

**CENTRAL BANK DIGITAL CURRENCY: CASES  
OF SWEDEN AND GREAT BRITAIN**

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**Author: Petteri Virtanen  
Subject: Economics/Banking and International Finance  
Supervisor: Juha-Pekka Juntila**



JYVÄSKYLÄN YLIOPISTO  
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**ABSTRACT**

Author Petteri Virtanen	
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<p>Abstract</p> <p>Competition from private digital currencies has driven innovation from the central banks around the world to research a third alternative form of central bank money in addition to cash and reserves. The third alternative is the Central Bank Digital Currency. Another major driving force for CBDC is the decline in cash usage and the need for better settlement systems.</p> <p>In this thesis, CBDC is studied from the financial stability perspective to see how financial stability and payment systems are discussed in the literature of CBDC. Bank of England and Swedish Riksbank were selected as case studies in this thesis because of their early work and developments in CBDC. Since the CBDC research field is currently developing, the research was conducted using integrative research methods and database searches.</p> <p>After evaluating the literature, the main findings of this thesis are that according to the literature, there seem to be positive effects from the adoption of CBDC. Especially in terms of the efficiency of the monetary transmission process. Risks associated with the introduction of CBDC are somewhat notable but would be overcome depending on the adoption type of CBDC. The possible implications of this research are that further research is needed in the practical adoption methods. However, the theoretical aspects seem to be already ready for early adoption in the Bank of England and Riksbank.</p>	
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## TIIVISTELMÄ

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<p>Tiivistelmä</p> <p>Yksityisten kryptovaluuttojen kilpailu perinteisen käteisrahan sekä vähimmäisvarantojärjestelmän (reservi) kanssa on ajanut keskuspankit ympäri maailman tutkimaan kolmatta vaihtoehtoista keskuspankkirahan muotoa käteisen ja reservin ohelle. Kolmas vaihtoehto voisi nykytutkimuksen perusteella olla keskuspankin digitaalinen valuutta (CBDC, <i>Central Bank Digital Currency</i>). Merkittäviä CBDC:n tutkimuksen edistämiseen vaikuttava tekijöitä ovat käteisen käytön väheneminen sekä tarve uusille maksuselvitysjärjestelmille.</p> <p>Tässä tutkielmassa tarkastellaan keskuspankin digitaalista valuuttaa rahoitusvakauden näkökulmasta. Pyrkimyksenä on selvittää, kuinka tällainen valuutta vaikuttaa rahoitusvakauteen sekä maksujärjestelmien käsittelyyn.</p> <p>Koska CBDC-tutkimusala on vasta kehitymässä, tutkimus toteutettiin käyttämällä integratiivista kirjallisuuskatsausta sekä akateemisten tietokantahakujen avulla. Iso-Britannian ja Ruotsin keskuspankit valittiin mahdollisiksi varhaisiksi keskuspankin digitaalisen valuutan käyttäjiksi, koska nämä keskuspankit ovat tehneet tutkimusta CBDC:n osalta jo pitkään.</p> <p>Tutkielman päähavainnot ovat seuraavanlaiset: Keskuspankin digitaalisen valuutan käyttöönotolla vaikuttaa olevan positiivinen vaikutus eritoten rahapolitiikan välittämisen tehokkuudessa kansantalouden eri alueille. Keskuspankin digitaalisen valuutan käyttöönottovaiheessa on useita riskejä liittyen finanssi- ja pankkisektoreiden vakauteen. Kuitenkin useat tutkimukset osoittavat, että pankkivakauteen kohdistuvat riskit voidaan oikeanlaisilla toimilla välttää. Rahoitusteorioiden osalta tutkimus toteaa, että CBDC:n ensivaiheen käyttöönotto on jo mahdollista Iso-Britannian ja Ruotsin keskuspankeissa. Tutkimuksen mahdolliset käyttökohteet ovat CBDC:n käyttöönottovaiheen riskien tunnistamisessa.</p>	
Asiasanat CBDC, keskuspankki, raha, valuutat, rahoitusvakaus	
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**LIST OF ABBREVIATIONS****PAGE**

AML : Anti Money Laundering	59
API : Application Programming Interface	57
BoE: Bank of England	51, 53
CBDC : Central Bank Digital Currency	passim
DCA : Digital Currency Area	14
DLT : Distributed Ledger Technology	passim
ECB : European Central Bank	passim
ELB : Effective Lower Bound	24
Fed: Federal Reserve System	53
FMC : Fundamental Modeling Concept	50
MTM : Monetary Policy Transmission	23
NIRP : Negative Interest Rate Strategy	24
OCA : Optimum Currency Area	14
PIP : Payment Interface Provider	25
QE : Quantitative Easing	23, 34, 35, 59
RIX : The Swedish Payment System	57
RTGS : Real-Time Gross Settlement	52, 57
SEPA : Single Euro Payments Area	10
SMR : State Machine Replication	25



# 1 INTRODUCTION

When looking back into the 1940s or 1950s, it was clear to the public that money was strictly in the form of cash. It would have been very difficult or even outright impossible for researchers to think that in less than 60 years, the whole monetary system would be worldwide, with transactions to another side of the world being frequent, necessary, and instant. For consumers, the rise of applications such as Google Pay and Samsung Pay as payment providers and other more centralised digital wallets such as Alipay and WeChat in China to M-Pesa in Africa have transferred the global payments to be instantaneous. The outcry took place when Facebook revealed their plans for their own currency Libra. After their Libra plans were announced, the policymakers started to understand the need for their digital currencies.

There are many major innovative implications where digital currencies can be used or are used at the very moment. Digital currencies can “unbundle the functions served by money” in a way that could not have been even imagined three decades ago. The issuance of such currency does not necessarily have to serve every function of money (store of value, a medium of exchange, and unit of account) Nevertheless, instead, take one of the key functions and specialise.

One example is data gathering and social networking services. Data is treated as currency or social gathering where data objects, for example, in video games, are given value in other currencies (CS Go as one). Since these types of Digital Currency links are not necessarily country or even continent-specific but instead particular group, according to Brunnermeier, James, & Landau (2019a), there is a growing demand to create competitive digital currencies for the sovereign states. Using their own digital currencies, central banks can avoid digital dollarization which takes a historical term coined in the Bretton Woods era to our modern digital world. In order to retain monetary independence, sovereign states should create digital currencies to compete with modern dollarization platforms such as Libra. Central Bank Digital Currency can help to cope with the competition. (Brunnermeier M. a., 2019a)

The implementation of a central bank digital currency, or CBDC, is openly discussed by central banks and policy-making institutions. It is conceivable that the implementation and acceptance of CBDCs would be a milestone for the monetary and financial systems of advanced economies. Central banks can be turned into financial intermediaries that have to deal with conventional banking problems, such as the transition of maturity and exposure to liquidity demand. Banks are vulnerable to runs due to the optimum amount of risk-sharing. Can the transition of maturity still happen with a CBDC at the socially optimal level?

Ulrich Bindseil from the European Central Bank argues that the CBDC could be a third alternative that central banks could offer worldwide. The first is the overnight deposits offered for banks, certain financial institutions, and official sector depositors, with the second being the banknotes. (Bindseil, 2020)

European Central Bank has been analysing the payment systems thoroughly throughout all its existence. After the success of front-end development (the Single Euro Payments Area (SEPA)) system, the “back-end” of payment systems seems to have stalled<sup>1</sup>. There is no unified way for payments to be made instantly in electronic form in Europe. Even though efforts have been taken for ECB to encourage private frameworks or private payment initiatives, it seems that the Euro area is going towards CBDC with ECB continuing research in 2020. (European Central Bank, 2019)

Some developments and practical implications for CBDC can be seen from the Swedish Central Bank, i.e., The Riksbank. Their study series of E-krona will be discussed in Chapter 4, but it is already worth noting that there are actual roadmaps that the Riksbank has already made. Riksbank justifies their research with the significant decreases in cash usage as it has declined by 50 per-cent from the 2008 financial crisis. (Morten;Faruqui;Ougaard;& Picillo, 2018)

The background in the eurozone and Sweden, and Great Britain for CBDC vary between these countries. The eurozone specific adoption needs stem from the following points. Firstly, the use of cash is still relatively high. Almost 79% of all transactions in the eurozone were made using cash in 2019. (European Central Bank, 2020). However, there are estimates that cash usage drops in some countries by over 9% in the next two years (European Central Bank, 2020). For Finland and Sweden, the amount is even higher. The needs are categorised as scenarios that ECB has noted to be of high importance when setting the standards for CBDC or Digital euro standards. (European Central Bank, 2020)

So why, CBDC? The history of central banking is commonly in the media discussed in post-WWII developments of central banking when we look at media articles about central banking. The central banks were nationalised along with their duties, changing to a monetary stability provider. However, in historical terms, central banks have been conducting all banking duties by and large. For example, the Bank of England did accept private deposits and conducted lending activities for private individuals nearly 200 years. Bank of Spain did have 73 % of all demand deposits during the 1874-1914 era. The mandates of central banks were in historical terms, thus covering more duties now considered to be more commercial banks operating principles. CBDC, in its purest form, can thus be argued to be a leap back to a very traditional banking world.

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<sup>1</sup> Target Instant Payment Settlement or TIPS is another example where Central Bank funds can be transferred real time. ECB [article](#) discusses this in more detail. Since Target is mainly in Bank financed economy and this paper focuses on Central Bank macro-economical implications and opportunities for TIPS is not discussed in detail.

The CBDC as a research topic covers computer science and monetary economics disciplines, and the research themes span from payments and central banking to information safety and it-architecture. Since the topic is broad, the literature review should be constructed, and possible future empirical situations analysed in detail. In this thesis, theoretical aspects of CBDC are researched by using literature review methods. This thesis also looks at how two developed countries with independent central banks most likely will operate if they adopt CBDC: Great Britain (Bank of England) and Sweden (Riksbank). Other countries are experimenting with CBDC, namely Venezuela and China. Venezuelan Petro's problems (i.e., the new cryptocurrency issued in Venezuela in 2018) and known fraudulent practices with the Chinese government and reporting authorities. Reuters (2017) Lang (2019) Wei, Chen, Hsieh & Song (2019) I am choosing these two countries that are independent and exercise high levels of free-market policies. Interesting points arise whether the Brexit will create even more unique chances within the CBDC field. Also the different interests in Great Britain and Sweden are driving motivators for this thesis.

This thesis considers two research questions:

1. Does Adopting Central Bank Digital Currency help foster the monetary policy's price stability and effectiveness?
2. What type of financial stability effects might Central Bank Digital Currency have?

Next I will discuss the theoretical framework.

## 2 THEORETICAL FRAMEWORK

This topic belongs to the field of macro-economics, specifically monetary policy and payment systems. To grasp how digital currencies can affect central banking theoretical foundations are discussed first. This thesis will then go through the basic functions of money and various digital era functions. After reviewing what money is, the macro-economic theories associated with Central Banks and CBDC will be discussed. Technological and practical issues related to relevant theories are discussed in section 2.5.

### 2.1 Money in the era of Digitalisation

Monetary systems are experiencing perhaps their largest change ever in the history of banking and central banking. The basic functions of money as a medium of exchange, store of value and a unit of account are staying the same. However, the systems under which the currencies and money are used are changing. The competition of currencies for their capabilities is not a new interest for economists, and Hayek (1976) stated that a privately issued competition could fix government currencies' mismanagement. The competition of currencies in the modern era has been characterised by either being

1. Full competition: Where currencies compete as a unit of account, i.e., in the exchange as FIAT currencies (euro, dollar etc.) or as private currencies (Bitcoin etc.) or they compete
2. Reduced competition: the currencies are of the same unit of account but mainly compete in their medium of exchange characteristics. Deposits and tokens<sup>2</sup> are generally viewed in this form, and competition in the modern era is in the form of whoever is the fastest (Mobile banking etc.) (Brunnermeier M. a., 2019a)

The competition is relatively straightforward to understand, but money's roles also include convertibility in the modern era, where tokens or currency could be one to one convertible backed by a balance sheet of tech companies. The company with a larger balance sheet would assume store of value and others the medium of exchange. (Brunnermeier M. a., 2019a). Transaction costs and fees have also played a significant role in the exchange of different currencies, but nowadays, the internet infrastructure allows almost costless change to different

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<sup>2</sup> Tokens mean in the CBDC context an alternative to money. Token could be a digital asset or right to a digital asset. Non-fungible is also sometimes used from tokens in cryptocurrency context.

currencies. There is no need for third party settlement, and thus the fees would most likely be lower. Brunnermeier, James, & Landau (2019a) describe the beforementioned characteristics as “unbundling of money”, meaning that since the transaction costs are low and infrastructure is in place, there is no motivation even to coordinate one currency. Since all currencies are exchangeable instantly, this could lead to ever more increasing competition of currencies. Hayek (1976)

Currencies would be specialized to the different roles of money i.e., one currency is used as a medium of exchange while the other as a safe store of value. (Brunnermeier M. a., 2019a)

If the national currencies become obsolete, the new competitive advantage can be found from the platform that these currencies are traded. Different currencies use the traditional functions of money according to their specific strengths. Economic agents operate in such platforms without friction and harness aggregate data's power to conduct monetary actions. (Brunnermeier M. a., 2019a)

The platforms and currencies economics agents use differ from traditional currencies in many ways. However, perhaps the most essential features of these digital currencies are that the competition between them is distinct and inseparable from the platform. The competitive advantage of such currencies stems from the traditional money characteristics and the platforms' unique abilities. These abilities vary but can be information processing algorithms, data privacy policies of the countries they originated, and the available counterparties. For example, if Amazon accepts certain digital tokens, that could be considered an advantage. (Brunnermeier M. a., 2019a)

Let us think of how such platforms' economics differ from the current structure of the economic landscape and financial markets. The difference is that when now the banks offer settlement and payment services, the new platforms can do just that as well, but Facebook's colossal balance sheet could back them. The questions, of course, rise if such disruption would do other significant changes. In a platform-based environment, the payment systems are the pivotal function of the economy. This means that banks deposits might start to decrease when consumers seek more services from their payment providers and different experiences. (Brunnermeier M. a., 2019a)

The critical feature of platform economies is also data. Data are generated from everything, and who controls it and has access to it can benefit greatly from it; thus, the owner of data can gather information for everything they need to know and sell the usage right for such data to different third-party platforms. Interoperability of various platforms ensures that the systems and data are used efficiently, and the convertibility of digital currency increases the chances of different quasi-monopolies rising from tech-companies. In the short term, such monopolies can be beneficial for customers and the economy overall. However, as discounts turn to increased costs and monopolistic behaviour, there might be a reason to worry. (Brunnermeier & Niepelt, 2019)

The competitive arena for currencies is not platform-based per se, but Brunnermeier, James & Landau (2019b) argue that the competition happens

mainly in Digital Currency Areas. Digital Currency Area or DCA is defined as a “network where payments and transactions are made using currency that is specific to this network”. DCA’s participants only use the payment instrument as a medium of exchange, or the currency area uses its own unit of account distinct from other currencies.

