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CDBC DESIGN FEATURES AND ITS POSSIBLE USE AS AN INSTRUMENT OF MONETARY POLICY

Augusto Lorran da Silva

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Professor Manuel Luís Costa

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Everyone can create money;
the problem is to get it accepted.
Hyman Minsky

Abstract

Cash, until now, is the only central bank liability at the disposal of the households. This medium of payment is state-guaranteed and has no risk attached to it. The disuse of cash exposes the citizens to be dependent private payments companies. The creation of a Central Bank Digital Currency (CBDC) will provide to citizens the safest form of money, central bank money. This dissertation addresses important design features and possible use of CBDC as an instrument of monetary policy. In the first chapter, the main theories of money and the conventional tolls of monetary policy are presented. The second chapter elucidates the zero lower bound problem and the unconventional monetary instruments used to circumvent this problem. The third chapter presents the CBDC and its design principles that may be in its design. The last chapter shows how China and Sweden are conducting their pilot projects.

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Keywords: Central Bank Digital Currency, Monetary Policy, Zero Lower Bound, Negative Interest Rates, Central Bank

List of Tables

List of Figures

List of Abbreviations and Acronyms

APP – Asset Purchase Program
BoE – Bank of England
BIS – Bank of International Settlements
CBDC – Central bank digital currency
CPMI – Committee on Payments and Market Infrastructures
DC/EP – Digital Currency Electronic Payment
EONIA – Euro Overnight Index Average
ECB – European Central Bank
FED – Federal Reserve
GDP – Gross Domestic Product
GDPR – General Data Protection Regulation
LSAP – Large-Scale Asset Purchase Program
LTRO – Longer-Term Refinancing Operations
MRO – Main Refinancing Operations
MEP – Maturity Extension Program
OMT – Outright Monetary Transactions
PBOC – People's Bank of China
QE – Quantitative Easing
ZLB – Zero Lower Bound

Summary

Introduction

Money has taken many forms over the years, at the early stages of development money took form of commodity with an independent barter value, this type of money can being called as commodity money (Davies, 2010). And it assumed forms as objects with a direct utility value as iron, axes, grain, cigarettes, feathers, shells, and precious metals (Söderberg, 2018). The idea behind the use of those objects as money is that it can act as a tool or material not needing to rely on the honesty of the previous owner. An important factor that should be cited is that the form of money depends on the available technology.

With the development of technology, money started to be precious metal in form of coins. Coins were pieces of precious metals shaped in a circular form to facilitate the storage and transportation between distant locations. At that moment, money was no longer many types of objects that represent different types of utility (commodity money), but a representation of possession of precious metal.

The introduction of banknotes came to complement coins. Due to the facility to issue money in form of banknotes, some standards started to be implemented in order to prevent inflation in the economy. The gold standard was implemented before the First World War, but it was abandoned because it was almost impossible to conduct a monetary expansion. After the Second World War the Bretton Woods system was established. The countries that signed that agreement started to link their currency to the US dollar and having dollars in their possession central banks could redeem them into gold. Now, banknotes do not represent any precious metal (Söderberg, 2018), and their digitalization is part of the evolution of what is so called money.

The general public has in their possession two main forms of money. Money in accounts (digital) and cash (physical). With the development of the means of payments, deposits into bank accounts are used as money; that development led to a much smaller use of money in its physical form in many countries.

Until now central banks only issue money in its physical form, but recent technology allows central banks to create its own version of their digital currency. Central bank digital currency (CBDC) is an evolution of the monetary system (Li & Huang, 2021).

Until now, there is no consensus on the definition of central bank digital currency. For the Committee on Payments and Market Infrastructures (CPMI), central bank digital

currency is a new form of central bank money. That is, a central bank liability, denominated in an existing unit of account, which serves as a medium of exchange and store of value (Committee on Payments and Market Infrastructures, 2018). For The European Central Bank (ECB), CBDC is central bank money handled through electronic means and accessible to the broad public (Bindseil, 2020a).

According to the Bank of England (BoE), CBDC can be defined as an electronic central bank money that: (i) can be accessed more broadly than reserves, (ii) has much better performance for retail transactions than cash, (iii) has a different operational structure to other forms of central bank money allowing it to provide a different aim, and (iv) can be interest bearing and, under some assumptions, would pay a rate different from the rate on reserves (Kumhof & Noone, 2018).

At least 36 central banks around the globe have started research on this topic, and there are at least 6 pilot projects ongoing, to name some countries that already started their pilot we have China, Sweden, and South Korea. Each central bank is studying the best way to design their digital version of the currency in order to fulfill their unique economic needs. This has led to the research question of this work: How should CBDC be designed in order to become a monetary policy tool for central banks?

After the 2008 financial crises, central banks in some developed countries lowered the interest rate close to zero and lost their capacity to intervene in the market via the most common and conventional instrument of monetary policy, open market operations. This opened space to new non-conventional monetary intervention, such as the quantitative easing (asset purchase program), forward guidance, outright monetary transactions (OMT), and long-term refinancing operations.

The motivation for this research is to know how this new asset (CBDC) could be designed in a way to be an instrument of economic policy to help economy recovery in the time of financial crises. The Zero Lower Bound (ZLB) hindered central banks' ability to lower interest rates, forcing them to find unconventional policy instruments. A well designed CBDC can increase the toolkit of monetary instruments at the disposal of central banks and, in the process help to improve the fiscal policy transmission channels in the economy.

This work aims at elucidating whether a digital currency issued by the central bank can be beneficial for the entire financial system. Even with all the concern regarding this topic, this is an important step into the future of what is money, opening space not only as an

economic policy instrument, but also to fight crimes as money laundering and terrorism financing proving a safer environment for the economy.

In order to design a CBDC, some core principles should be settled. Some institutions like the Bank of England and the Bank of International Settlements (BIS) suggests that a CBDC must follow three core principles: (i) be reliable and resilient; (ii) fast and efficient; and (iii) innovative and open to competition. Those are the principles approached in this dissertation as some remuneration designs that may help the central bank to better achieve its aims. Regarding the three core principles, in both pilot projects, conducted by China and Sweden, that is presented in this work seems to follow these principles and, regarding the remuneration design both economies, at the current moment try to replicate the characteristics of cash into their digital currency.

The dissertation proceeds as follows. Chapter 1 presents a brief history of what is considered money and some theories behind it, and then elucidates the most conventional tools of monetary policy. Chapter 2 focuses on the Zero Lower Bound problem and some of the unconventional monetary policy tools used by the major central banks to circumvent the ZLB problem. Chapter 3 introduces the main topic CBDC some design features are presented and contains three proposals for a remuneration design of the Central Bank Digital Currency presenting its pros and cons. Chapter 4 will be an analysis of the CDBC designed by the People's Bank of China and Sveriges Riksbank (Central Bank of Sweden). Finally, the main conclusions are presented, and the limitations of this dissertation are exposed.

1. Theories of Money and Conventional Monetary Policy Tools

1.1. The different forms of money and its theories

As mentioned above, money has assumed numerous forms, after some time, money started to have a symbol of political power, and started to be issued by the state. With the development of printing techniques money started to have a paper representation. Paper money was introduced as a complement to coin and led to a hyperinflation (Söderberg, 2018). A lack of control in the offer of money could lead to great damages at the society. As a consequence, states started to take off the power of private institutions to issue money and delegate that to the central banks that began to be created and therefore, central banks have the monopoly of issuing money.

Those banknotes had their value because they could be redeemed in form some of those metals, gold, silver, or even cobalt. But in the 19th century an international standard was created, and the banknotes should be redeemed in gold, the gold standard. Gold became the main source of value of money. It remained until the first world war, between first and second world wars there were attempts to resume but the great depression in the 30s brought those attempts to an end. (Söderberg, 2018)

After the second world war another type o standard came in order to establish rules for commercial and financial relations, the Bretton Woods system. In this system, countries' currencies had their worth linked to US dollar, while the dollar is redeemed in gold. This system remained until the late 1960s after some years United States abandoned this system and from then onwards money is not linked to any external worth (Söderberg, 2018).

There are numerous theories defining what money is and which characteristics an object should have to be considered money. Here it will be illustrated the three main views that elucidate what money is. It is important to mention that no matter the theory, trust is the most important characteristic of money. A number in your bank account has value if people believe it does. That said, the three main theories are metallism, chartalism, and functionalism.

For the first one, metallism, money should be linked to something that has an intrinsic value. A commodity money can be easily related to this view, as well as coins, and banknotes, but these ones should have their value redeemed in precious metal, being responsible for the maintenance of the value of money (Goodhart, 1998). The gold standard is a good example of implementation of this view.

