

Different designs of CBDC, the likelihood of bank disintermediation and the impact on monetary policy; a literary review

Author: Wouter Wilmer
University of Twente
P.O. Box 217, 7500AE Enschede
The Netherlands

ABSTRACT,

Central Banks all over the world have started examining the concept of Central Bank Digital Currencies (CBDC). The specifics on the topic are still highly uncertain, such as the possible designs for CBDC, its impact on commercial banks and bank lending, the effects on monetary policy and the possible use as a monetary tool. This paper examines these topics and provides a literature review of recent scientific literature. Literature from multiple central banks, financial institutions, leading economists, but also student theses are included in this research. By conducting this literature review, it came to light that many different designs are possible when contemplating CBDCs. The impact on banks is strongly dependent on the design that is chosen by the central banks. An attractive digital currency may have big implications for the banking sector. There are also methods found to reduce the impact on commercial banks, considering the important role that banks play in the economy. The impact on monetary policy remains uncertain, though an enrichment of the monetary toolkit is possible with the introduction of CBDC. First, the key concepts of CBDC are discussed. Secondly, an overview of different design options in various literature is provided. Thirdly, the effects on commercial banks and bank lending are examined. After examining the effects on commercial banks, the effect on monetary policy is discussed.

Graduation Committee members:

Dr. Jorg Osterrieder

Dr. Vijay Marisetty

Keywords

CBDC, design options, bank disintermediation, monetary policy, negative interest rates, Financial stability

1. INTRODUCTION

A Central Bank Digital Currency (CBDC) 'is a digital payment instrument, denominated in the national unit of account, that is a direct liability of the central bank' (BIS, 2020). CBDCs have four characteristics. 1) The currency is issued by the central bank and is a liability of the central bank (Ozili, 2022), 2) the currency is emitted digitally, 3) the currency gains acceptance because of its status as legal tender (L Tyree, 2021) and 4) the digital currency could be used as a monetary policy tool (Davoodalhosseini et al., 2020).

Digital currencies can be seen as the successor of cash, since they are both variants of central bank liabilities (Boonstra & Van Goor, 2020b). CBDCs and commercial bank money differ in their liability structure. CBDCs are liabilities of the central bank, while bank accounts represent liabilities of commercial banks. A digital form of public money was already discussed in the 1980s (Guo et al., 2022).

The financial crisis of 2008 revealed the risks of fractional reserve banking (S Musgrave, 2014). The bursting of the housing bubble in 2007 in the United States, followed by the collapse of Lehman Brothers and AIG, triggered a worldwide recession in 2008. The crisis prompted critics to scrutinize the contemporary banking system and sparked discussions around the concept of a full-reserve bank (Etzrodt, 2018). The Netherlands experienced a debate about a full-reserve bank in 2015. That year, a citizen's initiative raised the idea to introduce a private full-reserve bank, but the initiative failed to get a licence that excluded the bank from the deposit guarantee scheme (Van Der Linden, 2020).

The Dutch politician Mahir Alkaya introduced the idea of a public full-reserve bank that would be owned by the government. According to Alkaya, the introduction of a public full-reserve bank would cause the end of an era in which a system has private profits, but public losses. CBDCs have no counterparty risk and may act as a 'safe haven' (Van Oordt, 2022). Though the public full-reserve bank has not been established, CBDCs may fulfil Alkaya's desire for a public safe haven, acting as an alternative for regular bank accounts.

Even though central banks are now investigating and piloting the possibilities of CBDCs, the idea of digital currencies has not always been embraced by central banks. In the annual report of the Dutch central bank in 2017, the bank was not in awe of the new currency; 'The introduction of CBDC would create an asset that competes with government bills and notes, and guaranteed bank deposits' (De Nederlandsche Bank, 2017). The Dutch central bank had concerns about potential bank displacements in the event that a central bank digital currency was embraced by a large number of people and gained widespread popularity. Furthermore, it would erode an essential source of bank funding, making funding more costly and undermining a bank's lending capacity. The national bank reached the conclusion that the arguments opposing the issuance of central bank digital currency outweighed the arguments in favour. As a result, the bank adopted a critical position in the ongoing discussion regarding the potential implementation of a CBDC.

2017 was the year of a major upswing in the crypto market (Arslanian & Fischer, 2019). In 2018, Facebook announced

plans to put forward a particular digital currency issuance with the same design features as stablecoins and with the potential of becoming a widely accepted means of payment, called the 'Libra' (Tercero-Lucas, 2020). Due to its large customer base, the Libra was seen as a competitor for both commercial and central banks (Chaum et al., 2021). This led to speculations that the introduction of the Libra led to the revised stance of central banks and initiated accelerated CBDC efforts (Kim, 2020; Chorzempa, 2021). The big potential of the Libra, along with the increasing prominence of cryptocurrencies, prompted central banks to delve into the realm of CBDC (De Nederlandsche Bank, 2020; Schamowski, 2022).

Central banks all over the world have now started researching and piloting CBDCs (Kosse, 2022). CBDCs have already been adopted by various central banks, such as the central bank of Nigeria (Ozili, 2021). CBDC has also been launched in the Bahamas (Alonso et al., 2021). Many other central banks, including the European Central Bank (ECB), the Federal Reserve (FED) and the Bank of England are still in the research and development phase. The availability of public and private currencies on the market can provide an element of choice to consumers (Coulter, 2023).

The impact of CBDCs on the economy is still a subject of thorough research. Many topics are still uncertain. What are the different design options for the CBDC? How could CBDCs change the role of central and commercial banks? Does CBDC have an impact on monetary policy? This paper will provide a literature review of these topics and will mainly focus on the European context, though research conducted outside of Europe is also relevant. This paper will first provide an overview of the core concepts for CBDCs to explore different design options for the digital currency. Secondly, proposed designs in different papers are examined. Thirdly, the problem of bank disintermediation is discussed. After that, the impact on monetary policy will be addressed. Finally, a personal assessment will be provided, as well as a conclusion.

2. METHODOLOGY

This literary review will research what design options there are for CBDCs and how the design options will affect commercial and central banks. For this research, a great variety of literary sources is included, ranging from position papers of central banks such as the ECB and the FED, to papers from the BIS, papers from economic journals, various reports written by research institutes and books written about economic topics. Since this paper is a literary review, it would not suffice to only focus on the literature of central banks. Much of the literature is found by using Scopus, Google Scholar, Arxiv and SSRN. The key concepts explore the fundamental theories of the subject. Theories of money are included, together with concepts for CBDC designs. After that, the creation of money is addressed, first by commercial banks and finally by central banks.

3. KEY CONCEPTS

This part describes the theoretical fundamentals of the thesis. In order to understand CBDCs, one must also understand what money actually is. This part examines different theories of money, together with how money is created.

3.1 Money

Money is a broad concept and can be defined in many different ways. The IMF defines money as anything that can be used as a unit of account, a store of value and as a medium of exchange (IMF, 2012). In order for something to properly function as money, it needs general acceptance (Orléan, 1992). Many different objects have been used as money, such as cigarettes in Prisoner of War camps, for example (Burdett et al., 2001). In the USA, several states used tobacco as a standard of money (Davies, 1994). In these states, the quality of the money deteriorated, because people smoked the high quality tobacco and used the tobacco of poor quality to pay their bills. The phenomenon that people tend to hoard the money with high intrinsic value and pay with lower value money is known as Gresham's law (Boonstra, 2020). Gold also had a wide presence as a money standard. After the fall of the Bretton Woods system, money is fiduciary and is not backed by gold anymore (Knafo, 2006).

Riksbank (2018) distinguishes three theories of money; metallism, chartalism and functionalism. The gold standard is an example of metallism, since money was backed by gold. There have also been silver or parallel standards (Vanthoor, 2003). Chartalism states that money has value because of its status as legal tender. Money does not need to be issued by the state to have value, the value is derived from its general acceptance. Functionalism states that money must fulfil a certain amount of functions. It needs to act as a means of payment. It must also have a common standard of value. The last condition is that it should maintain value. Functionalism resembles the definition of the IMF and is the current most accepted theory of what money is.

3.2 CBDC

Many different design options are available when contemplating CBDCs. One example is the choice between an account-based CBDC and a token-based CBDC (Bordo & Levin, 2017). The central bank could choose to issue tokens that would circulate electronically among private individuals and firms and that might only rarely be redeposited back at the central bank. In a token-based transaction, the validity of a token is checked (H. M. Kim, 2023). Many cryptocurrencies are examples of tokens, though some research points to the ambiguities of cryptocurrencies (Garret et al., 2020; Milne, 2020). A. Lee (2020) argues that the exchange of tokens between individuals eventually led to the use of accounts to decide ownership and to facilitate transactions. Thus, when money is transferred between accounts of an intermediary, the currency is defined as an account-based digital currency. If an account-based CBDC is the chosen design, the accounts can either be held directly at the central bank, or at intermediaries, such as commercial banks or other financial institutions (Beniak, 2019). Paper bills are examples of tokens, money on a bank account is an example of account-based money.

Another example of a difference in design options is the possibility to be remunerated. The interest rate that the CBDC in such case is bearing can be set at the policy rate of the central bank, but could also be set below the policy rate (George et al., 2021). Central banks could also choose to design a CBDC that bears no interest (Toraman, 2022; Agur et al., 2021). An interest-free design makes the design of CBDC more

reminiscent of cash, since cash is interest-free as well. If the CBDC is remunerated, this could have implications for the banking sector, since central banks may start competing with commercial banks (Schwarz, 2023).

Furthermore, it is important to distinguish between a wholesale CBDC, which is only kept and used by banks and financial institutions, and a retail CBDC, which can be used by a large customer base (A. Opare & Kim, 2020; Auer, 2020). Calle and Eidan (2020) argue that the primary purpose of a wholesale CBDC is to enable banks to settle debts among themselves and could provide faster settlements of payments. A retail CBDC is found to reduce the costs of cash management (Morales-Resendiz et al., 2021). A retail CBDC may also mitigate negative effects of the declining use of cash (Baeriswyl et al., 2021). If a CBDC is introduced, the central bank will remain in control over the money supply, even if cash diminishes in the future.