The difference of DCA and the traditional Optimum Currency Area (OCA) is that while in OCA, the monetary authority can help agents with economic shocks and create risk sharing abilities, OCA: s has traditionally been divided into geographical links. Mundell (1961). DCA: s differs not only because they might grow more significant than national economies of different operating countries but also by the digital interconnectedness these platforms do not seek (at least for now) any form of monetary policy function but instead take advantage of instantaneous payment transfers<sup>3</sup> and data. Brunnermeier, James & Landau (2019b)

DCA: s can become global, but the regulatory pressures they currently face, especially the private initiatives, are significant. Immense scrutiny towards Facebooks Libra was one example, separate data privacy and regulation frameworks also make it harder for private entities to grow as the only player in the payment landscape. Brunnermeier;James;& Landau (2019a)

Large DCA: s could, in certain circumstances, lead to dollarization in the digital world if the regulatory differences are not set. Since currencies tend to become international either by being a global store of value or as a medium of exchange, there are ways where DCA currencies in their platforms could become even a reserve asset, especially in smaller economies. Dominance over national currency can be achieved if DCA: s size, depth, and liquidity of US financial markets and suitability as a reserve asset are satisfied. Gopinath, et al. (2016) These points could be satisfied by large corporations such as Facebook. (Brunnermeier M. a., 2019a)

The concept of dollarization can create synthetic digital currencies that are internationalised and used worldwide. Dollarization could mean that such currency could become a safe asset of a sort if constructed by using various safe-like assets. If such currency would also be widely used in international trade, the shocks to US dollars would not severely impact global trade. However, if currency would be linked to a company's balance sheet, it could fluctuate with the relative riskiness of the balance sheet and the platform owner. (Brunnermeier M. a., 2019a)

Now that we have understood money in the digital era, we must understand public versus private money.

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<sup>3</sup> It is important to note that while it seems that payments are real time with Credit and Debit transfers, they are not. Peer to peer transfers however are instantaneous and allow huge benefits other than traditional cards.

## 2.2 Public versus private money

Since we are talking about how the economy's overall currency landscape could change, it is imperative to look at what the proponents and opponents of CBDC are saying about it and the principle outlooks for such a currency.

One of the main concerns for central banks in the current environment is that there are risks of losing monetary freedom for private companies operating in payment and money creation processes. The latter is being disrupted by different cryptocurrencies that use open technological “ledger” and anonymity for their users. The former is disrupted from multiple directions, FinTech’s New Banks and other competitors are changing the payment landscape to a more instant Cash free alternative. New disruption does not only stem from the entering of new competition but the overall decline of Cash in many countries, especially in Scandinavian countries, namely Norway and Sweden, where such developments are as much as 40% (Armeliuss, Claussen, & CA and Reslow, 2020)

Currently, public money is issued in physical Cash by central banks and electronic central bank deposits, i.e., reserves for banks. Central banks also support private money or deposits provided by banks created by the fractional reserve banking system. Generally speaking, central banks support commercial banks with the allowance to settle interbank payments with central bank deposits, ensuring the convertibility of private and public money and by offering liquidity with some mandates of being the lender of last resort. One of the most important notes is that only Cash and reserves are considered liabilities in central bank balance sheets while private bank deposits are not. (Bank of Canada, European Central Bank, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, Board of Governors Federal Reserve System, BIS, 2020)

The competition between private and public money raises questions. In the past, economists have widely argued that private currencies face huge difficulties as a store of value since they do not have a fiscal anchor. Thus, if private currency users start to believe that it would not be accepted in the future, the currency will lose its value. (Brunnermeier M. a., 2019a) Countries and their governments can use taxation and buy reserves to create a fiscal anchor, legality questions where the government promotes one legal tender, and the fiscal theory of price level<sup>4</sup> create needed stability for public money. (Obstfeld & Rogoff, 2017) Private money offers still some benefits that public money (at the moment) does not. Private cryptocurrencies can be used to evade capital control, grant access to smart contracts, predict markets, instantaneous transfers, and the owner of the digital platform. The only form of tender can be the one they are willing to have on the platform.

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<sup>4</sup> “Ability to pay taxes in a government issued currency puts a lower bound on the currency value”

There are various terms for new disruption in private and public money and the real challenges in the academic literature. Brunnermeier & Niepelt (2019) talk about developing the “right” monetary architecture and how-to asses different arguments made by various academics. Their model is based upon the assumption that when public and private money is based in certain sufficient conditions, it is irrelevant which one we are using. The approach is widened by choice sets which goes through several key risks and policies regarding the adoption of CBDC.

Their model's theorems go through liquidity, value, and equivalence, i.e., how the swap from CBDC could affect the inside and outside money. They also construct conditions where the swap would be indifferent from the current situation where CBDC is not used.

The key points affecting the risks and restrictions which are used in their model are discussed next:

1. **Wealth-Neutrality:** The assumption that open market operations in this context do not alter wealth distribution, i.e. central bank can swap currencies without fear to affect economic outputs, and as stated by Barro (1974), it is irrelevant if the central bank conducts lump-sum transfers. Thus, it could be argued that a swap to CBDC could be done as lump-sum transfers instead of open market operations. Brunnermeier and Niepelt (2019) continue to argue that if the deposit supply, formerly in their scenario provided to banks, is offered by market rates, the swap does not change bank rents.
2. **Liquidity-Neutrality:** The liquidity source is irrelevant, being it at the micro or macrolevel the liquidity is socially costless to provide Friedman (1969) however the resource costs should not rise with the swap, making it harder to justify, for example, Bitcoin applications that rely heavily upon electricity costs. The final note is that for banks in general, it is irrelevant where the deposit supply comes from.
3. **“Pass-Through” Funding and Absence of Crowding Out:** The risk aspect for partially dismantling the traditional fractional reserve banking system could shorten bank balance sheets since the deposits would be swapped to central bank liabilities, also leading to reduced investment funding. Brunnermeier and Niepelt argue that the Central bank, instead of banks, could fund investment projects<sup>5</sup>. The central bank could also be a pass-through entity between banks and other financial firms (non-banks), thus effectively “insulating” banks from the swap.
4. **Multiple Equilibria and Bank Runs:** Behaviour of agents and sunspots, i.e., the economy can turn to equilibrium even if the agents do not believe that the outcomes might differ. (Woodford, Learning to Believe in Sunspots, 1990) Thus, sunspot theory can be applied with Brunnermeier and Niepelt

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<sup>5</sup> Chapter 2.7 discusses the problems that there might be from such a phenomenon.



theorem. The theorem states that the equilibrium allocation of and the overall pricing system is identical in past and present terms.

5. Cash-Deposit-Substitutability and Gradualism: Small steps are needed by the central bank when conducting a swap to CBDC Brunnermeier Niepelt theorem constraints for an aggregate sum of Cash and deposits cannot be approximated for large swaps since the constraints are unknown.

Public and private money could thus be separated and used in either a similar way or as different vehicles.

The main problems that might arise when banks are forced to swap deposits to central bank money are various. First, even if, in theory, it is possible to prove that open market operations that swap deposits to central bank money are indeed wealth and liquidity neutral, real-world applications are far from being efficient. Equivalence after the swap requires that banks be indifferent to balance sheet implications and profits of zero due to competition and other factors, such as mismanaged assets when the bank liabilities are switched to CBDC. (Brunnermeier & Niepelt, 2019).

In the real-world, such a situation does not hold. However, Brunnermeier and Niepelt propose that “reduction in private deposits” does not imply that the total deposit funding decreases when the central bank conducts pass-through financing. Brunnermeier and Niepelt Equivalence Theorem states with proof that central banks balance sheet expands under the condition of Wealth neutral, open market operation. Since the Wealth neutral market operation for the adoption of CBDC is crucial, the Brunnermeier and Niepelt theorem is opened below:

It is only possible to swap deposits to CBDC if various economic agents' financial wealth does not change in the process. By constructing open market operation with compensating transfers does not change the wealth at  $t + 1$  in any history unless there are portfolio adjustments the change in agents wealth might change at date  $t$ .

The theorem could be used to justify that the equilibrium allocation from deposits to CBDC is possible, and with the right pass-through policies and transfers that the swap is possible. Brunnermeier and Niepelt argue even further that the argument made against CBDC where the CBDC swap would affect banks' balance sheet. Such a swap that bank run risk to rush for CBDC from deposits is reduced by larger swap since the Central Bank would be the largest deposit holder after the swap. Meaning that the financial stability would not be undermined or the bank funding compromised, but rather the composition of all financial deposit would change to CBDC. (Meaning;Dyson;Barker;& Clayton, 2018)

## 2.3 CBDC characteristics

There are various interpretations of the fundamental characteristics that the CBDC should have. This chapter focuses on the literature and research concepts that have been created upon the characteristics of CBDC. As we know, money's primary functions are a medium of exchange, a store of value, and a unit of account. Various CBDC applications' characteristics depend on whether it would have to satisfy all of them and if it is a substitute for Cash and deposits or substitute one of them or even act as a financial tool on its own without any substitution.

Analysis of different functions of CBDC has already been conducted. Notably, Bordo & Levin (2017) discuss how CBDC can consider all the money characteristics. Characteristics are defined by being account-based interest-bearing while also enabling the paper currency to disappear, prompting interest rate features, where CBDC is not constrained by lower bound. Bordo and Levin continue their research to other macroeconomic inspirations, which are addressed later in this thesis. The implications on private accounts, which would be based in the central banks themselves, could be twofold (Dyson & Graham, 2016):

1. Direct Customer account for all firms and individuals in the Central Bank to hold CBDC or
2. Accounts are supervised by commercial banks, which in turn would have corresponding accounts at the Central bank themselves.<sup>6</sup>

There is no need or even want for CBDC to be the only payment system in the future, according to European Central Bank (2020) and Bordo & Levin (2017). Rather, the increasing competition from private payment systems puts pressure on legislators to develop a practical choice for governments to facilitate market competition. Thus, creating a ground where large multinational banks could see the benefits for public-private CBDC relationships and how the state provides currency is more beneficial than private money alone. (Smith, 1776) (Friedman & Schwartz, 1986).

CBDC could be viewed as containing cash-like features such that user's anonymity is preserved with low usage cost for smaller transactions. Alternatively, it could be considered a deposit like where accounts could be held in central banks or as a universal digital currency used in all transactions. (Keister & Sanches, 2019).

Other more technical definitions for CBDC are introduced by Kumhof & Noone (2018). Kumhof & Noone separate CBDC from reserves and Cash all along and define it as something that the more general public can access than current reserves. This CBDC has functions for retail usage and interest-bearing abilities

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<sup>6</sup> Note: For smaller banks this could be especially beneficial in the digitalization age where "relationship banking" is their differentiator. (Bordo & Levin, 2017)

but with a different structure than other central bank money. CBDC is also characterised as a “credit-based currency in terms of value, a crypto-currency from a technical perspective, an algorithm-based currency in terms of implementation, and a smart currency in application scenarios” Yao, (2018). The potential for making traditional money smart is also Yao’s idea. Broader definitions are that CBDC is electronic universal Bjerg (2017) and serves in three possible scenarios:

1. CBDC is electronic Cash, i.e. a medium of exchange
2. CBDC is reserve currency, i.e. store of value
3. CBDC is a currency of a nation, i.e. unit of account

All three scenarios are possible, and almost every scenario can be used with or without other scenarios. In the first one, CBDC could be converted to Cash and deposits. In a second scenario, there remains a parity between bank deposits and CBDC, but Cash would be replaced. The third scenario replaces bank deposits and conducts monetary policy and liquidity measures based on any given economic scenario. (Bjerg, 2017)

An alternative design is for a medium of exchange because CBDC could be used as tokens in a distributed ledger, much like bitcoin but controlled by the central bank. The medium of exchange could also be CBDC accounts where the CBDC are used in a similar way as deposits now, easily with debit or credit cards but in an instant manner. (Bordo & Levin, 2017)

Bordo and Levin also discuss the store of value possibility for CBDC as follows:

1. CBDC issues Cash like currency with constant nominal value and the constraints for central banks to push interest rates to negative would be affected.
2. CBDC would be price level indexed and have a stable real value, which would also constrain negative interest rates.
3. Interest bearing CBDC where the interest rate could be pushed in negative or positive and with the help of price level indexing create a stable unit of account.

