UNIVERSITY OF LJUBLJANA

SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

AN ANALYSIS OF THE EFFECT OF DIGITAL CURRENCIES ON THE MONETARY SYSTEM

Ljubljana, September 2023 PETJA KRUPENKO

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LIST OF ABBREVIATIONS

Altcoin − Alternative cryptocurrency

AML − Anti-money laundering

Bit-DNS − Decentralized Doman Name Systems

CBDC − Central bank digital currency

CFT − Combating the Financing of Terrorism

DAO − Decentralized Autonomous Organization

DApps − Decentralized applications

DeFi − Decentralized Finance

DLT − Distributed ledger technology

EOA − Externally Owned Accounts

EVM − Ethereum Virtual Machine

FinTech − Financial technology

ICO − Initial Coin Offering

IOU − I owe you

KYC − Know Your Customer

MEP − Members of the European Parliament

MiCA − Markets in Crypto Assets regulation

PoS − Proof-of-Stake

PoW – Proof-of-Work

SVB − Silicon Valley Bank

INTRODUCTION

Technological developments have a wide impact on our way of life. Since the launch of Bitcoin and blockchain technology in 2009, cryptocurrencies have grown to become one of the most interesting technological advancements. In November 2021, the global crypto market capitalization reached a record high of around 3 trillion dollars, which can be compared to the values of the global automobile manufacturing industry or one of the world's best−performing technological stocks, Apple (CoinGecko, n.d.; Ngrave, 2022). Since then, the cryptocurrency market experienced many price jumps and drops that in May 2023 lowered global market capitalization to $1.1 trillion. Cryptocurrencies are digital assets that aim to create a decentralised financial system that would operate without regulated intermediaries (White House, 2023). For investors, trust, security and speed of transactions, as well as decentralisation and its volatility, are paramount as they create the opportunity for high returns. Despite the popularity and promise of a financial revolution, recent headlines have been overshadowed by crypto crashes, illicit activities and aggressive government crackdowns (Yaffe-Bellany, 2023). The purpose of this master thesis is to analyse the effect of digital assets on the monetary system. I chose this topic to discuss my interest in cryptocurrencies. I wanted to connect my curiosity about cryptocurrencies with the economic and financial knowledge I acquired during my studies. With this master's thesis, I want to broaden my knowledge about the digitalization movement so that I can apply it to my further career path.

Digitalization and globalization have intertwined with all aspects of our lives and the monetary system is no different. Money is one of the most important human inventions (Arvidsson, 2019). Through time the concept of money existed in many shapes and forms, from minted coins to paper bills, credit cards and digital wallets. Regardless of its form, money aims to serve as a medium of exchange and a widely accepted payment mechanism. Rising digital technologies and the Covid-19 pandemic have transformed the way we make payments and how we use money. The trend towards cashless societies has been increasingly gaining ground (Arvidsson, 2019). Such a change can potentially question the future nature of money and the role of central banks. The central banks around the world represent the main monetary instrument that aims to achieve economic growth and financial stability with low and stable inflation (International Monetary Fund [IMF], n.d.). Unfortunately, with multiple financial crises and repeated bailouts of financial institutions, many people have lost trust in governmentally controlled entities. Growing scepticism and new user demands have spurred new blockchain technology innovations like Bitcoin, Ethereum and stablecoins (He, 2018). Decentralized blockchain technology operates as a secure and open network without third-party intermediation or central bank oversight. While digital assets are currently not a threat to existing financial services, the great growth potential of assets like stablecoins could have important implementations in the future (Financial Stability Board, 2022). For that reason, governments are looking to install proper regulations for digital assets while simultaneously developing central bank digital currencies (CBDCs).

This master's thesis aims to analyse the changes introduced with digital assets. As part of the thesis, I want to find out whether digital systems will persist, to what extent they will change our lives and what impact they will have on existing traditional systems. I have sought the answers through four targeted research questions:

1. Can cryptocurrencies/digital currencies replace fiat money?
2. Can Monetary policy be effective in the world without central banks?
3. Can the Digital Euro strengthen monetary policy?
4. Can the broader world beyond the digital asset ecosystem benefit from stablecoin implementation?

This thesis uses qualitative research methods. The theoretical part is based on secondary data research, presenting the main themes from several academic articles and journals. In the practical part, I conducted empirical research based on semi-structured and unstructured interviews. I conducted interviews with MSc Anja Blaj, policy expert and the President of the Blockchain Think Tank Slovenia, strategy advisor and economist PhD Oliver Beige and a member of the board of Pokojninska družba A, Blaž Hribar. Their expertise covers all aspects of my master's thesis, from cryptocurrency and regulation, to economic and monetary systems. The aim of using primary data was to draw conclusions and connections within the scope of the content of the thesis.

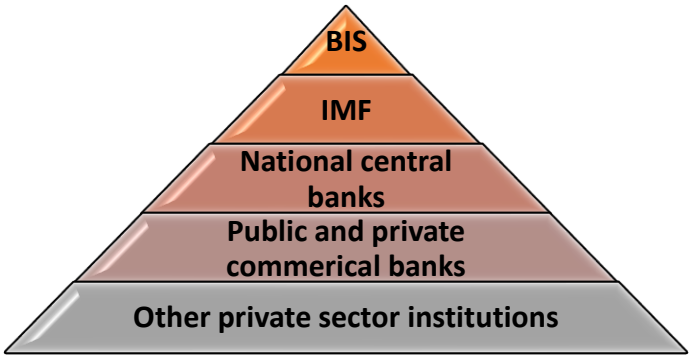
The structure of this master thesis can be split into two separate parts. The first part will discuss monetary systems. The discussion will start with money and the role it plays in the rapidly evolving world of digital currencies. The next subsection will touch on central banks and the functions they have acquired over time. Hand in hand with central banks goes the discussion on monetary policies. The first part of the master thesis is concluded with a discussion on central bank digital currencies (CBDCs) and in more detail on the digital euro. The second part of this thesis focuses on the expeditious world of decentralized technologies with Bitcoin, Ethereum and stablecoins. After an in-depth analysis of the roles, applications and features of the aforementioned crypto assets, we also study the case of Silicon Valley Bank and USD stablecoin, which shows the interconnection between traditional banking and crypto assets. The last part of this master thesis is the empirical analysis which includes the methodology, a discussion of research questions and a conclusion.

1 MONETARY SYSTEM

The monetary system is a governmentally controlled system that provides money in the economy. The complex and intertwined structure between public and private institutions must operate on multiple levels to ensure a globally cohesive monetary environment. Central banks play a vital role in setting regulations and judicial systems that support a country's monetary exchange. Individual central banks are connected on the global level with

international institutions such as Bank for International Settlements (BIS) and International Monetary Fund (IMF). Listed financial supervisory establishments represent countries that jointly account for around 95% of world GDP. BIS serves as an international bank for central banks and offers other financial services to promote international cooperation and monetary and financial stability. On the other hand, IMF strives to offer policy advice and financial assistance for central banks to reach monetary medium- and long-term targets (BIS, 2022a; IMF, n.d.).

Figure 1: International banking and monetary structure



Adapted from Kubus, Mascareñas Pérez-Iñigo & González Fernandez (2020).

As seen in Figure 1, national central banks like the ECB, Bank of England, Bank of Japan, the Federal Reserve Bank and the People's Bank of China represent the heart of the monetary system. Their exclusive role is to manage currency and control the supply of money in the economy. Another big player in the money supply system are commercial banks, which create new money in the form of deposits. Besides money creation, commercial banks also perform borrowing and lending services for other private entities such as multinational corporations, venture capital funds, stock exchanges and private investors (Mcleay, Radia & Thomas, 2014a; Prasad, 2021a).

1.1 Money

To better understand how changes on an institutional level affect users and our payment systems we first have to dissect a complex notion of money. In early history, goods and services were exchanged with bartering. With the development of metal coins trading became easier. Goods were priced based on specific commodity standards of weight. With increased international trade, cumbersome metal coins, were substituted with bank notes, which are predecessors to the fiat money that we know today (White House, 2023). Regardless of its form, money has to hold value, facilitate transactions and be widely adopted. When the economy works well, financial institutions can adjust the demand and supply of money to avoid financial instabilities (Prasad, 2021a).

The nature of money has given different forms and faces. Nonetheless in all forms money must satisfy three principal functions: medium of exchange, store of value and unit of

account. The form of money is accepted as a medium of exchange when an object can be exchanged for any other good or service[1]. Secondly, when an asset can maintain purchasing power over time it represents an efficient store of value. Lastly, the unit of account measure determines the monetary value of goods and services in the market (Mesk, 2023; Mishkin & Serletis, 2011). Though functions are tightly connected, each function plays an essential and distinct role in the economy. Most assets like gold, stocks, Bitcoin or even real estate fulfil one or more functions, but not all three (Senner & Sornette, 2019).

Moving on from a textbook definition, we can classify money also based on a technical monetary perspective. Throughout history, economies developed from autarkies where people were able to consume only what they produced to exchange economies where people traded different goods and services at different points in time. This can be accomplished with I owe you (IOU) claims. IOU is a promise of repayment at a later date. When we make a deposit, that is a commercial bank's IOU to us. When we go to the grocery stores, we pay with credit cards which is an IOU to the store provider. As such, currencies like the euro, dollar or yen represent a unique type of IOU claim. To say it simpler, money is a social convention because it is supported by universal IOU claims. Additionally, it is also globally accepted, as a currency and a means of payment, because people trust and accept it as such (Mcleay, Radia & Thomas, 2014b; Senner & Sornette, 2019). The debt obligations are recorded on the centralized bookkeeping system, which combined represents elements of static money analysis. The true value of money, however, has to also consider the dynamic aspect. Senner and Sornette (2019) lean on Schumpeter's theory of dynamic capitalism that is categorized with an emphasis on innovation, entrepreneurship and social destruction. Listed elements are the driving force for economic development and wealth creation through new forms of money. An example is commercially issued inside money, which will be in more detail mentioned below. The dynamic approach skews the definition to better fit the future implications. Money is therefore a "claim on tomorrow's goods and services" (Senner & Sornette, 2019, p.971).

To avoid confusion, this thesis will recognise assets as money only if they are widely accepted and if they fulfil principal functions and technical monetary perspective. The latter will be crucial when considering cryptocurrencies and their functions in the market. Before discussing the effect of cryptocurrencies this chapter first elaborates on money creation and money supply.

1.1.1 Money Creation

Fiat currency or outside money is a special form of money. It represents banknotes and coins issued by central banks or other governmentally authorized institutions. It holds no intrinsic value of its own. The value is determined by government decrees and accepted because

[1] A very similar notion to a medium of exchange is a means of payment function. Objects can serve as a means of payment if they can always be used to pay for goods and services. In most circumstances, money entails both concepts, making both functions interchangeable (Kiyotaki & Wright, 1992).

people place trust in the centralized authorities. It is nationally recognized as a legal tender and a medium of exchange (Jin, Zhu, Yang & Wang, 2021; Prasad, 2021a; Rrustemi & Tuchschmid, 2020). Unlike commodity money with finite available amounts, fiat money is in theory not constrained by the supply amount. However, in practice, increasing the fiat money supply can lead to high inflation and possible economic collapses (Prasad, 2021a). In recent times, the importance of fiat currencies has been eroding. Countries like China and the majority of the Scandinavian countries are already operating in predominantly cashless economies (Arvidsson, 2019).

On the other hand, money can also be issued by commercial banks in the private sector. The so-called inside money represents a preponderance of money in the modern economy. Currently, commercial banks account for around 97% of newly issued money (Werner, 2023). Commercial banks approve loans to individuals or multinational corporations and create new money in a form of a bank deposit. In other words, when a consumer wants to borrow money for a mortgage, commercial banks credit the mortgage amount to the consumer's bank account. This in turn creates new money. When bank loans are repaid, the money is destroyed. This way commercial banks increase economic activity and influence market liquidity. Because a mortgage is a liability for an individual but an asset for the bank, the net position for the private sector is zero. In a similar sense, central banks issue money that creates a liability for the banks and an asset for the private sector. Overall, central banks' money creation is in the form of a bank's debt obligation rather than the assets available by the bank. Similarly to fiat currency, inside money entails all three main functions of money (Mcleay, Radia & Thomas, 2014a; Prasad, 2021a).

1.1.2 Measure of Money Supply

The second categorization measures the amount of money in the economy. There are four measures distinguishable by the liquidity factor of money components. Measuring the overall money supply is pivotal for controlling economic activity and inflation. If the economy has too much money supply, this will raise inflationary pressures. Just the opposite, a shortage in money supply will decrease economic activity (Prasad, 2021a). The first group is the monetary base. Monetary base or M_0 presented in equation (1) is the sum of currency in circulation including bank reserves.

$$M_0 = \text{currency} + \text{reserves} \tag{1}$$

Currency, such as banknotes and coins, are the most liquid and risk-free assets available in the financial system. The second measure is M_1, known also as monetary aggregate or "narrow money". The amount of narrow money is calculated with equation (2).

$$M_1 = M_0 + \text{traveller's checks} + \text{sight deposits}^2 \tag{2}$$

[2] Sight deposits are also known as demand deposits or current accounts, The funds can be withdrawn immediately without any fees (Law & Smullen, 2008).

M_1 combines M_0 with traveller's checks and other sight deposits. Both monetary money and monetary aggregate present liquid components that primarily serve as a medium of exchange (Burda & Wyplosz, 2005a; Finnegan, 2019).

The better measure for the supply of money in the economy is the so-called broad money. Broad money accounts for 97% of all money in circulation. Under broader aggregate specification we incorporate groups M_2 and M_3.

$$M_2 = M_1 + \text{savings accounts} \tag{3}$$

M_2 presented in equation (3) includes M_1 and some fewer liquid assets, such as savings deposits. When comparing it with previous groups, M_2 has components that primarily serve as a store of value.

$$M_3 = M_2 + \text{fixed-term deposits and money market funds} \tag{4}$$

Analogously, M_3 seen in equation (4) includes M_2 and larger fixed-term deposits that cannot be instantaneously transferred or withdrawn. An example of such would be assets held in a money market account. Components in the last group served as a close substitute for money (Burda & Wyplosz, 2005a; Finnegan, 2019).

1.1.3 Can Crypto Currencies Replace Fiat Currency?

Central banks with fiat currencies have represented an important part of the monetary system. Great Inflation in 1970, the financial crisis in 2008 and the most recent Silicon Valley Bank crisis are just a few crashes that have raised doubt about the banks' ability to protect against financial shocks. Economic downturns tend to directly affect financial institutions and indirectly people's trust in government and banking systems (Jin, Zhu, Yang & Wang, 2021). Without secure and legal protection, fiat currencies bear to lose value (Rrustemi & Tuchschmid, 2020). In such situations, people gravitate towards alternative more valuable currencies. With technological advances, many took an interest in Bitcoin, a peer-to-peer electronic payment system that operates without a central authority (Nakamoto, n.d.). The exact coexisting relationship was discussed by Jin and others (2021). They note that uncertainty in the traditional monetary system can raise demand for Bitcoin. They detect a negative relationship between cryptocurrencies and fiat currency uncertainty (Jin, Zhu, Yang & Wang, 2021). Today, Bitcoin represents just one of the multiple options in the digital world. This part will elaborate on the probability of cryptocurrencies dominating or coexisting in the market.

In the paper *Coexistence of Cryptocurrency and fiat money*, Yu (2022) studies three markets: cryptocurrencies, fiat currencies and the combination of both markets together. Yu's studies are built on Bitcoin-like-cryptocurrencies where profit-maximization miners increase marginal production costs while having an upper bound on the aggregate nominal stock. Yu concludes that the stationary equilibrium in such markets can only be reached when the inflation rate is zero. The new production would replace already existing but depreciated

currency. If there is no loss or depreciation in the equilibrium, there should be no new money. Similarly to Yu, Villaverde and Sanches (2019) conclude that a purely private market with an upper bound on supply would lead to price stability, however, produce an inefficient market. They claim that even the most optimal equilibrium does not provide social optimality. This result also matches Senner and Sornette's discussion of monetary features for Bitcoin-like-crypto assets. The limitations on production and inelastic supply contradict the current monetary system that requires greater liquidity for economic growth. Senner and Sornette point out that a fixed supply of cryptocurrency would not emerge endogenously. Meaning that large-scale adoption would require additional market liquidity to ensure economic growth. Additional factors would reflect suboptimality. This paper concludes that a fixed number of coins cannot ensure adequate price stability and economic growth. Flexible supply is crucial for instruments to serve as money (Senner & Sornette, 2019).

Additionally, scholars discuss markets where both cryptocurrency and fiat money would coexist. Yu states that the total effect of mixed economic systems depends on monetary regulation and the ability to ensure fiat money growth. On one hand, by banning cryptocurrencies in decentralized markets we are losing the opportunity cost of trade surplus. If the opportunity cost is greater than the energy-intensive mining process, the ban would negatively affect economic welfare[3]. On the other hand, in an economy with low inflation and unfavourable cryptocurrency money, banning cryptocurrency would avoid resource waste, which would consequently positively affect economic welfare (Yu, 2022). Villaverde and Sanches show that competition is a socially profligate economic activity. Although they acknowledge that private and public market elements can provide market discipline by forcing governments to issue only "good money"[4]. They conversely explain that holding privately issued currencies suppresses the return on money, and in turn, causes problems for the constant money growth feature of traditional economies (Fernández-Villaverde & Sanches, 2019).