The use of CBDCs households could be restricted by placing caps on the CBDC accounts. This is likely in a situation where CBDCs could possibly displace current intermediaries or in a situation of a bank run (Wenker, 2022). The displacement and disintermediation of banks will be analysed in section five.

3.3 Banks and debt

Banks play a very important role in the money supply. Whereas central banks create money by printing paper bills and minting coins, commercial banks create money by creating loans (Boonstra, 2020). Money can be divided into several money aggregates, where M0 is the monetary base. M1, M2 and M3 are wider definitions. M1 includes demand deposits, M2 includes 'near monies' that can be made liquid easily. M3 includes repurchase agreements and shares in money market funds. Money created by commercial banks contributes to M1, M2 or M3. The central bank is responsible for M0. Paper bills only contribute 7% of the M3 aggregate (Stellinga et al., 2021). The relationship between the money aggregates, and thus the amount of money that banks create, is known as the multiplier. A great fraction of the money is created by commercial banks. Commercial banks, therefore, play a pivotal role in the money supply.

Bank disintermediation means that the share of bank deposits drops in favour of other holdings. This would happen if bank customers exchange bank deposits for CBDCs en masse. The intermediation capacity of banks will then be affected. This could have implications for the creation of debt and the cost of borrowing. CBDCs may therefore have a big impact on commercial banks.

3.4 Monetary policy

Different central banks have different objectives. Some central banks aim at certain inflation targets, whereas others strive for a stable exchange rate. China's monetary policy was long focused on keeping a stable exchange rate to the dollar (Morrison & Labonte, 2012). The FED has a dual mandate and should not only ensure price stability, but should also aim for maximum employment (Thomson, 2012). The goal of the ECB is maintaining price stability, which used to be defined as an annual inflation of below, but close to 2%. Recently, this objective has been changed and is now at 2% annual inflation (Bottone et al., 2022).

To reach this objective, a variety of monetary tools is available to the ECB. The primary tool is the set of interest rates (European Central Bank, 2021b). The rate on the main refinancing operations is the rate that banks pay on short-term funds borrowed from the central bank. The rate on the deposit facility is the rate that the central bank pays to commercial banks for short-term deposits. This rate is lower than the rate on main refinancing operations. Finally, there is the rate of the marginal lending facility, which offers overnight credit to banks. This rate is higher than the rate on main refinancing operations. As of June 21, the deposit rate is at 3,50%, the refinancing rate is at 4% and the marginal lending rate is at 4,25% (European Central Bank, 2023e).

The ECB also has other tools, such as open market operations, which is a tool to provide liquidity support to the financial sector in times of distress (Da Silva, 2022). Reserve requirements also function as a monetary tool. Stricter reserve requirements act as a tool to tighten monetary policy (Federico et al., 2014). This is because it obliges banks to maintain higher reserves. Banks decrease lending in such cases.

From 2014 onwards, the ECB engaged in more unconventional methods. This included Quantitative Easing (QE). In these operations, government and corporate bonds were bought through commercial banks, enlarging the reserves of commercial banks (Boonstra, 2020). Fratzscher et al. (2016) found that QE not only lowered bond spreads, it also boosted equity prices. The expansionary policies of the central bank have also led to increasing prices of properties, commodities and stocks (Huston and Spencer, 2016; Jawadi et al., 2017).

QE aimed at ensuring stable inflation in times when fears for deflation surged (Böhl et al., 2020). QE played a role in stabilizing the markets just as yield spreads within the Eurozone began to rise (Afonso & Jalles, 2019). Original economists of the Austrian School of Economics have pointed to the excessive rise in the relative price of capital goods if the interest rate was set below the neutral rate. Modern views on the topic have linked asset-price inflation to the concept of malinvestments (Brown & Pollock, 2015).

Negative interest rates would also be considered an unconventional tool. However, central banks now have difficulties with setting interest rates far below zero. This is because people will then benefit from exchanging deposits into cash, which bears no interest. This is known as the Effective Lower Bound (ELB) (De Fiore & Tristani, 2018).

4. DIFFERENT DESIGN OPTIONS IN THE LITERATURE

Different research papers assume different CBDC designs. Already in 2018, the BoE wrote a staff working paper in which a possible CBDC had four core principles (Kumhof & Noone, 2018). In their paper, the CBDC would pay an interest rate that could be adjusted, which was the first of four principles. The second principle contained a separation between CBDC and a bank's reserves, to eliminate the risk of a 'run by the back door', which could occur if customers collectively transferred their deposits into CBDC. Complementary to the second principle, the third principle ruled out the obligation of commercial banks to convert deposits into CBDC, since this would have implications for financial stability. The fourth

principle is that the central bank only issues CBDCs if they are exchanged for assets, such as government bonds. This is to reduce the risk of bank disintermediation.

Bindseil (2020) examines a retail CBDC and explores two technical options. The first design is an account-based CBDC. Though the accounts could be held directly at the central bank, third parties would ensure increased efficiency. A project of the Bank of England also found that a public-private partnership would facilitate retail payments (Bank of England, 2023). The project put forth a two-tier model where the central bank would be responsible for issuing the currency and providing the ledger infrastructure. Subsequently, private entities facilitate payments and offer user services like digital wallets.

Alternatively, the second option that the research of Bindseil examines entails a token-based CBDC that provides a lot of privacy. In such a case, the CBDC would likely circulate through a decentralised ledger (Bhawana & Kumar, 2021). In this case, there is no central ledger, which gives the possibility of anonymous payments. The research of Bindseil refers to the research of Berentsen and Schär (2018) to point out that the latter design increases the opacity of the payments and that a token-based CBDC makes money laundering easier.

In an opposing view, Amelius (2021) states that the account versus token-based distinction is not relevant when designing a CBDC that resembles cash. For token-based CBDCs, as well as for account-based CBDCs, a remote ledger is required for transactions. This is also the case for token-based CBDCs because tokens are typically stored in a remote location and because a double spending problem may arise if no remote ledger exists. The research, therefore, does not see a major difference in terms of peer-to-peer functionalities, offline transactions and anonymity.

This has again been opposed by Chaum et al. (2021), who state that the choice between tokens or accounts is relevant, since a cash-like CBDC with a high degree of privacy is only possible if the digital currency is introduced in the form of a token. Accounts are held at an intermediary and carry information about all transactions involving the account. Tokens, on the other hand, carry information on the value and the issuer of the token. Full anonymity is only possible in the form of a token.

Bindseil (2020) also points out that CBDC holdings may have a tiered remuneration, which is the case when interest paid on the deposit is nonlinear and when different tiers of a deposit bear different interest rates. Suppose that, for example, a customer has a CBDC account of €50.000. CBDCs can be designed in such a way that the first €30.000 does not pay interest, whereas the remaining €20.000 bears a negative rate to disincentivise larger holdings. Instead of the deposit amounts, transactions can also be tiered for privacy concerns. Transactions could be divided into low-tiered and high-tiered transactions, according to which a certain amount of privacy is granted (The White House, 2022).

In the pilot report of the Swedish central bank, the Riksbank (2021) explored the option of a token-based e-krona. The distribution model of the pilot is similar to the distribution of cash in terms of roles and responsibilities. In their model, the Swedish central bank points out that the central bank is the only issuer of the e-krona. The central bank maintains a relationship

with parties that distribute the kronor to their customers. The distributing parties, also called participants, run their own nodes in the model and verify the transactions. Participants check whether the token of the transaction has been issued by the central bank and has not been used in previous transactions. After the transaction, the participant creates two new tokens; one token with the remaining value of the payer's account and one token that represents the value of the payee's account after the payment.

In the second pilot phase, the Riksbank also explores the option of a central database by introducing the possibility of an alias to make CBDCs more user-friendly (Riksbank, 2022). In Sweden, the app Swish already allows users to address bank accounts by using telephone numbers, which is easier than addressing accounts by the underlying account number. A CBDC account could also be linked to names or QR codes. An alias would make the use of CBDC easier, but also comes with a centralised database. This also begs the question which party is then responsible for managing the data. The Riksbank, therefore, also explores a decentralised way of using aliases, but stresses the complexity of such a structure.

In their report of 2022, The Riksbank also differentiates between two methods of storing tokens for its e-krona: either on the e-krona network or on a local device like a mobile phone. Based on the pilot, storing tokens on the local device would offer users a CBDC experience that closely resembles cash and enables the possibility of offline payments. However, the possibility of successful forgery is higher if devices are developed that allow for offline payments (Chaum et al., 2021). If tokens are stored on the network, Riksbank (2022) points out that more functionalities are available and that a lost or broken device does not mean that the users have lost the money.

The Riksbank has a positive stance towards programmability if transactions can be made programmable, for example in the case of Delivery versus Payment (Riksbank, 2023). The Riksbank uses an example in which a customer buys a car from a car dealer. The parties that participate in the transaction may prefer an option to automatically fulfil the transaction if both parties have fulfilled their duty. The technology used in this transaction is seen as a lock on the amount of e-krona that the customer owes the car dealer. If the car has been delivered, the money will automatically be wired into the account of the car dealer. However, the programmability of CBDC should not limit or control the e-krona's areas of use, according to the Riksbank.

The Federal Reserve long held a sceptical stance towards CBDC, which changed after the possible introduction of Libra (Chorzempa, 2021b). The American central bank has not made a decision about a possible introduction of a digital dollar, but has researched the topic for the past period. The FED, excludes the possibility of direct accounts at the Federal Reserve for individuals (Federal Reserve, 2022). It also deems the verification of the holder of CBDC necessary, which points to an account-based CBDC with a lower degree of privacy than cash transactions. A design with characteristics of a peer-to-peer functionality, together with an intermediary that provides the account has also been pointed out (The White House, 2022). Considering that there are still millions of Americans that do

not have access to financial services, a CBDC could boost financial inclusion (Jackson et al., 2022).