The next theory is called chartalism, money is what the state imposes, no necessary it is issued by the government, they just set in legal terms of what it considered money (Söderberg, 2018). And it can be anything, just need to have the legal tender, some economists as Keynes advocated in favor of this view.

The last view is functionalism, which is currently the most accepted. According to this view, money is considered an object that must fulfill three functions. It must (i) act as means of payment, (ii) be unit of account, acting as a standard of value that can measure goods and services, and (iii) it need to be a store of value, its value must have stability and provide security to companies and households making them indifferent of purchasing a good or service in the present days or future (Söderberg, 2018).

During the gold standard money fulfilled all the requirements for the three views, today's money for us it cannot fulfill the requirements of metallism. Money does not need to satisfy all the requirements named above in all the theories. In any case monetary transactions require trust, and this cannot be violated.

Table 1: Theories of Money

View	Conditions
Metallism	Consists of or is tied to na article with a markert value
Chartalism	Legal creation issued by bational state
Functionalism	Must functios as:
	1)Means of payment
	2) Unit of account
	3) Store of value

1.2. Conventional Monetary Policy Tools

In the modern configuration, central banks acquire some roles and responsibilities, as being the bank of the government and other banks, conduct the monetary policy via money supply and interest rate, supervise and regulate the financial system, manage exchange market and be the lender of last resort (Carlin & Soskice, 2015). The objectives of central banks may include price stability, gross domestic product (GDP) and employment stability and growth, financial stability or other. However, price stability is a primary aim shared among almost all the central banks, but it may be not the unique goal of a central bank. Exchange-rate stability is also important, as financial stability, and output stabilization.

As an example, The US Federal Reserve (FED) aims to provide price stability and output stability on an equal footing, but it also has the commitment to provide financial stability. In contrast, the Bank of England (BOE) mandate specify that its primary aim is price stabilization, and output stabilization comes as a secondary goal (Pisani-Ferry et al., 2010).

To achieve this objectives, central banks have some instruments of monetary policy at their disposal. Open market operation, standing facilities, and reserve requirements are the three conventional instruments of monetary policy. "Open market operations play an important role in steering interest rates, managing the liquidity situation in the market and signaling the monetary policy stance"(Rakić, 2021, p. 4).

The Eurosystem employs two types of regular open market operations. The main refinancing operations (MRO) and the longer-term refinancing operations (LTRO). The first one provides one-week liquidity for operation in euros, as the second provides liquidity for three-month operations. As a result, the MRO is used to guide the short term interest rate, to signal the monetary policy and to control the liquidity provision, while the LTRO extends the refinancing of financial institutions (Rakić, 2021, p. 4).

The second tool, standing facilities, provides or absorbs liquidity from the market with an overnight maturity (very short run). The Euro Overnight Index Average (EONIA) measures the effective interest rate in the euro interbank overnight market. The interest set by the central bank works inversely to central bank's intention to increase or decrease the amount of money in circulation (Rakić, 2021).

As to the last conventional tool, minimum reserves, commercial banks are required to keep a percentage of their liabilities in form of deposit with the European Central Bank, and its magnitude may vary according to the central bank monetary policy objectives (Rakić, 2021).

The most important way to affect the market via monetary policy is through the interest rate channel. A central bank tries to influence the market rate in a direction of the objective. However, there is a limit to the central banks' action via interest rate, the zero lower bound (ZBL), which means that, central banks cannot go below this limit. In normal times this is not a problem, a central bank does not need to go this point in order to conduct policy. On the other hand, if the economy is facing a crisis and it requires an intervention from the central bank on the market in other to get the economy back on track this can be

a problem. Some developed economies faced this problem during the last financial crisis, central banks lowered their interest rates to the limit, but it was seen as not enough, the economy required more stimulus. At that point, the central bank loses its power to influence the economy via conventional monetary policy. Without the efficacy of the main instrument, they needed to innovate their action on the market via unconventional monetary policy, such as the quantitative easing (asset purchase program), and forward guidance.

2. The Zero Lower Bound and Unconventional Monetary Policy Tools

In the years prior to the 2007-8 financial crises, the aim of the macroeconomic policy in numerous countries was price stability through the most conventional monetary policy instrument, open market operations being the interest rate the tool to achieve that goal Saraiva et al. (2017). In the words of Blanchard et al. (2010, p. 3):

> We thought of monetary policy as having one target, inflation, and one instrument, the policy rate. So long as inflation was stable, the output gap was likely to be small and stable and monetary policy did its job. We thought of fiscal policy as playing a secondary role, with political constraints sharply limiting its de facto usefulness. And we thought of financial regulation as mostly outside the macroeconomic policy framework.

The Zero Lower Bound (ZLB) puts a limit to how low the interest rate can go. When an economy reaches that point the central bank loses its ability to stimulate aggregate demand via interest rate, and also loses its main instrument of monetary policy. The problem of maintaining the interest rate at a low level is the liquidity trap phenomenon.

According to Keynes (1937) the liquidity trap occurs when the interest rate, usually the short term interest rate, falls to a level close to the lower bound (zero bound) where the preference for liquidity is virtually absolute, which means the agents in the economic have their preference to hold their wealth in form of cash instead of bonds, the interest rate on bonds are so low that do not attract the majority of people to maintain their wealth in this type of asset. At this point, the central bank loses its ability to influence the economy via interest rate. In other words, the monetary authority needs to find different ways to stimulate the economy.

When a country suffers with this phenomenon described by Keynes (liquidity trap), new injections of money do not affect the real output. Economic agents create the expectation of a possible increase in the interest rate in the future. So, they tend to delay their investment keeping money in their possession. This is because they believe that an increase in the interest rate in the future will reduce the present value of their investments. In this scenario, an additional liquidity provided by the central bank will not be converted into investment or consumption. For Krugman et al. (1998), the economic agents believe that money and bonds are perfect substitutes, making them indifferent to hold cash or bonds. The rationality behind this behavior, holding wealth in form of cash can be explained by the

following logic. Both assets working as perfect substitutes the economic agents prefer to hold the one with higher liquidity, which means in cash. Bonds are less liquid and may have, in some cases, a negative return, cash will always have a zero return and also is considered a synonym of liquid.

Another danger that may amplify the negative effects of the liquidity trap in the economy is the deflationary spiral (deflation trap). It occurs when the economy is having an undesirable output performance, and the central bank stimulates the aggregate demand through the interest rate instrument. The lower bound narrows the power of the monetary authority, and if the yields are already close to the limit, and the negative area is not a possible option, there is not much to be done via changes in the nominal interest rate. The conventional monetary policy becomes ineffective.

Due to this scenario experienced by some major economies and ineffectiveness of the conventional instrument of monetary policy, central banks started to interact with the market in a non-conventional way. A new form of monetary intervention took the spotlight: quantitative easing started to become famous in 2008 with the announcement of initial rounds by the Federal Reserve (FED).

2.1. Quantitative Easing: An Unconventional Monetary Policy

The first country to use quantitative easing was Japan in 2001. However, this instrument became more known only after the Federal Reserve announced its use to combat the 2007-8 financial crisis. Quantitative Easing (QE) consists in a large-scale asset purchase by central banks, those assets being usually of long-maturity. Its main differences in relation to a conventional monetary policy are: focus of intervention on long-term interest rates, instead of short-term, and the huge increase of liabilities in the central bank balance sheet.

This unconventional instrument is normally used in an unusual time, when the short-term interest rate is too low (close to zero), and its aim is to stimulate output, with a view to prevent the economy to enter in a deep recession and preventing the deflation trap. According to Williamson (2017, p. 1):

> QE consists of large-scale asset purchases by central banks, usually of long-maturity government debt but also of private assets, such as corporate debt or asset-

backed securities. Typically, QE occurs in unconventional circumstances, when short-term nominal interest rates are very low, zero or even negative.

To implement quantitative easing, the central bank uses its ability to create means of payments, creating electronic money and crediting it on its own account. With these resources, it is able to purchase public and/or private bonds in certain markets, from selected agents. By doing this, the central bank reduces the options of assets at the market inducing the economic agents to change their portfolio allocation decisions, those agents will be provided with additional liquidity and with less options of bonds. This additional liquidity is result from the acquisitions of bonds by the central bank which are now part of the central bank assets. This movement inflates the price of those assets, and consequently, a reduction in their remuneration rates, reducing the cost of financing and stimulating spending in the economy.