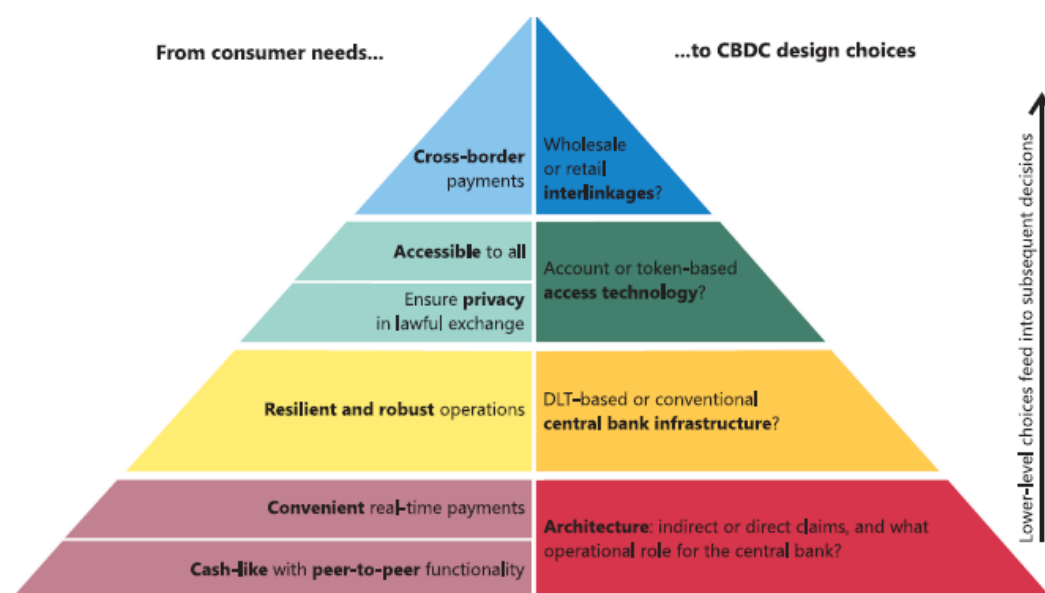
With constant nominal value, the monetary policy effects of CBDC would remain similar to those currently used, i.e. adjusting short term nominal interest rates and conducting inflationary methods such as quantitative easing when the rates are at zero level. Bordo and Levin also state that price level indexing could use, and this means that the target price level could follow an upward sloping path without a constant target.

Price level indexing could also mean that CBDC accounts are indexed to former price levels. However, the problems that would occur, such as the relative hardness of indexation and zero lower bound constraint, could also mean that this alternative is unlikely. The interest-bearing alternative is the most lucrative in new monetary policy tool possibilities. (Bordo & Levin, 2017)

The risks for adopting a negative rate opportunity for CBDC is that the public would avoid using it by holding Cash, or if not available foreign currency or even private cryptocurrencies, which could mean a rather lot of legislative work to come across. It is likely that negative rates also would face a lot of opposition and lobbying, creating sentiments against using CBDC. Such sentiments would limit the effectiveness of CBDC as a payment system. (Bank of Canada, European Central Bank, Bank of Japan, Sveriges Riksbank, Swiss National Bank, Bank of England, Board of Governors Federal Reserve System, BIS, 2020)

According to various research, the core features of CBDC vary depending mainly upon how it is viewed. When viewed from the retail aspect and consumer needs, CBDC solutions play a crucial role. Bank of International Settlements Auer, Cornelli & Frost (2020) introduces a pyramid approach for core features and CBDC design alternatives worldwide.

Figure 1 The CBDC pyramid



As we can see on the left is consumers' needs, and on the right, the CBDC design alternatives. When we are thinking consumer and their choices

The design choices are as follows:

1. Architecture in this context means what the actual operational model of central bank digital currency the classification is in four dimensions is
  - a. Direct CBDC, where the whole payment system is operated by the central bank which does offer payment services and ledger infrastructure for CBDC;
  - b. Hybrid CBDC, with two paths, where intermediaries handle all regular payments and CBDC is a direct central bank claim central

- bank, keeps the central ledger for all transactions and fails in intermediaries act as a backup technical infrastructure.
- c. Intermediated CBDC, where a central bank only has a ledger containing the wholesale features, but not all retail transactions. Intermediaries execute payments;
  - d. Synthetic / Indirect CBDC, where intermediaries and consumers operate the payment system, only have deposits/claims to these intermediaries. The liabilities to clients are backed with claims on the central bank.
2. Infrastructure decisions in CBDC operations mainly mean whether the ledger used is a centralised database or Distributed ledger. Technical characteristics are discussed more in chapter 2.5. However, Auer, Cornelli & Frost (2020) describe the main difference: the protection and efficiencies where DLT replaces the trust traditionally held by financial institutions to trust the technology used.
  3. Accounts and tokens are one of the key aspects that are discussed in the CBDC literature. Overall, the decision to adopt either choice is crucial to the whole system of CBDC in any given jurisdiction. Access to CBDC is the key consideration, and for those who only use Cash, it is highly challenging to trust or gain access to either CBDC accounts or tokens. (Auer;Cornelli;& Frost, 2020) (Brunnermeier M. a., 2019a)
  4. Tokens are perhaps slightly easier to be used by individuals avoiding everything else than cash but as is argued in Auer, Cornelli & Frost (2020), the pre-paid tokens that could be exchanged physically are at risk for illicit activities and counterfeiting, undermining one of the core reasons to adopt CBDC at all.
  5. Wholesale or retail use of CBDC has different meanings in different literature. In the BIS pyramid above, it is described as cross-border payments between residents and non-residents. However, other authors have also written that wholesale or retail means also the similar aspects that in the architecture choices, whether the general public would have access to CBDC or not Kumhof & Noone (2018) discuss the monetary policy aspects that are closely linked to wholesale versus retail use of CBDC.

## 2.4 CBDC and monetary policy

To answer the central questions of how Central Bank Digital currencies work, we must establish an understanding of the financial institutions and monetary policies. In this chapter, operations and links to commercial banks and central banks, all the way to depositors, is linked to the money supply process.

First, it is important to understand the role and function of a central bank. Central banks must operate to maintain monetary stability and financial stability. It is important to note that different central banks have different mandates that differ from country to country. However, almost everyone does have monetary policy, exchange rate policy, liquidity management and foreign exchange functions as their main responsibility. (Bank for International Settlements, 2009)

The volume of money in the economy results from the entire banking sector and other money-holding entities (households, non-financial corporations' government, etc.). The volume of money can be extended to a textbook illustration of "broad money", which usually covers deposits, short-term money market items, money market funds and other short-term liquid asset classes. In most textbook examples, when we are thinking of how monetary policy is conducted and transmitted, it usually references how the reserves created by central banks are transmitted to the economy. Interest-channel and money channel are used to describe how interest rates adjustments are made to "clear markets"<sup>7</sup> and influence borrowing/lending in the economy. (Carpenter & Demiralp, 2010) The third channel is called a credit channel which guides the quantity and price of loanable funds.

The practice that the channels mentioned above and broad money definitions describe is called the money supply process and is often derived from a relatively simple money multiplier. The money multiplier approach has been used for a long time, such as by Keynes (1930). It assumes that the central bank is the driving factor that set the monetary base and thus the monetary policy solely by supporting the outside money to banks that make inside money. More commonly known as deposits available while controlling the short term interest rates in order to maintain or bring supply and demand to an equilibrium. In a textbook context where all else is being equal, and all the players behave in an assumed way, money multiplier and stimulus to through it have a credible explanation of how the process of money supply work. All else added together, central banks tend to implement monetary policy by steering interest rates and not manipulating monetary policy in traditional and unconventional monetary policy situations. (Goodhart C. , 2010)

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<sup>7</sup> Traditionally market clearing is the process where the supply of something traded is equated to the demand.

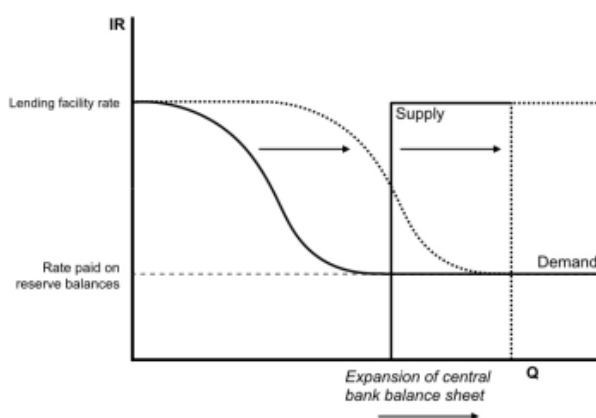
### 2.4.1 Monetary Policy transmission

The monetary policy transmission mechanisms would predominantly be affected by the CBDC by the interest-bearing account model but potentially by token-based models. Monetary policy transmission or MTM could be thought of as a logical three-step model with an additional fourth step for quantitative easing with CBDC.

The monetary transmission takes place in the overnight rates that central banks set. In the secondary markets, the central bank target interest rates for reserves to set the supply of central bank money, which is cleared at the market. Shocks in the demand side are insulated by remunerating some balances at the deposit rate, which is smaller than the target rate. Central bank could also set ceilings to lend central bank money elastically. (Meaning;Dyson;Barker;& Clayton, 2018) Since the financial crisis led to QE and asset purchases. The monetary infrastructure shifted to a supply floor system. Supply floor system works as the quantity of reserves is expanded so that the market clears at the rate paid on reserve balances with all reserve balances paid at that rate shifting the secondary market focus of interest rates to interest rate paid on reserves. Since reserves are not universally accessible, the secondary market activity has diminished, meaning that there might be a reason to adopt universally accessible CBDC. (Meaning;Dyson;Barker;& Clayton, 2018)

The non-banks and other such institutions would have increased demand when CBDC would be issued, meaning that central bank money's demand curve shifts to the right. Figure 2 represents the shift.

Figure 2 Demand curve For CBDC<sup>8</sup>



With access to CBDC there is a chance that monetary policy would return to interest rate corridor type of situation which in turn could mean that secondary markets might through interest rate pass through gain momentum.

<sup>8</sup> (Meaning;Dyson;Barker;& Clayton, 2018)

### 2.4.2 Zero Lower bound

Some central banks, especially the ECB and Denmark, Sweden, Japan, and Switzerland, have adopted a negative interest rate strategy (NIRP). However, issuing zero-remunerated CBDCs without access or quantity limits would mean the end of NIRP. It would also mean that NIRP would no longer be feasible in the future, as issuance would likely boost nominal long-term yields. However, these restrictions will limit the size and scope of use of CBDC and, consequently, its efficacy and usefulness as a means of payment. (Bindseil & Panetta, 2020)

To stimulate aggregate investment and demand, central banks usually lower short-term interest rates. This strategy is less successful when interest rates are close to the Effective Lower Bound so that individuals can increase their cash holdings. The opportunity cost agents carry when carrying means of payment could be minimized by an interest-bearing CBDC. A CBDC with a non-zero interest rate could, for instance, provide a floor for deposit rates. An account-based system may be preferable to a token-based payment system, as it allows time-varying and contingent on balance held to be the policy interest rate. By offering depositors an external alternative, the CBDC rate could affect the deposit market, making the deposit market more important. Few quantitative estimates of the benefits of breaking below the ELB are available. The use of a time-varying deposit fee on physical currency is one suggestion. This would allow the central bank to establish an exchange rate between bank deposits and the physical currency. (Bindseil & Panetta, 2020)

The large adoption of new means of payment denominated in the domestic currency would not jeopardize the central bank's ability to conduct monetary policy. A CBDC, if properly planned, could offset the introduction of alternative payment methods. Most of the money in the economy is in the form of bank liabilities, "inside money" Cash is a small fraction of balances. Most transfers are made using central bank money (reserves) as a settlement asset through the electronic transfer of inside money. Monetary policy may be applied with or without Cash in circulation if payment providers claim a central bank-controlled settlement asset. (Bindseil & Panetta, 2020) (Davoodalhosseini, Rivadeneyra, & Zhu, 2020)

## 2.5 CBDC technical aspects

Digital currency systems maintain a global state, consisting of all their users' balance sheets. These may be easy fund transfers or smart contract interaction. The state is the consequence of processing the transactions according to their order in the ledger. The system should allow participants in a serial order to add blocks so that the system progresses in a well-defined manner. It should allow all transactions that comply with its predefined rules and prevent removing a block, which would have implied a reversal of history.



The blocks and status should be repeated to prevent susceptibility to the crash or misbehaviour of one or more devices. In the literature of distributed systems, this is called State Machine Replication (SMR). There are hardware failures even in a centralized environment, so it is wise to integrate multiple nodes for fault tolerance in IT device design. The architecture of the underlying SMR and networking layers impacts the system's efficiency and protection. This selection determines how open the process is to participants and how much it is in a few individuals' hands.

Without satisfying specific basic information security properties, no digital currency can remain operable and in use for a long time. Distribution and decentralization methods, the key to both cryptocurrencies and CBDCs, come into action. How do we ensure that each of these knowledge dimensions is met, and what kinds and degrees of costs are we prepared to incur to guarantee them? This is where decentralization and delivery methods come into play.

Depending on the needs and wants of the Central Bank and, to some extent, the state, the most relevant alternatives are Distributed systems, Decentralised systems, or Role separation. (Allen, 2020)

**Distributed systems:** Essentially, a distributed system consists of multiple devices which communicate and organize over a network. A distributed ledger, of course, is the most important form of a distributed system for a CBDC. In this way, conventional client/server and cloud computing infrastructures prefer to use distribution mainly to safeguard accessibility and position the biggest investments towards this objective. For example, geographically dispersed systems spread a service's replicas (such as a ledger) through data centres. (Allen, 2020)

**Decentralised systems:** Systems that are not under the control of a single central authority are decentralized systems. The decentralization of a structure by autonomous authorities decreases the amount of confidence we have to put in each of them. The weakest but practical and universal type of "decentralization" is the division of a system into various functions that are qualitatively different.

An example of (limited) decentralization through role separation in a CBDC design is the Bank of England's proposal to delegate the account management role to a commercial Payment Interface Provider (PIP). A large-scale example of role separation is the distinction between central banks and commercial banks' roles in classical economics. (Bank of England, 2020)

Many different companies introduce the PIP function on behalf of their customers. In theory, only those clients of a given PIP need to trust the PIP. However, each user must completely trust their selected PIP because the harm to those customers can be severe if one is compromised. If one or more of the authorities

playing such a role becomes too large to fail, even the global security provided by the dispersal of confidence can be reduced. (Bank of England, 2020)

At least in terms of its availability, a distributed ledger, spread through a distinct community of servers, provides a threshold of confidence. Consensus or replication by state machines would not inherently shield users from failures in the system's integrity or confidentiality. It may be possible for any single compromised server to fake or rewrite history. Users may divide their trust into many bodies that function in the same position separately so that no single authority has absolute control over any consumer. The definition is like a board of directors or parliament, whose members are unanimously trusted but cannot behave alone by a single member. (Allen, 2020)

## 2.6 Principles of Central Banking theories and Monetary policies

In this chapter, the fundamentals of modern monetary policies and central bank theories are explained. Thammarak (2014) explains that there are five main practises that should be understood when thinking of central banking and monetary policy I will go through all the five principles and then discuss the central banking theories closely related to the policies.