The digital currency of the Bahamas was introduced with the main purpose of boosting financial inclusion (Wright et al., 2022). A retail CBDC is therefore introduced, together with an education program to improve financial and digital literacy (A Roll, 2023). The use of CBDC is also incentivised by reaching out free digital currencies for early adopters (Central Bank of the Bahamas, 2023). Usage rates are still low, but several updates are expected for the upcoming period to improve the convenience of the digital currency. The adoption levels of the Nigerian digital currency have also been reported to be low (J. Ree, 2023). Ozili (2022) stated that a remunerated CBDC would increase adoption, together with better customer experience.

Meanwhile, the Chinese central bank already started the project on the digital Renminbi in 2014. The Peoples Bank Of China (PBOC) now explores a retail CBDC that is partly account-based and partly value-based. Furthermore, the digital currency is capable of domestic and cross-border payments (People's Bank Of China, 2021). Since payment services are not yet fully developed in many Chinese regions, the purpose of the e-CNY is to boost financial inclusion in underdeveloped regions (Soderberg et al., 2022). In the pilot of the e-CNY, offline transactions were possible by using Near-Field technology. Online peer-to-peer payments could also be done by using QR codes. These technologies offer advantages in terms of convenience. Payments can be fulfilled much easier with these innovative technologies.

After the Russian invasion of Ukraine, Russian forex accounts have been frozen (Nölke, 2022). This led several countries to shift away from the dollar and seek for alternatives (Thiagarajan et al., 2023). If cross-border payments can be conducted conveniently with the e-yuan, the internationalised renminbi would allow for international transactions that can be settled independently of the dollar (Caudevilla & M. Kim, 2023).

The e-CNY is intended to substitute cash and will therefore not bear interest. The digital coin could provide anonymity for small transactions up to a threshold according to a tiered authorisation system (Cheng, 2022). For a level four account, which is the basic wallet that only allows a small amount of e-CNY, only a telephone number is required (International Monetary Fund, 2021). Telephone companies cannot provide information about users to the PBOC. If more e-CNYs are held, the wallet will enter a higher level, with more extensive authorisation methods. In level three, users need to authenticate with a Chinese residency card. Level 2 requires the account to be bound to a regular bank account. Level 1 requires a bank certificate, which makes it a wholesale wallet. With this wallet design, small transactions can be fulfilled with a degree of privacy, but as the volume goes up, the amount of privacy goes down.

Offline transactions and privacy related to CBDC have been thoroughly examined by the Bank for International Settlements. 49% of the central banks consider the possibility of offline payments vital (BIS, 2023). According to the BIS, there is no one-size-fits-all solution, but various options exist

for different central banks. Offline payments can be facilitated through the utilization of tamper-resistant hardware, software, or a combination of both. This hybrid approach ensures robust security measures. Offline capabilities can vary, ranging from complete offline functionality to staged offline processes, providing flexible options for conducting transactions. In fully offline payments, the payer and payee can remain fully offline without connecting to a ledger. In staged offline transactions, the transaction is only settled when the payee is online. This is similar to the design of Riksbank (2021). There is also an intermittent variant, in which offline transactions are possible, but where participants are required to synchronize with a central system every period before being able to transact offline again.

5. EFFECTS CBDC ON COMMERCIAL BANKS

If a central bank starts offering bank accounts to customers, central banks could start competing with commercial banks (Chaum et al., 2021; Schwarz, 2023). The introduction of CBDC could in such cases lead to the disintermediation of banks. Lending out money is one of the core functions of a bank and could be reduced if banks experience difficulties finding cheap funding (Wenker, 2022b). This could lead to shrinking balance sheets and higher funding costs for banks.

Burlon et al. (2022) point out that only the news of the digital euro led to lower returns on bank stocks. The returns on bank stocks remained relatively stable until 2 October 2020. After the ECB released the news that it was going to intensify its work on a digital euro, returns on bank stocks were running a negative marginal return. The markets seemed relieved after Panetta announced the probability of caps on the amount of CBDC that customers could hold (European Central Bank, 2021).

The occurrence of bank disintermediation is largely dependent on whether users will exchange CBDCs for cash or for commercial bank money. If cash is substituted by CBDCs, the substitution process does not involve commercial banks. Only households and central banks will replace cash with CBDC on their balance sheets. However, large holdings of CBDC at the expense of bank deposits could endanger the relatively cheap funding of banks, possibly changing the role banks play in the economy. It is therefore informative to look at the literature about bank disintermediation and CBDC.

5.1 Bank disintermediation

Adalid et al. (2022) state that the intermediation capacity of banks will not be affected if bank markets are perfectly competitive. They also state that the effects of a possible digital euro on European banks would probably be manageable. The research of Adalid et al. has determined four channels through which the balance sheets of various stakeholders can be affected by a digital euro. If CBDCs come in the place of paper bills, bank balance sheets are not affected and bills on balance sheets of stakeholders will simply be replaced by CBDCs. Banks would merely be distributors of the digital euro and CBDCs do not appear on the bank's balance sheet. A decrease in bills on the balance sheets of households or central banks will be offset by an increase in CBDC (channel I). Customers may also wish to

replace deposits by CBDC. In this scenario, both bank deposits and reserves will decrease. This is the typical bank disintermediation scenario where bank balance sheets shrink (channel II). Such a displacement might raise the funding costs of banks, which could raise the costs of lending (Group of central banks, 2021). Adalid et al. depict the effect of CBDC on commercial banks in several scenarios through a stylised balance sheet approach. This thesis uses the figures of the research of Adalid et al. in figure 1, 2, 3 and 4. The typical bank disintermediation scenario is depicted in figure 1.

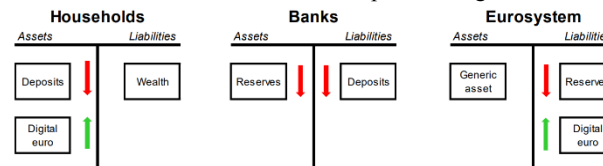


Figure 1. Typical case of bank disintermediation

Banks can avoid shrinking balance sheets by increasing borrowing from the central bank (channel III). This causes households to change deposits into CBDC and causes commercial banks to replace the outflow of deposits by increased lending from the Eurosystem. The balance sheets of central banks increase in this scenario, which is depicted in Figure 2.

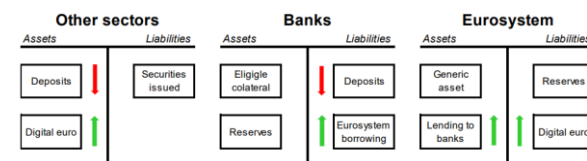


Figure 2. Banks increase wholesale funding

A fourth channel is twofold and is focused on the assets that can be sold to make up for the loss of deposits. Bonds and loans are on the asset side of the commercial bank balance sheet. Banks can use securitisation to convert illiquid loans into liquid securities (Loutskina, 2011). Banks can sell these assets to obtain reserves. The balance sheet will then still shrink if customers demand CBDC, as depicted in Figure 3.

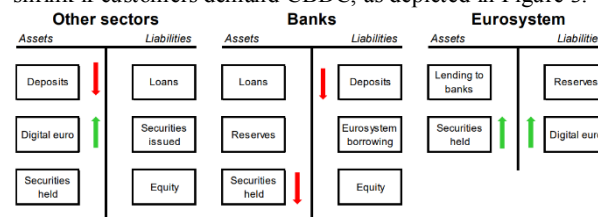


Figure 3. Banks sell assets to Eurosystem

Shrinking bank balance sheets, and therefore bank disintermediation, can be avoided if CBDCs can only be obtained by substituting assets for CBDCs and if these assets are sold to the Eurosystem on behalf of other parties. In this scenario, the private sector would sell the assets through the commercial banks to the central bank, thereby obtaining the digital currency. If this is the only channel through which CBDCs are put into circulation, this does not affect the volume of bank deposits and could avoid the disintermediation of banks. The balance sheet of the central bank expands, since the central bank buys the securities of the

private sector. This scenario is depicted in Figure 4.

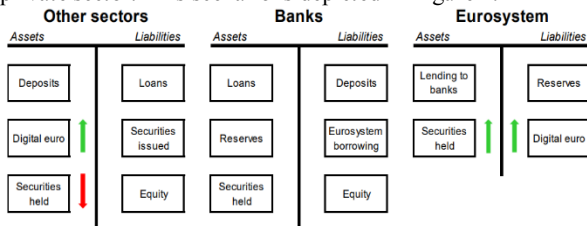


Figure 4. The private sector sells assets to Eurosystem

In their literary review, Infante et al. (2022) distinguish four aspects that determine the impact on commercial banks. Two of these aspects were discussed in the key concepts of this paper; remuneration and CBDC holding caps. The third aspect included is the availability of wholesale funding to replace withdrawn money from deposits. This is similar to the third channel of Adalid et al. (2022). The last factor is the competitiveness of the banking sector, which is how the degree of market power that banks have. They point out that the competitiveness of the banking sector is highly relevant by referring to research that reaches opposing conclusions.

On the one hand, the research of Infante et al. refers Andolfatto (2021), who explores a case in which the bank is a monopoly player. In such case, the research finds that the introduction of an interest-bearing CBDC increases the supply of deposits. The CBDC rate acts more as a floor on the deposit rates offered by the bank. The monopoly bank is being competed by CBDC and is forced to offer more favourable terms to customers and will increase lending as well. On the other hand, Infante et al. refer to the research of Keister and Sanchez (2022), who come to the conclusion that bank disintermediation is inevitable if the CBDCs are introduced that are like bank deposits in a perfectly competitive banking sector. In such case, CBDCs will start substituting bank deposits. The research of Keister and Sanchez also points out that disintermediation is less likely if a cash-like CBDC is introduced. However, other research suggests that disintermediation will still arise if an unremunerated CBDC is introduced, given its similarity to deposits that are not interest-bearing (Lukonga, 2022).

The hypothesis that bank lending is reduced after the introduction of CBDC is opposed by (Brunnermeier & Niepelt, 2019), who state that the outflow of deposits will simply be offset by an increase in wholesale funding by central banks. The European central bank has already been very active as a provider of liquidity (Boonstra & Van Goor, 2020b). The outflow of deposits would only make the implicit role of the central bank as a lender of last resort more explicit. The research, therefore, calls it 'unclear' whether CBDCs actually lead to reduced lending. Ferrando et al. (2021) also state that central banks wield market expectations and that these expectations play a big role in the amount of bank lending. Hence, a possible decline in bank lending might not be the result of an introduction of CBDCs, but may be the result of the expectations that come along with it, as well as the expectation of the future monetary policy of the central bank.

