conference as ECB President in November 2019 that the ECB will intensify efforts concerning CBDC and announced that an internal CBDC Task Force will be established. Words were promptly followed by deeds: The two ECB publications previously described show that the ECB is now intensively researching a CBDC.

In addition, the ECB has joined a consortium of several central banks including the Bank of England, the Bank of Japan, the Riksbank and the BIS to share experiences from their analyses of potential use cases for CBDCs and to jointly explore the implications of a CBDC introduction (see ECB, 2020b). Thus, it seems possible that a CBDC could become reality in the Euro area in a few years. Whether it will be based on the DLT remains to be seen.

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1 This article builds on and extends our German article Klein, Groß, Sandner (2020), which has published in March 2020 in ifo Schnelldienst.

2 These include Tobin's Deposited Currency Accounts in Tobin (1987) and the Chicago Plan in Fisher (1936).

3 On confidence in central banks, banks and other players in an economy, see OMFIF (2020).

4 The report "Central Bank Digital Currencies" by IBM Blockchain World Wire and OMFIF (2018) provides an overview of the results of the wholesale CBDC projects conducted to date.

5 Crypto assets such as Monero, Dash or Zcash enable anonymous payments and are to be regarded as an exception here.

6 A high degree of anonymity could be implemented, for example, in DLT systems using zero knowledge proofs and ring signatures. For an overview of ways to implement anonymity in DLT systems, see ECB, 2020a.

7 Alipay and Tencent must cover all deposits in central bank reserves (see Adrian, Mancini-Griffoli, 2019).