### 2.6.1 The quantity theory of money

Famous theory that describes the relationship between money, economic activity, and the general price level in the long run. In this theory, during the long run, it is assumed that the total output of an economy will depend upon non-monetary factors (factories, infrastructure, labour technology etc.)

Fisher Equation below is represented as the equation of exchange below. (Thornton, 1983)

$$M \times V = P \times Q$$

Where M is the overall quantity of money in the economy, V is the velocity of circulation of money<sup>9</sup> P is the general price level and Q the quantity of products sold in the economy. Traditionally P and Q taken together represent the GDP. Velocity and quantity are assumed to be mostly affected outside of the equation, i.e. payment technologies etc. (Goodhart, 2012)

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<sup>9</sup> The velocity of money is a measure of the number of times that the average unit of currency is used to purchase goods and services within a given time period.

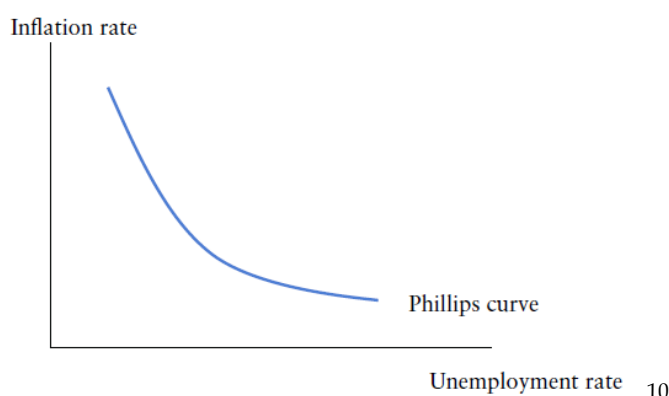
It is imperative to think how Quantity theory works when studying any central banking-related content. In this theory, an increase in  $M$  (money) will lead to an increase in  $P$  (general price level) in the long run. When thinking in traditional terms, money is easily printed and can, if printed exhaustively, debase the value of money relative to other goods, more commonly referred to as inflation.

Many real-world hyperinflation cases are known. Perhaps the most famous is Germany after World War 1 and Zimbabwe in the 21<sup>st</sup> century. Thus the quantity theory is backed by extensive empirical evidence related to paper money or Cash and is one of the foundational theories in central banking. (Samuelson & Nordhaus, 1998)

### 2.6.2 The Phillips Curve

Since monetary policy, according to the quantity theory of money, cannot be used to directly fuel the economy, in the long run, there are possibilities to influence economic activity in the short run. There is an inverse relationship between inflation and unemployment, which was found out in the 1950's. This relationship is called the Phillips Curve. In theory, the Phillips Curve would allow the central bank to lower the unemployment rate by allowing more inflation, i.e. stimulate the demand and economic activity, which would mean that firms and households can borrow and invest more easily, leading firms to hire more labour while simultaneously the new demand for goods and services drive the prices up leading to inflation. Figure 3 represents this.

Figure 3 The Phillips Curve



Thus, we can see that at least in the short run, stimulus packages can help central banks (with such a mandate) to reduce overall unemployment. If

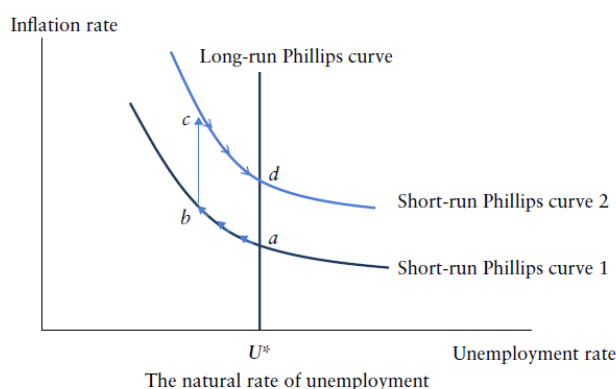
<sup>10</sup> Source: Thammarak Moenjok: Central Banking theory and Practice Wiley (2014)

however, the theory would be in practice so straightforward, central banking would be a much easier task. Since Phillips Curve itself does not account for any disturbances or different unemployment types, it remains a theoretical concept in itself but does generate a more firm ground for other theories.

### 2.6.3 The Natural Rate of Unemployment and NAIRU

While the Phillips Curve, in theory, would work itself, it does not account for different stages of unemployment, and because of the weakening relationship, new concepts were created to account for the role of expectations (Phelps, 1967) and the natural rate of unemployment. The Natural Rate of Unemployment is derived from concepts where the economy itself is already at its full capacity, but for some reason, there will always exist some unemployment resulting in the inflation rate not changing. This rate of unemployment at which inflation does not change is The Natural Rate of Unemployment. (Friedman M. , The Role of Monetary Policy: Presidential Address to the American Economic Association, 1968)

The nonaccelerating Inflation Rate of Unemployment or NAIRU represents the natural unemployment rate under the condition that inflation will not rise. In the 1970s, this relationship by using stimulus was largely adopted by different central banks of the world but by the late 1970s. Inflation started to rise, leading to a synthesised theory of NAIRU and Vertical long-run Phillip's curve where prices and inflation adjust in the long run while the short-run Phillip's curve shifts up figure 4 represents this. What this means is that the natural rate of unemployment remains the same over time<sup>11</sup> , but short-run shifts can be seen. If the central bank finances, the economy unemployment might shift in the short term, but as the wages and inflation rate start to rise general population will shift their inflation expectations to point c due to rising investments and consumption. But since the economy can't run at this capacity forever, the shift toward NAIRU or  $U^*$  would occur in the long run.



12

Figure 4 Long-Run Phillips Curve

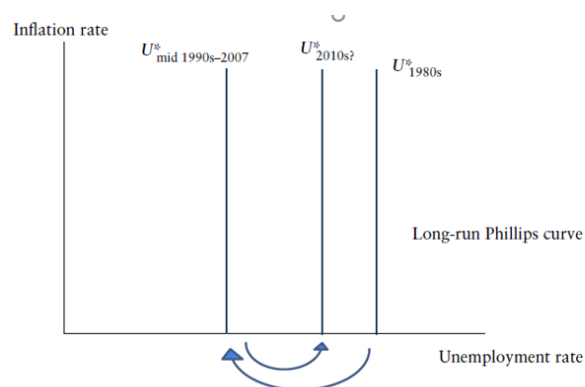
<sup>11</sup> Given that there are no shocks in the supply or demand side.

<sup>12</sup> Source: Thammarak Moenjajak: Central Banking theory and Practice Wiley (2014)

Since economies do not ever stay in line and are constantly evolving with new ideas, more skilled labour, better technologies, and new economic concepts, the Nairu does not necessarily hold over the long run. Thus, in the 1990's concept of shifting Nairu was established due to different new technologies, namely in information and communication, which means that Lawrence Ball and Gregory Mankiw believe that unemployment could be pushed further down than it had been previously possible. (Ball & Mankiw, 1997)

In the different theories' economists have tended to state how unemployment goes down. It can also come up as is the theory with shifting Nairu. Figure 5 illustrates this phenomenon with different unemployment rates from different years. Phillips's curve does still exist in the slow recovery environment, but the inflation itself has not taken momentum in the last 5-10 years. The mismatches occur in a new way there are more vacancies but not enough workers for these vacancies leading to a conclusion that Nairu had shifted up. (Gordon, 2013)

Figure 5 The Shifting NAIRU



13

As stated by Gordon (2013) "A jump in information and communication technology helped push the natural rate of unemployment in United States down since the mid-1990s". Structural changes might have pushed the rate up again.

#### 2.6.4 The Rational Expectations Hypothesis

The rational expectation's hypothesis has been developed to address the unknowns in economic theories. This is based largely on another theory which, in more traditional terms, is to rely too largely upon historical data or, in economic terms, adaptive expectations. In this framework, future values are expected to stay near the last historical values, i.e. inflation or other economic variables. Since not only is this unrealistic, it is dangerous for the public

<sup>13</sup> Source: Thammarak Moenjaj: Central Banking theory and Practice Wiley (2014)

to think only in past terms. Therefore, the rational expectations hypothesis addresses this problem by assuming that individual economic players take all the available information into account when making any predictions. This means that, on average, individuals are correct.

There are a couple of different important implications to keep in mind while thinking of the rational expectations hypothesis. The first one is the Lucas critique which specifies how studying the highly aggregated historical data is futile since individuals in the economy change their perspectives and expectations according to only present terms, i.e. if the central bank uses quantitative easing in excess amounts, individuals and firms only take the status qua situation and do not necessarily consider the historical tendencies of such policies. (Lucas, 1976)

One way to look at Lucas Critique is to try predicting macro-economic development by using micro-economic behaviour.<sup>14</sup>

Other problems and criticism regarding the rational expectations hypothesis are the policy ineffectiveness which means that whenever a central bank wants to use quantitative easing or other measures to, for example, reduce unemployment, the economic individuals will fully anticipate these moves and would raise their expectations accordingly, leading to a possible situation where inflation would continue to rise but unemployment staying the same. (Sargent & Wallace, 1976) Also, behavioural economics suggests that individuals are making their choices and expectations largely on biased non-rational views, which hurts the principle theory that all the investors are rational. (Thaler, 1991) However rational expectations hypothesis continues to serve as a guiding principle and effective starting point for economic analyses and in central banking policies.

### 2.6.5 The Time Inconsistency Problem:

While all the theories described in this thesis so far have been rather theoretical, they are, in essence, the targets for different tools that central bankers have in their arsenal. But the main question that arises here is how can these theories be used in practice, and should there be tight policies in place when considering perhaps market operations to lower inflation? According to research by Kydland and Prescott (1977), the best monetary policies are, in fact, tighter because of the Time inconsistency problems.

Their research shows that without rules and regulations in place, rational individuals know that the policy makers can always retreat from announced policies creating inefficiencies within policies that are targeting the well-being of all the individuals. Such inefficiencies are likely since rational individuals will alter their behaviour immediately when a policy is launched.

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<sup>14</sup> These could include different Dynamic Stochastic General Equilibrium (DSGE) models to mimic behaviour of individuals in larger scale. See for example (Sbordone; Tambalotti; Rao; & Walsh, 2010)

Practical implementation is that when the central bank wishes to reduce inflation, it can announce its plans, but if they start to deviate at a certain point to cap the unemployment generated by inflation, the public will still expect that inflation remains high, making it harder for the central bank to operate at all. (Kydland & Prescott, 1977)

## **2.7 Main Tools and Policies in Central banking**

So far in this thesis, the main ideas for Central banking have been more of theoretical form. In this chapter, the focus shifts towards the actual Central bank rules and tools to achieve monetary policy stability through five different main agendas:

1. Exchange Rate Targeting
2. Money Supply Growth Targeting
3. Risk management approach
4. Inflation Targeting
5. Unconventional monetary policies

Some of these theories are only discussed in brief as they are not in the scope of this thesis. These five main approaches are selected on the basis that they are widely used and have been in use after the break of Bretton woods. (Mishkin F. , 1999)

### **2.7.1 Exchange Rate Targeting**

Exchange rate targeting is, in its essence, a policy where the central bank promises to keep the exchange rate under a pre-determined threshold. What this means is that central banks do not usually deviate from or change monetary supply largely due to time-inconsistency problems. For smaller countries, exchange rate targeting normally means pegging their currency to that of the larger country, creating price stability in the process. In more modern times, exchange rate targeting can be conducted to a basket of currencies, usually the main trading partners. (Branson & Katseli, 1981)

### 2.7.2 Money Supply Growth Targeting

As the title states, money supply growth targeting is precisely about how the central bank targets to increase the money supply to boost economic activity. Money supply growth, when kept at a target rate that is consistent with the real economic activity inflation, should stay low and stable. It is based upon the quantity theory of money

$$M \times V = P \times Q$$

When rearranged

$$P = \frac{M \times Q}{V}$$

With V and Q being exogenous to the equation and assumed constant change in P is equal to a change in M

$$\frac{dP}{P} = \frac{dM}{M}$$

Differentiating with respect to time (t) the changes in money will be equal to changes in the quantity of money in the economy.

$$\frac{dP}{P} = \frac{dM}{M}$$

The last calculation states that the economy's price level is equal to the rate of change in money supply over time. While there have been certain successes, namely in Germany, the money supply targeting has been mostly replaced by inflation targeting worldwide. Money supply targeting needs a very clear communication strategy and a rational audience to follow it to succeed as a strategy for inflation control. (Mishkin F. , 2000)

### 2.7.3 Risk management approach

The risk management approach is a policy that aims to maintain price stability and prompt employment by looking at how different types of economic data behaves and then trying to model such behaviour. It is more of a forward-looking pattern and generally considered following the Taylor rule.

Taylor rule represents an equilibrium level of inflation and the rate of GDP growth around the inflations potential rate. It is expressed as a formula:

$$i_t = r_t^* + \pi_t + a_\pi(\pi_t - \pi_t^*) + a_y(y_t - y_t^*)$$

Where  $i_t$  is the interest rate at time t  $\pi_t$  is the inflation rate  $\pi_t^*$  is the desired inflation rate  $r_t^*$  is the assumed equilibrium real interest rate  $y_t$  is the actual GDP



growth rate,  $y_t^*$  is the GDP growth rate at full potential, and  $a_\pi$  and  $a_y$  are the relative weights assigned to keep inflation at the predetermined threshold. Risk management approach did have some initial success when conducted in the United States. Until 2007, the Federal Reserve started to publish more information about their targets and goals, leading to a more inflation-targeting approach that in essence, needs transparency. (Taylor, Discretion versus Policy Rules in Practice, 1993)

## 2.7.4 Inflation Targeting

The most influential tool that central banks are using in modern times is inflation targeting, and it has been widely adopted to be the go-to strategy when dealing with shocks to the economy. Inflation targeting requires transparency and accountability when conducted to show how the central bank is going to achieve the wanted inflation target. In its essence, inflation targeting is a forward-looking policy more so than many other previously discussed policies. Forward-looking is needed, especially in inflation targeting when the effects from the tools available, i.e., short-term interest rates, have taken up to 24 months to have a real effect on the economy. Moreover, inflation targeting basis its research upon historical values and aggregate economic data models while making these forward-looking assumptive policies. Figure 6 represents the inflation targeting policy model.