Overall, to date there is little president in cryptocurrencies replacing or efficiently complementing fiat currencies (Senner & Sornette, 2019). While in its nature, decentralized currency proves risky and unstable, it does offer transparency and security that fiat currency lacks. A wider acceptance and adoption would drive up demand and consequently increase its value (Jin, Zhu, Yang & Wang, 2021). Although the substitution role is negligible, there is a strong belief that the rapidly evolving cryptocurrency system can reach a point where it will endanger the stability of traditional financial systems. The recent collapse of venture capital bank - Silicon Valley Bank, points to the high interdependency between crypto and traditional banking (McCaul, 2023). Such correlations hint at the importance of regulatory frameworks to best navigate between both worlds.

[3] Negatively in the sense that it would support government to overprint fiat currency (Yu, 2022).
[4] Good governmental money ensures equilibrium outcomes either by maximizing social welfare, following the money growth rule or through issuance of Pareto-like efficient action plans (Fernández-Villaverde & Sanches, 2019).

1.2 Functions of Central Banks

Modern central banking has been developing for many years. Figure 2 outlines monetary and financial stability roles as two separate categories. Monetary stability includes money creation and regulation of money. While financial stability includes functions such as payment system facilitation, lender of the last resort and banking supervision. The interconnection between both categories is many times blurred and correlated, which is also the purpose of the arrow shape in Figure 2. We will outline five key mentioned functions. First, is the issuance of the national sovereign, which safeguards the value of the national currency. Second, is managing monetary policy, which controls the supply of money in circulation with monetary instruments such as financial market operations and interest rates. The third function describes central banks as payment systems facilitators. Main responsibilities include supervision of payment transactions and protection against systematic risks. The fourth function is extremely important for market liquidity.

Figure 2: Central Banking roles and functions

	Monetary Stability	Financial Stability
Roles	Maintain stable value of the currency	Maintain smooth and effective functioning of the financial system and guard against financial imbalances in the economy
Functions	1. Money issuance	1. Payment systems supervision and oversight
	2. Regulation of money conditions (i.e., the conduct of monetary policy) ⟷	2. Lender of last resort 3. Banking supervision*

Source: Moenjak (2014c).

Central banks serve as lenders of the last resort. Liquidity can be provided in a form of a short-term loan, to individual banks or markets, or by undertaking risk capital. The last central bank function is banking supervision. By monitoring and regulating commercial banks, central banks are believed to minimize the possibility of insolvencies and market crashes (Moenjak, 2014c).

To better understand how each of the central banks' roles came into play, we will shortly summarize the development of central banks through history. The story of central banks circles back to Swedish Riksbank in 1668 and the Bank of England in 1694. Although the Bank of Amsterdam existed prior, it hardly operated as a central bank. Mainly it was responsible for sorting and classifying coins. A true central bank ancestor and currently the oldest world central bank, is the Bank of Sweden. The bank primarily served as a clearing house and governmental lender. Another early-developed bank was the Bank of England which additionally facilitated also other banking services such as interbank transactions and short-term liquidity. Increasing governmental spending in wartime created urgency for more

institutions that would help finance the war. A good example is Banque de France, created by Napoleon in 1800 to mitigate inflationary pressures that came with French Revolution (Moenjak, 2014b; Warjiyo & Juhro, 2019). The several waves of panics of the nineteenth century only solidified central banks' role as government lending institutions and the distributors of national currency. Because the need for money was growing, central banks created accounts for commercial banks and earned another role as bankers' banks. The last pronoun role, as a lender of last resort and protector of the wider financial system, developed with multiple bank failures and financial panics (Moenjak, 2014b).

Central banks grew from institutions responsible for securing metal coins to institutions that offer resources as lenders of the last resort. The riskiness of the last-mentioned function forced central banks to forgo some of the roles they acquired throughout history. Central banks can provide a true supervisory role in the markets when their focal point is acting in the public interest rather than competing for-profit and monopolistic power against state-charted banks (Moenjak, 2014b).

1.3 Monetary Policy

Monetary policy is the responsibility of the European Central Bank in Europe, The Federal Reserve Bank in the United States and the Bank of England in the United Kingdom. The primary objective for most central banks is to establish price stability. ECB and the Bank of England define price stability when there is 2% inflation over the medium term (Bank of England, n.d.-a; European Central Bank [ECB], 2015). For some other countries like the United States, monetary policy goals include stable inflation and maximum employment (Federal Reserve Board, 2021). Because central banks cannot control objectives directly, they rely on instruments and targets. Different countries use different strategies to achieve monetary objectives. For example, the United States uses the Taylor principal approach, the Bank of England uses flexible inflation targeting while the ECB stands by a two-pillar monetary policy strategy (Meyer, 2001). To better understand the primary features of monetary policies we will shortly summarize monetary policies, exchange rates and the role of central banks in different historical periods.

1.3.1 History of Monetary Policy

1.3.1.1 The Gold Standard Era

Most central banks, including the Fed, were formed with the establishment of the gold standard. The Golden Era arrangement existed between 1879 and the early 1920s. The classical gold standard directly tied national currencies to a specific amount of gold. As such, gold was money. Monetary authorities were printing money based on gold supplies. The main central bank's responsibility was to control domestic prices and follow the peg values. Currency pegging resulted also in fixed exchange rates on the international level. The classical golden era broke in 1914 with the First World War, because countries needed more

money to cover war financing. During the Interwar period, countries accepted the gold exchange standard that re-pegged leading currencies to gold and smaller currencies to major currencies (Bordo, 1981; Burda & Wyplosz, 2005b; Moenjak, 2014b; Pugel, 2016). Central banks initially controlled economic stability with gold reserves. The so-called passive monetary policy was more concerned with defending the fixed rate than stabilizing domestic economies. Other central banks' responsibilities that entail wider internal political concerns such as employment, real economy activities and price levels became important after World War I (Bordo, 2007; Moenjak, 2014b).

1.3.1.2 The Bretton Woods System

The Bretton Woods system was a negotiated international monetary system that was established after the Second World War. The aim was to provide a reconstructing mechanism that would return to the modified gold standard. The classical gold standard ended after the First World War. The Inter-war periods caused severe currency devaluations and tariff wars that made the Great Depression even worse. To improve the inter-war situation, a new global monetary order envisioned an economy with exchange rate stability, minimal currency devaluations and economic growth (Burda & Wyplosz, 2005b).

Because the U.S. did not participate in the war, the country held the majority of world gold reserves. War members experienced dollar shortages, which enabled them to import energy and resources needed for an economic rebuild. All this concerning, the new monetary regime declared a fixed exchange rate system where the dollar is fixed to 35.00 ounces of gold. While the dollar was pegged to gold, other currencies were pegged to the dollar. Fixed but adjustable exchange rates ensured stability and growth of trade (Bordo, 1981; Burda & Wyplosz, 2005b; Ghizoni, 2013). The Bretton Woods system was different from the gold standard especially as it moved towards activist monetary policy. Instead of stimulating only economic activity in the form of gold reserves, the United States especially, worked to simultaneously ensure economic growth and low unemployment (Moenjak, 2014b).

The Bretton Woods system was suspended in 1971 by President Nixon. The economy began to sink with the Vietnam War outbreak. The military spending and social programs in the U.S. substantially raised public debt which corresponded to increased inflation and growing account deficits. While the U.S. was using seigniorage revenue to pay for increased social and political events, other countries did not have that flexibility. When the dollar became overvalued, European countries started to demand gold, for trade settlements, instead of dollars. The decline in American gold reserves destroyed the credibility of the gold standard. After 1971, the majority of the world entered the fiat monetary system (Burda & Wyplosz, 2005b; Issing, 2010).

1.3.1.3 System After Bretton Woods

After the Bretton Woods system, activist monetary policy showed as a poor long-term instrument. The inflationary pressures that followed the collapse forced central banks to become independent from governmental control. Especially due to politicians' tendencies to overlook long-term stability for short-term benefit (Moenjak, 2014b). The system after Bretton Woods was shaped by three major boiling points.

(i) The late 1970s and 1980s presented high inflationary pressures with stagnating economic activity. Countries aimed to control inflation by targeting the growth of the money supply, which eventually proved inefficient (Moenjak, 2014a). This type of monetary targeting works only if there is stable money growth related to inflation. Initial success quickly took a turn with unstable money demand that limited central banks' ability to control the supply in the market (Jahan, 2017).

(ii) After the Bretton Woods system, central banks around the globe searched for nominal anchors. While major economies like U.S., Japan and UK floated their currency, smaller economies in Asia or Central America pegged their currency to U.S. Dollar to avoid constant price volatility (Burda & Wyplosz, 2005b). The biggest problem in the fixed exchange regimes was speculative currency attacks, which threatened domestic currency devaluations or transition to floating exchange rate regimes (Friedman & Meltzer, n.d.).

(iii) The last turmoil was the 2008 financial crisis. Shaky grounds of 2007, with shadow banking and short-term funding market problems were already knocking on the door. The peak was reached in the second half of 2008, when the fourth largest investment bank in America, Lehman Brothers, filed for bankruptcy. The turmoil caused a run-on money market mutual funds, commercial papers and securitized bonds (Helleiner, 2011; Nakamoto, n.d.; Tatar & Burniske, 2018; Thakor, 2015). Recovering period after the global financial crisis forced major central banks such as the ECB, Bank of England, Bank of Japan and The Federal Reserve Bank to aim for low-interest rates and engage in non-standard monetary measures (Moenjak, 2014a).

1.3.2 Monetary Policy Today

Traditionally, countries manoeuvred between predetermined exchange rate targeting or specific monetary aggregates. The downside of the exchange rate targeting famously applied with the Bretton Woods system is the inability to efficiently respond to domestic and external shocks. The targeting regime became unpopular during the 1980s when countries introduced money substitutes. While the long-term correlation between money and inflation was still adequate, it proved less efficient in the short term. Since then, inflationary targeting has emerged as a leading framework for monetary policy (Burda & Wyplosz, 2005c; Croce & Khan, 2000).

1.3.2.1 Inflation Targeting

With failed attempts to provide a nominal anchor, the Reserve Bank of New Zealand in 1989 provided a solution with inflation targeting monetary policy regime. A monetary regime that controls general price levels, through adjustment of interest rates, has been implemented in the monetary systems around the world. The goal is to stabilize economies by determining long-term inflation targeting rates. Because interest rates influence the cost of borrowing and economic activity, it directly affects the inflation rate (Jahan, 2017; Moenjak, 2014b).

1.3.2.2 Quantitative Easing

Additionally, we can also briefly mention the above-mentioned non-standard monetary approach known as Quantitative easing (QE). QE became popular after the 2008 financial crisis and later with the COVID-19 pandemic. Counties use this monetary tool to bring inflation to targeted levels. In times of financial distress bank rates are low while interest and inflation rates are high (Bank of England, n.d.-b). To support economic activity, governments buy "bad" assets from commercial banks and other non-bank institutions. This injects money into the economy without creating an inflationary spiral (Werner, 2023). By way of explanation when central banks purchase bonds, this creates more money for the banking sector, lowers interest rates and makes borrowing more affordable. In turn, this stimulates spending and economic activity (ECB, 2021).

1.3.3 Can There Be a Monetary Policy Without Central Banks?

Although the majority of current monetary systems are built on central banking, historical events point to self-regulatory environments that have operated without centralized control. In the distant past bartering was a trading system without any governmental interference. Multiple commodity-based systems linked the value of the currency to commodities like silver and gold (White House, 2023). This thesis will turn attention to commodity standards with free banking (White, 2011). The free banking system is not a new phenomenon, it already existed in numerous countries around the world. The majority of free banking episodes ended on the verge of the 20th century. Smith and Hayek's idea of competition that can automatically regulate the market was overshadowed by the centralized system with full governable control, seigniorage revenues and claimed superiority over the free banking periods (Curott, 2017; *Free Banking*, n.d.). This section will focus on the 19th century American Free Banking period. The question presents whether central banks hold too much power and whether a decentralized system could benefit the wider economy.

The Free Banking period was a monetary system installed after the last U.S. central bank mandate in 1836. Regardless of the name, the system did not operate without any regulations. While private institutions were allowed to issue notes without the charter's approval, they still had to conform to operational rules and collateral requirements. The Free Banking period exhibited many inefficiencies and risk-taking behaviours especially due to

insufficient information that provided different discount rates in different geographical regions. This created fraudulent banking notes and an extensive banking crisis, referred to as a period of "wildcat banking" (Sanches, 2016; Economist, 2021). Besides fraudulent activities, Sanches (2016) argues that the main problem can be attributed to large commercial bank collateral restrictions that proved problematic with constant state bond price volatilities (Sanches, 2016). Sanches argues that "the problems free banks faced were not very different from those encountered by banks in other periods" (Sanches, 2016, p. 13).

In the paper titled *Financial Stability without Central Banks*, Selgin (2017) argues that central banks' regulation can many times distort and negatively affect existing financial markets. The inadequate responses to financial crises have questioned the need for central banking. When comparing, 17th and 18th century decentralized banking economies like Scotland and Canada with the centralized United Kingdom and the United States, decentralization proved as more stable and efficient. Competition installed in the free banking systems served as an automatic mechanism, that restricted banks overreaching and stabilized spending in the overall economy. Selgin claims that monopolistic systems respond worse in times of financial crisis, than decentralized systems. This was evident in the case of England and the United States, where both countries suffered a crisis whilst above-mentioned decentralized central banking economies avoided. Selgin concludes that macroeconomic stability lies with stability of the spending rather than the inflation rate. As such, Selgin marks central banks as poor market instruments. He believes decentralized banking would prove more stable and less prone to inflation if given the opportunity. Optimization of fiat monopolies would require central banks to streamline responsibilities and exclusively focus on supplying reserves for the economy. Such restrictive operations would create a banking-free system, similar to one that already existed in the past and similar to the one we could be experiencing with digital decentralization (Selgin, 2017).

While free banking arguments made by Selgin can present a compelling argument against central banking there is still an undeniable "widespread agreement that there is a role for government in money" (Surro, 2015, p.1). The initial proposal for decentralized efficiency with market competition made by Friedrich Hayek was revised to prove that multiple currencies cannot ensure market efficiency. Hayek proposes a stabilized economy with a singular or limited number of currencies (Senner & Sornette, 2019). In a similar matter, conventional economists are quick to point to extensive boom and bust cycles, multiple banking crises and an increase in counterfeit behaviour when describing systems without centralized control. Free entry and greater competition seem to be less desirable than monetary stability with government control (Selgin, 2017). Central banks were established to install trust and to better control liquidity problems in the banking sector (Senner & Sornette, 2019).

The goal of this topic was to show that a monetary system without central banks can and has existed throughout history. Although the discussion on the efficiency of the abovementioned systems goes beyond the scope of this thesis, we can draw a similarity between the regulated

decentralized system of non-chartered banks with rapidly emerging privately controlled crypto assets. The global rise of stablecoins has reopened a discussion about free banking. Stablecoins are crypto assets that link their value to some underlying asset, which ensures a stable value. The resemblance between stablecoins and privately issued money in antebellum America was drawn from the lack of regulation and governmental oversight. The Securities and Exchange Commission chairman, Gary Gensler and U.S. Senator, Elizabeth Warren are just a few of the critics that connect stablecoins with wildcat banking. The relationship was discussed by economists Gorton and Zhang. They state that while U.S. Free Banking Era was an efficient market in the financial sense, however from an economic point of view, the market operated inefficiently. They strongly believe that if crypto-assets, more specifically stablecoins, would be globally excepted as money, the backing asset risk would cause time-varying discounts, similar to waves of illicit prices in the American Free Banking period. While acknowledging the threats of stablecoin technology it is only right to address also the counterarguments. In modern economies, stablecoins are one of many available options and types of banking services which provide users with versatility. In addition, critics often equate the era of free banking with wild banking, to the complete exclusion of countries such as Scotland and Canada, where systems operated stably (Gorton & Zhang, 2021; Economist, 2021).

To conclude, if central banks would not represent the main monetary authority, commercial banks or decentralized digital markets could serve as monetary systems substitutes. There is a great debate about whether either stated alternative could better serve the economy (White, 2011). While Selgin and White argue for a system where private banks work without central banks' control, Hayek and a majority of other economists defend the issuance of single or limited currencies. When considering crypto market alternatives, decentralized governance has yet to proven self-sufficient since it lacks a nominal anchor, resulting in structural faults and scalability fragmentations. As such, crypto currency system would pose many risks and uncertainties as a leading monetary policy provider (BIS, 2022b). A key takeaway from the Free Banking Era is that "innovation is not to be smothered, the quality of regulation matters" (Economist, 2021).

1.4 CBDC

Based on the economic history, the lack of uniform regulation and different un-charter private institutions have the potential to endanger monetary sovereignty (Gorton & Zhang, 2021). Central bank digital currency (hereafter CBDC) is an instrument central banks want to develop to stay comparable and relevant in a world of electronic money and payments. With a downward demand trend for fiat currency, CBDC could represent the new digital form of public money. Enlarged access would reflect the same core properties as paper money but in an electronic form. The right CBDC implementation should not change objectives or frameworks set by monetary policies (Bank of Canada et al., 2020; Lukonga, 2023).

1.4.1 Historical Background of CBDC

The first glimpse of a digital currency was introduced in 1990. The Bank of Finland took an innovative approach to smart card technology called Avant. Finland's central bank introduced a debit card that was able to store governmentally issued money. The money like assets were a direct liability of the central banks. "Once debit cards became less expensive and were upgraded to use smart card technology, Avant became obsolete and was shut down" (Grym, 2020, p.2). Even though Project Avant might be overlooked by some, it was one of the first forms of CBDC and crucial innovation for electronic payment regularization (Grym, 2020).