There are several transmission channels that an unconventional monetary policy may have. One is the portfolio reallocation channel; the economic agents will allocate their wealth in other types of assets. The transmission channels of the quantitative easing are: portfolio reallocation, bank financing, and expectation (Fiedler et al., 2016).

The first experience of QE occurred in Japan in 2001. QE had the aim of boosting the economy and put an end in the deflation cycle. The Japanese central bank, between 2001 and 2006, acted actively on the market through QE, buying public and private financial assets of different maturities.

The objective of the central bank of Japan was to buy government bonds held by the banking sector and thereby increase the levels of cash reserves that the banks held. The hope was that, when banks reached a sufficiently high level of reserves, they would increase the amount of loans to the economy, helping to raise asset prices and steer the economy away from deflation (Joyce et al., 2012). Rinban is the name of the Japanese quantitative easing, during the program the balance sheet grew from ¥5 trillion of yens in 2001 to ¥34 trillion of yens in 2004. (Fasano-Filho et al., 2012)

The American experience started late 2008, but early in 2007 the Federal Reserve had noticed some warning signs given by the economy. So, the FED began to act changing the trajectory of interest rates, which had been rising until 2007. In September of 2007, the FED stated to cut the remuneration of the FED funds, closing 2008 with remuneration between 0% and 0,25%. Other conventional monetary instruments were also used like standing

facilities, holding of reserves but they showed little effect to combat the crisis that had started.

To stimulate the economy the Federal Reserve launched two programs, the Large-Scale Asset Purchase Program (LSAP) and the Maturity Extension Program (MEP). The first one, as the name suggests, had the aim to buy bonds in a large-scale in order to support the credit market, in particular the mortgage market, reducing the long-term yields, via purchasing treasure bonds from mortgage agencies, like Fannie Mae, and Freddie Mac. On the other hand, the MEP was meant to change the bonds maturity, in order words, this program had the aim of reducing the long-term yields via changing long term bonds to short term. This would help create a better environment to the economy promoting better financing conditions (Saraiva et al., 2017). Those two programs originated a big increase of the FED balance sheet. Between 2007 and 2013, the Federal Reserve balance sheet grew by more than US$ 3,7 trillion (350%) via the quantitative easing program. This intervention helped the US economy to overcome the 2008 financial crises.

Europe also used this unconventional monetary program in order to overcome the European debt crises (eurozone sovereign crisis). Asset Purchase Program (APP) is the name of the European quantitative easing. Different from the Federal Reserve, the European Central Bank response to this crisis via unconventional monetary policy were less rapid than the American.

There are numerous reasons that can explain the late response by the European Central Bank via unconventional monetary instrument. One of the reasons for the delay in the launch of the program was that the eurozone is a union of several states sovereign. Ewing (2018) addresses this difficulty to the way that eurozone was designed and he states that:

> Before the program began, some experts had said that quantitative easing couldn't be done in the eurozone. The eurozone is not a government and does not issue bonds. There was no form of European Union debt comparable to the U.S. Treasury bonds that the Federal Reserve bought as part of its emergency stimulus program.

There are two main obstacles that may explain the inefficacy of the use of the conventional monetary policy in the European Union. First, is the zero lower bound, the short-term yields were already close to zero and could go beyond this limit, otherwise the economic agents will prefer to hold money in its physical form. The second obstacle is related

to the transmission channels, part of the financial system ran into solvency problems, the level of uncertainty suddenly grew, the increase of liquidity promoted by the central bank was not converted into loans to the private sector (Joyce et al., 2012). The conventional instruments of monetary intervention reached their limits being unable to stimulate the economy in this macroeconomic context.

Between 2015 and 2018 the European Central Bank intervened in the economy injecting more than €$ 2,6 trillion of euros, and it was responsible to double the balance sheet (taking 2015 as base year). The European Central Bank purchased bonds from its 19 member states via their local central banks. These acquisitions were proportional to the size of each member state. The American model focused the acquisition of bonds issued by companies that were guaranteed by the American government, while the European Central banks allowed the acquisition of private bonds from the eurozone corporations.

The aim of the ECB in the use of this non-conventional instrument was to stimulate aggregate demand and avoid the deflation cycle that was starting to begin. There were some critics about the use of this program stating that the ECB was financing governments, what goes against the European union rules. But the program overcame its legal difficulties. In the words of Draghi (2018, p. 5): "*QE has been the only driver of this recovery (European recovery)".*

Summing up, the lower bound puts a limit on the central bank's intervention via conventional instruments. In order to circumvent this problem, central banks started to stimulate their economies with non-conventional instruments, quantitative easing. Another solution that may come to help and increase the monetary toolkit at the central bank disposal is the Central Bank Digital Currency (CBDC). Until today the only form of money that is issued by central banks is cash and coins. With the development of technology and financial innovations, deposits into commercial banks accounts may have same properties as cash.

Money in its physical form is being less and less used in the society, in Sweden for example, for the year of 2020 trades using money in its physical form represents less than 10% according to the Sveriges Riksbank (2020). The Covid-19 pandemic helped the world to speed this progress of digitalization of the means of payments, and some central banks started to study a way to launch the digital version of its currency. For the next chapter, it will be described what is the CBDC and how some central banks are designing this new asset, taking the Chinese and Swedish example. It will also cover three ideas for its economic design and will be shown how it may help the central bank to circumvent the lower bound problem.

3. The Central Bank Digital Currency (CBDC)

A Central Bank Digital Currency is a digital version of fiat money. The evolution of the means of payments is leading to a reduction in the use of cash. According to the Sveriges Riksbank (2020) (Swedish Central Bank) the use of cash in its physical form had fallen from almost 40% in 2010 to less than 10% in 2020. At least 87% of the payments were made with debit and credit cards. Assuming that this direction will be kept, Sweden may be one of the countries with a minor role for cash. For the Swedish economy this marginalization of cash is a concern for the monetary authority of the country, if we attach to the fact that one of the characteristics of the Swedish economy is a high concentrated payment provided market, a non-creation of a central bank digital currency could create a monopolistic environment letting no place for new players.

Because of instant conversion, households can convert bank deposits easily into money making this asset almost as liquid as cash. However, bank deposits are part of M2, and this instant liquidity relies on the solvency of the institution that hold this money, in trouble times these institutions may face problem to do this convertibility. A CBDC would ensure that the population has access to a secure, efficient and convenient means of payment. (Hanna Armelius, 2020)

Different from cash, which is risk free (apart from inflation) deposits have the risk of bankrupt. The Deposit Guarantee Fund protects depositors' savings by guaranteeing deposits up to 100 000 euros, which means that in case of bankruptcy or order financial instability the fund will protect deposits until 100 000 euros. This scenario changes with the launch of the CBDC. The CBDC will be the digital version (e-cash) of fiat money, so there is no bankruptcy risk attached to it, it will be like holding cash. In case of a bank run, or any order financial instability the public that hold e-currency will not have a risk of a possible wealth lost. In order words, in a bank run the agents in the economy try to convert their deposits into cash as fast as possible, if the agent holds CBDC this conversion will no longer be necessary.

Another reason for central banks to launch the digital version of their currency is to strengthen the resilience of the payment system. In case of a disruption of the private payments system an alternative option provided by the state can promote a safer

environment for society. Normally, cash will function as a backup alternative if the private system fails, but the case is that the use of cash has been decreasing.

The launch of a Central Bank Digital Currency will promote many facilities for the society, but it can also create some concerns. Until now, central banks that are studying a way to launch their digital currency emphasize that an e-currency would not replace cash, but rather complement it. According to the Bank of England (2020), a central bank digital currency must fulfill some principles as being reliable and resilient, fast and efficient, and open to innovation and competition.

It is important to mention that an e-money should be designed in such a way to not compete with private financial institutions, as commercial banks. The idea is to provide a safer option for society allowing innovation and competition through the private sector, like is done now with fiat money. The design of a Central Bank Digital Currency is an essential topic to be discussed. A well-designed digital currency to be used in retail transactions can help the central bank to achieve its aims of financial stability.

A digital currency issued by a central party can work as a backup alternative in case of a disruption of the private payment system. It is important to mention that a digital currency is different from as crypto asset (like Bitcoin, Litecoin or any other). Those assets are, in the most cases, privately issued and not backed by any central institution. As seen for an object to be considered money it must fulfill the requirements of unit of account, store of value and means of payments. If we take Bitcoin, the most famous crypto asset as an example, it does not fulfill these requirements. Bitcoin is too volatile to be a store of value, it's not widely accepted being not able to serve as means of payment, so it is also not used as unit of account.