Chiu et al., (2019) also point out that the introduction of a remunerated CBDC can foster competition if the market is not perfectly competitive. If many customers wish to deposit money in a bank account, rates tend to go down. However, if a

CBDC with a competitive interest rate is introduced, banks are forced to react and increase deposit rates.

Gong et al. (2023) argue that disintermediation is unlikely, because they assume that CBDC is an inferior substitute to bank deposits, because CBDCs can only be used in a fraction of the transactions and because commercial banks are far more experienced in offering payment services compared to central banks. The strong performance of payment services by banks has also been highlighted by Boonstra (2022). Large-scale bank disintermediation also seems unlikely if usage caps are established on the CBDC. These caps can either be flow-based or stock-based (BIS, 2021). Although Minchin (2021) found holding ceilings to be the most effective policy to avoid disintermediation, Assenmacher et al. (2021) found total welfare to be reduced if these caps exist, because CBDC ensures a more efficient allocation of resources. Tiered remuneration can also be used to discourage large CBDC holdings, by reducing the interest rate on CBDC above a certain threshold (Bindseil, 2020).

The research of Gong et al. does not take into account, however, that a CBDC can be maintained and operated by commercial banks (Bindseil, 2020; Riksbank, 2021). If commercial banks manage CBDC payments, the convenience value of CBDC might be closer to the convenience value of bank deposits (Henry Stewart Publications, 2019). CBDCs can be used to facilitate cross-border payments. CBDCs and the interlinking of domestic payment systems are found to be the highest potential of facilitating easy cross-border payments (Bindseil & Pantelopoulos, 2022). The convenience value of CBDC would rise sharply if cross-border payments can be conducted more easily by using CBDC than via commercial banks. As mentioned in section three, China advocates a design with easy cross-border payments. The Eurosystem also supports cross-currency transactions for their digital currency (European Central Bank, 2023c).

A drawback of CBDCs is that they will be subject to usage limits (European Central Bank, 2021), whereas traditional bank deposits do not have such restrictions. However, banks are susceptible to bankruptcy, highlighting their inherent fragility. This vulnerability has prompted over 70% of countries to establish deposit insurance schemes that safeguard deposits up to a specific threshold (R Barth et al., 2019). In contrast, central banks cannot go bankrupt, making CBDCs an appealing and secure refuge for individuals seeking financial stability. However, the usage cap of the digital currency is not likely to exceed the threshold of the deposit scheme, which makes the extra convenience on this aspect negligible. The amount of disintermediation, therefore, is dependent on how attractive CBDCs will be in terms of convenience, security, and remuneration. There are also still many countries where there is a high preference for cash over digital currency (Ozili, 2022). Large-scale bank disintermediation in those countries seems unlikely in the short term, even if a very attractive CBDC is available, since CBDCs will compete with paper bills instead of bank deposits.

Whited et al. (2023) conclude that a CBDC that is emitted through commercial banks can obtain a large market share, especially when the currency pays interest. According to the research, a CBDC need not affect bank lending, since the loss

of deposits is replaced by wholesale funding. This does, however, have implications for the stable funding of banks. Wholesale funding is more sensitive to short-term interest rate changes. Choi and Choi (2021) found that most larger banks rely on wholesale funding. These banks increase wholesale funding often during a recession. After the introduction of CBDC, customers exchanging deposits for CBDC may bring about changes in wholesale funding.

Positive effects of bank disintermediation are also concluded by the research of Eren et al. (2022), who call this phenomenon 'efficient disintermediation'. Their model shows that a well-designed CBDC can improve the long-run efficiency of allocations. Lending is also increased, even though the balance sheets of the banks have shrunk. The introduction of CBDC in China also led to a conclusion that it could lead to extra economic growth of 0,15%, while the impact on bank disintermediation is considered limited (Tong & JiaYou, 2021).

5.2 Market stress

The availability of CBDCs could potentially increase the risk of bank runs during periods of financial distress (Infante et al., 2022). This is because CBDCs offer a liquid and secure alternative that individuals may prefer if they perceive traditional banks to be unsafe or unreliable. The spring of 2023 saw several banks in trouble, because of large unrealized losses after the interest rate had gone up to fight the inflation (Van Vo & Le, 2023). If risks for bankruptcy increase, the possibility of customers quickly switching deposits into CBDC could accelerate a bank run. If demand is unconstrained, a digital euro could potentially lead to an increase in the scale and speed of a system-wide bank run if markets are stressed.

Williamson (2021) argues that CBDCs offer greater convenience than cash. A CBDC could also be remunerated, which makes the digital currency even more attractive. People will therefore exchange their holdings faster if panic in the banking sector arises. Even though CBDCs could encourage a bank run, total welfare may be increased, given the increased convenience of CBDCs over cash. The research also points out that a bank run is less likely if deposit insurance exists. Customers are less likely to exchange their holdings if they know that their holdings are covered.

As mentioned before, the effect on banks can be limited if caps exist. The ECB mainly discusses two variants of these caps (Adalid et al., 2022). A hard limit would entail a holding limit. A soft limit would mean an interest rate that discourages holdings that exceed a certain threshold. The latter is based on the tiered remuneration of Bindseil (2020). The research shows that the effectiveness of such a limit depends on the calibration of the limit. A tiered remuneration with a deep negative interest rate is found to be effective in preventing large withdrawals. Central banks could also limit the convertibility of the currency. This is similar to one of the principles that the Bank of England set in 2018, as discussed in section 4. The presence of a CBDC

does not affect the severity of bank runs if the limits are well-designed.

6. CBDC AND THE EFFECT ON MONETARY POLICY

6.1 Conventional monetary policy

Foreseeing the impact that CBDCs have on monetary policy is no easy task. Niepelt (2020) states that understanding theory is not enough to advise policymakers in introducing a well-designed CBDC, but the research urges policymakers to develop a comprehensive model. Chen and Siklos (2022) also stress that there is still much uncertainty on the topic of CBDC and its impact on monetary policy. Hence, the impact will remain uncertain until strong empirical data is present.

In developing countries, CBDCs can strengthen the position of central banks. The introduction of CBDC in Nigeria allows the Nigerian central bank to increase control of the money supply, considering that a large part of the bills in circulation are now being counterfeited (Central Bank of Nigeria, 2020). CBDC also improves the availability of data for the central bank (J. Ree, 2023b). The increased control over the money supply, together with the increased availability of data, allows the central bank to conduct a more effective monetary policy. However, central banks of developed countries have lower amounts of counterfeit money in circulation and have better data available to conduct policy. That is why a CBDC may have a higher impact on developing countries. even though price stability is also found to be supported in Western countries if a remunerated digital currency is introduced (Bordo & Levin, 2017b).

One of the important channels through which the introduction of CBDC could impact monetary policy is that it could possibly increase the velocity of money (Lukonga, 2022). That is because cash transactions require physical presence of both parties, which slows down the transaction process and causes higher transaction costs. Since CBDCs are digital, transactions can be completed and fulfilled remotely and can bring about a structural increase in money velocity. A disruption in the relationship between the amount of money and inflation levels has been found if the velocity of money changes rapidly (E. Castañeda & Luis Cendejas, 2023). An increase in the velocity of money is merely the case for the transactions where CBDCs are used instead of cash, since the performance of payment systems is already considered high (European Central Bank, 2022a; Boonstra, 2022; MOB, 2018). Hence, the velocity of money is not expected to increase if CBDCs are used instead of bank accounts.

The research of Lukonga also examines how the use of cash changed after previous periods of digitalisation and finds that the digitalisation of payments brought about a structural shift and instability in money velocity, although the effects were eased because of macroeconomic factors. According to the research, M1 was more volatile after payments digitalised in several countries. M2's volatility was more moderate, because the aggregate M2 is also influenced by other factors, such as income, economic policy, demand for money, price levels, inflation and interest rates.

Chen and Siklos (2022) argue that the Taylor rule may need to be abandoned and their research revives McCallum's monetary

policy rule that merely focuses on money growth. A central bank's capability of monitoring the money aggregates increases if the use of CBDC is increasing. The research of Chen and Siklos, thus, revives McCallum's rule and states that central banks can better focus on the money supply growth instead of focusing on interest rates. Huber (2023a) also finds that money quantity policy options become available after the introduction of CBDC. Other recent literature also employs McCallum's rule and states that the introduction of CBDC does not cause higher inflation (Rehman et al., 2023).

There is also research available that suggests that central banks could steer the velocity of money once CBDCs are introduced (Copic & Franke, 2020). Given that many CBDC designs allow all transaction data to be recorded, it becomes feasible to determine the precise timing of CBDC transfers made by users. Central banks could in such case encourage faster or slower transfer activity. On the other hand, the interest rate tool of the central bank could gain effectiveness if cash diminishes, possibly allowing for negative interest rates. This will be discussed in the next section.

6.2 Unconventional monetary policy

The introduction of CBDC also paves the way for new forms of unconventional monetary policy. Recent years have seen widespread stimulating policies, such as Quantitative Easing (QE). In these operations, government bonds were bought through commercial banks, enlarging reserves of commercial banks. CBDCs may fulfil a role in the unconventional policies that the ECB might engage in during a next crisis.

Pfister (2019) shows that the introduction of a CBDC that bears no interest could raise the Effective Lower Bound (ELB) to zero. Slightly negative interest rates are now possible because of the costs related to cash. CBDCs incur lower costs as they do not necessitate physical storage. Negative returns on government bonds might also disappear after the introduction of an unremunerated CBDC. A CBDC may, therefore, diminish the effect of asset purchases by the central bank.

Eren et al. (2022), on the other hand, show that if central banks engage in a next stimulating program, this program can be conducted equally effectively with CBDC as in previous programs. The research also shows that central banks can reduce costs by funding asset purchases by CBDC instead of by reserves. Jiemeng and Zhou (2022) argue that central banks can perform open market operations, and thus QE, even more effectively, because better availability of data to perform open market operations.