Not long after, in 2017, Sweden reached a milestone when Sveriges Riksbank launched investigation into e-krona. Because Sweden has been experiencing an unforeseeable decline in cash used in retail payments, Sveriges Riksbank proposed a digital form of centralized money that would work complementarily to cash. In 2019, Sweden released a three-stage action plan that would offer a digitalized solution for the future. The e-krona network is built on DLT technology. The currency, E-kronor, circulates on the company R3's Corda platform, where participants have to be accepted and checked for the validity of tokens (Atlantic Council, n.d.; Sveriges Riksbank, 2021). The isolated test environment in the first stage was broadened on technical and operational levels by major Swedish bank Handelsbanken and IT provider Tietoevry. In April 2022, Riksbank released the findings of phase two that showed success with questions concerning e-krona implementation, legal framework and offline functionality. Currently, the project is in the final pilot stage. The main tasks include investigation of additional safety measures, legal amendments and technical improvements of the e-krona engine. While the decision to launch e-krona is still underway, Sweden is extending research testing also to cross-border payments alongside the Central Bank of Norway, Israel and BIS (Atlantic Council, n.d.; Sveriges Riksbank, 2022a, 2022b).

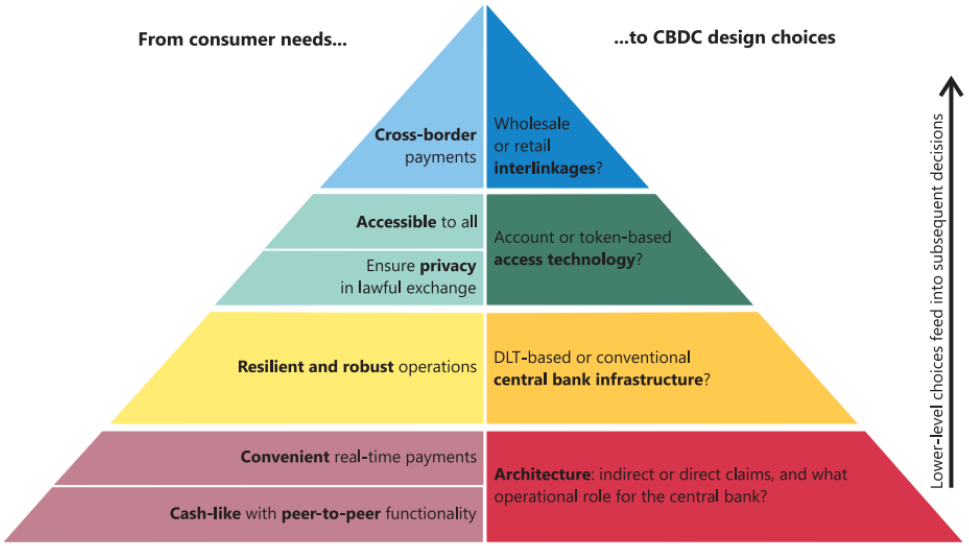
1.4.2 Technical Design of CBDC

As it is a novelty, there is much to be decided before CBDC can become a form of legal currency. The basic design classifications presented below in Figure 3 will determine the primary functions of CBDCs either as payment instruments or interest-bearing assets, their flexibility and operational specifications.

The hierarchical representation in Figure 3 illustrates four major layers. The bottom layer decides on CBDC's operational role with direct or indirect claims. Additional two layers that follow make decisions on CBDC technology and identification requirements. Lastly, the top layer decides on wholesale and retail payment possibilities (Auer & Böhme, 2020). Central banks are at the centre of the CBDC ecosystem. The goal of central banks is to manage and perform all functions in the CBDC network, by offering a digital cash-like instrument with traditional payment system conveniences. As mentioned above, CBDC can have direct or

indirect claims. When CBDC has a direct claim on the central banks, the central bank is responsible for the issuance of CBDC and recording and verification of all transactions.

Figure 3: CBDC technical design choices



Source: Auer & Böhme (2003).

Nonetheless, central banks are more likely to outsource customers' part of the ecosystem to intermediaries (Bank of Canada et al., 2021b; Outlook, 2022). With outsourcing, the central bank defers customer services verification and record-keeping on intermediaries, while still pertaining responsibility for the wholesale accounts. The second layer is tightly connected to mentioned legal claims, because it must ensure the safety and security features of cash-like instruments. Central Bank must decide between a conventional centrally controlled database or a decentralized ledger operational setup (Auer & Böhme, 2020).

The next layer of Figure 3 aims to ensure widely accessible and easily adaptable services that will provide the appropriate balance between anonymity, safety and legal requirements (Bank of Canada et al., 2021b). The central bank can create an account or token based CBDC. Account-based CBDC is generally preferred for wholesale transactions, where users make transactions through verified accounts and wallets that prove users' identification. Token-based CBDC, on the other hand, tends to be preferred for retail transactions, where transactions are executed on a decentralized network that does not require user identification. Instead, transactions are universally accessible and directly transferable between users. Transactions are executed when public keys can check for digital signatures validity (Auer & Böhme, 2020; Outlook, 2022).

The ultimate decision is related to interlinkages and cross-border payments. CBDC can be either wholesale or retail. Wholesale payments are generally transactions with big sums of money, such as bank transfers. In contrast, retail payments are considered more low-valued everyday transactions, such as card payments or debit transfers (CPMI, 2018). The discussion on the wholesale CBDC has been operating for ages. It is a well-known central

bank reserve system that offers means of payment for financial institutions. An already existing interbank system operates on cross-country payments and security settlements. A novelty proposed for wholesale CBDC is the implementation of DLT technologies, which would enhance efficiency, especially with securities and derivates (CPMI, 2018; Panetta, 2022a). The process of implementation would have to ensure the fulfilment of AML and CFT requirements, while still complying with the robustness, efficiency and convenience aspect of the current payments system (CPMI, 2018). Moving on to the concept of retail CBDC where a digital form of central bank's money would be available to the public. For that reason, it is also referred to as general-purpose CBDC. With the recent declining number of cash transactions, the digital form of central banks' money could be a supplement and a resilience mechanism for the existing payment system (Auer & Böhme, 2020; CPMI, 2018). There are two ways a retail CBDC could be set up. First is setting it up in a decentralized manner in the form of digital tokens, which would provide cash-like anonymity. Complete anonymity towards the central banks can rise many legal, political and social issues that have to be resolved and in line with existing law requirements. The alternative option is technologically not an innovative one. Retail CBDC can be also based on central banks 'deposit accounts, which would considerably improve the number of accounts (Mersch, 2020).

1.4.3 Global CBDC Implementation

There is a global prodigious interest in digital currency implementation. The goal of the world central banks such as the Fed, ECB, People's Bank of China and others is to implement the right balance of innovation while still maintaining stability and trust in the governmental entities. As of December 2022, there are more than 95% of global countries that are exploring CBDC (Atlantic Council, n.d.). Out of those, two-thirds plan to issue retail CBDC in the short to medium term (IMF staff, 2023). Despite the high level of activity, there is still a vast majority of CBDC initiatives that remain in nascent stages. While CBDCs have many potential benefits, each country must decide if there is a compelling case for its implementation. The set of macroeconomic instruments depends on digital literacy, amounts of unbanked people and the availability of macroeconomic tools. The following can ensure a smooth transition from traditional to digital mechanisms. Since Avant's cancellation in 2006, there have been numerous countries entering the research or even the pilot status. For example; Sweden with international CBDC Project Icebreaker, multination Project Dunbar, that includes Australia, Malaysia, Singapore and South Africa, Japan and European Union collaboration on project Stella and others. In 2023, there are also countries such as Jamaica, Eastern Caribbean, The Bahamas and Nigeria that have already implemented CBDCs in their economies (Atlantic Council, n.d.; CBDC Tracker, n.d.; Denecker, d'Estienne, Gompertz & Sasia, 2022). Further discussion will shortly summarize the implementation of digital ruble, digital yuan and digital euro.

1.4.3.1 Digital Ruble

The Bank of Russia (hereafter: BoR) is determined to promote FinTech solutions to facilitate digitalization. In the first quarter of 2023, BoR moved from the pilot status to the first testing phase (Atlantic Council, n.d.). The goal is to implement digital ruble for stability, usability, speed and effectiveness in the domestic market. Furthermore, with the adoption of cross-border payments, the country aims to become less dependent on foreign currencies, such as dollars or euros. In the same time, it would allow the domestic market to be less affected by Western sanctions imposed with the Russian invasion of Ukraine (Bank of Russia, 2022a).

The digital ruble is a retail two-tier CBDC model. The first tier represents the central bank. Its responsibility is to issue CBDC and develop general CBDC rules and regulations. The second tier are financial institutions, which carry out the verifications process, creation and replenishment of wallets and other payment services. The plan is to implement cost-free transactions that bear no interest. The digital ruble should be debited in a 1:1 ratio with the traditional ruble fiat currency (Bank of Russia, 2021). Stage one mainly focuses on opening digital wallets by banks and households and ensuring intra-community transfers. The second stage which will be conducted later in 2023. It plans to further connect financial intermediaries, introduce wireless transactions and offer the availability of wallets even for non-residents. Gradual stage-by-stage implementation of CBDC will allow participants to adapt to new platforms (Bank of Russia, 2022b).

While the initial pilot group with three banks has already implemented digital ruble in banking mobile implications, a few more banks announced participation. The first digital ruble platform successfully exchanged non-cash rubles for digital ones and secured transfers between clients (Bank of Russia, 2022b). The set plan to implement real payments in April 2023 was postponed until after the adoption of the appropriate legal regulatory framework (TACC, 2023).

1.4.3.2 Digital Yuan

The most obvious forerunner in the development and testing of CBDC is China with digital yuan (e-CNY). While most countries are still working towards online payment implementation, China has already built up a cashless society. The emergence of the coronavirus pandemic in 2019, only accelerated the need for a digital payment system. The number of online payment users from before the pandemic in 2018 rose to about 904 million in June 2022, which is a more than 50% increase. The biggest online payment providers in the Chinese market are Tencent with WeChat and Ant Financial with Alipay. WeChat is a Chinese version of Facebook, while Alipay can be compared to Amazon. Both digital payment solutions strongly rely on decentralized systems running on digital wallets and QR codes. Both combined account for more than 94% of all mobile payments, which has already undermined the effect of Chinese central banks (BIS, 2021). Stata forecasts that WeChat and Alipay will together reach almost 2.5 billion users within two years (Statista, 2021).

In recent years, the People's Bank of China has been researching the third payment option called Digital Currency Electronic Payments (DCEP), that would reduce the power of private entities. DCEP or digital yuan (hereafter e-CNY) is part of a digitalization project that would assure resilience, scalability and counter digital duopoly. E-CNY uses hybrid architecture with distributed and centralized design. Technologically, it aims at a long-term evolution approach, with the gradual adoption of new features. Design-wise, e-CNY uses wallets with different synergies that offer less risk and more anonymity. The research started in 2017 and reached the second stage in April 2020. The pilot stage was first extended to commercial banks for internal testing. By August 2020, the program launched in twenty-eight major Chinese cities (BIS, CPMI & Innovation Hub, 2022, p.51). Data from December 2023, points to 13.61 billion digital yuan in circulation. Which accounts for 13% of the Chinese M_0 (The state council of People's Republic of China, 2023).

China's goal is to challenge global currencies and transfer political and economic power to Asia. With the developing projects[5], China is working towards "greenfield payment rails" that would step away from dollar domination. To do so, China would have to explore cross-border opportunities and offer partners direct transactions between RMB and their currency. This could potentially replace the current USD exchanges (Aysan & Kayani, 2022; Bansal & Singh, 2021).

1.4.3.3 Digital Euro

Like Russia and China, Europe is also working on an electronic form of CBDC - digital euro. Although ECB is technology neutral it is trend-focused, which explains the hype to adopt a digital version of centralized money. If the digital euro is designed prudently, it can ensure better usability, higher speed and lower costs for domestic transactions and consequently greater transmission and resilience of the overall European payment system (Panetta, 2020). However, if the system is not adequately programmed, it could reshape society and gain monopoly control over the private sector. The success of digitalization would have to be as least as attractive as available payment solutions, for the project to succeed (ECB, 2020, 2023a).

The digital euro would exist in unison with the existing form of fiat money. It would serve as a payment mechanism available to individuals, private companies and other governmental entities. The electronic form of nominal anchor would solidify the central bank's role even in a digitalized environment. The end users would have access to three main digital euro components. A payment instrument that should offer both online and offline services, a mobile wallet service and lastly user device applications. The latter would provide digital euro services through already existing payment apps or through central bank-provided apps. In both cases supervised, regulated and standardized intermediaries would oversee digital

[5] The so-called projects and primal steps to renminbi's internationalization. Such projects were the Silk Road Developing Strategy in 2013, SRD Valuation and inclusion of RMB in currency value of goods in 2016 and projects with Thailand, United Arab Emirates and Hong Kong for the construction of multiple central bank digital currency projects (m-CBDC) (Aysan & Kayani, 2022; Bansal & Singh, 2021).

euro distribution (ECB, 2023b). The main focal point is wallet-to-wallet and point-of-sale payment interaction. Individuals would be able to interact with digital money through intermediaries, which would facilitate transactions among users and ensure user privacy. Intermediaries will be able to track and monitor personal and transactional information only for AML and CFT requirement purposes. For other cases, unless differently specified by law, privacy data should not be disclosed to Central Banks or any other institutions (ECB, 2020, 2023a). Going up the hierarchy, intermediaries would be overseen by Governing Council. The following would be responsible for the issuance, verification and redemption of the digital currency (ECB, 2023a, 2023b). An efficient digital euro would integrate control with a combination of remuneration and limit-based tools such as waterfall functionality, transactional limitation, or money expiration date (ECB, 2023a; Eurogroup, 2022). At the moment of writing this thesis, digital currency is in the investigation phase of the digital euro project. The potential realization of the project will be decided in autumn 2023 (ECB, 2023a).

1.4.3.3.1 The Implementation of Digital Euro

Digital centrally issued money would be able to compete in the digital landscape with decentralized payment services, that already reduce transactional costs and offer a near-instant transfer of funds (BIS, 2021; ECB, n.d.). Additionally, the digital euro would also provide a more resilient instrument that would not succumb to more internationally dominant trading partners, like the Chinese yuan, but could maintain euro dominance. When foreign currency brings innovation and other benefits into the domestic market, there is a threat that foreign money can replace domestic currency, or at least some of its functionalities. For that reason, ECB is trying to push for a digital euro project that would ensure national sovereign power is pertained in the hands of national central banks even in the future. The loss of monetary sovereignty would restrain monetary policy and the ability to ensure a stable financial environment (Ahnert et al., 2022; Lagarde, 2023).

The second important digital euro consideration is regarding control. Both Agustin Carstens and Christine Lagarde have publicly admitted that CBDC would install “absolute” or “limited” control on the rules and regulations for the digital euro payment system (IMF, 2020; Lagarde, 2023). Direct central banks’ control could be beneficial especially for monitoring economic operations and effectively adjusting policy decisions to meet the monetary goals. Additionally, control would also help to prevent or push back against illegal crypto activities and terrorism (Bank of Canada et al., 2020; ECB, n.d.). Members of the European Parliament (MEP) have already advanced in this area of activity. MEP implemented stricter regulations to fight money laundering and terrorist financing by setting hard limits for cash (up to €7000) and crypto assets (up to €1000) (European Parliament, 2023a). Besides providing a more secure environment, governmental control entails also social surveillance that could limit individual autonomy. While central banks are persistently asserting that the collection of user payment data is not the goal for the digital euro, we cannot overlook the possible downsides (ECB, n.d.). Privacy concerns arise first with digital

euro design features, where there is no sign of heavy encryption or DLT utilisation. Additionally, a true problem of privacy concerns does not lie with users' payment information but rather with the potential to cross-index and merge personal information with data. Based on Blaj, this could be especially alarming for the creation of transactional comprehensive profiles, which would disclose spending habits, preferences and other confidential user information (Blaj A., interview, May 16th 2023). If the digital euro and all other CBDC projects are not properly regulated there is a possibility of data exploitation. Although digital euro distribution is the responsibility of payment, electronic money and credit institutions, they have to be strictly supervised and regulated to prevent data misuse and unauthorised insight and control (Bank of Canada et al., 2020).

The last critical point is regarding digital euro alternatives. The ECB is aware that "the counterfactual to a digital euro is not the status quo but a financial system in which private payment assets may dominate" (Eurogroup, 2022, p.4). The private market digital ecosystem already offers instant, cheaper and more available payments for users. Greater adoption of such instruments could risk economic fragmentation, over time even domination in the payment sector. The goal of the digital euro is to incorporate benefits introduced with cryptocurrencies and private corporate payment services, while still pertaining design features of traditional payment systems (Beau, 2021). The BIS finds private technological giants like Facebook and Amazon the biggest threat to existing payment services and national sovereignty (BIS, 2021). This is especially due to their large user base and direct interactions, which can create a competitive advantage when dominant digital providers extend their digital and social services to payments and other financial market operations (Ahnert et al., 2022; BIS, 2021). Once again, we convert back to the sovereign point, as major private companies would be more likely to peg their stablecoins to dollar or other non-euro currencies, Europe could lose its strategic autonomy in retail and international transactions (Lagarde, 2023; McGuinness, 2023).