The Bank of England (2020) highlights seven ways which CBDC could support the Bank's main objective to maintain monetary and financial stability:

- Supporting a resilient payment landscape
- Avoiding the risk of new forms of private money creation
- Supporting competition, efficiency, and innovation in payments
- Meeting future payments needs in a digital economy
- Improving availability and usability of central bank money
- Addressing the consequences of a decline in cash
- Enabling a better cross-border payments system.

3.1. The design of the CBDC

The design of a digital version of a fiat money could imply numerous solutions to facilitate the daily life, however it also brings some concerns. Nowadays, only some financial institutions have access to a central bank digital currency. The idea behind the pilot projects that are being developed around the globe is to spread the access to the retail market, allowing not just financial institutions, but also all the other segments of society namely households and small retail businesses.

The ECB states that a digital euro would not imply a replacement of cash, in fact the digital version will work as a complement. It will provide to the households an additional option of payments. In the words of Christine Lagarde "*Our work aims to ensure that in the digital age citizens and firms continue to have access to the safest form of money, central bank money*[1]*"*.

The digital euro would give people an additional choice of means of payment. Not only the ECB, but some others monetary authorities, like the Bank of England, plan to launch their digital currency, primarily, as a complement of cash. Having this in mind, it's not clear to which degree the population would convert their deposits into CBDC. Given that, banks offer numerous benefits for account holders to keep their deposits, a CBDC with limited features may not be attractive to part of the population. In the end, households will choose which payment means is more convenient.

On the order hand, a CBDC with a high adherence may be a problem. If not well-designed, because it could bring in bank disintermediation, putting the central bank as a competitor with the other banks (commercial banks).

The Bank of England (2020) presents some core principles that a CBDC should follow. For a retail market a central bank digital currency should be:

- Reliable and resilient
- Fast and efficient
- Innovative and open to competition.

To fulfill the first core principle, a central bank digital currency must be (i) resilient: be able to recover from an operational disruption; (ii) secure: must provide to its user a secure environment with high standards against cyber-attacks and fraud; (iii) available: the system

[1] For more look at The European Central Bank website: https://www.ecb.europa.eu/paym/digital_euro/html/index.en.html

must support 24/7 payments and transactions; (iv) scalable: being able to support a high increase at the volume of payments; (v) compliant: it should be under some regulation anti-money laundering (AML), and also not be an instrument of finance terrorism; and (vi) private: it must provide data protection. (Bank of England, 2020)

To meet the second core principle fast and resilience stated by the Bank of England (2020). The Central bank digital currency must be: (i) fast: the process of payment from the payer to the payee must be as fast as possible; (ii) user friendly: the platform must be intuitive; (iii) efficient: the cost of transaction must be as low as possible; (iv) transparent: the cost of the use of the platform must be transparent for all the users; (v) inclusive: must be able to minimize barriers.

For the third core principle, innovation and competitiveness, the Bank of England (2020) states that the central bank digital currency must: (i) be designed around comparative advantage: it should be build (at part of it) on the expertise of private institutions; (ii) be open to competition: aiming to facilitate a competitive market; (iii) be interoperable: should be able to process payments from different provider; (iv) extensible: must provide apace for innovation from the private sector.

Let us now address some important aspects like competition, confidentiality, anonymity, crime prevention and bank disintermediation.

3.1.1. Competition and distribution

For the Bank of England (BoE), a high adherence of the central bank digital currency for the households wouldn't let to a scenario where the BoE competes with commercial banks. This is because, the Bank of England (2020) would provide the digital version of the sterling with limited features. Why would the Bank of England promote a digital currency with limited features? To answer this question, I would like to make you think what would happen if the BoE provided all the features for its digital currency, including the interface and all the point-of-sales integrations? If the BoE takes all these responsibilities to itself, the Bank wouldn't let space for competition. The private sector would have no room for innovation, because all the features would be implemented by the BoE, in this scenario the BoE would become monopolist, going in the opposite direction of the principles that were settle earlier in this chapter.

A way to promote competition is the central bank launching a CBDC platform with two key characteristics, the core ledger, responsible to record and process all the payments, and *Payment Interface Providers*, an extension where the private sector would work connecting the end-users. The core ledger would provide a minimum necessary functionality for payments, in order to ensure a reliable, secure and fast system. The Payment *Interface Providers* would be directly connected to the central bank system providing new functionalities, features, and an interface for the households. This way, the central bank concern would be to maintain the core of the system fully working while the private sector launches its innovations and features.

This approach makes easier the operation of the central bank, playing comparative advantage. While commercial banks already have the know-how and the technology to provide services and products to a large number of customers, central banks deal only with financial institutions, promoting a competitive environment. To build an interface, and develop new features, services and products takes time and implies costs. Financial institutions could charge a fee on the transactions or a monthly account fee in order to generate revenue and maintain the viability of the entire system.(Bank of England, 2020)

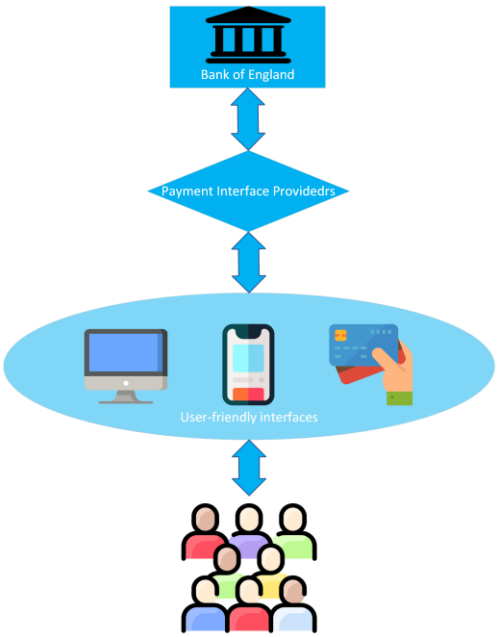
The Swedish Central Bank (Sveriges Riksbank, 2022) found a similar way to promote its e-money in such a way that the central bank wouldn't compete with the private system. At their pilot project the e-krona would have a similar distribution model as cash. The Sveringes Riksbank creates the e-money (e-krona), and this money is distributed via participants in the e-krona network. They call it the two-tier model and would work like the distribution of cash. The participants (commercial banks as an example) would operate as nodes that are able to order e-krona from the Riksbank which are debited from their reserves. The e-krona wallet would be linked to the customer accounts in the participants internal system allowing the households to exchange e-krona and pay with account balance.

The pilot project that is being developed by Sweden aims to create a technology that could be integrated with the internal system of what they call participants. This way the central bank would be responsible for the emission of the money (like is now with fiat money), and financial institutions that belong to the e-krona network distribute it. In this approach, the individual or firm that want to use the Swedish CBDC (e-krona), would necessarily have an account with one of the participants of the e-krona network. The Sveringes Riksbank would not be connected with the customers directly. This is the

participants' task, allowing the customer to open a wallet and link it to an account and exchange their deposits and CDBC (Sveriges Riksbank, 2022).

When it comes to competition, each country has some peculiarities. For example, in the UK there are much more firms in the financial market then in Sweden. The idea behind the creation of a CBDC that allows competition is to protect the private sector, but also to protect households from the creation of new monopolies through a highly concentrated payment providers' market, and increasing the entry barrier for new competitors, and hindering innovation.

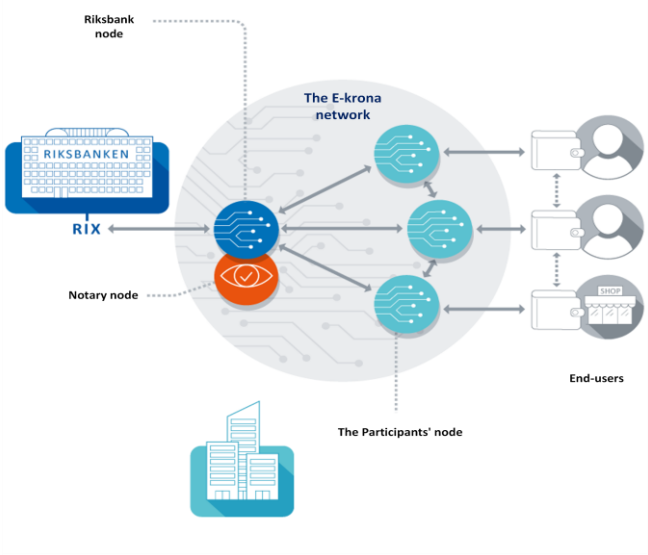
Figure 1: BoE CBDC distribution



Source: Bank of England 2020; Author's elaboration

Figure 1 illustrates how the Bank of England plans to distribute its digital currency allowing the private sector to promote innovation and competition. Figure 2 shows how the Sveriges Riksbank plans the distribution of the e-krona. Even though Sweden and the UK have different financial markets, the digital currency distribution model is similar.