The introduction of a Central Bank Digital Currency also allows the central bank to pay the general public directly in CBDC without involving a commercial bank (Infante et al., 2022c). CBDCs could also be used to implement a 'people's QE', a scenario in which the central bank directly finances either government or household investments (Coppola, 2019b). The idea of people's QE is different than implementing conventional QE by replacing banks for households. This is because conventional QE was merely an asset swap (Gieck, 2014; Boonstra & Van Goor, 2020b), whereas people's QE, or helicopter money, distributes money without any strings attached (Masciandaro, 2020). Central banks had to rely on commercial banks to increase the money supply, the

introduction of CBDC could enable central banks to do so without any third parties. The idea of helicopter money could then be put into practice (Jiemeng & Zhou, 2022).

6.3 Negative interest rates

A negative interest rate policy could help central banks deliver additional monetary stimulus in a challenging macroeconomic environment (Arteta et al., 2018). This is because it discourages saving and encourages investments. Central banks reduced interest rates after the Global Financial Crisis in 2008, which put the interest rate of the ECB to zero. However, the existence of physical currency limits the possibility of deep negative interest rates (Fischer, 2016). The possible outflow of deposits places a floor on interest rates (Gerlach & Lewis, 2014). In June 2014, the ECB was the first prominent central bank to cut the deposit facility below zero. Since then, the ECB has continued to lower the deposit facility rate, reaching a negative 40 basis points in March 2017. This incentivised banks to bring down excess reserves and increase lending (Bräuning & Wu, 2017). The refinancing rate has not reached negative levels. If CBDCs replace cash, central banks could, in theory, break the ELB on the refinancing rate (Yang J, Zhou G, 2022).

In order to break the ELB, a cash alternative should not exist to prevent customers from exchanging their holdings for cash. The use of cash has declined drastically in many Northern-European countries (Norges Bank, 2022; Riksbank, 2020). In the Netherlands, for example, only 20% of the transactions were paid with cash in 2022 (De Nederlandsche Bank, 2023). However, on a European scale, cash is still used in 59% of the transactions, although the percentage came from 72% in 2019 (European Central Bank, 2022c). In Italy, cash is also extensively used for low-value transactions among people that prefer cashless instruments even when alternative payment methods are accepted (D'Italia, 2022). Also in other European countries, such as Germany, large groups of customers still use cash in various transactions (Deutsche Bundesbank, 2022). Cash is, therefore, still a popular means of payment.

Cash has some advantages over digital money. Not only does it provide privacy, it also serves as a backup for when bank systems are down (Krueger & Seitz, 2018). This may explain why cash is often hoarded by households (Deutsche Bundesbank, 2020). Cash also has the advantage of being available to everyone, whereas commercial bank money is only available to the people with a bank account. Due to the advantages that cash offers, central banks in Europe stress the importance of the future availability of cash (Banque de France, 2022; Zamora-Pérez, 2022). There are several downsides to cash. It lacks transparency, it is less efficient and the infrastructure is expensive to maintain. Cash still plays a large role in criminal activities because of its opacity (Riccardi & Levi, 2018). However, a possible aim of reducing cash is not found to be supported by big groups of customers (Harasim, 2016). Ozili (2021) also found a strong preference for cash over digital currency. This preference, together with the usage caps on CBDC, makes it unlikely that cash is soon replaced by CBDC. The presence of cash creates difficulties for central banks that wish to break through the ELB. A negative interest rate policy, therefore, seems unlikely in the near future, even if CBDCs are introduced.

7. DISCUSSION

In this research, it has come to light that there are a lot of different designs for CBDCs that can be considered. One of the options entails the choice between an account-based or token-based digital currency. It must be noted that even though a strict distinction is often drawn between a token-based and an account-based CBDC, a token-based CBDC could also be designed in a way that it resembles an account-based CBDC and acts as regular account, as stated by Armelius (2021). The Swedish central bank also investigated a token-based CBDC that also had an alias to increase convenience (Riksbank, 2022). A token-based CBDC could also differ significantly from an account-based CBDC, since a full-anonymous currency would be a token-based CBDC, as stated by Chaum et al. (2021). Further research should focus on the design of tokens and the difference between an account and a token.

The design of the digital currency is largely dependent on the objective that is set by the central bank. If the currency is introduced because the use of cash is decreasing, the design may be fundamentally different than when the central bank's objective is to enrich the monetary toolkit. A cash-like CBDC might, for example, be focused on privacy and offline transactions, as examined by BIS (2023). A CBDC that should function as a monetary tool is more likely to be account-based and may have tiered remuneration, as examined by Bindseil (2020). The objective of the PBOC is to enhance financial inclusion, but the digital currency resembles cash (Soderberg et al., 2022). This shows that the design of CBDC is largely dependent on the objective of the digital currency. Further research can be conducted on how to reach the different objectives with different designs for CBDC.

The effect on banks, in turn, is dependent on the design of the currency. Factors that determine the attractiveness of the digital currency are remuneration, convenience, usage caps and anonymity. If an attractive CBDC is introduced, the digital currency could start competing with bank deposits. This has been depicted in Figure 1 by Adalid et al., (2022). This could have severe implications for bank lending, as examined by (Wenker, 2022b). However, contradicting conclusions exist, for example by (Brunnermeier & Niepelt, 2019), who state that banks will simply seek for other sources of funding. Whited et al. (2023) state that CBDCs may obtain a large market share and that banks will replace the loss of deposits with wholesale funding. This comes at a risk, since banks will be exposed to larger interest rate fluctuations.

One could wonder whether banks will really be rivalled by CBDCs. A large outflow of deposits would only happen if bank deposits are inferior. However, Gong et al. (2023) found CBDCs to be inferior to bank deposits. This is because the bank payments systems perform very well and because CBDCs will likely be constrained to usage caps (European Central Bank, 2021). The ECB will publish a proposed design later this year. Further research can be conducted on the impact that the proposed design will have on commercial banks in the EU.

The introduction of CBDC will pave the way for an enrichment of the monetary toolkit, if properly designed. The idea of helicopter money will be more feasible with a CBDC (Coppola, 2019b). Central banks will also have increased availability of data to make decisions on the interest rate. In theory, negative

interest rates could be possible, but the presence of physical currency makes such a policy unlikely. Negative interest rates are only a realistic option when cash has been replaced by CBDC (Yang J, Zhou G, 2022). The importance of cash has been stressed by multiple central banks. A disappearance of cash, therefore, seems unlikely in the short term, especially if there is still demand for cash. Though some research points towards the possibility for central banks to abandon the Taylor-rule and continue with alternatives, this has not been examined thoroughly. Further research could examine the alternative policies that CBDCs make possible.

Central banks should carefully look at the design of the digital currency and evaluate the preferences of customers. Customer preferences could range from a token with a high degree of privacy and the ability to conduct peer-to-peer and offline payments, to an account with a wide range of innovations, such as conditional payments. A successful CBDC implementation seems unlikely if customer preferences are not taken into account.

8. CONCLUSION

This paper provided a literature review on CBDC design options and its impact on commercial and central banks. Though many different design options are possible, many of these differences come from the core concepts discussed in this paper; remuneration, tokens versus accounts, wholesale versus retail and the presence of restrictive caps. The design found in the literature mostly ranges from a token-based CBDC that is more similar to cash to an account-based CBDC that is remunerated, which makes the CBDC account reminiscent of a regular bank account.

The effects on commercial banks are largely dependent on how attractive a CBDC is for customers, the structure of the bank market and the availability of wholesale funding. If a CBDC is attractive and starts replacing deposits, CBDCs could cause higher funding costs for banks and affect bank lending. However, literature also shows that disintermediation is likely to be manageable by increasing wholesale funding. The probable existence of usage caps also limits the likelihood of disintermediation. Banks could also choose to discontinue the convertibility of the currency.

CBDCs possibly enrich the monetary toolkit of central banks. The idea of 'helicopter money' might be implemented more easily if customers have CBDCs. In theory, central banks could also break through the Zero Lower Bound, although this is not likely when cash is still an option. Literature does not point towards a phasing out of cash, since central banks and national parliaments stress the importance of the availability of cash.

9. ACKNOWLEDGEMENT

I would like to thank my supervisor, Jörg Osterrieder, for his help on this project. His profound knowledge of Central Bank Digital Currencies and literary research really helped me to write this thesis. I would also like to thank the second supervisor, Vijay Marisetty, for his assessment. Furthermore, I would like to thank my fellow students who chose the circle of Central Bank Digital Currencies. Though their research topic was different from mine, it really helped to discuss the progress of the thesis.