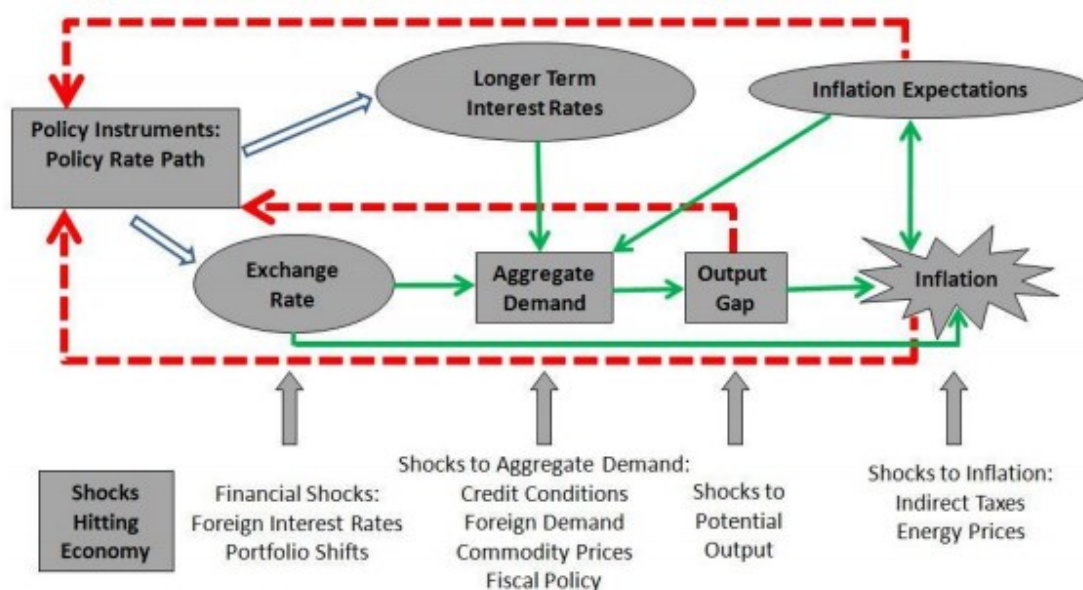


Figure 6 Monetary Policy Model: IFT Feedback Response and Transmission<sup>15</sup>

As we can see any expected path, the policy inflation rate has to be adjusted if any shocks hit the economy. Red arrows represent the “Policy feedback” ensure that the actual nominal inflation anchor holds. Blue arrows represent the

<sup>15</sup> Source IMF p. 12 <https://www.imf.org/external/pubs/ft/wp/2015/wp15132.pdf>

actual impact that central banks have by raising or lowering their rates and expectations using the Taylor rule in the long-run inflation target should be reached.

### 2.7.5 Unconventional monetary policy

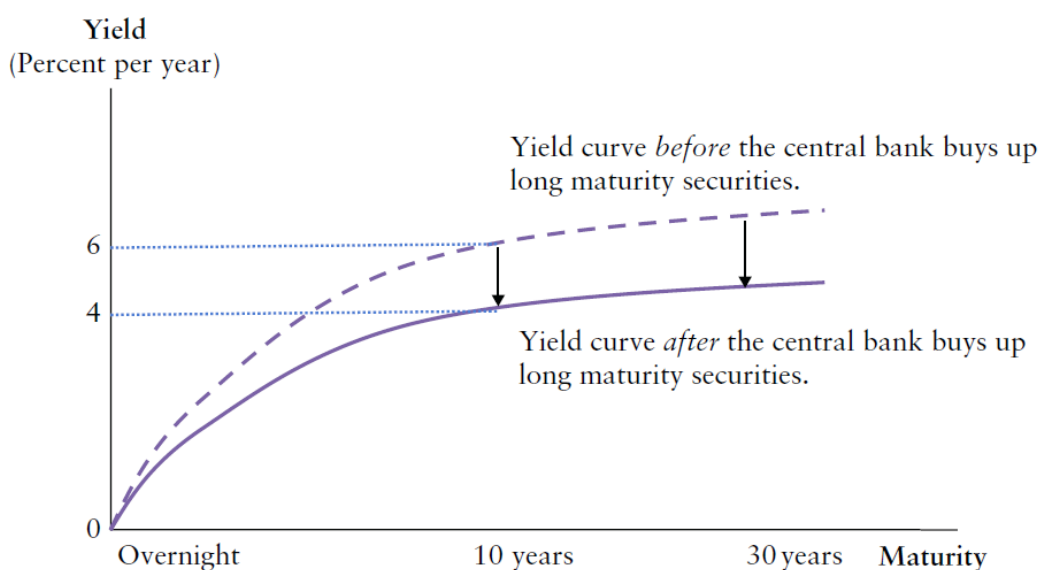
When we are talking about unconventional monetary policy, we are referring to activities of central banks after large financial crises such as sub-prime crisis or European debt crisis. In these scenarios, central banks have already pushed policy interest rates to zero, but the economy needs still more stimulus. Three major tools have traditionally been used:

1. lending to financial institutions.
2. providing liquidity to key credit markets
3. purchasing long-term securities

The first two are generally considered to be used as per central banks mandate as lender of last resort. Thus, the third one commonly referred to as Quantitative easing or QE will now be discussed.

To further stimulate the economy after the policy rates are at zero per cent, the central bank can buy long term government securities exclusively from the private sector to lower long-term borrowing costs and restoring liquidity. The central bank generates liquidity by providing money injections to the private sector by purchasing very large chunks of securities.

Figure 7 Yield curve



When the central bank buys these securities, it lowers the yield curve for long-maturity securities. This can be seen in figure 7. Since the private sector uses these yield curves to calculate their own borrowing and lending interest rates, lower rates mean lower rates in the private sector which should lead to more liquidity in the markets. It is especially important to note that often mortgages and other instruments are tied to longer-term rates, and by lowering those rates, central banks can ease the credit burden in the slowed economy. When the government buys securities from the private sector, the cash amounts in banks increases, which means that banks can lend more out, boosting economic activity.

It is also argued that there are several problems with the Unconventional Monetary policy. The main arguments are that central banks move away from the fiscal policy and undermine the credibility; however, we have seen that markets, especially during crises such as Covid-19, expect the central bank to boost economic activities. There is also a chance that asset prices can form a bubble if the central bank money is only driven to asset markets, meaning that the real economic activity is not actually boosted. Inflation could become a problem in a long-term QE process, but with the ability to adjust policy rates higher, this problem could also be dealt with.

### 2.7.6 Financial market operations

In this subsection, we will go briefly through the financial market operations that central banks can use. Generally divided into five main parts, financial markets play a key role in the economy. Thus, the function and stability of the markets are one of the most important aspects of central bank operations.

Table 1 represents the different financial markets, their functions and central bank policy toolkits for influencing each of them.

Table 1 Functions of Central Bank Funding

<b>Financial market</b>	<b>Transactions</b>	<b>Central Bank tools</b>
Money market	Short-term funding	Managing the policy interest rate.
Foreign exchange market	Forex funding	Interventions to curb volatility
Government securities market	Funding government	Creating liquidity
Credit market	Funding other sources than government	Creating liquidity

The money market is the market in which participants borrow or lend money for the short term. (Bodie, Kane, & Marcus, 2013) The central bank is effectively trying to influence the tightness or looseness of the financing conditions. By tightening the lending conditions on the money market, liquidity or availability of funds, lending becomes scarcer. Tightness in short-term lending conditions could also lead to tightness in other markets and in long-term funds, as investors could struggle to pursue cheaper financing elsewhere. In the same spirit, by loosening short-term financing conditions, the central bank could also indirectly loosen financing conditions in other markets and in Long-Term Funding. (Fabozzi, Mann, & Choudhry, 2002)

### **3 IMPLEMENTATION OF THE RESEARCH AND RESEARCH GOALS**

This chapter will review the integrative research method used in constructing this Thesis. The process and various parts of this thesis are listed and evaluated. First the research purpose of this thesis is discussed.

#### **3.1 Literature review as a research methodology**

The main aspects and reason to conduct the literature review are to create a synthesis by gathering academic information with research questions. Research questions must be narrow enough to form a synthesis and conclusion for research. (Cooper, 1998) With a literature review, the researcher can show new aspects based on existing academic literature and evaluate the subject's academic cohesion. A literature review can also point to the further research aspect of the academic field in question. With different literature review processes, there are among other four main alternatives to conduct one: Narrative, systematic, semi systematic, and integrative. The differences between literature review processes stems mainly from the analysis, usage, and variety of academic literature present from the researched subject. Narrative research is usually used in undergraduate texts without a specific problem or research question; rather, the subject is only touched on a general level.

Systematic and semi-systematic reviews are more common in an academic context. The Integrative review is commonly used to either criticise or synthesize narrow or sometimes even broader contexts.

Table 2 represents the differences between the three most commonly used approaches for literature reviews.

Table 2 Approaches to literature reviews (Adopted from Snyder, H 2019)

Approach	Systematic	Semi-systematic	Integrative
Typical purpose	Synthesize and compare evidence	Overview research area and track development over time	Critique and synthesize
Research questions	Specific	Broad	Narrow or broad
Search strategy	Systematic	May or may not be systematic	Usually not systematic
Sample characteristics	Quantitative articles	Research articles	Research articles, books, and other published texts
Analysis and evaluation	Quantitative	Qualitative/quantitative	Qualitative
Examples of contribution	Evidence of effect Inform policy and practice	State of knowledge Themes in literature Historical overview	Taxonomy or classification Theoretical model or framework

As can be seen from Table 2, there are relevant differences in literature reviews in how those are constructed and where they are used. The systematic and semi-systematic models are often used when there are highly empirical studies and meta-analysis, or other statistical methods can be utilised to create reliable findings from the existing empirical literature and draw conclusions from them. An integrative literature review is used for different purposes, to assess critiques and synthesise the topic in question and to bring possible new research alternatives to light. It is imperative to document the process of gathering information in order to replicate the study if necessary. In this thesis, the integrative research method was used for a relatively simple reason. There is no empirical data or empirical literature on the subject matter yet to be analysed. An integrative approach was chosen.

### 3.2 Implementation of the research

The research problem and the literature review process lay the foundation for a holistic view of the whole thesis and guide the process itself. From the basis of the problem and the process, research questions can be derived, and since the process is documented and followed if necessary, the process could be expanded or narrowed. The processes to derive research problem were already started in

early 2020 with some specific questions for supervisor and database research. After the first steps were taken, it could be concluded that there are no significant empirical studies concerning CBDC. Some experiments have been done, but there is no relevant academic research available. Thus, systematic and semi-systematic literature reviews were dismissed.

Research question types were constructed multiple times since new academic literature is published all the time. However, literature published after December 2020 is not taken into account as the process was already in such a state that it would not have been feasible to account for the ever-growing research. The main points when deriving the research question were that they would need to lead to a better understanding of CBDC and the monetary policy implications that the adoption of CBDC could provide they possess. In defining the research problem and formulating the research questions, the topic was approached from a neutral perspective without any preconceptions towards CBDC. The research questions were formed to be limited and clear but not too narrow. At the same time, it was also noted that it is possible to respond to them within the available resources and time. The terminology used in the research questions was structured in a consistent manner. (Fisch & Block, 2018)

### 3.2.1 Search for information

The search phase for constructing this thesis was the most peculiar part. Since CBDC is a relatively new theme, the first steps were googling and trying to hit the right place without empirical foundations. A more systematic approach was then selected to gain enough relevant literature for the discussion part. The search terms for different databases were constructed from the research questions. Keywords were used to detect abstracts if such a function was available in the database. However, since not all the academic literature will be found using keywords, free word search was also utilised. Below is a list of all the primary keywords and keyword pairs that were used:

- CBDC
- Monetary policy and CBDC
- Characteristics and CBDC
- Transmission and CBDC
- Long-term and CBDC

After searching for a while, it was decided to only use CBDC as a keyword to get more relevant matches.

Integrative literature review data search should be as broad as possible. The data search should include electronic databases, manual search from the academic publications, and careful review of articles' references. (Tavares De Souza, Dias da Silva, & Carvalho, 2010) In this thesis, the main points of information found were from the online databases and review of references. At the start of

the research process, authors contacts in the financial industry were used to get started, and the supervisor provided the relevant path for sources.

In this thesis, there was no strict distinction not to include any non-academic information. However, for credibility, non-academic information was only collected from sources that show specific professional understanding of the topic, these being Central Bank publications and other related material<sup>17</sup>. Data gathered from databases were academic journal articles or working papers. The lack of empirical research made it challenging to create criteria for what is relevant and what is not relevant in academic literature. Thus, most of the articles that were found were included in this literature review.

The criteria's for including the article for the thesis:

- The article answers research questions
- The article is related or credible to scientific research. Report or journal article
- The language of publication of the studies is Finnish or English
- The publication year 2009-2020

The criteria's for excluding article for thesis:

- The article does not answer the research question
- The article relates to countries without independent Central Bank
- The article is not scientifically relevant
- The article cannot be accessed
- The article is about private Cryptocurrencies
- The article does not relate to monetary policy

The data search was conducted in December 2020 into databases mentioned in Table 3. The articles were reviewed in stages, starting with headings, considering inclusion and exclusion criteria. After this, abstracts were read from the remaining articles, and the full texts were read from the articles eliminated in the final stage. At every stage, an article that did not meet the inclusion criteria or met the exclusion criteria were excluded. The remaining articles formed a set of studies approved for the final literature review.

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<sup>17</sup> BIS, IMF and WEF publications are examples of related material



Table 3 Databases used in research

Database	Description
Business Source Elite (EBSCO)	This international business and economics database provides full text for over 1100 scholarly journals (over 500 peer reviewed).
Accounting, Tax & Banking Collection (ProQuest)	Results from sources ranging from current news to professional and academic journal articles covering the trends and history influencing important accounting, tax.
Web of Science - WoS	Web of Science provides access to the Science Citation Index Expanded, Social Sciences Citation Index and Arts & Humanities Citation Index.
ABI/INFORM Collection (ProQuest)	ProQuest ABI Inform provides articles and abstracts dealing with economics and business, public and private companies, industry research, management, marketing and advertising, finance and human resources.
NBER Working Papers	National Bureau of Economic Research is a private, non-profit, nonpartisan research organization dedicated to promoting a greater understanding of how the economy works.
SCOPUS	Scopus is a comprehensive scientific, medical, technical and social science database containing all relevant literature.