The initial steps for the central banks are to structure a regulatory framework that would support digital improvement but ensure oversight to better navigate towards financial stability. In 2020 ECB has already introduced the first part of the Digital Finance Package with the Digital Operational Resilience Act (DORA). The attempts to improve business resilience have been ameliorated with the Markets in Crypto-Assets (MiCA) regulation which will be in more detail explained in a later chapter. MiCA regulation aims to provide better transparency and supervisory regulations for crypto transactions (Beau, 2021; European Parliament, 2023b). With time, regulation will become even more flexible and useful, but only if it will be admissible on national and international levels. The final say on the design features and regulations will be decided in the autumn of 2023 if Governing Council decides to launch the next phase of the digital euro project (ECB, 2023b). The legislation should address questions regarding user privacy, legal tender status, functions of the digital euro as a means of payment, not an investment instrument, the area of distribution and the possibility to offer a financial inclusion mechanism (McGuinness, 2023).

Subsequent decisions could more accurately determine whether the digital euro introduction could truly strengthen centralized market power.

1.4.4 The Effect of CBDCs on the Monetary System

The financial system is constantly developing. Throughout the years it has successfully steered different structural and technological changes. This chapter will elaborate on the potential effects of CBDC implementation. There are many positive effects concerning payment assortment with cross-border transactions, financial inclusion and monetary policy tools. The first consideration is regarding payments. The concentration of power in the hands of private institutions could create inequalities in the system and result in market fragmentation. CBDC as an alternative to existing payment systems would offer a resilient structure with central banks' digital money. Financial inclusion is the second important benefit, especially for less developed countries, where the number of unbanked people is high. Lastly, CBDC could also improve policy transmission by using the digital euro as a monetary tool. This could increase the effectiveness of economic policies and ensure faster and more adequate responses to financial shocks (Bank of Canada et al., 2020; Panetta, 2022b). At the same time, there is great uncertainty regarding the successful implementation of the CBDC, mainly due to four significant unpredictable factors. The organization of future financial systems, the CBDC design, policy frameworks and lastly the scale of general acceptance (Bank of Canada et al., 2021a). Regardless of each factor, the adaption of the CBDC can fundamentally change the structure of the monetary systems and reshape the responsibilities of central and commercial banks in the economy. This subsection will first focus on challenges for the banking sector and later also discuss implications for wider monetary policy and financial stability.

(i) Banking Sector

Alternative means of payment offered by central banks can lead to bank disintermediation, deposit crowding out and limited availability of credit for the banking sector. President's Report states "Substitution effect could reduce the aggregate amount of deposits… increase bank funding expenses, and thus reduce credit availability or raise credit costs for households and businesses" (White House, 2023, p.271). Because private money is not issued by the federal authority, banks are subject to capital and liquidity requirements. This result in less favourable conditions for banks, and thus, for depositors. CBDC as an instrument issued by the federal authority, should ensure higher convenience value for depositors and gain market power. To stay comparable, banks would either have to increase deposit rates, decrease lending, deleverage some assets or switch to alternative market-based funding sources (Bank of Canada et al., 2021a; White House, 2023; Whited, Wu & Xiao, 2022). Neither combination of actions stated above would be costless for the current banking sector. Based on European Statistical Data, the loans to deposits ratio for Europe in Q3 of 2022 is equal to 104,80 (ECB - Statistical Data Warehouse, 2023). To say it in another way, deposits from

households and non-financial corporations represent more than 100% of the amount in loans. This especially holds true for smaller banks and banks in less concentrated markets. The first, explains that smaller banks have higher levels of transactional deposits and are thus more vulnerable. While the letter has a small markup cushion and is more affected by the CBDC competition. Nonetheless, the majority of commercial banks do not rely only on deposits, they have what is called "wholesale funding". A long-term debt alternative that can help maintain the same lending values and liquidity ratios, while offsetting possible CBDC deposit losses (CPMI, 2018; Whited, Wu & Xiao, 2022).

For the first part of the trials, Whited, Wu and Xiao use non-interest-bearing or unremunerated CBDC. The experiment raised questions about whether bank deposit disturbances have a direct effect on bank lending. The paper shows a strong correlation between CBDC and bank deposits while rather mild effect on lending. Whited, Wu and Xiao state: "A one dollar increase in CBDC reduces bank deposits by around 70 cents…. only a third of the impact on deposits is passed through to lending" (Whited, Wu & Xiao, 2022, p.4). The following holds true if there is an instrument, like wholesale funding that offers additional funding for banks. While it represents an additional cushion, it must be pointed out that wholesale funding is not a perfect substitute. Relying more on wholesale funding exposes banks to higher interest rate risk and wholesale market spreads. In the end, lost deposits, reduce profits and in turn reduce lending capacities (Whited, Wu & Xiao, 2022). If we circle back, a similar conclusion was also made by Andolfatto (2018). His paper claims that if interest rate policy rules are compliant, there should not be any damaging effect on the lending activity of banks. As long as the opportunity cost of bank lending is linked to the IOR rate, rather than the CBDC rate (whose rate is set independently), lending should not be affected (Andolfatto, 2018).

The second part of the Whited discussion elaborates on the interest-bearing or remunerated CBDC. This type of deposit would detract from a vast number of current banks' deposits. The differences between interest and non-interest-bearing deposits can be best explained numerically. While non-interest-bearing CBDCs represent 7.6% of deposits, a CBDC that pays federal funds rate represents 31.3%. Even when central banks pay only half of the federal funds rate, that still accounts for almost double of deposits from non-interest-bearing CBDC. Similarly, lending rates are -1.4% with non-interest CBDC and -7.9% with interest CBDC. The data also shows that interest-bearing CBDC is a near-perfect substitute for savings deposits. Last but not least point extends the level of interest paid on the CBDC (Whited, Wu & Xiao, 2022). Whited, Wu and Xiao state "When CBDC pays interest, each additional percentage increase in CBDC's market share also leads to larger declines in bank value" (Whited, Wu & Xiao, 2022, p.28).

To conclude, CBDC replaces a significant amount of bank deposits, especially when it pays interest. With non-interest bearing CBDC lending possibilities are not as affected when wholesale funding replaces lost fractions of deposits. Whited and others conclude that because CBDC does not set a floor rate, banks can pay lower CBDCs rates and still pertain to some portion of deposits (Whited, Wu & Xiao, 2022).

(ii) Monetary Policy and Financial Stability

The effects of CBDC on the banking sector will also translate to an effect on financial stability. The transfer of deposits from commercial to central banks will change the existing financial economic models. When holding non-interest-bearing CBDC, there is no strong preference between CBDC and cash, because both pay zero rate of return (Ahnert et al., 2023). Nonetheless, when weighing the factors people do account for the ease and speed of usability, privacy and liquidity of their funds (Bank of Canada et al., 2021a). In an interest-bearing CBDC society, riskless central bank liability would be especially appealing to risk-averse users. In the event of an economic downturn, users would be expected to withdraw commercial bank deposits and move them to the central bank's accounts. The excessive transfer of funds could expose commercial banks to a bank-run risk (Federal Reserve Board, 2022). Especially in times of financial crisis, CBDC could serve as a safe haven instrument. The innovation that offers instant payments and online money transfers can create even greater bank runs in a matter of hours (Bank of Canada et al., 2021a). The health of commercial banks and their ability to stay afloat will depend on direct outcomes of interim withdraws and indirect outcomes reached by lowering deposit rates to preserve user funding (Ahnert et al., 2023). Additionally, with a presence of an interest-bearing CBDC, with overall market credit reduction and credit cost increases, markets can experience a spillover effect on other low-risk market instruments. With such tools becoming less desirable, businesses and corporations would have two options. Either move deposits to the central bank if the cost of shifting would be considerable or transfer money to different less-restrictive electronic alternatives (Federal Reserve Board, 2022).

The most direct route to mitigate the potential substitution is to implement the safeguards that can limit the negative CBDC effect. Design choices would differentiate for different CBDC account holders and their motives. The central bank would be able to set quantity and price-based limits for individuals, maybe even negative interest rates, to avoid holding CBDC as a financial investment (Bank of Canada et al., 2020, 2021a). While holding limits are insignificant for unremunerated CBDC, optimality that can be achieved with remunerated CBDC, would not further benefit by setting limits. However, when a bank is not allowed to set the CBDC rate openly, holding limitations can create positive and negative effects on welfare. Whilst imposing holding limits with a high CBDC rate would stabilize the market, limits in a low CBDC rate environment could potentially lead to bank runs (Ahnert et al., 2023).

Barrdear and Kumhof base their research on the macroeconomic effects of retail interest-bearing CBDC in a steady state. Predetermined values of CBDC in a steady state equal to 30% of GDP. A limited amount of CBDC shows a 3% increase in the long-run GDP. This will come into play through a reduction in real interest rates, cost of transactions and distortionary taxes rates. Lower interest rates can be offered since interest-bearing CBDC can be used as a replacement for defaultable debt. CBDCs' introduction would make government financing less costly and increase liquidity in the economy. Additionally, CBDC

would introduce a monetary policy instrument, either the amount of CBDC or CBDC interest rate, which could help stabilize the economy through different business cycles (Barrdear & Kumhof, 2022). The conclusions are aligned with BIS, where careful implementation and design choices of CBDC should not disrupt financial stability. The problem would rise if the adoption would be instantaneous or if there were risks present with new transitioning, technology, or management (Bank of Canada et al., 2021a).

The monetary policy targeted inflation rate is controlled through the supply of reserves and short-term interest rates. While unremunerated CBDC demand would not cause greater supply spikes and keep interest rates predominantly stable, the remunerated CBDC would show much greater volatility, comparable to other low-risk assets' rates of returns. For that reason, domestic and even foreign demand would present the need for a greater average level of reserve requirements. The uniqueness and ample scope of interest-bearing CBDC can be used as a new monetary policy tool (Federal Reserve Board, 2022). Moreover, because central banks would control the supply of CBDC, it would be easier to control inflationary pressures. In times of inflation, banks can destroy digital coins, in times of deflation they could mint more. The central banks could even extend their power to fiscal policy. The control over money movement could result in taxation deductions maybe even penalties (Bank of Canada et al., 2020).

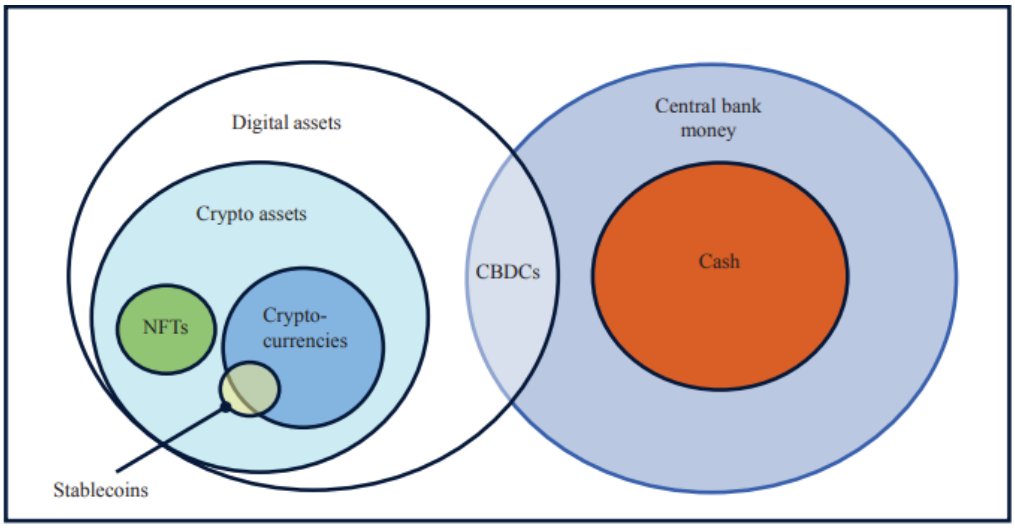
CBDC's introduction would strive to provide safe, controlled and improved payment alternatives (Federal Reserve Board, 2022). The goal of the central bank is to support digital inclusion while keeping and protecting inset financial systems. If we orient the design of CBDC based on the existing Bahamian sand dollar and Nigerian e-naira we can anticipate the digital euro to be non-interest bearing and based on traditional technologies, not DLT. Therefore, the extended discussion on interest-bearing CBDC might not be a probable design choice for the European monetary system. Nevertheless, non-interest-bearing CBDC would still reduce the amount of bank deposits. If not properly regulated, the loss of market power for banks could lead to bank intermediation (Bank of Canada et al., 2021a).

2 DIGITAL CURRENCIES

The second part of this master thesis is going to discuss digital currency assets. Based on digital technologies permeating the market, the economy has been reaching unforeseeable lengths. The majority of innovative payment systems in the market are already built on platforms such as the Internet, storage card, mobile devices etc. To compete with physical money, digitalization has offered alternative payment systems such as Visa, PayPal, MasterCard, Apple Pay, Dash and Venmo. While the growing use of digital currency offers more flexibility and faster transfer of money, it is very limited and dependable on the central authority (Nakamoto, n.d.; Pak Nian & Kuo Chuen, 2015). The main differentiating factor between digital currencies and electronic bank payments, is open-source software with no legal authority overseeing the transactions. Most known cryptocurrencies like Bitcoin, Ethereum and Tether operate on blockchain public ledgers or personalized networks. Digital

currencies are part of the broader e-money categorization. Their aim is to serve as potential alternatives to traditional payment schemes. In general, we can differentiate between centrally controlled digital currencies, which were mentioned in the previous chapter and de-centrally controlled digital currencies, which will be discussed below (Committee on Payments and Market Infrastructures [CPMI], 2015). To better understand the types of assets or currencies in the market we can revert to Figure 4.

Figure 4: Taxonomy of Digital assets



Source: White House (2023).

This chapter elaborates on digital assets that are presented on the left-hand side of this figure 4. For the purpose of this thesis, digital assets and digital currencies will be used interchangeably. Digital assets are assets operating on a digital platform. The subcategories are crypto assets and centrally controlled CBDCs (White House, 2023). We can further unbind crypto assets into cryptocurrencies with stablecoins and NFTs. This subsection will pivot on cryptocurrencies, such as Bitcoin, Ethereum and stablecoins like Tether, USCD, EUROC, Dai, Rai and others. The goal of this chapter is to present decentralized alternatives to traditional financial systems. Here we are aiming primarily at blockchain and a wider range of applications such as smart contracts, DeFi and DAOs available on the Ethereum network. The last-mentioned features can be used beyond crypto currency applications. Smart contracts for example, can be used in the government voting and healthcare system, real estate market, online vehicle leasing, supply chain etc. (Kaushal, Kumar & Panda, 2021; Tatar & Burniske, 2018).

2.1 Bitcoin

Bitcoin is a digital coin that represents ownership of the digital currency. It works on an open-source system, that fully discloses the source code and all the transactions on the public ledger called blockchain. A copy of the ledger is available on every computer on the network. This way, the system is not built on trust but rather on proof of work consensus mechanisms.

Information on the ledger is secured with cryptographic methods including digital signatures and hash functions (River Financial, n.d.). While hash function utility is crucial for the speed of operations. The chain of digital signatures establishes trust in transactions and the system (Nakamoto, n.d.; Tatar & Burniske, 2018; Wang, He & Ji, 2020).

Bitcoin is the most popular cryptocurrency with a market value in May 2023, of around $525B. Bitcoin first boomed from a fraction of a dollar to its first peak in December 2017, where the value jumped to around $18,000. The 2018 to 2019 Bitcoin entered a co-called Crypto Winter, which caused a great price decline. Further downtrend continued also in 2020 with the global outbreak of coronavirus. The all-time high price was reached in November 2021 amounting to $65,000. In a matter of a year, the all-time peak price decreased by more than 25% as it followed another crypto winter of 2022. In mid-May Bitcoin's market price stands at around $27,000 (Ashmore & Powell, 2023; Blockchain, 2023a; CoinMarketCap, n.d.-a).

2.1.1 Bitcoin's Historical Background

Bitcoin takes us back to the global financial crisis of 2007-2008. The economic crisis took a toll on financial institutions but more importantly resulted in distrust in governmental and banking systems (Helleiner, 2011; Nakamoto, n.d.). A month after the collapse of Lehman Brothers pseudonymous founder, Satoshi Nakamoto, introduced Bitcoin. In the paper titled *Bitcoin: A Peer-to-Peer Electronic Cash System* Satoshi presented an electronic payment system that operates without existing financial intermediaries. It would potentially serve as a decentralized financial system, which could in the future replace traditional payment structures. It is no coincidence that a new class of assets was introduced when the trust in governmental institutions was at its lowest (Nakamoto, n.d.). Bitcoin was officially launched as open-source software in January 2009. The first block of Bitcoin (BTC) is referred to as the Genesis block. It recorded one transaction and distributed 50 BTC as a reward for mining. The first person-to-person (P2P) transaction was a reward (10 bitcoins) made to an early distributor Hal Finney in January 2009 (Blockchain, 2023c; Finney, 2013). The growing interest in decentralized assets has brought Bitcoin to a Japanese-based online exchange, Mt. Gox. Although Mt. Gox was primarily trading fantasy game cards, it helped expand Bitcoin to other virtual exchanges (Yermack, 2015). The first commercial transaction known as Bitcoin Pizza Day was broadcasted on the Bitcoin network in May 2010. An early miner named Laszlo Hanyecz made a post on the Bitcoin forum. He offered to pay 10,000 bitcoins for two large pizzas. At that time, the transaction made to Jeremy Sturdivant was valued at around $41. Just as a comparison, today's value of the first pizza transaction is estimated to be more than $223,547,000 (Blockchain, 2023b). At the end of October 2013, the first Bitcoin ATM came into use. The so-called Robo-coin located in Vancouver, Canada was able to exchange digital credits for Canadian Dollars (Yermack, 2015).