Figure 2: The E-krona distribution model



Source: Sveriges 2021

It is important to mention that every economy has its own peculiarities, knowing that the chosen approach for each central bank may not be the same, but should be similar. China is also developing its digital currency. The distribution model designed by the People's Bank of China (PBOC) follows a similar structure to the ones addressed before. The PBOC is responsible for issuing while commercial banks develop wallet and exchange the digital money for the public (Li & Huang, 2021), resulting in no competition between the central bank and financial institutions. In order to promote a safe environment for competition it is likely that other major central banks choose a similar approach to the British, Swedish and Chinese distribution models.

3.1.2. Confidentiality, anonymity, and crime prevention

Another concern that arises with the launch of a central bank digital currency is about confidentiality and anonymity. One of the great advantages of the use of cash instead of other type of media of payment is that it is not traceable. However, most of the payment with a high value made today are not done with cash. Households and firm process those payments via digital media of payment. But still the central bank should be aware of this concern and provide an answer to it.

As mentioned, the launch of a central bank digital currency will not come with the extinction of money in its physical form. The CBDC will complement cash and provide a safer and risk-free option of digital money compared with other digital assets available in the

market. People can always choose to use cash instead of a digital payment. However, most of the central banks that are planning to digitalize their currency are aware of this concern and through its design and regulation are planning to circumvent this situation providing to the public a digital currency resemblant to cash.

According to the annual payment report published at the Sveriges Riksbank (2021) website, payments in cash in Sweden in 2020 represented 9% of the total amount of payment, and it is possible that the pandemic may have speeded this process. The central bank digital currency would come to complement the use of cash, however in economies like Sweden, where cash plays a minor role, it is possible that the launch of a digital currency will bring the use of cash to a minor role. The central bank will meet the demand for cash as long as it exists. However, it is possible that in the future some societies the demand for a physical media of payment would be diminished.

Regarding the concern about confidentiality and anonymity, it is necessary to design a digital currency that can offer an identical or almost identical level of privacy as cash. Designing a digital currency that replicates the same level of privacy and anonymity as cash is almost impossible. The monetary authority needs to deal with the trade-off between anonymity and crime prevention. One of the great advantages of a central bank digital currency is that the central bank can design it in a way to comply with anti-money laundering regulations and combat the finance of terrorism. But, in order to achieve some level of privacy would need to be lost.

For Bank of England (2020), the British digital currency would need to have privacy regulations like the General Data Protection Regulation (GDPR), which should be applied to the entire CBDC system. An alternative option as suggested by the Bank of England (2020), is to design a CBDC that givers control to the user over who they share the data with.

The digital currency would follow all the anti-crime regulations, being compliant with laws to combat terrorism finance and money laundering, would also be regulated regarding data protection, but also will give to the end user the possibility of not sharing his data with the payee (Bank of England, 2020). In a transaction, the payer would choose if s/he wants to identify her/himself. By doing that, the payee would not be able to collect information regarding her/his shopping habits. It does not guarantee total anonymity like using cash, but this balancing exercise is the right approach. Common citizens would have the guarantee of a level of confidentiality.

The Swedish central bank is designing a digital currency that is token based. Each transaction consists in one or more tokens, after someone uses the token, this token is automatically destroyed and new tokens are generated, one with the amount the payer to the payee and another with the remaining amount to the payer. The ideas behind the use of tokens are to ensure that the payment is valid, the participant will check if the token is genuine, and second, that it would be possible to trace the token back, since all the tokens are issued by the Riksbank it would be possible to track until its origin, the Riskbank. When it comes to confidentiality, the responsibility relies on the participants (financial institutions inside the e-krona network). The participants are not allowed to disclose customer information to unauthorized persons or institutions. (Sveriges Riksbank, 2022)

3.1.3. Disintermediation and the commercial banks' balance sheet

The last concern about the design of the central bank digital currency that will be covered next is about the remuneration. If a central bank digital currency should be or should not be interest bearing.

A digital currency issued by the central bank available to the population will bring about bank disintermediation, given that an exchange between deposits into CBDC will have the same effect as a withdrawal of cash at an ATM. If households exchange banknotes into CDBC, this trade will maintain the commercial bank' balance sheet unchanged. However, if the trade is between bank deposits into CBDC the balance sheet will become shorter (Bindseil, 2019). Let us illustrate how this may occur to a bank balance sheet.

An exchange between deposits into CBDC has the same effect of a withdrawal of cash on any ATM. When a person chooses to exchange 20 euros from its deposits into 20 CBDC, for the person the only thing that has changed is the composition of its portfolio. Now, that person has less 20 euros in deposits and more 20 in CBDC. The bank loses 20 euros of deposits (liabilities) and 20 euros in reserves (assets), contracting its balance sheet by 20. (Bank of England, 2020, p. 36)

The exchange of deposits into CBDC would affect the funding costs of the banking system. This is because sight deposits are one of the cheapest sources of funding, and the launch of a CBDC would affect the households' composition of wealth (Bindseil, 2019, p. 315). Households might shift part of their wealth from deposits in commercial banks into CBDC. The CBDC will be recorded as a liability on the central bank's balance sheet and

backed by assets held by the bank (Bank of England, 2020, p. 35), with an effect on the monetary aggregates (M3). Short/medium term deposits represent an important participation of the bank funding and, with less deposits, commercial banks would need to use more expensive sources of funding like central bank credit or bank bond issuance.

If a large exchange of deposits into CBDC occur, commercial banks may not have enough high quality collaterals to obtain the reserves that they need (Bank of England, 2020). On one hand, the commercial banks would be more dependent of credit from the central bank. On the other hand, if there is a big shift away from deposits, the central bank would have to hold more risk collaterals from the commercial banks (Bindseil, 2019).

However, the current trend is that the new types of media of payments are already causing bank disintermediation, and the CBDC would help to manage the disintermediation. According to the Bank of England (2020, p. 37): "*CBDC could give the Bank more opportunity to manage these risks and, depending on its design parameters, may not result in greater disintermediation than is expected regardless of the introduction of CBDC".*

Depending on its design, the disintermediation can occur in a small or big scale. An unremunerated CBDC currency may not have the same appeal as a remunerated one. In any case, in order to succeed, the CBDC will give origin to some disintermediation. The adherence to the digital currency defends on the benefits the population recognizes in its use and their decision to adjust their portfolio composition in order to allocate some CBDC into it. (Bank of England, 2020)

The process of disintermediation can cause some damages to financial institutions, especially at the balance sheet. In order to decrease those damages, the central bank can design in a way to protect the private sector, like lowering the monetary policy rate, or limiting the amount of CBDC for an individual, implementing a remuneration system, opening to competition and delegating the responsibility of the distribution to the financial institutions. The financial institutions sector can also create mechanisms to protect themselves and smooth the damages that may occur, like increasing the interest rate paid on deposits as example.

Kumhof and Noone (2018) proposed some design features for the introduction of the CBDC, if those features are followed bank funds will not be significantly reduced and the liquidity provision to the financial institution does not contract. Such design features would be: (i) CBDC pays interest rate, (ii) CBDC and reserves are distinct, and not

convertible into each other, (iii) bank deposits would not guarantee convertibility on demand of CBDC, (iv) the central bank issues CBDC only against eligible securities. Some of those features could be problematic regarding their practical feasibility, especially the one concerning convertibility.

Therefore, it is possible that the central bank and the private financial institutions will create mechanisms to smooth the damages of a bank disintermediation.

3.2. Central Bank Digital Currency and the Zero Lower Bound

This section addresses the remuneration design of the central bank digital currency and three design proposals for applying remuneration on a digital currency.

The remuneration design of CBDC may be considered one of the most important aspects of digital currency. Should the central bank digital currency bear interest? This question is most of the times the center of the discussion. Now, let us go in more detail whether a digital currency should bear or not interest.