Business Source Elite (EBSCO) after search term CBDC with source types: academic journal 11 articles came up with 10 relevant results.

Accounting, Tax & Banking Collection (ProQuest): after search the term CBDC with source types: Reports, Scholarly Journals, Working Papers 3 results came up.

ABI/INFORM Collection (ProQuest): after search term CBDC with source types: academic journal and trade publications and working papers, 26 different results came up

NBER Working Papers after search term CBDC with source types: academic journal and trade publications and working papers 7 different results came up with 6 relevant.

SCOPUS after search term CBDC with source types: academic journal and trade publications and working papers 11 different results came up with 2 of them relevant.

After the search terms, the list was stylised from the same articles that came up from different databases, leaving 39 academic publications. According to their publication country and academic credibility, 15 relevant were chosen according to their publication country. The credibility was mainly assessed through whether the article was an academic or potential working paper. Credibility was also deemed insufficient if the paper was published by researchers who all work at the same central bank or if the paper was from China, Russia or Latin American central bank publication.

### 3.2.2 Data quality assessment

The quality of the studies selected for the literature review must be assessed to conclude how reliable the information obtained from the studies is.

In an integrative literature review, quality assessment is more complex because the integrative method allows for studies from different perspectives and various methods and material. These factors should also be considered when assessing the literature quality. (Whittemore & Knafl, 2005) It is recommended to use quality assessment checklists as assessment tools, in which case the assessment is consistent and comprehensive (Fisch & Block, 2018)

To assess the quality of the studies, it was decided to use a checklist suitable for assessing the quality of the multi-method studies adapted from (Hawker, Payne, Kerr, Hardey, & Powell, 2012).

The studies were reviewed according to six different evaluation criteria of the checklist (Table 4). Each point was scored, and finally, the total score was calculated. The studies' total scores can be read from the research table (Appendix 1). In this thesis, the studies were not excluded due to quality deficiencies, as it can be very complex, and it is recommended to be performed by an experienced researcher. However, if the study got 15 points or less or did not consider monetary policy in western-style economies or the study was about private cryptocurrencies or only technical aspects of CBDC, the study was immediately not selected for further assessment. After evaluation, 12 papers were selected for the data analysis part of this thesis. Appendix 2 contains the table for selected literature.

Table 4 Article Evaluation criteria

Evaluation criterion	Score	Score description
1. Abstract and title	4 points	Systematic, all-inclusive abstract and clear title
	3 points	An abstract containing almost all the information
	2 points	Incomplete abstract
	1 point	No abstract
2. Introduction and research purpose	4 points	An adequate and concise description of the background of the study (e.g. Literature review), highlighting information needs. Research purpose, objective and tasks are clearly stated
	3 points	The background of the study is somewhat described. Research questions outlined.
	2 points	Background described but purpose, goal and tasks missing or the opposite.
	1 point	Purpose tasks and goal are missing. The background of the study/literature review has not been done.
3. Analysis	4 points	The analysis clearly described. Quantitative research: hypothesis testing justified; statistical significance considered. Qualitative research: Describe how themes are derived, validation/triangulation of respondents.
	3 points	Analysis described
	2 points	Analysis poorly described
	1 point	The analysis was not described
4. Results	4 points	The results are described in an accurate, easy-to-understand and logical order. The tables are explained in the text. Purpose and objective in relation to the results. Sufficient data presented to support the results.
	3 points	Results described but insufficiently substantiated
	2 points	Results described at random, inaccurately and illogically
	1 point	The results are not described or are not related to the purpose and objectives
5. Results generalizability and portability	4 points	The framework and the backing assembly and adequately described, so that the referencing is potential.
	3 points	The framework, background, and layout life were partially described
	2 points	The framework, background, and layout life were shortly described
	1 point	The framework, background, and layout life were not described
6. Usability of results	4 points	1) Provides new knowledge, understanding or perspective 2) Further research ideas suggested 3) Suggestions for practical work presented
	3 points	Two of the above points described
	2 points	One of the above points described.
	1 point	Utilization of the results was not mentioned at all.

### 3.2.3 Data analysis

Data analysis in an integrative literature review means organizing, coding, cataloguing, and combining information. Qualitative data and multi-method research, for example, are suitable for the analysis of an integrative literature review methods used for analysis (Whittemore & Knafl, 2005) The data contained in the selected original studies were compiled and summarized by inductive or data-driven content analysis. In this thesis, the material analysis was started immediately after the application process in December 2020, because then it was easier to supplement and clarify the material if necessary. First, the material was read, looking for answers to research questions. The material was underlined, with expressions giving answers to various research questions. The expressions were then grouped into groups according to the research questions. The original expressions were then reduced and combined into groups describing the same topic. Finally, they were formed into categories that can summarize the information contained in the material. (Tuomi & Sarajärvi, 2009) The results part has tables three and four, where the categorizations and relevant articles are mapped. Articles are mapped in numbers, and the corresponding numbers can be found in appendix 2.

## 3.3 Results

According to the literature review and analysis, the central bank digital currency can affect price stability, and financial stability table 5 shows the topics more thoroughly:

Table 5 CBDC and Monetary Policy Transmission

Article reference number:	Subcategory	Category
1.3. 9. 12.	CBDC Trilemma "True price stability"	1. Price stability
1.3. 7. 9. 11. 12.	Nominal / Effective zero lower bound Central bank asset purchases Bank runs "Helicopter" money	2. Financial stability

### 3.3.1 Price stability

Price stability and CBDC was mentioned in 4 studies. It should be noted that price stability as one of the core functions of the central bank is a recurring topic in CBDC literature, and there are multiple approaches dangling around themes such as true price stability where the real value of CBDC would remain stable in terms of traditional CPI. (Bordo & Levin, 2017) There are problems associated with such indexation, namely in times of economic distress, possibility to create zero lower bound on real interest rates when agents shift their assets into zero real interest rate CBDC<sup>18</sup>. If CBDC is interest-bearing, there is a chance for the central bank to reduce interest rates in CBDC to foster price stability. True price stability could, if conducted accordingly potentially boost macroeconomic stability better than inflation targeting. (Taylor, 1993) (Clarida, Gordi, & Gertle, 1998) (Clarida, Gordi, & Gertle, 1999) (Woodford, 2003).

In IMF staff discussions, CBDC is considered not to offer near term assurance to price stability. IMF authors argue that only in the long term and if adopted widely and cash is eliminated, there is a chance that price stability could be achieved. (Mancini-Griffoli, Peria, Agur, Kiff, & Popescu, 2018)

Certain Bank of England's researchers argue Bank of England(2020) that monetary policy target as price stability could be easier with CBDC and digital cash using helicopter drops with targeting certain accounts. Bindseil from ECB argues that this is only supported by the staunch supporters of helicopter money in general. (Bindseil, 2019)

The second perceived danger, namely that inflation is needed to address the assumed over-supply of CBDC, also would not come to the mind of central bank market operations practitioners. Central banks monitor, in a forward-looking manner, all factors impacting inflation in the medium term. They then adjust their target for some overnight interest rate which is the anchor for the short end of the risk-free yield curve. Hence monetary responses are generated to achieve price stability. (Bindseil, 2019)

Price stability is one of the three main components central banks, in general, try to achieve, others being financial stability and financial efficiency. (Schilling, Fernández-Villaverde, & Uhlig, 2020) Authors demonstrate a CBDC trilemma, where central banks can only achieve two of the three at most. This means that there is a trade-off between the three of them. In their paper, they argue that bank runs can occur to central banks, demonstrated by Diamond and Dybvig (1983) model.

In its role as the intermediary, the central bank collects and invests the real goods endowments of the agents in real production technology. The central bank observes aggregate nominal spending and then decides how much of its real investment to liquidate. A central bank run occurs if patient agents also decide to spend their CBDC balances early. The price level for real goods then adjusts such that nominal CBDC spending clears the real goods market. In dominant policies,

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<sup>18</sup> An option of Stable real value in (Bordo & Levin, 2017)

the central bank can always enforce the optimum social allocation. If the central bank's price stability objectives mean that the bank does not meet this threat, then allocations must be suboptimal or prone to runs. (Schilling, Fernández-Villaverde, & Uhlig, 2020)

### 3.3.2 Financial stability

Financial stability and CBDC was mentioned in 6 of the studies. The concern of financial stability has been clear from the start of CBDC research. The most common pro-CBDC note to support financial stability is derived from principles. CBDC should and is accepted to issuance if CBDC is issued against government debt and that the regime itself offers clear strategy and guidelines when the transition is made. (Barrdear & Kumhof, 2016) The risks are the bank runs that could occur even when the issuer is a central bank. (Schilling, Fernández-Villaverde, & Uhlig, 2020) A decentralised system could not completely mitigate risks to financial stability, and generally, it is agreed in literature that a DLT approach is more practical. (Barrdear & Kumhof, 2016) The introduction of a CBDC framework will be obviously advantageous for a stable economy. It seems inevitable due to the number of reasons listed below:

- Settlement system benefits would grant almost free collateral when settling large amounts
- The creation of a CBDC payment system can foster innovation and competition as banks would have to innovate in their offering of CBDC
- CBDC acts as another policy instrument, offering specific transactional services without the cost margins of bank deposits. Along with interest rates central bank could use CBDC in a countercyclical fashion.
- The second policy instrument provides two most evident alternatives: a quantity rule by which the central bank sets CBDC quantity in respect of GDP and the price rule by which the central bank defines that the policy interest rate is spread to (lower) the CBDC interest rate.
- The countercyclical version of these rules also responds by lowering the CBDC to GDP ratio during an economic expansion or increasing the gap between the policy rate and CBDC during an economic expansion (and vice versa during a recession).

Quantitative easing, a process where moving defaultable debt to central banks' balance sheet reduces equilibrium interest rates since this affects commercial banks and financial stability in the long term a CBDC asset purchases, without bank deposits or reserves could potentially reduce the risk requirements of commercial banks and the possible off-setting measures that follow. (Barrdear & Kumhof, 2016)

Since central banks operate under government mandates, CBDC can foster financial integrity, which in turn affects financial stability. From anti-money

laundering to reserve requirements, CBDC technical framework could boost fighting against corruption and fostering good governance. (Mancini-Griffoli, Peria, Agur, Kiff, & Popescu, 2018)

According to (Brunnermeier & Niepelt, 2019) CBDC does not generate any additional financial stability issues. The pass-through funding would be automatically generated if economic agents want to exchange deposits for CBDC and central banks accept them, thus not undermining the financial stability. It is, therefore, automatic substitution, and the central bank's balance sheet does not change.

Remuneration of CBDC is not necessary to clear the market for bank runs or control inflation. The ability to remunerate is still a valid instrument to control the interest rates on CBDC. The remuneration tool could help in financial crises to prevent runs to safe haven CBDC by providing negative interest rates. Risks are that if deposits are not promised unconditionally converted to central bank money, being it cash or CBDC, the financial stability could be threatened in the short term. (Bindseil, 2019) Bank funding costs would also most certainly increase with the decrease of deposit financing. (Bindseil, 2019)

To curb excess volatility and the risk of a bank run, Allen et al. (2020) propose technical compliance rules for CBDC systems. Such systems could prevent excess runs, which are underlined as one of the risks for financial stability by several sources. (Bank of England, 2020) (Bindseil, 2020)

In chapter 4, these theories are applied to the Bank of England and Riksbank in addition to their own research literature.

## 4 DISCUSSION OF THE RESULTS AND CENTRAL BANK RESEARCH

### 4.1 Introduction to the Bank of England and Riksbank

As mentioned earlier, I will discuss different plausible scenarios in two modern independent central banks. Bank of England and Riksbank were chosen as alternatives since they possess the necessary qualities and compliance measures, and independence in their operations. CBDC research is also conducted in both central banks; however, the nature of adoption is slightly different. Chapter 4.4 discusses the Bank of England's adoption scenarios and chapter 4.5 about Riksbank. For both discussions, the database constructed in chapter 3 will be used as a reference point. In addition to the database, the discussion will use reports released by the Bank of England and Riksbank discussing the adoption of CBDC and the characteristics of CBDC are included to get a more solid look for the possible future adoption policies and scenarios.

### 4.2 Monetary policy transmission

The effective lower bound could pose a tighter constraint upon conventional monetary policy, and smaller economies could still provide stimulus from a monetary policy such as foreign exchange operations (depreciating currency) with CBDC.

A transition from a physical currency to a CBDC would not impact monetary policy implementation's fundamental mechanics. The central bank could define a negative nominal interest rate by merely reducing the balances on electronic wallets at a pre-announced rate. In theory, this should not be possible in an economy with physical cash, as customers (and companies) have the option of carrying physical currency banknotes. Via "helicopter drops" of currency, monetary policy may also be enforced, once seen as only a theoretical possibility of increasing cash holdings in an economy. In these circumstances, channels for quickly and efficiently injecting outside capital into an economy become relevant (Allen, 2020)

By resorting to CBDCs to escape the liquidity trap, central banks could dramatically reduce deflationary risks. Coordination will be essential to prevent double-dipping or multiple-dipped drops of money from the helicopter money. Instead of quantity-based monetary policy measures, central banks now use price-based monetary policy measures (policy interest rates). The central bank's ability to shrink CBDC-holding electronic wallets could not do anything to regulate the overall supply of money in a growing inflationary economy. (Allen, 2020)



Money transferred in "helicopter drops" can carry conditions of expenditure that allow only specific categories of expenditure. A patent application has been filed by the People's Bank of China that indicates the concept of a central bank issuing currency for loans carrying interest rates set by the central bank. The non-fungible currency will provide new mechanisms for government oversight of people's expenditure actions that could catalyse new groups of "nanny state" measures that could be unduly heavy-handed or micromanaged and threaten the civil liberties of consumers. Ultimately, every penny could be feasible to be its smart contract at the extreme limit. (Allen, 2020)

Central banks are exploring distributed ledger technology (DLT) for the bilateral settlement of clearing balances. DLTs make it easier to track and check transactions, as discussed earlier. Will these developments dilute the central bank's power, through its regulation of very short-term policy interest rates, to influence interest rates in the economy? This comes to the crux of whether central banks, even if they are side-lined from some of their conventional positions, will retain their control over aggregate demand and inflation. (Allen, 2020)

If these payments and settlement processes are generated between banks, then the central bank can play a less critical role. Still, the use of DLTs as a choice for a trusted third party could be restricted by competitive forces. Non-bank and informal financial institutions, such as the Fintech lending network, are less susceptible than conventional commercial banks to shifts in policy interest rates. It is vital to further research the non-bank financial sector's relative vulnerability to adjustments in policy interest rates and other monetary policy operational instruments. There are improvements to the mechanisms of financial systems that could directly affect the application and dissemination of monetary policy. (Allen, 2020) Even though the scope does not reach the non-bank financial sector in this thesis, the effects can be crucial since the economy has become so interrelated and connected.