10. REFERENCES

1. Opare, E., & Kim, K. (2020). Design Practices for Wholesale Central Bank Digital Currencies from the World. *Symposium on Cryptography and Information Security*.
2. A Roll, J. (2023). *On Financial Literacy: Remarks by Governor John A Rolle- Central Bank of the Bahamas*.
<https://www.centralbankbahamas.com/news/press-releases/on-financial-literacy-remarks-by-governor-john-a-rolle?N=N>
3. Adalid, R., Álvarez-Blázquez, Á., Assenmacher, K., Burlon, L., Dimou, M., López-Quiles, C., Fuentes, N. M., Meller, B., Muñoz, M., Radulova, P., D'Acri, C. R., Shakir, T., Šílová, G., Soons, O., & Veghazy, A. V. (2022). Central Bank Digital Currency and Bank Intermediation. *Social Science Research Network*. <https://doi.org/10.2139/ssm.4108346>
4. Afonso, A., & Jalles, J. T. (2019). Quantitative easing and sovereign yield spreads: Euro-area time-varying evidence. *Journal of International Financial Markets, Institutions and Money*, 58, 208–224.
<https://doi.org/10.1016/j.intfin.2018.10.003>
5. Agur, I., Dell’Ariccia, G., & Dell’Ariccia, G. (2021). Designing central bank digital currencies. *Journal of Monetary Economics*, 125, 62–79. <https://doi.org/10.1016/j.jmoneco.2021.05.002>
6. Alonso, S., Vázquez, J. J., & Forradellas, R. F. R. (2021). Central Banks Digital Currency: Detection of Optimal Countries for the Implementation of a CBDC and the Implication for Payment Industry Open Innovation. *Journal of Open Innovation*, 7(1), 72. <https://doi.org/10.3390/joitmc7010072>
7. Andolfatto, D. (2021). Assessing the Impact of Central Bank Digital Currency on Private Banks. *The Economic Journal*, 131(634), 525–540. <https://doi.org/10.1093/ej/ueaa073>
8. Armelius, H. & C. C. a. & H. I. (2021). On the possibility of a cash-like CBDC. *ideas.repec.org*.
<https://ideas.repec.org/p/zbw/esprep/231485.html>
9. Arslanian, H., & Fischer, F. (2019). The Rise of Bitcoin. In *The Future of Finance*. https://doi.org/10.1007/978-3-030-14533-0_9
10. Arteta, C., Kose, M. A., Stocker, M., & Taskin, T. (2018). Implications of negative interest rate policies: An early assessment. *Pacific Economic Review*, 23(1), 8–26. <https://doi.org/10.1111/1468-0106.12249>
11. Assenmacher, K., Berentsen, A., Brand, C., & Lamersdorf, N. (2021). A Unified Framework for CBDC Design: Remuneration, Collateral Haircuts and Quantity Constraints. *Social Science Research Network*. <https://doi.org/10.2139/ssm.3896787>
12. Assenmacher, K., Bitter, L., & Ristinieni, A. (2023). CBDC and Business Cycle Dynamics in a New Monetarist New Keynesian Model. *Social Science Research Network*. <https://doi.org/10.2139/ssm.4442377>
13. Auer, R. (2020, March 1). *The Technology of Retail Central Bank Digital Currency*.
https://papers.ssm.com/sol3/papers.cfm?abstract_id=3561198
14. Bank of England. (2023). Project Rosalind: building API prototypes for retail CBDC ecosystem innovation. In *Bank for International Settlements*.
15. Baeriswyl, R., Reynard, S., & Swoboda, A. (2021). *Swiss National Bank (SNB) - Retail CBDC purposes and risk transfers to the central bank*. www.snb.ch. https://www.snb.ch/en/mmr/papers/id/working_paper_2021_19

16. Banque de France. (2022). PUBLIC ACCESS TO CASH UPDATE OF THE ASSESSMENT AT END-2020. In *Banque De France*. https://www.banque-france.fr/sites/default/files/medias/documents/464ta22_2022_07_12_cp-rapport_accessibilite_cp.pdf
17. Beniak, P. (2019). *Central bank digital currency and monetary policy: a literature review* *Munich Personal RePEc Archive*. <https://mpra.ub.uni-muenchen.de/96663/>
18. Berentsen, A., & Schär, F. (2018). The Case for Central Bank Electronic Money and the Non-case for Central Bank Cryptocurrencies. *Federal Reserve Bank of St Louis Review*, 100(2), 97–106. <https://doi.org/10.20955/r.2018.97-106>
19. Bhawana, & Kumar, S. (2021, September 24). *Permission Blockchain Network based Central Bank Digital Currency*. IEEE Conference Publication | IEEE Xplore. <https://ieeexplore.ieee.org/abstract/document/9574020>
20. BIS (2020). Central bank digital currencies: Foundational principles and core features. https://www.bis.org/publ/othp33_summary.pdf
21. Bindseil, U. (2020). Tiered CBDC and the Financial System. *Social Science Research Network*. <https://doi.org/10.2139/ssm.3513422>
22. Bindseil, U., & Pantelopoulos, G. (2022). Towards the Holy Grail of Cross-Border Payments. *Social Science Research Network*. <https://doi.org/10.2139/ssm.4178863>
23. Böhl, G., Goy, G., & Strobel, F. (2020). A Structural Investigation of Quantitative Easing. In *De Nederlandsche Bank*. De Nederlandsche Bank. <https://doi.org/10.2139/ssm.3782958>
24. Boonstra, W. (2022). Central bank digital currency: look before you leap. *ESB*. <https://esb.nu/central-bank-digital-currency-look-before-you-leap/>
25. Boonstra, W., & Van Goor, W. B. a. L. (2020b). *The Basics of Money and Banking: From Ancient Coins to Credit and Cryptos*.
26. Bordo, M., & Levin, A. (2017). NBER WORKING PAPER SERIES CENTRAL BANK DIGITAL CURRENCY AND THE FUTURE OF MONETARY POLICY. https://www.nber.org/system/files/working_papers/w23711/w23711.pdf
27. Davoodalhosseini, M., Rivadeneyra, F., & Zhu, L. (2020). CBDC and Monetary Policy. *RePEc: Research Papers in Economics*. <https://doi.org/10.34989/san-2020-4>
28. Bottone, M., Tagliabracchi, A., & Zevi, G. (2022). Inflation expectations and the ECB's perceived inflation objective: novel evidence from firm-level data. *Journal of Monetary Economics*. <https://doi.org/10.1016/j.jmoneco.2022.03.006>
29. Brown, B., & Pollock, A. (2015). *A Global Monetary Plague: Asset Price Inflation and Federal Reserve Quantitative Easing*. https://openlibrary.org/books/OL27225728M/A_global_monetary_plague
30. Brunne-meier, M. K., & Niepelt, D. (2019). On the equivalence of private and public money. *Journal of Monetary Economics*, 106, 27–41. <https://doi.org/10.1016/j.jmoneco.2019.07.004>
31. Burdett, K., Trejos, A., & Wright, R. (2001). Cigarette Money. *Journal of Economic Theory*, 99(1–2), 117–142. <https://doi.org/10.1006/jeth.2000.2731>
32. Burlon, L., Montes-Galdón, C., Muñoz, M., & Smets, F. (2022). The Optimal Quantity of CBDC in a Bank-Based Economy. *Social Science Research Network*. <https://doi.org/10.2139/ssm.4175853>

32. Caudevilla, O., & M. Kim, H. (2023). *THE DIGITAL YUAN AND CROSS-BORDER PAYMENTS; China's Rollout of Its Central Bank Digital Currency*.
33. Central Bank of Nigeria. (2020). *Annual Report 2020*.
[https://www.cbn.gov.ng/Out/2021/CCD/2020%20COD%20Annual%20Report%20\(FINAL%20APPROVED\).pdf](https://www.cbn.gov.ng/Out/2021/CCD/2020%20COD%20Annual%20Report%20(FINAL%20APPROVED).pdf)
34. Central Bank of the Bahamas. (2023, April). *Press Release: Public Update on The Bahamas Digital Currency—SandDollar-Central Bank of the Bahamas*. <https://www.centralbankbahamas.com/news/press-releases/press-release-public-update-on-the-bahamas-digital-currency-sanddollar-1>
35. Chaum, D., Grothoff, C., & Moser, T. (2021). How to issue a central bank digital currency. *Social Science Research Network*.
<https://doi.org/10.2139/ssm.3965032>
36. Chen, H., & Siklos, P. L. (2022). Central bank digital currency: A review and some macro-financial implications. *Journal of Financial Stability*, 60, 100985. <https://doi.org/10.1016/j.jfs.2022.100985>
37. Cheng, P. (2022). Decoding the rise of Central Bank Digital Currency in China: designs, problems, and prospects. *Journal of Banking Regulation*. <https://doi.org/10.1057/s41261-022-00193-5>
38. Chiu, J., Davoodalhosseini, M., Jiang, J. H., & Zhu, L. (2019). Bank Market Power and Central Bank Digital Currency: Theory and Quantitative Assessment. *Journal of Political Economy*, 000. <https://doi.org/10.1086/722517>
39. Copic, E., & Franke, M. (2020). Influencing the Velocity of Central Bank Digital Currencies. *Social Science Research Network*. <https://doi.org/10.2139/ssm.3518736>
40. Chorzempa, M. (2021). China, the United States, and central bank digital currencies: how important is it to be first? *China Economic Journal*, 14(1), 102–115. <https://doi.org/10.1080/17538963.2020.1870278>
41. Coppola, F. (2019b). *The Case For People's Quantitative Easing*. John Wiley & Sons.
42. Coulter, K.-A. (2023). *A Review of the Proposed Bank of England's "Retail" Central Bank Digital Currency (CBDC) as a Cryptocurrency Competitor*.
43. Da Silva, A. L. (2022, November 17). *CBDC Design Features and its Possible Use as an Instrument of Monetary Policy*.
<https://repositorio-aberto.up.pt/handle/10216/145319>
44. Davies, G. (1994). *A History of Money From Ancient Times to the Present Day*.
45. De Fiore, F., & Tristani, O. (2018). (Un)conventional Policy and the Effective Lower Bound. *Social Science Research Network*. <https://doi.org/10.2139/ssm.3266268>
46. De Nederlandsche Bank. (2017). Annual Report 2017. *Annual Report 2017*. <https://www.dnb.nl/media/a5tjuu30/2017-annual-report.pdf>
47. De Nederlandsche Bank. (2018). *Perspective on the structure of the Dutch banking sector*.
48. De Nederlandsche Bank. (2020). *Central Bank Digital Currency - Objectives, preconditions and design choices*.
<https://www.dnb.nl/en/publications/research-publications/occasional-study/nr-1-2020-central-bank-digital-currency-objectives-preconditions-and-design-choices/>