If a central bank wants to design a digital currency that has 100% of resemblance to cash, that digital currency must not have interest bearing. Money in its physical form has zero nominal remuneration, so a digital currency that wants to possess only the characteristics of a banknote should not have any type of remuneration attached to it. However, in this case, it may not have the same attractiveness as a remunerated one. The best appeal that the CBDC will have been to be a risk-free money. It should be noticed, however, that a central bank digital currency is a risk-free money. (Bank of England, 2020)

In fact, a non-remunerated CBDC brings no difference regarding the monetary policy, it only reinforces the operation of the lower bound. The (zero) lower bound puts a limit to how low the interest rate can go, if the interest rate falls below zero, households could exchange their assets into banknotes and hold it. However, it's hard for the banks to face all the withdraws, because it involves costs in terms of reserves as well as storage and logistics. With a digital currency households can simply exchange their assets into CBDC if the rates fall below zero, reinforcing this limit (Bank of England, 2020). Until now most of the central banks that are studying a way to issue their digital currency plan to launch it with no interest bearing. If the central bank chooses to remunerate, households may think that the CBDC is some type of investment giving room for speculation, and by the time that this "investment" loses its attractiveness they may want to switch to order types of assets.

In times of financial instability, the shift of deposits into CBDC may occur so fast that can cause severe liquidity problems to some financial institutions. During a bank run when the agents try to exchange the assets in their possession into cash, they may face a problem. Commercial banks usually keep in its bank branch the sufficient amount of cash to face the daily operations. Since the amount of physical money available is only a fraction of the demand for liquidity the banks won't be able to satisfy all the demanded withdraws. With a digital currency this limitation is not present and, economic agents would be able to change their assets into CBDC causing more damages to a bank in case of a bank run.

According to the European Central Bank (2020), a digital euro may be remunerated for monetary policy reasons and for financial stability. At the Report on digital euro, the ECB states that in order to prevent that the digital euro becomes a large investment intermediary, remuneration could preserve the role of euro in retail payments. The Sveriges Riksbank (2018) mentions some impacts of a non-remunerated e-krona. Right now, the bank is testing their pilot project and their biggest concern is about the technology and legal legislation. However, it is possible that the e-krona has interest bearing. The Sveriges Riksbank follows a similar logic as the European Central Bank. A non-remunerated e-krona may put an effective zero lower bound on all interest rates, adding a limitation to the monetary policy. However, if there is no limitation, the rates can go below zero (Armelius, 2020).

The digital currency that is now being developed by the People's Bank of China (Central Bank of China) will not bear interest (at least for now), in the words of the People's Bank of China: "*is a substitute for M0. Thus, it is treated the same as physical RMB under M0, which carries and pays no interest"* (People's Bank of China, 2021, p. 7). The PBOC does not specify if the e-CNY will bear interest. On the other hand, some central banks like the European Central bank do not exclude the possibility of designing a digital currency that have remuneration attached to them.

A Central Bank Digital Currency that bears interest increases the toolkit of monetary instruments at the central bank disposal. By attaching some type of remuneration, the Bank can use its interest rate as a transmission channel of the monetary policy.

Now let us present two suggestions of how a CBDC could be remunerated. First, if the monetary authority can design a digital currency that may help to achieve its aims, why not do it? Kumhof and Noone (2018, p. 11) supports the idea of remunerating the CBDC "*why would the authorities give up control over a second policy instrument when there is no necessity to do*

so…". One suggestion is to apply a remuneration on a central bank digital currency is using the two-tier remuneration system.

A two-tier approach is proposed by Bindseil and Panetta (2020), and it can work as follows: at the tier-one the central bank could apply an attractive remuneration rate setting a limit on the quantity of CBDC. Here, the central bank could commit to never apply a remuneration lower than zero on tier-one. By doing that, householders and firms that may use the CBDC as a medium of payment would be attracted to use it. While, at the second tier the central bank can remunerate in a way to discourage the use of the CBDC as a store of value.

Central banks are developing the digital version of their currency in order to promote a new option of media of payments for citizens. If the central bank does not regulate putting a limit on the possession of its digital currency it's possible that the account holders use it as an investment, in order words, the central bank would allow that its digital currency becomes a large-scale store of value, according to Bindseil and Panetta (2020): "*the central bank would effectively become an intermediary for private savings…".* The digital currency is being designed to work as an alternative media of payments and unit of account for the retail market, the store of value function should not play a primary role. If it does the e-money would become an investment, instead of an alternative media of payment, by doing that would give space for big players to speculate on a national currency.

That is why it is important to implement at least a second tier of remuneration. After a certain quantity of CBDC in the possession of the account holder, the central bank would implement a less attractive rate in order to prevent that the digital currency becomes a store of value (investment option). Central banks already apply this type or remuneration to bank deposit. (Bindseil, 2020b)

As to the European Central Bank, according to (Bindseil, 2020b, p. 24): "…*since the launch of euro in 1999, required reserves were remunerated at the rate of the main refinancing operating, while excess reserves were remunerated at zero…".* Central banks already have an experience using this type of system. However, the central bank does not need to be restricted to a two-tier system, this type of system allows a multi-tier remuneration. As an example, the Bank of Japan (BOJ) implemented a three-tier system with a positive interest rate, a zero, and negative (Bindseil, 2020b).

A multi-tier remuneration system has some advantages, the central bank would be able to explore a new instrument of monetary policy reaching negative areas, being extremely useful in times of financial stress. Bindseil (2020b) advocates in favor of this system, for him "*It allows assigning the payment function of money to tier one CBDC, while the store of value function would be assigned to tier two"*. That way it can prevent the central bank to become an investment intermediary. By doing that, households that are willing to use CBDC as a medium of payment would be preserved at tier one, and also, it would preserve the ability of the central bank to explore the negative interest rate policy (Bindseil & Panetta, 2020).

Regarding the quantity of the tier one, the central bank could implement a quota. Bindseil (2020b) explains that an amount of 3000 euros monthly could cover the average monthly net income of euro area households. This quantity would be assigned to the tier one, meaning that the remuneration would never be lower than zero, and for quantities above that level would be assigned to tier two. Tier two would be less remunerated that the one, and also would be able to follow the monetary policy that the central bank would be implementing at the moment, allowed to be negative. For the firms, the central bank could provide an allowance with the size of the presumed payments that the company needs to make. This allowance would have a remuneration set to zero (Bindseil, 2020b).

To sum up, the multi-tier system proposed by Bindseil and Panetta (2020) could solve the lower bound limit and allow central banks to go into the negative area. The ECB could offer (in sufficient quantities to be use as means of payments) CBDC at an interest rate that is never lower to that on banknotes (never below zero), and for others means it can implement an interest bearing. This way could maintain CBDC as a medium of payment and not a large-scale store of value.

The use of a multi-tier remuneration is suggested to increase the monetary policy toolkit at the disposal of the central bank helping to overcome the lower bound. Most of the central banks that are about to create a digital currency plan it as a complement to banknotes, and they do not have the intention (at least now) to stop issuing cash in its physical form. However, if the central bank chooses to discontinue the issuance of banknotes, it does not necessarily need to implement a multi-tier remuneration system.

A second suggestion to apply remuneration on central bank digital currency is to dissociate the function unit of account from banknotes (physical currency), allowing then to be the only medium of payment and store of value. The function unit of account would be

a characteristic of the digital currency. This idea is an adaptation of what was proposed by Eisler (1932).

Eisler (1932) proposed the introduction of two types of money, named "money banco" and "current money" respectively. The first one, money banco, was meant to be the unit of account, all the contracts in the country were supposed to be settled using the money banco. The second, current money, was meant to be used as a medium of payment and store of value. According to the author, a rate of conversion would be applied according to a weekly index-number. This would act as an interest rate, for people to have access to the money that function as medium of payment they would need to exchange the money banco (money on which income is valued and settled) to current money (media of payment).

Bringing this discussion to present days, Buiter (2009), Agarwal and Kimball (2015), and Assenmacher and Krogstrup (2018) propose similar ideas to decouple money in physical and digital forms.

This system would work as a dual local currency system. The central bank would issue two types of currency, an electronic (digital) and a physical (banknotes). The central bank digital currency would have the function of unit of account in the economy, which means that all the contracts (wages and taxes for example) will be settled in terms of the central bank digital currency, while the function of means of payments and store of value would apply to the banknotes. For the households to exchange their digital currency into banknotes would be applied a conversion rate (Agarwal & Kimball, 2015), this fee should follow the monetary policy that is implemented by the central bank. This conversion fee would work as a channel of monetary policy increasing the monetary policy toolkit at the central bank disposal.

By means of the implementation of a dual local system, the central bankwould be able to circumvent the zero lower bound. In the words of Assenmacher and Krogstrup (2018, p. 5) : "*Decoupling cash from electronic money, in effect of establishing a dual local currency system, would allow for implementing substantially negative interest rates without a large-scale substitution into cash, by engineering a similarly negative yield on cash in terms of electronic currency".*

The idea of decoupling the function of money is not new, and it's been adapted over the years with the development of the technology. It was stated by Eisler (1932), and then Gesell (1958) with the demurrage fee (stamped currency) to discouraging massive storage of cash when the interest rates are low. But until the launch of a CBDC those ideas could be

costly and hard to implement, the launch of CBDC would come to facilitate this implementation.