There have been many developments and changes on the platform since the first transaction in 2009. The total supply of coins is currently seating at 19 million, which accounts for 92%

of Bitcoin's total supply (CoinMarketCap, n.d.-a). The total amount of supply, amounting to 21 million BTC coins, is expected to be reached by 2140 (Pak Nian & Kuo Chuen, 2015; Yermack, 2015). For now, bitcoins are created through the mining process that takes around 10 minutes. To ensure a progressive growth of bitcoins, the reward is halved automatically every 4 years. The current reward stands at 6.25 BTC (Nakamoto, n.d.; Pak Nian & Kuo Chuen, 2015). As of March 2023, there are more than 780,00 blocks in the blockchain, all forming unbroken sequences that started with the Genesis block. With a new global financial technological system, developers all around the world have new derivations of Bitcoin (Blockchain, 2023a). The majority of Bitcoin mining is done on Asian and North American soil. Various bans and cryptocurrency regulations have limited Chinese mining capacities, which in turn increased the amount of mining in the United States (Yermack, 2015). Based on Stata, in the 4Q of 2019, China accounted for around 75% of the world's hashing rate. The country was the leading force till mid-2021 and dropped to around 20% of world mining power by January 2022 (Cambridge Centre for Alternative Finance, 2022).

2.1.2 General Bitcoin Features

Bitcoin is one of the most prominent digital currencies today. Since it is a decentralized peer-to-peer system, all transactions are publicly available. The history of transactions is recorded with blockchain technology, which serves as the authority of the record. Ledger is built on the branch of mathematics referred to as cryptography. A study for securing information and privacy through different encrypted and decrypted algorithms (Nakamoto, n.d.; River Financial, n.d.; Tatar & Burniske, 2018; Wang, He & Ji, 2020).

2.1.2.1 Blockchain 1.0

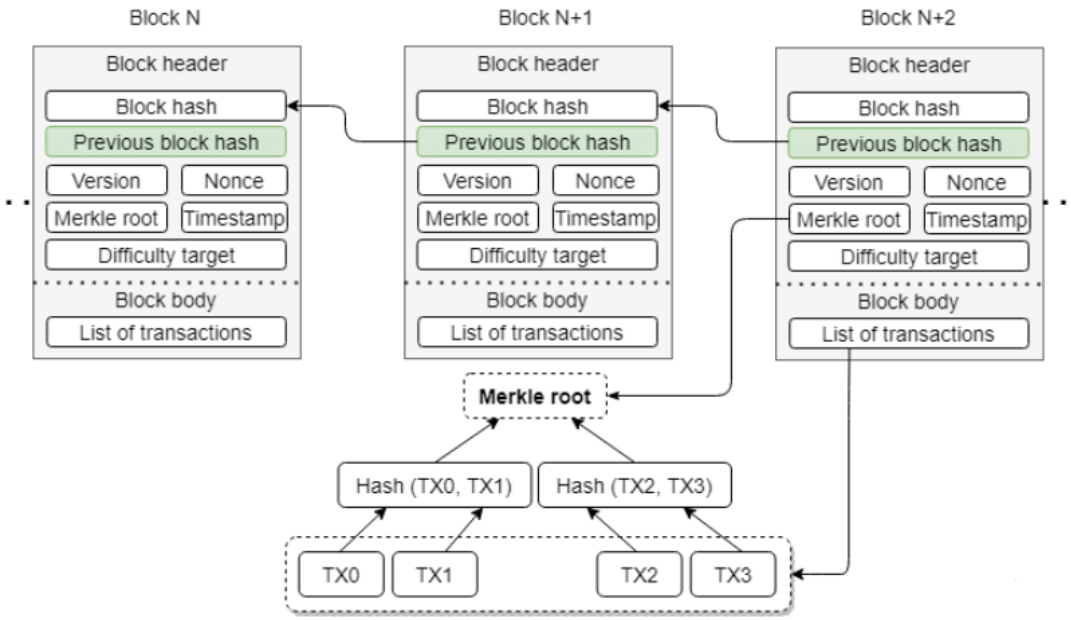
Blockchain is a self-sufficient system of users, miners and nodes. Users initiate transactions on the blockchain network. Miners are special types of nodes responsible for the validation and verification of transactions. The accumulation of validated transactions forms a block. The last participants on the blockchain network are nods. Nods are a system of safe keepers that serve as network consensus mechanisms. Nods are computers located all around the world that validate transaction blocks sent by miners before they are added to the chain of blocks (Orenes-Lerma, 2023; Shrimali & Patel, 2022).

The inception of blockchain started with the idea of eCash in late 1990 when David Chaum proposed to use cryptography to secure private transactions. While a centralized system with patent algorithms did not see the finish line, it provided the base for what we essentially know as blockchain. The following decade introduced many cryptographic ideas. Just to name a few, in 1991 Stuart Haber and W. Scott Stornetta published a paper on time-stamping digital documents and derived a concept of a cryptographically secured chain of blocks (Haber & Stornetta, 1991). In 1997, Adam Back proposed a Hashcash protocol and primal Proof of work concept that was born from the idea to limit spam e-mails (Back, 2002). The mechanism was applied in 1998 by Nick Szabo, an early collaborator on the project of eCash,

who proposed “Bitgold”. He proposed a decentralized digital currency that is securely stored and transferred with minimal third-party dependence (Szabo, 2005). The version of Bitgold was in 2004 implemented in a system called Reusable Proof of Work (RPoW). Computer scientist Hal Finney introduced it as a prototype for digital cash. Although Blockchain was not invented by Nakamoto, it became popular with the success of Bitcoin (Raikwar, Gligoroski & Kralevskaet, 2019; Shrimali & Patel, 2022).

Blockchain, as the word itself describes, is a chain of blocks. Figure 5 depicts a moment on the blockchain with three sequential blocks Each block has a header and a body. For now, we are going to focus on the first two features in the block header: a unique current hash value and a hash of the previous block (Iqbal & Matulevicius, 2021). A hash value represents a function that can transform transactional binary data into some fixed-length hash values. A hash function is mostly used with digital signatures to ensure the confidentiality and integrity of the transactions (Menezes, Van Oorschot & Vanstone, 1996). That is why, blockchain is many times referred also as a string of digital signatures. The blocks are connected on the chain when the owner of the block verifies and digitally signs the hash of the previous block (Nakamoto, n.d.). Additionally, Figure 5 also illustrates other important block header fields such as the root of the Merkle tree, nonce value, timestamp and the difficulty target (Iqbal & Matulevicius, 2021; Kaushal, Kumar & Panda, 2021).

Figure 5: Blockchain structure



Source: Iqbal & Matulevicius (2022).

While the block version is self-explanatory, we are going to first turn our attention to the Merkle root tree and the nonce value. Merkle root is depicted in Figure 5 below Block N+1. Merkle tree is a type of binary tree essential for securing and storing transactions on the block. Merkle tree root represents the hash of the whole transactional block. Nonce, on the

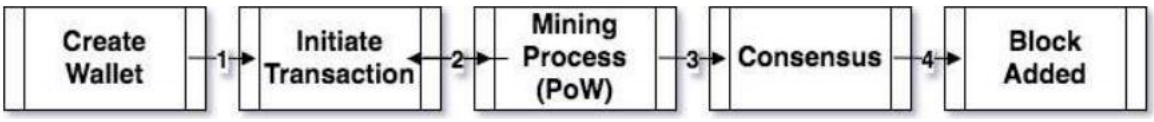
other hand, is short for “Number only used once”. It is a value that creates algorithmic puzzles.

Validators use different consensus algorithms to find the value of the nonce that falls below the set difficulty target. Difficult target is determined by the number of leading zeroes in the nonce that changes based on the network’s load, the number of users and expected mining time (Martínez, Hernández-Álvarez & Encinas, 2020; Kaushal, Kumar & Panda, 2021; Shrimali & Patel, 2022). While the difficulty target and nonce value are used for the block’s mining process, timestamping is crucial to avoid double spending. The double spending problem is a generic problem for most digital payment systems. Once the transfer on the blockchain is verified, a hash of a block is timestamped and broadcasted to the entire Bitcoin network, ensuring bitcoins or other digital assets cannot be spent again. Each timestamp forms a chain with previously approved items in the block (Nakamoto, n.d.).

2.1.2.2 Blockchain Transactions

The mentioned block structures are crucial for further understanding how transactions are added to the blockchain. The five-step process is illustrated in Figure 6. The initial step to participate in the blockchain includes creating a wallet. Each user receives a public and private key that together construct their digital identity. The public key is used for transactions on the network and should be publicly available. On the other hand, the private key is needed to create messages on the networks and should be confidential (Kaushal, Kumar & Panda, 2021). Wallet programs create digital signatures, which verify the authorship and integrity of transactions by checking cryptographic keys and hash functions (Martínez, Hernández-Álvarez & Encinas, 2020).

Figure 6: Steps in the Bitcoin ecosystem



Source: Kaushal, Kumar& Panda (2021).

In the second step, users initiate transactions. Each transaction has to enclose the input, output and transferable amount. The input contains information and the coin address of the sender, while the output has the coin address of the recipient (Orenes-Lerma, 2023). The initiated transactions are retained on the memory block[6] and broadcasted to the entire blockchain system. The number of transactions on the memory block determines the network congestion (Kaushal, Kumar & Panda, 2021). Because block size is limited, users pay gas fees to compensate miners for validating their transactions (Orenes-Lerma, 2023). A single block can contain around 2000 transactions. Each validator validates transactions and stores

[6] Memory block or mem pool serves as a waiting room that holds all “pending” transactions (Binance Academy, n.d.-a).

the transactional input with a secure hashing algorithm (SHA256) that produces fixed-size output. The output hash can be used for address generation, solving cryptographic puzzles and digesting messages. The hash functions are irreversible as it is impossible to predict the input from the output hash. Also, they are deterministic because the same input is always going to produce the same output hash (Kaushal, Kumar & Panda, 2021).

The middle and most important stage marks the blockchain mining process. Validators or miners compete with one another by solving difficult cryptographic tasks. This entails incrementing a nonce value that issues a required zero bits hash value (Nakamoto, n.d.). For a transaction to be validated the arbitrary number has to be below the difficulty target value. To carry out this process, a great amount of computational power is needed, which is why mining is so costly. The difficulty level is adjusted dynamically according to the total computational power in the network, so that solution to the mathematical puzzle is solved every 10 minutes (Tatar & Burniske, 2018). When a target value is successfully reached, the nod broadcasts the hash target value to the blockchain network, which brings us to the consensus step in the Bitcoin ecosystem. All the nods in the system can check the miner's proof of work. Bitcoin protocol uses the PoW mechanism, which needs 51% of computers on the network to verify the newly mined block. All consensus mechanisms are, however, not the same. The is a differentiation between public or permissionless and private or permissioned consensus mechanisms. Public systems, like Bitcoin, Ethereum, Zcash and Monero allow anyone to participate in consensus as well as to transact on the Bitcoin network. Private blockchain, on the other hand, allows only authorized people such as organizations and financial institutions to join the network (Kaushal, Kumar & Panda, 2021; (Raikwar, Gligoroski & Kralevskaet, 2019; Tatar & Burniske, 2018). The PoW mechanism ensures the secure transfer of information as long as no single mining nod holds more than half of the computational power on the network. Lastly, when the majority of the network confirms the hash, the block is added to the blockchain. A nod that solves the cryptographic puzzle first, receives the reward for his computational work (Bitcoin Developer, n.d.; Hofmann, Schatz & Winkelmann, 2020; Nakamoto, n.d.).

2.1.3 Benefits and limitations of Bitcoin

Bitcoin with blockchain brought a wide range of benefits and limitations. This subchapter will uncover several benefits including freedom of payment and lower transaction costs. While also touching upon several limitations due to the design, environment and safety of the Bitcoin network.

2.1.3.1 Freedom of Payments and Lower Cost

Peer-to-peer electronic cash system allows sending and receiving bitcoins anytime and anywhere in the world. By eliminating intermediaries in the payment cycle, Bitcoin and other cryptocurrencies save transaction costs and give transparency to all users. This is especially

evident in the cross-boarded payments and settlements. Bitcoin can assure fast transfers without expensive transactional processing fees (Nakamoto, n.d.; Pak Nian & Kuo Chuen, 2015).

2.1.3.2 Privacy and User Control

Traditional banking system achieves privacy with limited publicly available information. In contrast, an open-source system, like Bitcoin, uses private and public pair keys. While transactional details and users' public keys are available to the general public, the data disclose only individuals' pseudonymous identities (Nakamoto, n.d.). The information breaking ensures safety, however, it can also be a source of transaction risk. Transactions on the Bitcoin network are irrecoverable, which means that if the end-user loses its private key, the bitcoins are also lost. Poor wallet protection and information sharing can be a reason for theft and loss of funds (Pak Nian & Kuo Chuen, 2015).

2.1.3.3 Volatility

Additionally, we can discuss Bitcoin's price volatility. Bakas, Magkonis and Young Oh (2022) analysed the drivers of Bitcoin price swings. The empirical analysis reveals that Google trends, total circulation in bitcoins, US consumer confidence and fluctuations of the S&P500 index are the most essential factors in Bitcoin's price changes (Bakas, Magkonis & Young Oh, 2022). Users tend to use Bitcoin as a speculative investment decision and a diversification asset. The constant price fluctuations can create significant returns in upturn cycles, but also significant losses in times of downturns. Though many perceive Bitcoin as a high-risk high-reward opportunity, IMF research points to a less significant return when adjusted for the volatility risk factor. IMF concludes that over a longer period, Bitcoin returns adjusted for risk are performing similarly to US real estate and S&P 500 benchmarks. Nonetheless, relative attractiveness is justified for some worse-performing assets and countries with weak currencies and low monetary power (IMF, 2021).

2.1.3.4 Instability of Fees

In the current Bitcoin system, miners that are verifying transactions collect mining rewards and transaction fees which further incentivizes them to secure the network. The value of mining rewards in 2021 amounted on average to over $1 billion per month (IMF, 2021). Mining is profitable with mining rewards. Once incentives disappear, the system can face numerous questions, for example: who will verify the transactions if the miners stop receiving benefits and can the Bitcoin network operate only on transactional fees. Even though, Nakamoto writes that incentives to verify transactions can be funded with inflation-free transactional fees, results from Carlsten, Kalodner, Weinberg and Narayanan (2016) show a different view. With only transactional fees, the regime could hurt the stability of Bitcoin mining and the ecosystem as a whole. With exponentially distributed block arrival times, miners would have the incentive to fork blocks with high transaction fees,

consequently overtaking the rewards (Carlsten, Kalodner, Weinberg & Narayanan, 2016; Nakamoto, n.d.).

2.1.3.5 Facilitation of Criminal Activity

Bitcoin is a recent phenomenon that is still not a globally accepted payment method. Although is accepted by a small group of online merchandise like Amazon, Microsoft, Uber and Overstock etc., the number of providers is still insufficient to rely on Bitcoin as a currency. The main reason for the slow adoption is regulatory scrutiny and the collapses of major currency exchanges. Online infrastructure for Bitcoin currency exchanges has been on shaky ground since the collapse of Japan's Mt. Gox exchange in 2014 and the Futures Exchange (FTX) in November 2022. Such historical events connect cryptocurrency with scandals and failures. Furthermore, greater anonymity and absence of the rules have opened Bitcoin doors to Black-market trades, money laundering, gambling sites and financial terrorist activities. One of the first Black-markets that supported Bitcoin transactions was Silk Road. Anonymous online marketplace, which operated on a Tor dark web network to sell illicit goods such as narcotics and counterfeit passports (Pak Nian & Kuo Chuen, 2015). The above-mentioned scandals are just a few reasons for governmental reservations when it comes to cryptocurrency implementation. The future of Bitcoin and cryptocurrencies depends largely on strict governmental regulations, which should be guided to minimize criminal activity and keep a stable financial mainstream (Böhme, Christin, Edelman & Moore, 2015; Economist, 2022).

2.1.3.6 Limitations in the Bitcoin Design Feature

Further limitations arise from the design of the underlying system. The first design feature is the presence of forks. Forks are a change in the existing software protocols. When incentives to modify to source code are proposed, the miners have to decide if they will support the original blockchain or the new proposed one. When the set of rules is accepted by the majority, the latest version of the blockchain is developed. Disagreements have fostered many alternative cryptocurrencies. With a change in the Bitcoin hash algorithm Litecoin (LTC) fork was created. An increase in the size of the block created Bitcoin Cash (BCH) fork. The creation of forks increases uncertainty and price volatility, which induces risk in portfolios and the riskiness of the investment as a whole (Bazán-Palomino, 2020). The second design feature is very connected to fork creation. The miners are rational and will behave in Nash Equilibrium. With the increasing difficulty of the hash puzzle, only miners with strong computers can solve the cryptographic algorithms. The bigger players congregate in mining pools or so-called “pool hopping”. With a displacement of smaller miners, they create a centralized system that collaborates to increase the possibility of solving the hash. The rewards are split proportionally based on the amount of computational work that was contributed (Bazán-Palomino, 2020; (Böhme, Christin, Edelman & Moore, 2015). Additionally, there is a risk of selfish miners and malicious actors. The former risk arises when the miner hides the solved puzzle to gain the next block before others (John,

O'Hara & Saleh, 2022). The latter should not cause problems if honest nods represent the majority in the Bitcoin system (Nakamoto, n.d.).