### **4.3 Long-term effects of CBDC**

In the Barrdear & Kumhof (2016) working paper, the arguments are how the CBDC system should be created and what are the risks. Their suggestion is an application of such a permissioned system that would be the issuance of a central bank digital currency - universal, electronic, 24x7, national-currency-denominated and interest-bearing access to a central bank's balance sheet. The financing through money creation banking model of Jakab & Kumhof (2015) where monetary bank deposits are created by the extension of loans.

A realistic model of banks is essential for the exercise performed in Barrdear & Kumhof (2016), because of the vital role of banks as providers of the monetary transaction medium that would compete with CBDC in the real world.

A critical ingredient in the FMC framework introduced in Jakab & Kumhof (2015) is the existence of private-sector demand functions for monetary transactions balances, with the supply of monetary transactions balances prior to the introduction of CBDC, in the form of bank deposits, determined by commercial banks.

These demand functions for monetary transaction balances can ignore central bank money other than CBDC because, during normal economic times, central bank reserves are endogenous and are, in any event, not held by the non-bank private sector, and because cash is a tiny and non-constitutive part of the financial system.

Many critical questions concerning CBDC are therefore related to the functional form and calibration of the joint demand function for CBDC and bank deposits.

Barrdear & Kumhof (2016) analysis suggests that the only conditions needed to secure these gains are that a sufficiently large stock of CBDC is issued in a steady state and that the issuance mechanism for CBDC ensures that the central bank only trades CBDC against government debt instruments.

Central banks have continued to behave as stable and conservative institutions in the historical sense, paying strict attention to their mandates and being prudent in their operations. However, many central banks have taken measures in recent years to erode such a prudent, conservative approach by deploying unorthodox monetary policy instruments. CBDC could serve as a "cost-less exchange medium, a safe store of value, and a stable account unit", according to Bordo & Levin (2017). The risks associated with the issuance of CBDC should also be known to policymakers making decisions.

Even though Bordo & Levin (2017) talk about how price stability could be achieved with an appropriate monetary policy framework, there are concerns that economy could become uncertain and turbulent with a lot of privately issued digital money.

Without competition from CBDC, there remains a chance that the entire payment system would become quasi-monopolistic where only a few privately issued currencies dominate the market, making any operational problems in the network high risks for the entire financial system.

Mancini-Griffoli, Peria, Agur, Kiff, & Popescu (2018) CBDC's case depends on whether it improves cash roles for users and central banks. As we already know, money is regarded as having three functions: a unit of account, a means of payment, and a value store. Users would pursue a form of cash that maximizes private benefits and minimizes costs and risks associated with them. CBDC helps central banks to accomplish their public policy objectives more thoroughly and to resolve particular market failures. The relative weight of each criterion will vary in terms of usage and costs and will vary by country and use and costs.

Anonymity covers the extent to which transaction parties, third parties, and the government are or may be made aware of identity and transactions. Central banks play a crucial role and ensure that money fulfils its three roles. The final leg of the conceptual process is to classify CBDC rivals. These fall into four

categories but will differ by country: cash, deposits from commercial banks, cryptocurrencies, and narrow finance. Everything but cash is changing and gaining market share rapidly.

Commercial bank deposits are going through significant enhancements. Debit card networks have historically enabled purchases. Venmo as one application enables transactions between mobile devices to take place and adds a protection layer. Central-bank-provided fast-payment solutions allow instantaneous settlement of payments of any size and form. The least appealing alternative is a cryptocurrency, earning a low settlement speed score due to current technical limitations. Cash provides instant settlement, no cyber or default risk, and total anonymity.

#### **4.4 Possible adaption scenario in United Kingdom**

Bank of England is one of the oldest Central Banks in the world. Their mandate currently is to act as an intra bank settlement provider, issuing notes, price stability methods using inflation targeting, acting as a regulatory authority for banks and non-banks by enforcing liquidity requirements and capital requirements. Bank of England also sets strategy plans for maintaining financial stability every three years.

In both the type of money given to the public and the payment infrastructure on which transfers would be made, CBDC will be a breakthrough. The Bank of England must consider the prospects and difficulties raised by CBDC to succeed in the above-mentioned mandates. There are multiple directions in which the CBDC, through the provision of new money and new payment infrastructure, could help the Bank's monetary and financial stability objectives.

The Bank of England supplies households and enterprises with banknotes for use as a medium of payment and store of value. Banknotes can provide an anchor in confidence in the financial system because households and companies know that they can turn deposits into cash from central banks. To enforce monetary policy, BoE use reserves as is with any modern central bank to support financial and monetary stability. To control the interest rates offered and charged by banks, BoE varies the interest rate paid on reserves, which has an impact on investment and inflation in the economy.

Most payments in the UK are now made by retail payment networks through the conversion of bank deposit. New forms of money and payments are also emerging, such as stable coins. CBDC could replace privately issued money as a new form of publicly issued central bank money. It could improve the capacity of the Bank of England to achieve its goals in the future. The development of monetary tools poses potential risks which extend beyond those typically associated with existing payment systems.

Bank of England staff discussions have created some theories to grasp and understand what CBDC could and should be in their sense. Common factors

seem that CBDC is indeed used with the traditional RTGS<sup>19</sup> system and not substitute it. One of the most important aspects is that CBDC should have an adjustable interest rate. The core reasons for adjustable rate is to ensure price stability and price parity. Several examples are given, but the main point is that since CBDC market equilibrium is needed, it requires that demand and supply meet. Since it is almost impossible to forecast the actual demand for CBDC, central bank could overshoot and break the parity between CBDC and other forms of money. Adjustable-rate can clear the market by meeting demand if increasing, and there is no need for any particular inflationary actions where CBDC would be supplied more and more.

Achieving the possible change from deposits to CBDC is daunting since no major economy central bank has yet implemented a CBDC. Important lessons can be learned from previous financial reforms in the UK that included bank intermediation, but substantial more research is required. A large-scale move to CBDC could result in banks losing their stock of reserves. The design of the CBDC will have to understand the implications of the central bank's monetary policy implementation, and this might lead to changes to the implementation process. CBDC could imply that improvements to the bank rate will be passed on sooner and more completely to the rates faced by households and businesses. If CBDC is more appealing compared to deposits, the degree of disintermediation of the banking sector would possibly be more significant. A reduction in the total amount of bank lending will also minimize the effect of bank loans on the overall transmission of monetary policy.

The Bank of England clarified that, once quantitative easing starts to unwind, it aims to satisfy banks' demand for reserves by lending to the central bank rate against high-quality collateral. But that may mean that banks will not have adequate quantities of the excellent quality collateral to access the reserves they need. This might lead the Bank to consider providing reserves against a broader range of collateral. (Barrdear & Kumhof, 2016)

CBDC could minimize systemic risk by offering core payment services that are outside and not dependent on the banking system. It could also give the central bank more opportunities to manage these risks, according to central bank. It does not result in more significant disintermediation than is predicted.

CBDC may also add financial stability risks, offsetting some of these advantages. In the move to CBDC, the decrease in bank balance sheets could have an effect on the availability of credit. During a time of stress or financial instability, households and businesses saw CBDC as less risky than commercial bank deposits. This rush to safety could cause broader systemic instability, such as a run on the banking system.

Running to CBDC, on the other hand, will almost certainly be much less expensive and time-consuming. This can encourage banks to take precautions to protect themselves, such as a propensity to 'hoard' reserves during times of stress.

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<sup>19</sup> RTGS real-time gross settlement (RTGS) refers to a funds transfer system that allows for the instantaneous transfer of money and/or securities.

This behaviour will have an even more significant effect on the functioning of money markets. (Schilling, Fernández-Villaverde, & Uhlig, 2020)

If a CBDC completely substituted transactional sight deposits at commercial banks, those banks will be entirely dependent on other sources of funding. Any expansion of the central bank's balance sheet to finance bank funding would raise the question of what assets would be needed to match the increased liabilities and how they would be supplied. There could be a lack of high-quality assets to back an expanded central bank in this case.

But if we think in terms of the current balance sheets of BoE, ECB and Fed, their balance sheets have grown without money market disturbance or lack of trust in the credit channels for banks. The even more broadening of central banks' balance sheet might happen, but with private partnerships, perhaps with investment banks, the expansion could be driven to such sources of assets that could be deemed safe. If private evaluators are included, there needs to be regulative authority inspecting dealings and the suggested dealings made by BoE.

The Bank of England believes that any CBDC infrastructure it builds should be secure, robust, quick and effective. It sees the participation of the private sector as the key to compliance with the third principle. BoE outlines a "platform" model involving two main elements: a central ledger supported by the Bank of England and a private-sector payment interface provider. The Bank would maintain ultimate control over currency formation and destruction but would rely on the private sector for many services, such as smart contracts and account management. The central ledger may or may not be kept on a decentralized basis. However, in any event, the Bank will maintain its ultimate power. The private sector would manage CBDC transactions to end-users (Bank of England, 2020).

The Bank of England states that if the CBDC succeeds, a degree of commercial disintermediation of the banks is inevitable. However, it considers that the net effects on monetary policy and financial stability may be positive if the changes are effectively handled. The BoE has three instruments at its disposal to help manage these risks. It will determine whether to pay interest on CBDC at all and, if so, at what amount. It could also use reverse tiering so that CBDC's balances above a certain threshold would cost less. The third option is to impose strict constraints for the amount that CBDC could be held. (Bank of England, 2020)

From these aspects, it is safe to say that adoption of CBDC would result in net positive effects, according to the literature. Risks are identified and could be managed. In the Bank of England's case, it seems that the practical application procedures should next be constructed by consulting private sector entities with enough know-how to build such applications. In Sweden, Accenture is already building some form of a platform, but the details are still unknown. (Riksbank Press Office, 2020)

## 4.5 Possible adaption scenario in Sweden

The central bank's consideration of CBDC, the E-krona, appears to be primarily motivated by worries regarding private payment providers in Sweden, where the use of cash is vanishing rapidly. A significant decrease in retail payment uses of cash took place in combination with a shift in the number of commercial participants, payment networks and infrastructures towards private payment systems and restructuring. The digital currency is based on a separate infrastructure that provides private agents who can provide E-krona payment services. For all payment suppliers and fintech firms getting connections to the network, all public will have access to the E-krona.

### 4.5.1 Payment system

In Sweden, cash usage is dropping rapidly, and the country is considering adopting a digital currency for the central bank. The Bergman (2020) shows that the implementation of an E-krona has at least five potential efficiency reasons. The goal is to improve competition for banks and clearing and processing services providers, such as BG, Visa and Mastercard. It also seeks to promote payment transactions routing, which effectively removes the need for separate clearing and settlement phases. This will strengthen the Swedish payment system's resilience and autonomy. Bergman (2020) offers an overview of policy options used in markets that share some of the payment market characteristics and addresses current procompetitive regulations that apply to payment markets. It aims to forecast the launch of a digital currency in Sweden on competition in the pay-for-payment industry.

The number of retail banks in Sweden is relatively high, and industry concentrations do not stand out as markedly concentrated as many other service markets. The reluctance of customers to move between banks weakens the competitive pressure. BG's<sup>20</sup> pivotal role in the clearing and processing markets and the fact that the dominant incumbents jointly operate it indicate that it would be beneficial to implement another routing payment transaction platform. However, the potential of an E-krona to intensify competition in the face of established competition remains to be seen. (Bergman, 2020)

A mobile technology-based app CBDC will expand access to financing for the vulnerable, rural households and other parts of the population that the banking system can underserve. A CBDC has many additional advantages. Another possible gain for a CBDC would be that the use of currency banking notes would deter illegitimacy and regain its dominance in the shadow economy, especially regarding banknotes of high denominations.

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<sup>20</sup> Bankgirot is a proprietary clearing system (a giro) in Sweden used for transactions such as bill payments. It is owned by Swedish banks. Much like RTGS.

The actual cash removal could help with this, but this could be rendered meaningless by the possible transition of unauthorized payments to decentralized payment systems by anonymously decentralised cryptocurrencies.

That is why Riksbank should take issuing CBDCs seriously to keep power or at least track payment processes that can be used so effectively for unlawful and lawful purposes. They also illustrate how various government policy variations, such as the amount of taxes and the punishment for undertaking tax evasion coexist, and in which cash and CBDC can exist.

The issue of whether public access to cash or CBDC is essential to the monetary system depends, according to the authors, on the national context. Armelius, Claussen, & Hendry (2020) argue that if institutions are solid, the uniformity of money can be sustained without cash, the government has the potential to fix structural issues rapidly, and payment alternatives are instantaneous. Before we can draw any definite conclusions about the position of cash and CBDCs in monetary system stability in each country, the authors conclude that more research is required into this mechanism. When considering the Swedish institutions, it could be argued that the institutions are solid, and the uniformity of money could be sustained.