An important characteristic that should be mentioned is that none of the suggested proposals to apply remuneration on central bank digital currency in order to increase the monetary policy toolkit at the central bank disposal and circumvent the zero lower bond requires the abolishment of cash. In both cases cash will still have a role in the economy. In countries like Sweden and Norway where cash plays small role, the launch of a digital currency issued by the central bank could represent the "extinction of cash", but that characteristic would come from the demand side, which means that households would not be willing to hold and use banknotes.

In this section, three suggestions were presented for the economic design of the central bank digital currency. The first one was to design a CBDC that will act just like banknote, which means, it would be a representation of cash in a digital way. Regarding to remuneration, since cash has no nominal remuneration, the same remuneration would be applied to the CBDC. As an example, the People's Bank of China already announced that the e-CNY would have no interest bearing just like cash. A problem with that approach is that it reinforces the zero lower bound. For countries that have problems with the ZLB this does not represent a solution.

The second approach is to implement a two-tier (or multi-tier) remuneration system as proposed by Bindseil and Panetta (2020). It consists in implementing at least two types of remuneration on CBDC. At the first tier the central bank should be committed to never apply a negative interest rate on it, the reason why that tier is supposed to be used as media of payment by the agents in the economy. To prevent agents to store CBDC the central bank would use tier two, with an unattractive rate in order to discourage households to store CBDC preventing the central bank to become an intermediary for private savings.

The third approach is to decouple cash from central bank digital currency. The dual local system was proposed first by Eisler (1932) and with the years other authors adapted this approach to the reality that they were living at the moment. Bringing this idea to present days, it represents the dissociation of the unit of account function from fiat money, in the scenario all the contracts would be settled in CBDC and, it would be implemented a conversion rate to exchange digital money into banknotes. This rate should be linked to the monetary policy rate, working as an instrument of economic policy increasing the monetary

policy toolkit at the central banks' disposal. Only the second and third approaches help the central bank to circumvent the zero lower bound.

4. How China and Sweden are implementing their CBDC pilot program

In this chapter a description of how China and Sweden are implementing their digital currency pilot projects is and what are the similarities between those two projects. It is also shown what are the core principles that guide their designs and how they fit those defined in chapter 4.

4.1. The Chinese case

The People's Bank of China was one of the first central banks from a major economy to conduct research on how to develop a digital fiat currency. Early in 2014 a task force was set up to work on this project and by the end of 2017 started to work with commercial institutions to develop and test the digital fiat currency (see at Sveriges Riksbank, 2018). This was called Digital Currency Electronic Payment (DC/EP); however, the name of the currency is e-CNY. The e-CNY is a digital version of a fiat currency issued by PBOC and operated by authorized operators. Xu (2022) defines it as a centralized digital cash designed to gradually replace traditional paper cash and coins (M0). (see at Sveriges Riksbank, 2018)

The Chinese digital currency is being designed to replace M0 so it will fulfill all the three functions of money, be unit of account, store of value and media of exchange. Like fiat currency, the e-CNY is distributed via a two-tier system, in which the state has the right to issue. In a single-tier operation model the central bank would direct provide e-CNY to households and companies. According to Xu (2022, p. 244) this type of system "*distracts the central bank from the mission of monetary policy making*" . He also states that this system would directly expose the central bank to unknow risks that could affect the monetary system. A way to prevent or reduce the exposure of the central bank to those risks is to adopt a double-layer system, another reason for the use of this type of distribution is because it also supports competition through the private sector.

Different from other types of digital money, the Central Bank Digital Currency is an official currency supported by the government and, because of this legal form, residents must accept this type of payment. As a legal tender they must accept the currency. The first experiment on e-CNY took place in October of 2020. China conducted an experiment in

Shenzhen sending to 50 000 randomly selected citizens 200 e-CNY to be used in offline[2] transactions among 3389 shops. The offline payments are supported via Bluetooth and NFC (Near Field Communication).

The e-CNY was designed to supply the needs of the retail market supporting very small transactions. The first core principle is reliability and resiliency. The offline payments supported via Bluetooth and NFC would reinforce the commitment to launch a 24/7 payment service meeting the requirements of the reliability and resiliency principle. (Sveriges Riksbank, 2018)

To support anonymity and also meet compliance requirements (like anti-money laundering) the e-CNY relies on a managed anonymity or semi-anonymity system. Different from total anonymity that provides anonymity to all the parties, in a semi-anonymity system the anonymity is only between transaction parties, and it is not anonymous for the central bank. The People's Bank of China provides to the end users privacy in small value transactions while it also supports the prevention of crimes as money laundering by tracing high value transactions (Bhattacharya, 2022).

In the Chinese case to open a wallet and make transactions with the e-CNY the minimum requirement is a mobile number. With only the mobile number the transactions are limited at their value, and in order to increase the number of transaction and also the value associated to it the user should provide more personal information. For small value transactions the payer can choose not to identify himself to the payee, by doing that the payee would not be able to collect data and build a shop profile. The mobile number represents the minimum requirement to possess and exchange e-CNY and the maximum requirements includes a valid identity document, a bank account and a visit to the bank branch to deal with some paperwork. (Xu, 2022)

It is important to mention that some rules about data protection and accessibility also need to be settled to protect and provide privacy to the users. When it comes to security the e-CNY uses encrypted character strings; this type of encryption is considered safe because it cannot be decrypted in a reasonable amount of time. (Xu, 2022)

[2] The three main differences from the e-CNY to a cryptocurrency is that the first is an official digital currency, supports offline transactions and supports semi-anonymity.Xu, J. (2022). Developments and implications of central bank digital currency: The case of China e-CNY. *Asian Economic Policy Review*, *17*(2), 235-250.

Let us remind the core principles settled in this work. Reliability and resilience are the first one, to fulfill this principle the digital currency should: (i) be resilient; (ii) secure; (iii) available; (iv)scalable; (v) compliant; (vi) private. (Bank of England, 2020)

The e-CNY fulfills some of the core principles mentioned in the section (see Xu, 2022 and Sveriges Riksbank, 2018). For the first core principle, reliability and resilience, (i) the two-tier distribution system of the e-CNY allows the currency to be resilient; (ii) Making the PBOC feasible to solve a possible operation disruption without putting the monetary system in danger, is secure; (iii) The type o encryption that the e-CNY is based provides a safer environment to the users, being available 24/7, it supports online and offline payments; (iv) It is scalable, the PBOC designed a e-currency that can support a large number of payments the experiment made on November of 2020 registered a transaction value of almost RMB 34.5billion; (v) The semi-anonymity system ensure that the e-CNY meets the requirements of the privacy; and (vi) compliant anti money laundry regulation.

For the second core principle, fast and efficient, the requirements are (i) be fast; (ii) user friendly; (iii) efficient; (iv) transparent; (v) inclusive.

When it comes to the second core principle, fast and efficient, there is not much to say, since the program is still on an experiment stage. However, the e-CNY will work as a double-layer operation system, the PBOC will be responsible to issue and the commercial banks to distribute. (i) By doing that the PBOC allows the commercial institutions to use their technology and it is expected that payments are processed in a fast way; Alibaba's Oceanbase system can support up to 61 million of transactions per second. (ii) Because of the two-tier distribution system, the private institutions would be the ones to develop a user friendly interface; (iii) it also would be more efficient and (iv) less costly; (v) the offline option would allow to include more people in the digital era, especially the ones that lives in an region with a bad quality internet server. (Xu, 2022)

For the third one, innovative and open to competition, the requirements are: (i) be designed around comparative advantage; (ii) open to competition; (iii) interoperable; and (iv) extensible.

The third core principle innovation and openness to competition. The design of the e-CNY aims to (i) support comparative advantages; (ii) competition; (iii) interoperability between the players of the market and (iv) also must be extensible. Summing up, the e-CNY

that is being designed by the People's Bank of China seems to follow all the core principles mentioned here.

The remuneration design consists in the way that the central bank will design the remuneration feature of digital currency in order to help to achieve its aims. The e-CNY is the digital fiat currency issued by the People's Bank of China with the aim to replace cash (M0), which means would pay no interest (People's Bank of China, 2021). Different from some order major economies, China does not need to deal with the lower bound problem. The PBOC is still able to use the conventional instruments of monetary policy to stimulate the economy.