2.1.3.7 Transactions and Energy Expenditure

Furthermore, we can discuss transactions and energy expenditure. The network suffers from the slow computation of transactions in comparison to existing payment systems like Visa or MasterCard. Visa can process around 24,000 transactions per second (TPS), Mastercard around 5,000 while with the original Bitcoin consensus protocol, Bitcoin is able to process only 2-7 TPS (Bazán-Palomino, 2020; Rodrigues, 2022). An additional limitation to Bitcoin transactions is the amount of computing power that is needed to solve the algorithmic puzzles. The validation process relies mostly on energy from fossil fuels. Mining with non-renewable resources is leaving a huge environmental footprint (Shifflett, 2021). The energy-intensive process of mining can be comparable to the energy expenditure of Austria or other medium-sized European countries (John, O'Hara & Saleh, 2022). To compare, 1 Bitcoin transaction uses around 2,200 kWh, which is enough power for 1,5 million Visa transactions (Digiconomist, 2022). The solution to the problem is switching from PoW to PoS consensus mechanism, already implemented on the Ethereum network (John, O'Hara & Saleh, 2022).

2.1.4 Economic Appraisal of Bitcoin

The exponential growth of Bitcoin has sparked interest for many investors. A decentralized currency that is known for extreme volatility but high return, is many times associated with "digital gold". The reasoning behind this association is the high similarity in properties of Bitcoin and gold. The limited supply of Bitcoins, with time-decreasing production but increasing mining difficulty, screams scarcity, which is also a desirable function of gold (The Royal Mint, n.d.; Yan, Lei & Wang, 2022). Both assets differ from other investment options, as they offer a hedge against inflation and a store of value. Based on Yan, Lie and Wang (2022), Bitcoin shows hedging asset characteristics attributes when the risk aversion level is high. On another point, when the risk aversion level is low and economic conditions are good, Bitcoin has pro-cyclical characteristics. Pro-cyclicality can recognize Bitcoin as a safe-haven asset (Yan, Lei & Wang, 2022; Yu, 2022). With unique functions of subdivision, record keeping and online presence, some believe Bitcoin might even represent an improved alternative to gold (Yermack, 2015). While it is still not able to challenge traditional currency, Bitcoin aims to overcome the weaknesses of fiat currency and gold-based assets (Yan, Lei & Wang, 2022; Yermack, 2015).

Early Bitcoin developers introduced the idea of Bitcoin replacing fiat currency. Since then, rule makers like U.S. Internal Revenue Service and blockchain supporters have been keen to dissect whether Bitcoin and other cryptos classify as money or assets/commodities. The instrument can be understood as money when it fulfils a technical monetary perspective and the three principal functions of money. Firstly, we can elaborate on static and dynamic aspects. Bitcoin holds an important transactional money property that ensures global

transfers that are recorded on an immutable ledger. While this partially fulfils the static money perspective, it lacks the debt anchoring aspect. With no intrinsic value and the lack of universal IOU backing, Bitcoin fails to meet the second static money requirement. As already mentioned in the previous sections, Bitcoin with a fixed number of coins, fails to fulfil also the dynamic money utilization aspect. The inability to produce new money contradicts Schumpeter's theory of economic growth (Senner & Sornette, 2019).

Secondly, money has three main functions: medium of exchange, store of value and unit of account. In current society, Bitcoin is used as a risky investment, a payment instrument for goods and services on the Bitcoin platform and for some, like El Salvador, even as a form of national tender. Although they provide some functions in the market, they do not fulfil the main economic functions of money. Firstly, Bitcoin lacks intrinsic value. Hard procurement of new bitcoins and the long verification process are just a few reasons why Bitcoin is still not commercially globally adopted. Baur, Honk and Lee conclude "Bitcoins are mainly used as a speculative investment and not as an alternative currency and medium of exchange" (Baur, Honk & Lee, 2018, p.1). Similarly, the literature poorly exhibits also the second and third roles of money (Baur, Honk & Lee, 2018; Yermack, 2015). Though many argue that Bitcoin is similar to gold in the sense that it serves as a longer-term investment, the majority still points to features like constant volatility, vulnerability to hackers and thefts and untethered value to any other prominent currency like U.S. Dollars, euro or yen. With that, Bitcoin exhibits also a weak and unreliable store-of-value feature. The last function is a unit of account. While most retail goods' prices can be comparable, the excessive cost of Bitcoins makes comparability and valuation much more difficult. Bitcoin price is quoted in four or more decimal places. In other words, the high price volatility and high big-ask spreads on different exchange platforms, are undermining Bitcoin functioning as a unit of account (Yermack, 2015).

While most of the literature coincides with Yermack's point of view, Bitcoin supporters are of the opposing opinion. One of the supporters is Vijay Boyapati. He claims Bitcoin is in its first development stage. He draws a similarity between Bitcoin and the initial stages of gold where both assets represented a collectable good. He believes that wider adoption will develop Bitcoin as a reliable store of value instrument. Although stating that further functions have yet to be developed, he points out that greater purchasing power could expand Bitcoin's functions also as a medium of exchange and unit of account instrument (Gillespie, 2021). Some other supporters like Krawisz, advocate against classic money functions. Krawisz believes the primal function of money is store of value, not medium of exchange. The "good" store of value can be exploited once everyone uses and understands the properties (Krawisz, 2015). For investors who lost trust in the existing financial system, Bitcoin can serve as an independent economy resort and instil trust as a reliable store of value. While these kinds of changes have the potential in the future. Both Nakamoto and Kravisz recognize that it might take time. Krawisz concludes that Bitcoin has the right properties to excel in the unstable world if the majority comes to terms with digital innovations and new monetary opportunities (Krawisz, 2015).

While the economic appraisal of Bitcoin shares many divided opinions, volatility remains a crucial barrier when thinking about Bitcoin as a legal tender and a payment system. Overall, we can conclude that at the moment of writing this paper, Bitcoin has not fulfilled its prophecy as a financial revolution instrument. The promises of cheaper widely accessible and decentralized transactions have yet to be fully realized. Mostly because major crypto exchanges have to go through a verification process that presents a processing fee (e.g. Coinbase has a 1% processing fee). Furthermore, major trading is done on centralized exchanges like Binance and Coinbase, which pertains to some sort of governmental oversight (Economist, 2023). Nonetheless, Bitcoin seems beneficial and more widely adopted in emerging countries like El Salvador, Argentina and Nigeria. Weak monetary policies and high inflationary or currency pressures create a compelling case for crypto applications (IMF, 2021; Economist, 2023).

2.1.5 El Salvador

Since 2008, Bitcoin has advanced from an electronic tracing payment system that solely serves as a store of value to additional features where it serves also as a medium of exchange. It is no wonder that this kind of Bitcoin adaption started in El Salvador. A small Central American country that strongly relies on the US Dollar, holds about 70% of unbanked people who are keen on financial freedom. Compared to other Central American countries El Salvador has been staging monetary experiments in the past. In 2001, Salvador's official currency colon was replaced by the U.S. dollar (Alvarez, Argente & Van Pattern, 2022). Later in 2019, the small coastal town of El Zonte received a Bitcoin investment and transform the ecosystem of the city. The so-called "project Bitcoin Beach" was a testing ground for Bitcoin and later for the launch of Bitcoin as an additional legal tender mechanism (Bitcoin Beach, n.d.). In three years, El Salvador became the first country that launched Bitcoin as a form of legal tender.

The Bitcoin project aimed to generate greater financial inclusion and employment opportunities that would attract national and foreign investors. The general provisions supported payments, especially for government taxes and outstanding debts. Additionally, it also served as a medium of exchange for different business transactions (Legislative Assembly of El Salvador, 2021). To further incentivize citizens to use digital payments, the Salvadorean government issued a $30 bitcoin bonus, which equalled to 0.7% of annual income per capita. Besides the adoption of Bitcoin and US dollars, President Nayib Bukele, also launched a governmental digital wallet named Chivo, with no transactional fees (Alvarez, Argente & Van Pattern, 2022). The use of such tools also supports lightning network operations. The lighting network is layer two of the Bitcoin blockchain that could process smaller transactions in a matter of seconds with negligible commissions (Arslanian et al., 2021).

The study conducted by Alvarez, Argente and Van Pattern shows that initial sign-up bonuses and subsidized fees caused a spike in September 2021, but have been decreasing dramatically afterwards. The number of blockchain-recorded transactions is low but relatively frequent. While Bitcoin withdrawals tend to be large but rare. Whilst current evidence does not show a substantial success rate of the Bitcoin experiment, future scenarios could be detrimental to countries' digital growth and economic dynamics (Alvarez, Argente & Van Pattern, 2022). Overall, Bitcoin adoption as a legal tender offers numerous business opportunities that are favourable, especially for countries with similar socio-economic issues as El Salvador. This could result in a global domino effect (Arslanian et al., 2021).

2.1.6 Bitcoin Versus Other Alternative Cryptocurrencies

Although Bitcoin is the oldest and leading cryptocurrency in the market, there are many alternatives, that combined comprise a cryptocurrency space referred to as Altcoins[7]. As of February 2023, there are around 8,700 active Altcoins with a market capitalization of over $625 billion (CoinGecko, n.d.; GP Bullhound, The Motley Fool, & Investing.com, 2023). Bitcoin has a large market capitalization that prevents testing different proposed modifications. Instead, innovative ideas are developed as part of a new altcoin system, separate from the original Bitcoin network. The value of Altcoins depends on market changes and valuations of Bitcoin (Ong, Ming Lee, Li & LEE Kuo Chuen, 2015).

The main differences between Altcoins are displayed based on the level of innovation. We differentiate between cryptocurrencies with small parameter changes, larger substantial innovations and Alt-chains. The majority of Altcoins are a pure copy of Bitcoin's C++ source code, with smaller parameter changes (Ong, Ming Lee, Li & LEE Kuo Chuen, 2015). These kinds of Altcoins do not hold any form of technical innovation that would drastically differ from existing Bitcoin or any other cryptocurrency. A variety of such altcoins are niche-targeted altcoins. They can be developed for specific online communities or financial gain. Small source code additions are present in Dogecoin (DOGE) that improve transactional time and in IxCoin (IXC) that mines with a more ecological approach (Decentralised Ixcoin Community, 2017; Kartal & Bayramoglu, 2019; Ong, Ming Lee, Li & LEE Kuo Chuen, 2015). Secondly, we can separate alternative cryptocurrencies that display greater innovative ideas. The separation can be between changes in the consensus mechanisms (eg. Litecoin, Peercoin and Blackcoin), mining purposes (eg. Primecoin, Curecoin) and privacy (eg. Zcash, CrytoNote) (Antonopoulos, 2014; Kartal & Bayramoglu, 2019; Ong, Ming Lee, Li & LEE Kuo Chuen, 2015).

The last type of innovation includes layers on top of the existing blockchain system. Due to extensive changes and distinct functions, we refer to them as alt-chains. Fitting examples are Ethereum (ETH) and Namecoin (NMC). Their primary function as non-currencies. These

[7] There is also a debate about whether Ethereum should be excluded as well. Because there is a great number of altcoins derived from the Ethereum network.

cryptocurrencies coin on Bitcoin 2.0 network. ETH is built and run on decentralized applications (dApps). The proof of stake model, further explained in a separate chapter, enables Turing-complete programming in the protocol level and execution of smart contracts. Similarly, Namecoin serves as a decentralized name registry, which is going to be explained in a later chapter (Antonopoulos, 2014; Kartal & Bayramoglu, 2019; Ong, Ming Lee, Li & LEE Kuo Chuen, 2015).

2.2 Ethereum

Ethereum is after Bitcoin, the second-largest cryptocurrency by market capitalization (CoinMarketCap, n.d.-c). The system operates as a world-shared computer and runs on the Ethereum Virtual Machine (EVM) (Dameron, 2019; Tatar & Burniske, 2018). Ethereum is not a copy of Bitcoin but rather a completely separate design, built on top of the Bitcoin blockchain concept. While both above mentioned currencies are similar, as they both operate on an open-source network, with a decentralized blockchain ledger and without third-party mediation, Ethereum extends the Bitcoin concept with a Turning complete programming language, to offer distributed applications and smart contracts by developing concepts such as scripting, meta-protocols and altcoins that were neglected in the original Bitcoin network (Buterin, 2015).

Ethereum has a native cryptocurrency called ether (ETH). Unlike Bitcoin, Ethereum is limited to the production of 18 million ETH per year (Senner & Sornette, 2019). Transactions on the Ethereum blockchain are processed every 12-15 seconds. Ether serves as a tradable currency but also as a platform for contracts, name registrations and decentralized applications. Owing to both functions Ethereum can be categorized as both; an altcoin and an alt-chain. From the latest data available from March 2023, Ethereum is valued at 1,747.64 U.S. dollars. The Ethereum market's all-time high was recorded in November 2021, worth 4,444.53 U.S. dollars. The reason for the historic jump was one NFT transaction valued at around 70 million dollars. The year 2022 was marked with The Merge but also with the collapse of the FTX exchange. The latter overshadowed the benefits of the Merge and more than halved the all-time high price of Ethereum (CoinGecko, 2023).

2.2.1 Historical Background of Ethereum

The Ethereum network was initially launched in November 2013, when programmer Vitalik Buterin released Whitepaper for Ethereum. A year later, cofounder and codesigned Dr Gavin Wood published the consensus rules in "The yellow paper" protocol. Other co-developers that helped the Ethereum vision become a reality: Charles Hoskinson, Anthony Di Iorio, Mihai Alisie, Joseph Lubin and Jeffrey Wilcke (Cryptopedia Staff, 2022b). The project Ethereum raised awareness with its Initial Coin Offering (ICO) in 2014. The participants bought Ethereum value tokens to raise funds for the development of blockchain-based protocols or other decentralized applications (Antonopoulos & Wood, 2019c; Cryptopedia

Staff, 2022a). The Ethereum crowdfunding mechanism sold 60 million ethers from July 2014 to the end of public sale in September 2014. With an initial price of $0.311, the ICO raised about $18.3 million in Bitcoin. The first Ethereum was minded on July 30th, 2015, under the prototype name Frontier (CoinMarketCap, n.d.-c; Cryptopedia Staff, 2022a).

Frontier was marketed as the first developing stage of the Ethereum blockchain, featuring mining and contract execution. Since then, there have been numerous developments on the platform. Most recognized are codenames Homestead, Metropolis and Serenity. The developments include sub-releases to upgrade protocols and functional changes on the Ethereum blockchain. Homestead served as the first production release with network and protocol changes after the experimental Frontier block. In October 2017, the Metropolis Byzantine fork changed network difficulty and block reward reduction from 5 to 3 ethers. Additionally, it also improved features for tokenization and digital applications (hereafter dApps) development. All earlier stages lay a foundation for the last phase update that started at the end of 2020. Serenity is in the last developing stage still in process. At the time of drafting this thesis, only two crucial features have been implemented. The first is staking with the Beacon Chain. While the second is merging Beacon Chain with the main Ethereum network, to switch to the PoS consensus mechanism (Antonopoulos & Wood, 2019c; Cryptopedia Staff, 2023; Ethereum, 2023c).

2.2.2 Alternative Applications Developed After Bitcoin

The issuance of the Ethereum blockchain later referred to as Ethereum Blockchain 2.0 would not be possible without additional applications coined from the decentralized Bitcoin system. Almost two decades ago, a computer scientist, Nick Szabo, developed ideas that seemed to be way ahead of his time. Until recently, his ideas did not have proper designs and mechanisms, however, with Bitcoin blockchain development, Szabo's prominent ideas for "Smart contracts" and "Secure property titles with owner authority" could be implemented (Buterin, 2014; Szabo, 1994, 1998). In 1994, the paper on Smart contracts envisioned a trustless digital marketplace, similar to a vending machine. Szabo's idea is a foothold for Ethereum smart contract implementation (Ethereum, 2023c; Szabo, 1994). The latter idea, developed in 1998, hints at replicated database system and transferable global rights, that would be enforced to names, attributions and other informatic property. The idea is crucial because, without a good interface, smart contracts will not be accessed. The Name service was fundamental for Ethereum dApps (Antonopoulos & Wood, 2019a, 2019c; Kalodner, Carlsten, Ellenbogen, Bonneau & Narayanan, 2015; Szabo, 1998).

2.2.2.1 Namecoin

Namecoin was developed in 2010 as the first non-currency application built on the blockchain. The censorship-free website works primarily as a supporting platform for name registration and as a storage platform for email addresses, SLL certificates, file signatures and encryption keys. The greatest improvements with Namecoin are the decentralized

Doman Name Systems (Bit-DNS) and merge-mining. The original bit-DNS is essential for most Internet providers as it maps host names to IP addresses. The vision for Bit-DNS is to prove censorship resistance by decentralization, to improve privacy and free website addresses. Merged mining is beneficial for Bitcoin and Namecoin. Both cryptocurrencies have the same consensus mechanism which means they can be mined simultaneously, without additional work. Miners are rewarded with coins from both systems, which gives Namecoin an increased amount of hash power (Kalodner, Carlsten, Ellenbogen, Bonneau & Narayanan, 2015; Namecoin, n.d.). Currently, in 2023 Namecoin is not widely used as an individual token. Nonetheless, the intended purpose and novelty that Namecoin brought to the cryptocurrency market hold immensely greater value.