49. De Nederlandsche Bank. (2023). Point-of-sale payments in 2022. In *De Nederlandsche Bank*.
<https://www.dnb.nl/media/m00mskgh/points-of-sale.pdf>
50. Deutsche Bundesbank. (2020). Cash hoarding by German households – how much cash do they store and why? *Deutsche Bundesbank Monthly Report*.
51. Deutsche Bundesbank. (2022). *Payment behaviour in Germany in 2021*.
<https://www.bundesbank.de/en/publications/reports/studies/payment-behaviour-in-germany-in-2021-894118>
52. E. Castañeda, J., & Luis Cendejas, J. (2023). *REVISITING THE QUANTITY THEORY OF MONEY: MONEY GROWTH, MONEY VELOCITY AND INFLATION IN THE US, 1948-2021*. Johns Hopkins Institute for Applied Economics.
53. Eren, E., Jackson, T., & Lombardo, G. (2022). *Efficient disintermediation with CBDC*.
54. Etzrodt, C. (2018). Modern Sovereign Money—Part I: The Moral Hazard of Fractional Reserve Banking. *Open Journal of Social Sciences*, 06(09), 101–115. <https://doi.org/10.4236/jss.2018.69007>
55. European Central Bank. (2021, February 10). *Evolution or revolution? The impact of a digital euro on the financial system*.
<https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp210210~a1665d3188.en.html>
56. European Central Bank. (2021b, November 10). *Monetary policy decisions*.
<https://www.ecb.europa.eu/mopo/decisions/html/index.en.html>
57. European Central Bank. (2022). Progress on the investigation phase of a digital euro. *European Central Bank*.
58. European Central Bank. (2022a, June 10). *TARGET Annual Report 2021*.
<https://www.ecb.europa.eu/pub/targetar/html/ecb.targetar2021.en.html>
59. European Central Bank. (2022b, December 21). *ECB publishes second progress report on the digital euro investigation phase*.
<https://www.ecb.europa.eu/paym/intro/news/html/ecb.mipnews221221.en.html>
60. European Central Bank. (2022c, December 20). *Study on the payment attitudes of consumers in the euro area (SPACE) – 2022*. https://www.ecb.europa.eu/stats/ecb_surveys/space/html/ecb.spacereport202212~783ffdf46e.en.html
61. European Central Bank. (2023, April 24). *ECB publishes progress report on digital euro and study on possible features of a digital wallet*. https://www.ecb.europa.eu/press/pr/date/2023/html/ecb.pr230424_1~395626f0d9.en.html
62. European Central Bank. (2023e, June 15). *Official interest rates*.
https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html
63. Federal Reserve. (2022). *Money and Payments: The U.S. Dollar in the Age of Digital Transformation*. Board of Governors of the Federal Reserve System. <https://www.federalreserve.gov/publications/money-and-payments-discussion-paper.htm>
64. Ferrando, A., Popov, A. I., & Udell, G. F. (2021). Unconventional Monetary Policy, Funding Expectations, and Firm Decisions. *Social Science Research Network*. <https://doi.org/10.2139/ssm.3937768>
65. Ferreira, C. (2013). Bank market concentration and bank efficiency in the European Union: a panel Granger causality approach. *International Economics and Economic Policy*, 10(3), 365–391. <https://doi.org/10.1007/s10368-013-0234-y>
66. Fischer, S. (2016). Monetary Policy, Financial Stability, and the Zero Lower Bound. *The American Economic Review*, 106(5), 39–42. <https://doi.org/10.1257/aer.p20161005>

67. Fratzscher, M., Lo Duca, M., & Straub, R. (2016). ECB Unconventional Monetary Policy: Market Impact and International Spillovers. *IMF Economic Review*, 64(1), 36–74. <https://doi.org/10.1057/imfer.2016.5>
68. George, A., Xie, T., & Alba, J. W. (2021). Central Bank Digital Currency with Adjustable Interest Rate in Small Open Economies. *Social Science Research Network*. <https://doi.org/10.2139/ssm.3605918>
69. Gerlach, S., & Lewis, J. S. (2014). Zero lower bound, ECB interest rate policy and the financial crisis. *Empirical Economics*, 46(3), 865–886. <https://doi.org/10.1007/s00181-013-0713-6>
70. Gieck, J. (2014). *Unconventional monetary policy in an open economy*. <https://www.econstor.eu/handle/10419/106788>
71. Gong, X., Han, H., & Zhu, Y. (2023). *Bank Market Power and Central Bank Digital Currency: A Case of Imperfect Substitution*. <https://fass.nus.edu.sg/ecs/wp-content/uploads/sites/4/2023/02/Bank-Market-Power-and-Central-Bank-Digital-Currency-A-Case-of-Imperfect-Substitution-Dr-Yu-Zhu.pdf>
72. Group of Central Banks (2021). Central bank digital currencies: financial stability implications. Report 4, Series of collaborations from a group of central banks.
73. Guo, S., Kreitem, J., & Moser, T. (2022). DLT Options for CBDC. *Social Science Research Network*. <https://doi.org/10.2139/ssm.4219738>
74. Harasim, J. (2016). Europe: The Shift from Cash to Non-Cash Transactions. In *Palgrave Macmillan UK eBooks* (pp. 28–69). https://doi.org/10.1057/9781137541215_2
75. Huber, J. (2023a). Central Banks and Monetary Policy Under Conditions of CBDC. In *The Monetary Turning Point* (pp. 151–188). https://doi.org/10.1007/978-3-031-23957-1_8
76. Huston, J., & Spencer, R. W. (2016). The Wealth Effects of Quantitative Easing. *Atlantic Economic Journal*, 44(4), 471–486. <https://doi.org/10.1007/s11293-016-9511-9>
77. Infante, S., Kim, K., Orlik, A., Silva, A. F., & Tetlow, R. J. (2022b). The Macroeconomic Implications of CBDC: A Review of the Literature. *Finance and Economics Discussion Series*, 2022–076, 1–65. <https://doi.org/10.17016/feds.2022.076>
78. IMF. (2012, September 1). *Back to Basics: What Is Money? - Finance & Development, September 2012*. <https://www.imf.org/external/pubs/ft/fandd/2012/09/basics.htm>
79. International Monetary Fund. (2021). *RECENT DEVELOPMENTS AND MACRO-FINANCIAL IMPLICATIONS OF THE E-CNY*.
80. Jackson, Howell Edmunds and Massad, Timothy, The Treasury Option: How the US Can Achieve the Financial Inclusion Benefits of a CBDC Now (March 10, 2022). Available at SSRN: <https://ssrn.com/abstract=4208346>
81. Jawadi, F., Sousa, R. M., & Traverso, R. (2017). ON THE MACROECONOMIC AND WEALTH EFFECTS OF UNCONVENTIONAL MONETARY POLICY. *Macroeconomic Dynamics*, 21(5), 1189–1204. <https://doi.org/10.1017/s1365100515000292>
82. Jiemeng, Y., & Zhou, G. (2022). A study on the influence mechanism of CBDC on monetary policy: An analysis based on e-CNY. *PLOS ONE*, 17(7), e0268471. <https://doi.org/10.1371/journal.pone.0268471>

83. Keister, Todd, and Daniel R. Sanches (2022). "Should central banks issue digital currency?" *Review of Economic Studies* (forthcoming), <https://www.restud.com/paper/should-centralbanks-issue-digital-currency/>
84. Kim, G. B. (2020). Why is China going to issue CBDC (Central Bank Digital Currency)? *Inteo'nes Jeonja Sang'geo'lae Yeon'gu*, 20(4), 161–177. <https://doi.org/10.37272/jiecr.2020.08.20.4.161>
85. Kim, H. M. (2023). Can Stablecoins Actually Improve Financial Inclusion: Exploring the IT Affordances of Token-Based Digital Currencies. *Social Science Research Network*. <https://doi.org/10.2139/ssrn.4412527>
86. Knafo, S. (2006). The gold standard and the origins of the modern international monetary system. *Review of International Political Economy*, 13(1), 78–102. <https://doi.org/10.1080/09692290500396693>
87. Kosse, A. (2022, May 6). *Gaining momentum – Results of the 2021 BIS survey on central bank digital currencies*. <https://www.bis.org/publ/bppdf/bispap125.htm>
88. Krueger, M., & Seitz, F. (2018). Pros and Cons of Cash: The State of the Debate. *Credit and Capital Markets*, 51(1), 15–40. <https://doi.org/10.3790/ccm.51.1.15>
89. Kumhof, M., & Noone, C. (2018). Central Bank Digital Currencies - Design Principles and Balance Sheet Implications. *Social Science Research Network*. <https://doi.org/10.2139/ssrn.3180713>
90. L Tyree, A. (2021). CBDC: Digital cash as legal tender. *JOURNAL OF BANKING AND FINANCE LAW AND PRACTICE*.
91. Lee, A. (2020, December 23). *Tokens and accounts in the context of digital currencies*. <https://www.federalreserve.gov/econres/notes/feds-notes/tokens-and-accounts-in-the-context-of-digital-currencies-122320.html>
92. Loutskina, E. (2011). The role of securitization in bank liquidity and funding management. *Journal of Financial Economics*.
93. Lukonga, I. (2022). *Monetary Policy Implications of Central Bank Digital Currencies Perspectives on Jurisdictions with Conventional and Islamic Banking Systems*. International Monetary Policy.
94. Masciandaro, D. (2020). COVID-19 Helicopter Money, Monetary Policy and Central Bank Independence: Economics and Politics. *Social Science Research Network*. <https://doi.org/10.2139/ssrn.3583466>
95. Milne, A. (2020). Argument by False Analogy: The Mistaken Classification of Bitcoin as Token Money. *Social Science Research Network*. <https://doi.org/10.2139/ssrn.3290325>
96. MOB. (2018). *Rapportage aan Minister van Financiën*. Maatschappelijk Overleg Betalingsverkeer.
97. Morales-Resendiz, R., Ponce, J., Picardo, P., Velasco, A., Chen, B. I. T., Sanz, L., Guiborg, G., Segendorff, B., Vásquez, J. a. G., Arroyo, J., Aguirre, I., Haynes, N., Panton, N., Griffiths, M., Pieterz, C., & Hodge, A. (2021). Implementing a retail CBDC: Lessons learned and key insights. *Latin American Journal of Central Banking*, 2(1), 100022. <https://doi.org/10.1016/j.lacb.2021.100022>
98. Morrison, W. A., & Labonte, M. (2012). *China's Currency Policy: An Analysis of the Economic Issues*. https://digital.library.unt.edu/ark:/67531/metadc228116/m1/1/high_res_d/RS21625_2013Jul22.pdf
99. Niepelt, D. (2020). Reserves for All? Central Bank Digital Currency, Deposits, and their (Non)-Equivalence. *Social Science Research Network*. <https://doi.org/10.2139/ssrn.3254206>