To convince their citizens to use the e-CNY, during the pilot program China randomly selected residents in the region that they were implementing the pilot and gave e-CNY to them. By doing that, the government is stimulating the society to download the wallets, store e-CNY and purchase goods and services via digital currency. This is a way to spread the use of the e-CNY and also stimulate people to experience this new type of medium of payments, after experiencing all the possibilities at their disposal the residents should choose the medium of payments that is more convenient to them.

4.2. The Swedish case

Another country that is considering to adopt an e-currency is Sweden, where the Sveriges Riksbank has been conducting studies on how to digitalize its currency since 2017. Digital payments play a major role in the Swedish economy, and payments in cash in Sweden represented 9% of the total amount of payment in 2020 (see Sveriges Riksbank, 2021).

The marginalization of cash raises concerns about the competition and resilience of the payments system. A characteristic of this industry in some countries, like Sweden, is that in this market is highly concentrated among a few players. In the past if the digital payment service were not efficient, households would convert its digital payments into cash. However, with the disuse of cash this threat does not have the same impact. The rapid disuse of cash in the Swedish economy is causing an unnecessary exposure of the citizens to private payment companies making them dependent of the service of those companies.

If the central bank does not act it is possible that the residents in Sweden be entirely dependent on private payments solutions (Sveriges Riksbank, 2018). This seems as a reason for the creation of a state-guaranteed means of exchange (Armelius et al., 2020).

The purpose of the e-krona is to manage potential problems on the payments system and ensure that the residents have access to central bank money. An e-Krona is being designed to meet the need of the households, providing a safe environment for smaller transactions. In 2019, the Swedish central bank created a special division to develop the pilot project of the e-krona (see Sveriges Riksbank, 2018).

As to the distribution of the e-krona, the option is to follow a model similar to the distribution of cash. The Sveriges Riksbank is the only entity that can create or destroy e-krona. The e-krona will be issued by the Sveriges Riksbank and the participant (commercial banks or order types of companies) of the RIX network would have the right to distribute it, so called two-tier distribution model, very similar to the e-CNY. One of the advantages of this model is that it allows competition among the approved participants.

The participants would operate in nodes and could order e-krona from the Sveriges Riksbank and the same amount would be debited from its reserves. The participants would have the job to connect to the households, like they do now and, by doing that, the Sveriges Riksbank allows the participants to promote innovation and create new services to the residents. With those services, like a user-friendly interface, the participants could charge fees to obtain income.

One of the major concerns of the Sveriges Riksbank is the technology behind the e-krona. The bank stated a partnership with some companies in order to develop a system that is safe and reliable and also is able to support numerous flows of data at the same time.

Let us now see how the design of the e-krona fits the principles addressed in this work.

As, to the first core principle, reliability and resilience, the Sveriges Riksbank is putting a hard effort in develop a system that is (i) resilient, that is, which is able to recover from an operational disruption; the technology supporting the e-krona is the R3 Corda based on a distributed ledger technology, and by far seems to be one of the most (ii) secure technology available; the Sveriges Riksbank is also developing a system of payments that allow (iii) offline transactions to ensure 24/7 payments. The (iv) two-tier operation system allows participants to operate on the Sveriges Riksbank node linking to their own technology making the system able to be scalable. When it comes to the regulatory status, the bank shows concern about a new regulation, for them the one that exists today does not supply the needs of a digital currency, and there is no doubt that (v) the new regulation that they are working on will be compliant with contemporary needs like anti-money laundering, as an example, and (vi) protect data privacy (Sveriges Riksbank, 2018).

The second core principle is fast and efficient. The technology that the system is being build, R3 Corda, would allow (i) a fast process of information. Like the Chinese case, the participants would be responsible to develop the interface of the platform and, by doing that the Sveriges Riksbank allows the participants to compete via developing (ii) a user-friendly platform. The participants would create the best experience that they can provide to the end users. The participants would also seek for (iii) efficiency, creating these interface at the lowest cost; (iv) transparence would also be an important instrument of communication with the customers showing the possible costs, like accounts fees, that the end-user could have since; and (v) would be inclusive, allowing people from different segments of the society to have access to an electronic wallet. (Sveriges Riksbank, 2018)

The third principle is innovative and open to competition. The e-krona distribution design allows the participants to (i) explore its comparative advantage; while (ii) also make sure that it is open to competition between the players at market. Today, the participants work at the RIX system to (iii) provide interoperability between the participants and the residents, and with the e-krona would work at the same way, and also (iv) would be able to extend the range of facilities that the participants may develop in order to be more appealing to the residents.(Sveriges Riksbank, 2018).

It seems that both digital currencies follow similar principles and structures. A topic that raises some concern is the anonymity and the remuneration feature. The anonymity feature would work as the one explained at the Chinese model, partly anonymous payments, small payments could be made anonymously (Sveriges Riksbank, 2017).

When it comes to the remuneration feature, would the e-krona bear interest? At the moment, the e-krona is not expected to pay interest; like in the Chinese model, it is being designed to replace M0, cash. But it is important to state that the e-krona is being built to make possible to accrue interest at a later point (Sveriges Riksbank, 2017).

Conclusions

The development of the means of payments is causing a decrease in the use of cash as medium of payment. Since the creation of debit/credit cards households are willing to substitute, at least, part of their transactions, from cash into deposits to be able to use cards. Nowadays, there are numerous ways of processing a payment, the households would choose the most convenient way to make their transactions.

The cost of storage, transportation, and risk of loss could be some of the numerous reasons why cash plays a less convenient performance in high value transactions if we compare with online payments. Another reason is the convenience to shop online makes more appeal to hold money in a bank account instead of cash. The digitalization of the means of payments is already happening, in Sweden for example, less than 10% of the payments were made by cash in 2020, and the COVID-19 pandemic just helped to speed this process.

Until now, cash is the only form of payment issued as legal tender, all the other options are private based. The marginalization of cash exposes the citizens to private payments providers, making them dependent of those services. In the digital era, it is important that the households have access to state-guaranteed means of payment (Armelius et al., 2020) .

The digitalization of a state currency arises as the answer to the concern above. The design of this new asset would also help overcome the zero lower bound. A well-designed central bank digital currency would help increase the monetary policy toolkit at the central bank disposal and help to achieve its objectives.

Some institutions like the Bank of England and the Bank of International Settlements propose three core principles that a central bank digital currency would have: (i) be reliable and resilient; (ii) fast and efficient; and (iii) innovative and open to competition. In this work is also cover three ideas for a remuneration design of a central bank digital currency. The first suggestion is to design a currency that replicates cash, in order words, it will not have any interest bear attached to it. The second proposal is to implement a two-tier (multi-tier) remuneration system, similar to what the central banks already does in the reserves of the commercial banks. The third is to implement a two-currency system, decoupling the function of unit of account from cash, allowing them to work only as means of payments and store of value. The digital currency would be the unit of account in the economy.

In this work was covered how China and Sweden are implementing their pilot projects of an e-currency. Both cases try to follow the same core principles, however it is still too early to say exactly how both e-currencies will be designed. There are some concerns

regarding the technology that will support the system, both countries are developing and testing the system that will support the currency.

Another concern relies on the data protection regulation, for Sweden as an example, it will be necessary to create new regulations for the treatment of data that supports the citizens' rights, according to the Sveriges Riksbank the regulation that the country has today is obsolete and does not support the need of a digital era. Related to this topic, the central banks are trying to build a digital currency that supports anonymity and at the same time is compliant to some regulations, like anti money-laundering, and terrorism finance as an example. The best way found to circumvent this problem is to implement a managed anonymity or semi-anonymity system. In this system, the end user would choose if s/he wants to identify itself for the payee, this feature will work for small value transactions.

When it comes to the remuneration design, the monetary authorities in both countries are not inclined for the moment to implement any type of interest bearing on its digital currency, designing it with the same functions as cash. Nevertheless, the central bank of Sweden states that its digital currency could bear interest in the future, because of it, the country is designing its currency in a way to support this feature. At the current stage, the central bank would not pay interest on the digital currency as an instrument of monetary policy.

This new type of currency would change the economy, in numerous ways, to name some it will allow smart contracts to be settled, the CBDC will allow to create programmable money, it is going to be possible to establish some pre-defined criteria and the transaction will be self-executed if the following criteria were met; improve the performance of cross-border payments; and will also allow to government to collect taxes instantly. However, it is still not clear which problems may arise, the implementation of the currency is still in the early stages. For a better understanding of the real impacts that the launch of this currency may cause it is needed more information about their performance and further research will be needed.

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