#### **4.5.2 Monetary policy and effect on seignorage**

What would be the demand for an E-krona to sustain the Riksbank's stable, long-term funding? According to Kjellberg & David (2019), the cash demand expected to produce revenue roughly equal to the bank's costs which will be SEK 30 billion, assuming a steady-state nominal interest rate of 3 per cent. This represents three times the value of today's approximately SEK 60 billion outstanding currency, but only about one-tenth of household bank deposits. Given that the essential characteristics of a potential E-krona are very little understood, its effects on seignorage are therefore unknown, says Kjellberg & David (2019). Simply replacing cash with an interest-bearing electric krona will likely lead to a significant reduction in seignorage. However, different assumptions about the level of the interest rate and the spread of the bond rate over the E-krona rate could yield different results. The seignorage would not change if a new E-krona replaced the current cash. However, the Riksbank balance sheet would need to be expanded. To secure Riksbank long term funding needs, (Kjellberg & David, 2019) estimates that the cash demand needed is half that which is currently incurred. It accounts for approximately 10% of existing household bank deposits and just over 3% of GDP. (Gustafsson & Lagerwa, 2020)

The creation of a CBDC also has a detrimental impact on the provision of bank loans. Banks can currently produce loan amounts that are ten times their liquidity reserves. CBDC being digital, bank deposits can be higher in times of systemic turmoil. CBDC will expose the banks to higher possible outflows than we claim. Inflows to cash and the danger of bank runs are the two fundamental causes of outflows for retail deposits. Gustafsson & Lagerwa (2020) suggest that

in the presence of CBDC, banks will take various steps to deal with large possible outflows.

. Central banks can purchase more collateral available for central banks and fund such purchases through the provision of stable funding tools to sellers. Any demand deposits may also be converted into term deposits. These initiatives are all planned to reduce the supply to the real sector of illiquid banking loans with potentially damaging repercussions on macroeconomic activities. Central banks may increase the availability of central bank reserves to mitigate the adverse effects. Also, direct purchases of illiquid assets from the central bank can stimulate the bank's supply of illiquid loans. If an increase in the banking industry's liquidity reserves is consistent with an increase in potential exit volume by a CBDC, CBDC will influence banks to lend more. Thus, the effect of the CBDC on banks' lending capacity is neutralised fully.

### 4.5.3 Concluding remarks Sweden

For the Riksbank, launching an E-krona will be a significant move. There are 10 million people in Sweden, and significant quantities of money are dedicated by commercial banks to managing large numbers of accounts. In the E-krona launch event, banks would likely have to employ substantially more people.

All of the above-presented ideas and scenarios guarantee access to the best source of money for the general public. In the event of bankruptcy, or if the intermediary fails to deliver its active service to the customer, there is still an operational risk. There is also a liquidity risk for the synthetic E-krona, as bankruptcy procedures are required for account holders to access their e-krona wallets.

To ensure that the model chosen for E-krona provision can operate smoothly for all interested parties, the Riksbank should cooperate with the industry. If the adoption is too small, it may not be possible to achieve the objectives of an E-krona. Since there are network effects (in this question, see Armelius et al. 2020),

All alternatives would boost competition, as the E-krona would compete with deposits from private banks. The most severe barriers to competition for E-krona in the payment industry exist in the level of wholesale and infrastructure. At present, barriers to entry for new entrants are high. Together, the largest banks own the clearinghouse (BG), from which almost all retail payment flows are handled until settlement in RIX<sup>21</sup> and the access rulebook. In compliance with European legislation on the finality of settlement for designated payment schemes, the settlement system itself is strictly controlled. It aims at ensuring the final and irrevocable settlement of transactions but also limits the access of credit institutions and clearinghouses to the system. Perhaps an alternative platform is needed

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<sup>21</sup> The Swedish payment system is called RIX and banks, clearing organisations, the Swedish National Debt Office and the Riksbank are participants. Source: <https://www.riksbank.se/en-gb/payments--cash/the-payment-system---rix/>



if it is deemed necessary to ensure that competition in the financial settlement industry is kept open. This could mean an alternative to RIX sort of E-Krona RIX with plugins and API to RTGS.

The E-krona, if provided by intermediaries rather than Riksbank, would not be able to provide technology that runs independently of other schemes. The E-krona may not be available to users in the event of interruptions in the intermediary's system. If many intermediaries use the same IT supplier, this could be especially important. In the E-krona design, less severe but more frequent disruptions, such as internet access, can be considered.

In theory, decentralized DLT technology-based models could be more robust than centralized approaches. This is because the entire ledger of transactions has its clone of each node. Thus, even if one account or several are down or one financial institution is experiencing malfunctions, the overall system would still work, even for the malfunctioning institution's customers. If the Riksbank develops a backup channel that allows users to access their E-krona holdings directly from the bank, resilience could also be improved. However, from a central bank viewpoint, such a compromise would not be optimal. At the cost of longer processing times and making all purchases publicly accessible, the growth in durability is great but this could be interpreted as a not user-friendly approach to an already sensitive subject of privacy and GDPR regulations.

Rules and mechanisms that protect personal integrity and privacy have to be set up. DLT solutions are more sensitive to exchanging information between participating nodes. More privacy options mean less resilience to only 'see' individuals own transfers are possible for nodes. It is too early to say that the best solution for enhancing cross-border transfers would be the use of the same approach in various jurisdictions such as in the euro-area or Great Britain. Suppose a decision to incorporate an E-krona is made. In that case, a comprehensive cost-benefit review will have to be performed with alternative E-krona models at a later level—the fewer the need for improvements to the current payment-acceptance infrastructure of retailers.

Economic design determines the acceptance of the e-krona and its impact on the banking system, financial stability, and monetary policy effectiveness. Under all the design alternatives discussed above, we can restrict access, apply caps, pay interest, provide for convertibility and subsidize E-krona. On all interest rates, short and long, a non-remunerated E-krona will place an efficient zero lower bound and thus add a new limitation to monetary policy.

Limitations on access and restrictions on E-krona holdings will minimize or avoid commercial banks' disintermediation. Similarly, limitations on entry to E-krona will restrict systemic bank runs into it. It should be remembered here that the demand for an E-krona is likely to depend on its interest rate compared to the interest rate for commercial bank deposits. In an article by Riksbank, the authors state that "A variable spread between the key policy rate and the E-krona could be a tool for regulating the demand." Some authors find that the monetary policy transmission would be improved by CBDC issue. However, in the case of Sweden, it seems not to be the case (Armeliu, Boel, Claussen, & Nessén, 2018)

If the Riksbank adopted a fully centralized E-krona model, it could improve resilience. To manage accounts for millions of people, such a model will entail significant technology and resources investments. The extent of participation and costs to the bank would be considerable in both the centralized model with intermediaries and the decentralized model with one intermediary. (Armelius, Guibourg, Johansson, & Schmalholz, 2020)

It would be relatively straightforward to adopt a synthetic E-krona<sup>22</sup> less expensive than the other alternatives. However, such a minimalistic strategy does not, to the same degree, accomplish the aims of expanded competitiveness and durability.

#### 4.6 Other consideration and future research

CBDC relation for private cryptocurrencies Bitcoin as a means of trade and a unit of account, high volatility makes it prohibitively expensive to use. Bitcoin cannot be considered a store of value considering its excess volatility over very long horizons. Not only does high volatility have a negative effect on Bitcoin's position as a currency, but also as an investment. Bitcoin can develop as an alternative to other value stores such as gold, in the long run, considering its high historical volatility compared to major currencies. Baur & Dimpfl (2021) claim that the deflationary architecture and the decentralized and global existence of Bitcoin improve its store of value properties. It is doubtful that any nation would recognize it as an official currency and lose control of the money. (Baur & Dimpfl, 2021) conclude that the excess volatility of Bitcoin does not make it a strong portfolio risk-diversifier. The results are technically endorsed based on the nature of Bitcoin, specifically its "deflationary" fixed supply. The evolution of digital currencies like Bitcoin illustrates the future position of private money that has been decentralized and denationalized. It remains to be seen if digital currencies that are unregulated and globally dispersed can compete with domestic fiat currencies and existing stores of value. Especially the competition with CBDC remains an open question and should be empirically studied when first CBDC adoptions in the large open economies are made. (Baur & Dimpfl, 2021)

If all the available financial information, including transactions, are in one general ledger it is only natural that CBDC significantly improves in investment banking and especially valuation.

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<sup>22</sup> "In this model, e-krona are issued and provided through intermediaries who hold 100 percent reserves at the Riksbank to back their value. One fundamental difference from the other models is thus that a synthetic e-krona will be a claim on the intermediary and not directly on the Riksbank" (Armelius, Guibourg, Johansson, & Schmalholz, 2020)

Valuation in general practises is based upon historical financial data and future expectations of a company. When keeping in mind principal agent theory, one of the trickiest tasks is to decide whether all the available financial information have been reported honestly. In the era of CBDC, there are vast advantages for general ledger where the financial data of any company can be pulled from almost at real time. This would make it possible for investment banks and other investors to make algorithmic models to quickly and effectively gain detailed information. This requires a structure where all the financial information that the company generates is recorded instantaneously to the general ledger, and using an only little bit of general software engineering, this information can be arranged in the shape of a balance sheet, income statement and cash flow statements.

This type of real-time information could be of limited access to all individuals but available for all public companies. It would make it far easier for investors to get the idea of good investment opportunities and the financial health of one company, and the comparable universe of companies. In a more general view of the financial markets, the open real-time financial information can create ever more efficient markets. Bringing us closer to theories of efficient markets and opening new research possibilities for real-time financial market efficiency.

CBDC funded asset purchasing programs could lead to a situation where defaultable debt on zombie companies is transferred to the central banks' balance sheet. This could mean that underperforming companies gain unnecessary stimulus to their operations and possibly even reduce the innovation process. Further research in zombie companies and QE programs is needed to confirm this statement, but there might be a risk of rewarding slackly inefficient behaviour if not considered.

Considerable investments are needed to hire educated staff to central banks if financial integrity and AML procedures, and good governance rules are made as a requirement of CBDC. Since the central bank could be considered a third-party investor, their processes and balance sheets should constantly review the companies they are funding or saving through QE programs. CBDC could make it more accessible as there are no similar requirements for the central bank (yet) to hide or mask identities for third parties, and the data would all be available in the DLT framework.

Further research should also be conducted towards the MAX effect which is a study the lottery-like behaviour of assets. Grobys & Junttila (2021) study the lottery like behaviour of cryptocurrencies and find out that investors expect cryptocurrencies that have high payoffs desirable, hence offering low returns. The MAX effect should be kept in mind and studied in the CBDC sense, especially if the availability of CBDC is to all making CBDC trading more desirable.

## 5 CONCLUSIONS

CBDCs offer the possibility, as a means of stimulating demand, of developing currencies with nominal negative interest rates. They could assume many settlements and liquidity management operations that are usually the central bank's province. However, threats, such as privacy issues and micromanagement by policymakers come with such capabilities. The wide variety of policies that can be enforced through highly focused policies may tempt policymakers into unduly complicated measures and serve special interests. It may also affect consumer conduct in ways that breach or otherwise harm civil liberties. CBDCs could be a valuable tool for regulators and policymakers to understand economic activity and monetary policies better.

In relation to research questions over Central Bank Digital Currency can help foster the monetary policy's price stability, effectiveness research requires empirical studies when a CBDC is adopted. CBDC can in addition enhance financial stability in regards of adding trust and privacy, depending upon the chosen technical approach. There does not seem to be large negative financial stability implications according to research currently.

In terms of literature, many of the papers studied for this thesis state that the financial implications are net positive in most scenarios. The risks that arise from the adoption tend to focus on the initial adoption moment of CBDC. Also, the characteristics of CBDC, i.e. the type of remuneration and whether CBDC is offered to the public or not. The net positive effects seem to outweigh the overall risks associated with the adoption of CBDC. The practical design choices remain to be seen. Further research is needed from the empirical part of CBDC when first adoption scenarios are undertaken.

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## APPENDIX 1 Selected Literature

Author	Title	Objective of the study	Publisher	Database	Year
Barrdear, John; Kumhof, Michael	The macroeconomics of central bank issued digital currencies	To study the macroeconomic consequences of central bank digital currencies and model financial DSGE model	BoE	Proquest	2016
Bordo, Michael D; Levin, Andrew	Central Bank Digital Currency and the Future of Monetary Policy	To analyze the key features of CBDC, focusing on basic design characteristics	NBER	NBER	2017
Tommaso Mancini Grifoli; Martinez Peria, Maria Soledad; Agur, Itai; Ari, Anil; Kiff, John	Casting Light on Central Bank Digital Currencies	To propose a conceptual framework to assess the case for CBDC adoption from the perspective of users and central banks.	IMF	Proquest	2018
Borgonovo, Emanuele; Caselli, Stefano; Cillo, Alessandra; Masciandaro, Donato	Between Cash, Deposit And Bitcoin: Would We Like A Central Bank Digital Currency? Money Demand And Experimental Economics	To analyse the demand of a central bank digital currency (CBDC).	BAFFI CAREFIN Centre	Proquest	2018
Chiu, Jonathan; Davoodalhosseini, Mohammad; Jiang, Janet Hua; Zhu, Yu	Central Bank Digital Currency and Banking	To build a model analysing CBDC and Bank activity	Society for Economic Dynamics.	Proquest	2019
Khiaonarong, Tanai; Humphrey, David	Cash Use Across Countries and the Demand for Central Bank Digital Currency	To Estimate how cash usage is tied to possible CBDC issuance	IMF	Proquest	2019
Brunnermeier, Markus K; Niepelt, Dirk	On the Equivalence of Private and Public Money	To study swap between private and public money equilibrium conditions	Journal of Monetary Economics	NBER	2019

Brunermeier, Markus K., Harold James, and Jean-Pierre Landau	The Digitalization of Money	To understand the key questions and economic implications of digital currencies and CBDC	NBER	NBER	2019
Bindseil, Ulrich	Central Bank Digital Currency: Financial System Implications and Control	To study different pro's and con's of issuing CBDC	International Journal of Political Economy	EPSCO	2019
Jesús Fernández-Vilaverde Daniel Sanches Linda Schilling Harald Uhlig	Central Bank Digital Currency: Central Banking For All?	To study how banking panics affect CBDC and Central Banking	NBER	NBER	2020
Sarah Allen Srđjan Ćapkun Ittay Eyal Giulia Fanti et al	Design Choices for Central Bank Digital Currency: Policy and Technical Considerations	To devise a framework for CBDC technical and Economic Challenges	NBER	NBER	2020
Linda Schilling, Jesús Fernández-Vilaverde & Harald Uhlig	Central Bank Digital Currency: When Price and Bank Stability Collide	To analyze the stability models and banking runs and how these might have an effect for	NBER	NBER	2020