Another additional application is metadata, where a software layer in the form of a currency or protocol is added on top of an already existing Bitcoin system (Antonopoulos, 2014). Foulonneau and Riley describe metadata as "structured information about a digital resource and its properties" (Foulonneau & Riley, 2008, p.6). Metadata serves as a label for food in stores. Knowing the name, ingredients and costs of the product will supply detailed information about the product, without tasting or feeling the product itself. Although this is just an analogy, metadata works very similarly. Application on the metadata network recollects metadata elements by identifying properties of the information stored. Hence, metadata uses Bitcoin scripting language to encode more data inside Bitcoin transactions or user addresses. The arbitrary pieces of data are saved for different purposes, which can be descriptive, administrative or structural (Antonopoulos, 2014; Foulonneau & Riley, 2008).

2.2.2.2 Coloured Coins

The emergence of technology that adds metadata to the Bitcoin blockchain expanded the fundamental Bitcoin function as a neutral medium of exchange. Co-authors Yoni Assia and Vitalik Buterin drafted a Colour Coined whitepaper that encodes crypto assets with special properties. This properties can help separate different assets. To transfer coloured coins, there must be a transaction from one address to the other. Such a process is possible with a tagging-based colouring algorithm. Protocol tags sequence numbers on given inputs to outputs and offers efficiency through multi-colouring possibility. The Colour Coined properties can be issued by issuing agents or by general public agreements and can be used to maintain ownership of company shares, for smart property, as a community currency, digital collectables or even as bank deposits and bonds (Antonopoulos & Wood, 2019b; Assia, Buterin, Hakim, Rosenfeld & Lev, 2018). The unique property of a coin took a first step towards decentralized exchanges and NFT developments (Assia, Buterin, Hakim, Rosenfeld & Lev, 2018).

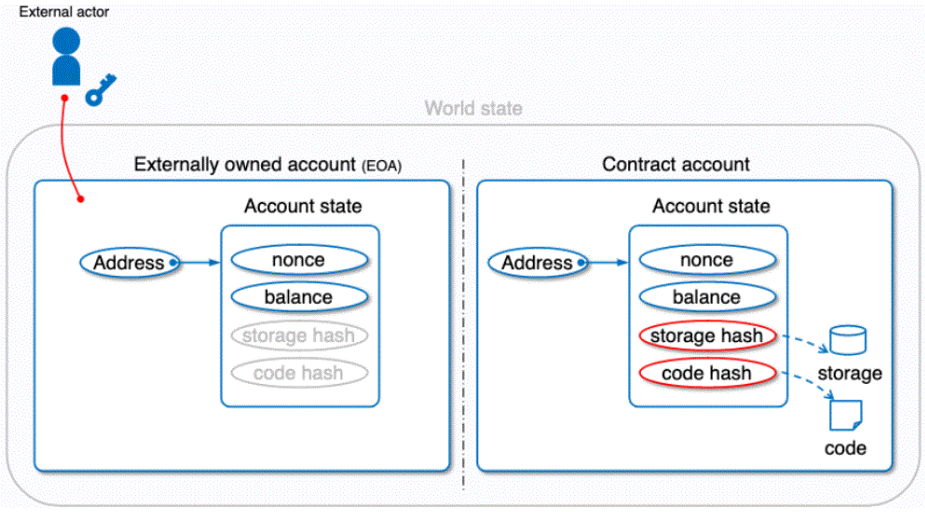
2.2.3 General Ethereum Features

Ethereum network supports a database of all current numbers of accounts on the blockchain. The so-called "state" database serves also for storage of balances, variables and smart

contracts. Different from Bitcoin where the state consists of unspent transaction outputs. The change of state is considered a transaction. With every transaction, the state is adjusted (Buterin, 2014; Wood, 2022). Figure 7 depicts the Ethereum world state. Each account on the Ethereum network has its own state. A connected system of accounts and account states creates a world state (Dameron, 2019; GitHub, 2022).

Figure 7 also depicts two types of Ethereum accounts. On the left side, we have externally owned accounts (EOAs) that are managed by private keys. When users create an account, they receive a public and private key pair that generates their ID address. The right side of Figure 7 depicts smart contract accounts. Unlike EOA, contract accounts are managed and controlled by the EVM code. Smart contracts can be understood as programs that are conducted on the Ethereum blockchain. Each contract has a code that determines the function and data that is linked to the contract state (Ethereum, 2023d). The smart contract address is generated when contracts are placed on the Ethereum network. While contracts cannot initiate transactions, they can return a response (Ethereum, 2023b; GitHub, 2022; Wood, 2022).

Figure 7: Ethereum World state



Source: GitHub (2022).

Just like Bitcoin, Ethereum block is also divided into block header and block body. Figure 7 is a simplified presentation that shows only the account's block header. Each accounts block header includes the nonce, ether balance, code hash with the contract code and shortage hash with the account storage and root hash of the Merkle tree (GitHub, 2022; Wood, 2022). Messages and transactions on the network operate similarly to Bitcoin. Cryptographically signed messages or instructions are building blocks for Ethereum transactions. They are recorded in blocks and chained on the Ethereum blockchain (Dameron, 2019; Wood, 2022). To prevent transactions from running an infinite loop, there is a set limit on the computational steps (Buterin, 2014). The computational effort is measured by the gas transactional fees. The amount of gas depends on the supply and demand of market

resources, transaction complexity and desired speed of execution. Gas prices are denoted in Gwei, which equals 0.000000001 ETH (OECD, 2022). The following text will elaborate on Ethereum's key features like blockchain, proof-of-Stake and process for sharing and staking.

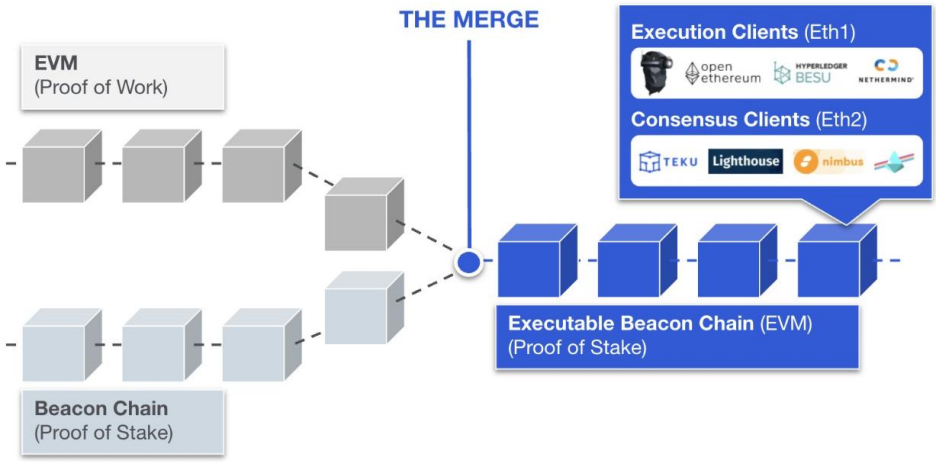
2.2.3.1 Blockchain 2.0

Blockchain 2.0 is an extension of revolutionized Bitcoin payment system understood under blockchain 1.0. Blockchain 2.0 works to improve on concepts such as transparency, security and decentralization through smart contracts (CoinMarketCap, n.d.-b). The fundamental layer that differentiated Ethereum from other applications that were built on top of Bitcoin builds is the Turing-complete programming language. As opposed to virtual machines in Bitcoin, Ethereum Turing Complete state machines that can solve any computational problem, if given time and sequential memory. The father of computer science, Alan Turin, invented the theoretical machine that would follow instructions and perform actions based on underlying code. The Ethereum Turing complete programming language is an imitation of the Turing complete machine that understands transactional instructions and can develop any application or smart contract. Smart contracts are written in Solidity code that runs with loops. To escape infinite loops, users determine the maximum number of computational steps and pay a fee accordingly (Binance Academy, n.d.-c; Buterin, 2014).

2.2.3.2 Proof of Stake

Similarly, as miners mine Bitcoin to get the reward, Validators in Ethereum mint the blocks to earn ether (Cryptopedia Staff, 2021a). From the start Bitcoin and Ethereum, both used proof of work security protocols. The transition from the Pow to PoS mechanism is illustrated in Figure 8.

Figure 8: The Merge of Beacon Chain



Source: Watson & Beck (2021).

In 2022, the Ethereum network switched from the PoW consensus algorithm to PoS with the Merge of the Beacon Chain. Before the Merge, Ethereum operated only on the execution

layer. The Beacon chain, however, operated as a separate entity working in parallel with the Ethereum network. Post-merge, depicted on the right hand of Figure 8, each Ethereum node consists of an execution layer known (Eth1) and a consensus layer (Eth2). Each layer or client can run on different client software. Most known executions clients are Geth, OpenEthereum, Hyperledger Besu and Nethermind and consensus clients are Teku, Lighthouse, Nimbus and Prysm (*Nodes and Clients*, 2023; Watson & Beck, 2021). Nodes must stake in the capital (at least 32 ETH) to enter the validation process. Execution clients verify the validity of the transaction. After, the transaction is added to the local mem-pool and broadcasted through the execution clients' gossip network. The execution client and consensus clients send instructions with the API engine. One of the nodes that deposited the stake is pseudo-randomly chosen to be the block proposer. The processed transactions are gathered in the "execution payload", which is further sent to the consensus layer and finally added to the Beacon block. The consensus layer then shares the Beacon block on the gossip network with other non-validating nodes (*Networking Layer*, 2023; *Nodes and Clients*, 2023; *Proof-of-Stake (POS)*, 2023).

Instead of solving hard algorithmic puzzles, the Proof of Stake Ethereum security protocol semi-randomly chooses a validator to create new blocks and verify the transactions. The higher the stake of nodes the higher the chances of one becoming the block validator. The process of choosing a validator depends on stake amount, random coin selection and coin age (Antonopoulos & Wood, 2019c; *Proof-of-Stake (POS)*, 2023).

2.2.3.3 Sharding and Staking

The Merge, marked by the unification of the Beacon chain and the Mainnet chain, was an upgrade milestone that switched from energy-intensive proof-of-work to a more scalable proof-of-stake algorithm. Successful implementation marked the era of a new and upgraded Ethereum 2.0 blockchain. The staging number of applications and users highlight the limitations and areas where improvements are still needed. Limitations include but are not limited to high transitional costs and gas prices, security and better user experience. Buterin published the development roadmap steps in three major phases outlined below (Cryptopedia Staff, 2021a).

Next to the already discussed Phase 0 is Phase 1 which works on shard chains and roll-up scaling. Shard chains are understood as separate blockchains that divide the network into shards for better capacity and speed. The partitioning data processing responsibility is especially crucial with scalability issues posed by high network activity. Instead of storing the data for the whole network, validators store data for randomly assigned shards. Phase 1's initial idea splits the Ethereum blockchain into 64 shard chains, where all shards answer to the Beacon chain (Bitcoin Suisse, 2019; Cryptopedia Staff, 2021b). Another implementation is the roll-ups scaling. This strategy processes transactions outside the main Ethereum network and settles them on the main chain. The minimal blockchain interaction base aims

to lower transactional costs and increase the number of transactions per second (TPS). A goal would be to reach 100,000 TPS (Buterin, 2022; Cryptopedia Staff, 2021b).

Phase 1.5 known also as the "Ducking phase" bridges Phase 0 and Phase 1 together. This step was completed in September 2022. The phase transfers to a fully PoS-based blockchain and sets the path for the last third phase of Buterin's roadmap (Bitcoin Suisse, 2019). Phase 3 is the least defined, it includes updates like an additional number of chards, increased privacy and security in the Ethereum network. With this phase, Ethereum 2.0 development will be complete (Cryptopedia Staff, 2021b).

2.2.4 Ethereum Applications

With the Ethereum introduction, developers were allowed to develop applications on top of the decentralized public ledger. There have been all sorts of decentralized services, that have the potential to redesign intermediary services for multiple industries such as finance, real estate, insurance, corporate governance etc. (Blockchain Review, n.d.). Buterin's White Paper categorizes three main Ethereum applications as financial, semi-financial and non-financial. The first category is broken down into "sub-currencies, financial derivatives, hedging contracts, savings wallets, wills and ultimately even some classes of full-scale employment contracts" (Buterin, 2014, p.19). Semi-financial operations have a monetary and non-monetary side, like self-enforcing bounties for computational solutions. Lastly, non-financial applications entail online voting, cloud computing, peer-to-peer gambling and decentralized governance etc. (Buterin, 2014).

A general categorization of all applications is useful since it gives a wide perception of the Ethereum network functionality. However, to utterly understand the revelation of the Ethereum system and its implications for the future, we would further in more detail elaborate on tokens, smart contracts, dApps, DAO and DeFi.

2.2.4.1 Tokens

Crypto tokens are subclasses of crypto assets, built with advanced cryptographic techniques. The main difference between cryptocurrencies and tokens is that tokens are transferable units of value that run on top of another cryptocurrency's blockchain (Binance Academy, n.d.-b). For example, Tether USD is a token designed to facilitate digital fiat currency and it runs on Ethereum's blockchain. Ether, on the other hand, is the base currency on the Ethereum's blockchain. Because tokens are not built on the blockchain they must access the blockchain through smart contracts. Tokens can be coded to perform a wide range of tasks, including commodity, utility, governance and security. Multiple functionalities call for a wide use of token standards. For the scope of this master thesis, we are going to focus on the ERC-20 and the ERC-721 standards[8] (Antonopoulos & Wood, 2019b; Cryptopedia Staff, 2022b) The

[8] ERC stands for "Ethereum Request for Comment". Numbers 20 and 71 refer to protocol identifiers (Ethereum, 2023e).

tokens can be fungible or non-fungible. While fungible tokens are divisible and can be exchanged one for another, non-fungible assets have digital signatures that hold unique values. The majority of fungible tokens are based on the ERC20 standard, which ensures the safe trading of assets on decentralized exchanges (Antonopoulos & Wood, 2019b; Curry & Conti, 2023). Non-fungible tokens or NFTs can be understood as any digital collector's item, from art, music, sports highlights, games and tweets to real estate and collectables (Curry & Conti, 2023). Rules and standards on unique NFT ownership are specified in ERC-721 standard. In 2014, Kevin McCoy created the first Quantum NFT on the Namecoin blockchain. In mid-May 2023, the NFT market cap accumulates to $9.04 B. This represents less than a 1% cryptocurrency market. The biggest NFT token providers are ApeCoin, The Sandbox, Decentraland, Flow and Theta Token (Coincodex, n.d.).

2.2.4.2 Smart Contracts

Financial derivatives such as options, futures and perpetual contracts are one of the most common Ethereum smart contract applications. The trading process can be beheaded automatically if contract conditions are met. Unmodifiable and irreversible smart contracts are executed on the Ethereum Virtual Machines (EVM). The EVM machines run on simple stack-based EVM code written in a bytecode language. Ethereum smart contracts tend to use Solidity. EVM defines the rules for block verification. With pre-determined rules, blocks are added and the machine's state is changed. Hence, EVM is in other words a transition state function (Buterin, 2014; Cryptopedia Staff, 2021c; Ethereum, 2023a; Wood, 2022).

2.2.4.3 DApps

Smart contracts serve as a building block for decentralized applications or dApps. DApps represent a system that runs on a decentralized peer-to-peer computer network. It gained popularity in 2017 with the issuance of non-fungible tokens (NFTs). Antonopoulos and Wood describe dApps as "at the very least, a smart contract and a web user interface" (Antonopoulos & Wood, 2019c, p.10). In other words, dApps is a complex of smart contracts, that can be used for financial applications and a wide variety of other decentralized applications. For example, dApps is used as a gaming asset like CryptoKitties, decentralized social media like Steemit, as a gambling platform or semi-decentralized exchange like IDEX. DApps are executed isolated from the blockchain network in Ethereum Virtual Machine (Cryptopedia Staff, 2021c; Lu & Jiang, 2019).

2.2.4.4 DAO

An extension of dApps is to create a complex of applications in a Decentralized Autonomous Organization (DAO). A community that would serve without a centralized government entity and would collectively own the platform. Reaching a 67% majority vote would allow the community to spend community funds or modify the code. The goal is to connect individuals to create an automated organization that will write and enforce rules using

software, while still allowing full participants control of funds. The power would be distributed through controlled tokens, which respectively represent the holder's voting and ownership rights. DAOs are integrated in Ethereum-like systems, that use Turning complete programming language on the blockchain network (Jentzsch, 2017). Although the legal status of DAO still remains a debate, this has not stopped researchers and programmers to develop ideas for algorithmically regulated governance (Jentzsch, 2017; Williamson, 2013).

2.2.4.5 DeFi

The last Ethereum application is the concept of Decentralized Finance or "DeFi" which was established with Ethereum, smart contracts and stablecoin developments. Decentralized Finance applications are built directly on blockchain technology. The aim is to operate on open-source software that can replace centralized intermediaries and offer automated, accessible and efficient platforms built on smart contracts (IMF, 2021, 2022; OECD, 2022). In recent years, the DeFi market grew from $20 billion at the beginning of 2021 to an all-time high of $172 billion in November 2021. The substantial jump was caused by the exponential growth of decentralized exchanges and credit platforms. The current DeFi market cap in May 2023 stands at $48.6 billion (CoinGecko, n.d.; IMF, 2021). DeFi applications offer a broader collection of financial solutions such as trading of derivatives, asset management, insurance and prediction markets (Adachi et al., 2022; Financial Stability Board, 2022; OECD, 2022). Although DeFi is mainly used in crypto markets, wider adoption to retail investors and developing markets can expand interconnections to existing financial institutions. Growth in the DeFi market plays an important role in the growth of stablecoins and the decentralized Web3 Internet phenomenon (IMF, 2021, 2022).