100. Norges Bank. (2022). *Retail payment services 2021*. <https://www.norges-bank.no/en/news-events/news-publications/Reports/Norges-Bank-Papers/2022/memo-22022-payment-services/content/>
101. Orléan, A. (1992). The Origin of Money. In *Springer eBooks* (pp. 113–143). https://doi.org/10.1007/978-94-015-8054-0_6
102. Ozili, Peterson K, Can Central Bank Digital Currency Increase Financial Inclusion? Arguments for and Against (November 13, 2021). Available at SSRN: <https://ssrn.com/abstract=3963041> or <http://dx.doi.org/10.2139/ssm.3963041>
103. Ozili, P. K. (2022). Central bank digital currency research around the world: a review of literature. *Journal of Money Laundering Control*. <https://doi.org/10.1108/jmlc-11-2021-0126>
104. Ozili, P.K. (2022), "Central Bank Digital Currency in Nigeria: Opportunities and Risks", Grima, S., Özen, E. and Boz, H. (Ed.) *The New Digital Era: Digitalisation, Emerging Risks and Opportunities (Contemporary Studies in Economic and Financial Analysis, Vol. 109A)*, Emerald Publishing Limited, Bingley, pp. 125-133. <https://doi.org/10.1108/S1569-37592022000109A008>
105. Ozili, P. K. (2023). eNaira central bank digital currency (CBDC) for financial inclusion in Nigeria. *ResearchGate*. https://www.researchgate.net/publication/365182332_eNaira_central_bank_digital_currency_CBDC_for_financial_inclusion_in_Nigeria
106. People's Bank Of China. (2021). *Progress Progress Progress of Research Research Research Research & Development Development Development of E-CNY in China*.
107. Pfister, C. (2019). Central Bank Digital Currency: One, Two or None? *Social Science Research Network*. <https://doi.org/10.2139/ssm.3470143>
108. R Barth, J., Nguyen, N., & Xu, J. (2019). Deposit Insurance Schemes. *Encyclopedia of Finance*.
109. R3, Calle, G., & Eidan, D. (2020). Central Bank Digital Currency: an innovation in payments. *R3*. <https://r3.com/reports/central-bank-digital-currency-an-innovation-in-payments/>
110. Ree, J. (2023b, May 16). *Nigeria's eNaira, One Year After*. IMF. <https://www.imf.org/en/Publications/WP/Issues/2023/05/16/Nigerias-eNaira-One-Year-After-533487>
111. Ree, T. W. J. (2023, March 7). *Nigeria—Fostering Financial Inclusion through Digital Financial Services: Nigeria*. IMF. <https://www.imf.org/en/Publications/selected-issues-papers/Issues/2023/03/07/Nigeria-Fostering-Financial-Inclusion-through-Digital-Financial-Services-Nigeria-Nigeria-530633>
112. Rehman, M. A., Irfan, M., Naeem, M. A., Lucey, B. M., & Karim, S. (2023). Macro-financial implications of central bank digital currencies. *Research in International Business and Finance*, 64, 101892. <https://doi.org/10.1016/j.ribaf.2023.101892>
113. Riccardi, M., & Levi, M. (2018). Cash, Crime and Anti-Money Laundering. In *Springer eBooks* (pp. 135–163). https://doi.org/10.1007/978-3-319-64498-1_7
114. Riksbank. (2018). *What is money and what type of money would an e-krona be?* <https://www.riksbank.se/globalassets/media/rapporter/pov/artiklar/engelska/2018/181105/20183-what-is-money-and-what-type-of-money-would-an-e-krona-be.pdf>

115. Riksbank, S. (2021). E-krona pilot phase 1. *Sveriges Riksbank*. <https://www.riksbank.se/en-gb/payments--cash/e-krona/e-krona-reports/e-krona-pilot-phase-1-report-3/>
116. Riksbank, S. (2022). E-krona pilot phase 2. *Sveriges Riksbank*. <https://www.riksbank.se/en-gb/payments--cash/e-krona/e-krona-reports/e-krona-pilot-phase-2/>
117. Riksbank, S. (2023a). Statistics on banknotes and coins. *Sveriges Riksbank*. <https://www.riksbank.se/en-gb/statistics/statistics-on-payments-banknotes-and-coins/notes-and-coins/>
118. Riksbank, S. (2023b). E-krona pilot phase 3. *Sveriges Riksbank*. <https://www.riksbank.se/en-gb/payments--cash/e-krona/e-krona-reports/e-krona-pilot-phase-3/>
119. Rod Garratt, Michael Lee, Brendan Malone, and Antoine Martin. (2020). *Token- or Account-Based? A Digital Currency Can Be Both - Liberty Street Economics*. Liberty Street Economics. <https://libertystreeteconomics.newyorkfed.org/2020/08/token-or-account-based-a-digital-currency-can-be-both/>
120. Rodney J Garratt & Jiaheng Yu & Haoxiang Zhu, 2022. "[The Case for Convenience: How CBDC Design Choices Impact Monetary Policy Pass-Through](#)," [BIS Working Papers](#) 1046, Bank for International Settlements.
121. Tarlin, S. H. (2021, September 1). *The Future of Cash*. <https://www.philadelphiafed.org/consumer-finance/payment-systems/the-future-of-cash>
122. S Musgrave, R. (2014). *The Solution is Full Reserve / 100% Reserve Banking*. *Munich Personal RePEc Archive*. <https://mpra.ub.uni-muenchen.de/57955/>
123. Schamowski, S. (2022). Central bank speeches and digital currency competition. *Finance Research Letters*, 49, 103072. <https://doi.org/10.1016/j.fl.2022.103072>
124. Schwarz, D. (2023). *Central Bank Digital Currencies and competition laws: recognising the importance of competition laws in the CBDC ecosystem*. Clifford Chance. <https://www.cliffordchance.com/briefings/2023/03/central-bank-digital-currencies-and-competition-laws--recognisin.html>
125. Soderberg, G., Bechara, M., Bossu, W., Che, N., Davidovic, S., Kiff, J., Lukonga, I., Mancini-Griffoli, T., Sun, T., & Yoshinaga, A. (2022, February 7). *Behind the Scenes of Central Bank Digital Currency: Emerging Trends, Insights, and Policy Lessons*. IMF. <https://www.imf.org/en/Publications/fintech-notes/Issues/2022/02/07/Behind-the-Scenes-of-Central-Bank-Digital-Currency-512174>
126. Stellinga, B., De Hoog, J., Van Riel, A., & De Vries, C. G. (2021). Money and Debt: The Public Role of Banks. In *Springer eBooks*. <https://doi.org/10.1007/978-3-030-70250-2>
127. Tercero-Lucas, D. (2020b). A Global Digital Currency to rule them all? A Monetary-financial View of the Facebook's Libra for the Euro. . . *ResearchGate*. <https://doi.org/10.13140/RG.2.2.12811.72482>
128. The White House. (2022). Technical Possibilities for a U.S. Central Bank Digital Currency. *The White House*. <https://www.whitehouse.gov/ostp/news-updates/2022/09/16/technical-possibilities-for-a-u-s-central-bank-digital-currency/>
129. Thiagarajan, R., F Lacaille, R., Hurd, A., Metcalfe, M., & Im, H. (2023). *De-dollarisation; is the US dollar dominance dented?*

130. Thomson, D. L. (2012). The Dual Mandate: Has the Fed Changed Its Objective? *Review*, 94(2).
<https://doi.org/10.20955/r.94.117-134>
131. Tong, W., & JiaYou, C. (2021). A study of the economic impact of central bank digital currency under global competition. *China Economic Journal*, 14(1), 78–101. <https://doi.org/10.1080/17538963.2020.1870282>
132. Toraman, Y. (2022). Interest-Free Finance Model by Using Blockchain-Based Company Tokens: Research on Digital Turkish Lira (DTL) and Borsa Istanbul with Technology Acceptance Model (TAM). *Emerging Markets Journal*, 12(2), 56–66.
<https://doi.org/10.5195/emaj.2022.275>
133. Van Der Linden, M. (2020). Toekomst van het geldstelsel. *Haagse Hogeschool*.
134. Van Oordt, M. (2022). Discussion of “Central bank digital currency: Stability and information.” *Journal of Economic Dynamics and Control*, 142, 104503. <https://doi.org/10.1016/j.jedc.2022.104503>
135. Van Vo, L., & Le, H. T. T. (2023). From Hero to Zero - The Case of Silicon Valley Bank. *Social Science Research Network*.
<https://doi.org/10.2139/ssrn.4394553>
136. Vanthoor, W. (2003). *De Nederlandsche Bank*.
137. Wenker, K. (2022). Retail Central Bank Digital Currencies (CBDC), Disintermediation and Financial Privacy: The Case of the Bahamian Sand Dollar. *FinTech*, 1(4), 345–361. <https://doi.org/10.3390/fintech1040026>
138. Whited, Toni M. and Wu, Yufeng and Xiao, Kairong, Will Central Bank Digital Currency Disintermediate Banks? (April 2023). Available at SSRN: <https://ssrn.com/abstract=4112644> or <http://dx.doi.org/10.2139/ssrn.4112644>
139. Williamson, S. D. (2021). Central bank digital currency and flight to safety. *Journal of Economic Dynamics and Control*, 142, 104146. <https://doi.org/10.1016/j.jedc.2021.104146>
140. Wright, A., C McKenzie, S., R Bodie, L., & L Belle, C. (n.d.). *Working Paper: Financial Inclusion and Central Bank Digital Currency in The Bahamas- Central Bank of the Bahamas*.
<https://www.centralbankbahamas.com/publications/working-papers/working-paper?N=N>
141. Yang J, Zhou G (2022) A study on the influence mechanism of CBDC on monetary policy: An analysis based on e-CNY. *PLoS ONE* 17(7): e0268471. <https://doi.org/10.1371/journal.pone.0268471>
142. Zamora-Pérez, A. (2022, August 2). *Guaranteeing freedom of payment choice: access to cash in the euro area*. European Central Bank. https://www.ecb.europa.eu/pub/economic-bulletin/articles/2022/html/ecb.ebart202205_02~74b1fc0841.en.html