2.2.5 Benefits and limitations of Ethereum

Ethereum is a large open-source decentralized computer system that works without governmental intermediation. Although Ethereum is the second in market cap, it gives an advantage over Bitcoin and other protocols with a wide variety of functions, from dApps and smart contracts to Defi and DAO. A globally established system with a tremendous developing community is also constantly upgrading to ensure a safe, scalable and sustainable environment.

Although Ethereum improved multiple limitations that were presented with Bitcoin, the system is in the ongoing finishing phase, which poses substantial risks. Methods like sharding and staking were built to reduce the problems and increase network efficiency. While Ethereum improved transactional time from the Bitcoin blockchain, it is still not comparable to Visa and Mastercard volume of transactions. The growing popularity and an increasing number of developers can create market congestion that will consequently raise transactional fees and limit networks' operations. This can be especially detrimental with DeFi and yield farming. Furthermore, in a system that offers such a wide variety of

applications and improvements, there is a high rivalry with other blockchain altcoins such as Solana, Cardano, Polkadot, Polygon, Avalanche and others. Another set of limitations that are present with all cryptocurrency assets is the cybersecurity vulnerabilities with errors and illicit activities. With the growing importance and usability of smart contracts, every system exploitation could lead to system collapses and significant monetary losses (Ma, 2023). Lastly, Ethereum is also confronting inflationary pressures. Though there is an 18 million limit on per year production, the lifetime limit is not restricted. Due to this, it does not serve as a potential inflation-hedging mechanism and is prone to substantial price volatility (Rodeck & Powell, 2022).

While there are many limitations to the Ethereum network, there are also many benefits. With increasing computer technology developments, there is going to be even greater adoption of crypto assets and applications. Ethereum automatization and decentralization achieved with smart contracts can present a double-edged sword. While technical advances in existing business models allow for the introduction of a newer digital future, scaling and security vulnerabilities, they can also represent a major weakness and a potential system collapse (Ma, 2023).

The variety of Ethereum applications can disrupt different financial and non-financial aspects of the traditional monetary system (Buterin, 2014). However, unlike Bitcoin Ethereum does not provide a direct threat to fiat currencies and monetary policies. The main purpose of the Ethereum network is to provide utility and produce value, not to compete as an alternative payment system or fiat currency. While Ethereum serves as a store of value and medium of exchange functions in the decentralised markets their applications beyond the crypto ecosystem can be negligible. A much greater threat are stablecoins, which will be mentioned in the next chapter.

2.3 Stablecoins

Cryptocurrencies like Bitcoin and Ethereum have been massively growing in popularity. Because of the high price volatility both crypto assets serve as highly speculative and have a tough time adapting as a currency or reliable payment mechanism. To ensure more stability, the public sector introduced the governmentally-backed CBDCs mentioned in the chapters above, while the private sector has been working on stablecoins. Stablecoins are tokens that focus on minimizing price fluctuations. Their value is in a one-to-one ratio pegged to some reference values such as fiat money, commodities, or other crypto assets (Delivorias, 2021). As such, stablecoins can be understood as “the manifestation of crypto’s search for a nominal anchor” (BIS, 2022, p.78). They represent a link between traditional fiat currency and cryptocurrency markets (Adachi et al., 2022). The majority of stablecoins are created and distributed on trading platforms, where they can be further exchanged for fiat currencies (Financial Stability Board, 2022). As a disclaimer, stablecoins use the prefix “stable” since they are less volatile than Bitcoin or Ethereum. However, their value also fluctuates, depending on the underlying assets’ volatility (Liao & Caramichael, 2022).

Bitcoin was designed as a peer-to-peer payment system. Even though the constant volatility prevents the asset from serving as such, stablecoins were built to solve Bitcoins' shortcomings. Stablecoins are designed as trading mechanisms that can store value and serve as a medium of exchange. The end goal for stablecoins is to function as an effective means of payment (Adachi et al., 2022; Macdonald & Zhao, 2022). Although the full adaption has yet to be accomplished, future improvements in the speed, cost and redemption conditions can make stablecoins a more feasible alternative to existing payment systems (Adachi et al., 2022). As of June 2022, stablecoins represent a 16% share of crypto assets with a market cap of $154.9 billion (Statista, 2022). Tether is the largest stablecoin on the market. It represents almost half of the stablecoin market with a total market value, from May 2023, of around $83 billion. While Tether's market value is negligible in comparison to Bitcoin, Ethereum or other non-Ethereum smart contract providers, the daily trading volume of Tether outruns all other crypto assets (CoinMarketCap, n.d.-a; IMF, 2021).

2.3.1 History of Stablecoins

The first origins of stablecoins can be linked with the Bank of Amsterdam in the 17th century. Initial account deposits were backed by stable-value assets like gold or silver coins (Frost, Shin & Wierts, 2020). Another important stablecoin milestone was "e-money" in the 1990s. Electronic money was a building block for the stablecoin innovation that we know today. The new forms of money and payment system improved with DLT technology (Arner, Auer & Frost, 2020).

The first stablecoin, named BitUSD, was launched in 2014. It served as a token on the BitShare blockchain system. The coin was backed by a basket of crypto assets including core BitShares tokens. This proved problematic because it served more as volatile security than a stablecoin. BitUSD stablecoin lost the one-to-one peg with U.S. Dollar in 2018 and never fully recovered (Chalopin & Scott, 2022). In the same year, NuBit was another primal stablecoin on the market. Different from BitUSD, NuBit used Bitcoin as a collateral asset. The asset lost its peg twice mainly due to improper reserve diversification that the downward pressures caused by Bitcoin's volatility. While both stablecoins were not capable of readjusting the peg, they served as important learning lessons (Chalopin & Scott, 2022; Reserve Research Team, 2018).

The idea of stablecoins was again highlighted with the Libra project introduced in 2019. Libra Association with Facebook proposed a digital currency that appeared on open-source blockchain technology. The payment system would be integrated through a social media app, which would aim to provide lower transaction and commission costs for domestic, as well as cross-border payments. Libra's permissionless system would allow users to cash in money for Libra tokens, which would allow users to make purchases on Facebook platforms such as Messenger and WhatsApp. Tokens would be backed by low-volatility assets composed of major international currencies and governmentally-backed securities (Amsden et al., 2020; Libra Association Members, 2019; Lu, 2019). Libra digital currency would be

a global medium of exchange for 3,71 billion people on Facebook platforms and a digital solution for 1,7 billion unbanked people around the globe (Lu, 2019; Statista, 2023). Although Libra aimed to build a more inclusive financial system with fully backed reserves, it was shut down due to raised concerns about data protection, consumer privacy and money laundering. In 2020, Facebook came up with a new proposal that would better comply with regulations and ensure more safety. To meet the demands Diem system created a more autonomous entity by separating the financial and social aspects of Facebook. With the new proposal also came rebranded name Diem and Novi wallet. Besides the separational aspect and greater wallet applications, Diem moved from a basket of goods instrument to a single currency stablecoin (Libra Association Members, 2019; Rrustemi & Tuchschmid, 2020). Diem stablecoin would be fully backed by chosen monetary sovereign currency like U.S. Dollar or Euro. As such it would serve as a store of value (Prasad, 2021b). Overall, rebranding and improvements of Diem were steps in the right direction, however, previous analytical data scandals and unconformity with other governmental regulations were detrimental to the Diem project (Libra Association Members, 2019; Rrustemi & Tuchschmid, 2020).

Developing systems like Libra and other global stablecoins have planted monetary instruments into digital decentralized environments. While digital technology implements numerous benefits, like cross-border transfers, it also raises concerns for monetary and financial authorities. The great social presence of Facebook or any other big commercial platform could reduce demand for governmentally issued money as a medium of exchange and a store of value. The problem would be significant for markets, countries and individuals if disturbances would limit central banks' capacities to control low inflation, exchange rates and volatility of the market (Prasad, 2021b). From the regulatory standpoint, the goal is to implement supervision, that would prevent criminal activity and protect consumers without hampering innovation and the stability of global financial systems (Arner, Auer & Frost, 2020). Although multiple countries like Japan, the U.S., Russia, Switzerland, South Korea, the United Kingdom and Nigeria are working towards crypto regulations, European Union was the first to endorse crypto assets regulation in the world. The regulation was primarily designed to prevent public projects like Diem to impact the European monetary sovereignty. European Parliament adopted the new regulatory framework called Markets in Crypto Assets (MiCA) in April 2023. The regulation is a part of the new Digital Financial Package that aims to implement registration and licensing regimes with AML and KYC controls. More importantly, it implements supervision, transparency and data disclosure to primarily protect the consumer and avoid financial stability risks in the cryptocurrency markets. The regulation is primarily important because it provides basic definitions and differentiates between crypto assets and tokens. The regulation will impact crypto issuers and asset service providers which include also stablecoin issuers (Arner, Auer & Frost, 2020; Bains, Ismail, Melo & Sugimoto, 2022; Banco Bilbao Vizcaya Argentaria, 2023; Banking Circle, 2023; European Parliament, 2023b).

2.3.2 Types of Stablecoins

Stablecoins can be classified based on many different mechanisms. This thesis will divide stablecoins based on their stabilization structure, which can be roughly split into three groups; collateralized, un-collateralized and private stablecoins (Moin, Sekniqi & Sirer, 2020).

(i) Collateralized Stablecoins

Collateralized stablecoins can be further divided into off-chain and on-chain subgroups. The first type is off-chain collateralized stablecoins. As the word itself describes, stablecoins are backed by traditional reserve assets, such as bank deposits, fiat money, commercial paper, Treasury bills etc. Off-chain stablecoins are operated by custodians since they are not represented by tokens on the blockchain. There are many reserved-backed stablecoins just to name a few: Tether (USDT), USD Coin (USDC) and Binance USD (BUSD) (Liao & Caramichael, 2022; Mai, 2022). Reserve-backed stablecoins represent more than 90% share of all stablecoins in the market (Statista, 2022). Additionally, we also consider commodity-backing stablecoins to be part of the off-chain group. The most common commodities are precious metals like gold and silver and other physical assets like oil or real estate. The most common is gold collateralization with Tether Gold (XAUT) and Paxos Gold (PAXG) (Cryptopedia Staff, 2022c; Mai, 2022).

On-chain stablecoins, on the other hand, are backed by cryptocurrency assets. They can be represented by tokens on public blockchains or other DLT networks. Programmable standards on the DLT ensure the creation of independent building blocks and the self-execution of smart contracts (Liao & Caramichael, 2022). The claims are operated on decentralized DeFi applications, without custodian accountability. Locked collateral tokens are due to the volatility of the underlying assets many times overcollateralized (Liao & Caramichael, 2022; Mai, 2022). An example of an on-chain stablecoin is Dai, which operates on smart contracts to maintain stable prices. The value of Dai stablecoin is pegged to the U.S. dollar. When volatile assets are deposited, the Maker Protocol generates Dai. The user receives Mined Dai loan that is pegged to the dollar against the crypto collateral. Smart contracts automatically liquidate the loan if the prices fall below the protocol set amounts (Maker Team, n.d., 2017; OECD, 2022).

(ii) Uncollateralized Stablecoins

The second type is uncollateralized stablecoins also known as algorithmic stablecoins. As the world itself describes, they are not backed by any asset. Instead, fully decentralized stablecoins, algorithmically adjust the outstanding number of tokens to control the supply in the market and maintain stable prices (Baughman, Carapella, Gerszten & Mills, 2022; Mai, 2022). The process of controlling the supply is similar to Central Banks' printing and destroying money in the Central Bank (Zhao, Li, & Yuan, 2021). If demand in the market increases, the prices will be above the peg, which will distribute new coins to users. In a

situation where prices fall below the peg, the system will sell bonds in exchange for stablecoins. To ensure a rise in prices, the received stablecoins will be destroyed (Baughman, Carapella, Gerszten & Mills, 2022; Mai, 2022). An example of an algorithmic stablecoin is TerraUSD (UST). The stablecoin crashed in May 2022 and lost most of its value in a matter of days. The Terra blockchain uses Terra-Luna dual token system. Stablecoin Terra USD was pegged to U.S. Dollar, while LUNA operated as a volatile unbacked cryptocurrency. The stability of TerraUSD was achieved with a smart contract-based algorithm. The mechanism would burn LUNA tokens or mint new UST in proportion to price deviations (Hernández Romanowski & Brantley, 2022). The hectic market conditions in May 2022 and poor stabilization mechanism performance caused UST to de-pegged. Similarly, to bank runs, people lost confidence and liquidated their holdings. This led to the crash of the Terra-LUNA token and a chain reaction to other crypto providers such as lender Celsius, hedge fund Three Arrows Capitals and later FTX futures exchange. The collapse points to the fragility of algorithmic stablecoins (Briola, Vidal-Tomás, Wang & Aste, 2023; CoinMarketCap, n.d.-e; Hernández Romanowski & Brantley, 2022; Macdonald & Zhao, 2022).

Another stablecoin worth mentioning is Rai. Unlike all the others, Rai is an algorithmic stablecoin operating on the Ethereum blockchain that does not peg its value on any external asset. Its value is created with arbitrage opportunities in the demand and supply market. The goal of the PID controller is to use smart contracts to drive prices as close to the redemption price as possible. The end goal is to maintain stable prices in the long run. The redemption price depends on the amount of collateralized Ether (Ionescu & Soleimani, 2020, Pellicer, 2023). In reality, Rai has been decreasing in value, which makes it costly to hold. The current price in April 2023 stands at $2.77 which is more than a 9% yearly decrease (CoinMarketCap, n.d.-d). Although a decrease in value for stablecoin is not a desirable feature, in the bear market, Rai stablecoin portrays medium volatility and responds better than some international currencies relative to U.S. Dollar[9] (Pellicer, 2023).

(iii) Private Stablecoins

Lastly, there are private or institutional stablecoins that circulate on the private decentralized blockchain systems. Traditional financial institutions, like JPMorgan Chase &Co., have developed tokenized deposits, pegged one-to-one to U.S. Dollar. Their stablecoin named JPMorgan Coin (JPM Coin) can be compared to PayPal payment services, as they offer instantaneous transfers and payments within the system. The difference lies in the centralized database available solely to JPMorgan clients and smaller multi-national banks (Liao & Caramichael, 2022; Onyx Coin Systems Product Team, n.d.).

[9] Pellicer draws a graph that shows a time from March 2022 to March 2023. We can see that currencies like JPY, GBP, CNY and EUR relative to USD have shown more losses than Rai (Pellicer, 2023).

2.3.3 Role of Stablecoins

Before diving into a discussion on the role of stablecoins, we will turn our attention to the effect the abovementioned types of stablecoins can have on the traditional forms of inside money. Fiat-backed stablecoins fulfil a static monetary perspective with centralized and universally accepted IOU claims. Regardless of the stability and anonymity provided, fiat-backed cryptocurrencies are linked to traditional fiat money which consequently enables them to exist as independent currencies. For that reason, they cannot serve as a replacement for existing fiat money. Inversely, the crypto-backed and algorithmic stablecoins are inferior to IOU debt claims. While the volatility of crypto assets cannot sustain stable prices, algorithmic stablecoins dynamically adjust the supply to meet the targeted prices. The fairly new concept lacks the collateral and infrastructure designs for wider user adoption. This part concludes that neither of the stablecoin types presents an effective substitute for fiat money. Stablecoins are more likely to coexist than to replace fiat money (Senner & Sornette, 2019). Gordon and Zang (2021) make similar conclusions. They claim that as of now, stablecoins do not effectively serve as a medium of exchange or an alternative to fiat money. They claim that the main problem for the future monetary systems can become the fast growth of stablecoin innovation, which does not align with the speed of stablecoin regulations (Gorton & Zhang, 2021).

The role of stablecoins differs between countries. For example, the U.S. offers the majority of payment services, mainly because 99% of service providers use U.S. Dollar as a reference unit of account (Macdonald & Zhao, 2022). On the other hand, European countries are exposed to limited stablecoin adoption, due to stricter regulations and a restricted number of euro-pegged stablecoins (Adachi et al., 2022). Regardless of countries' differences, stablecoins are predominantly used in decentralized environments. Its decentralization and programmability features are vital in DeFi applications and crypto banking activities (Liao & Caramichael, 2022). DeFi applications dominantly utilize stablecoins for trading on centralized or decentralized crypto exchanges (Aramonte, Huang & Schrimpf, 2021). Additionally, they are also used as a stable mechanism for collateralized lending that offers an above-average yield of invested funds, derivatives and other market services (Macdonald & Zhao, 2022). As such, stablecoins in the crypto ecosystem operate as a medium of exchange and a reliable store of value instrument. This is especially true, for countries like Turkey or Argentina. The latter country is greatly exposed to increasing hyperinflation. In an attempt to stabilize the national currency, the Argentinian government set limits on foreign currency holdings. These limitations have caused spikes in the cryptocurrency markets, especially with Bitcoin and U.S. Dollar backed stablecoins. Crypto assets offer a safe haven instrument that can pertain value, minimize reserve exposure and fight against inflation (Engler, 2022; Haqshanas, 2023). Greater DeFi protocol could integrate broader financial services and greater overall stablecoin demand (Baughman, Carapella, Gerszten & Mills, 2022; Cryptopedia Staff, 2022c; Liao & Caramichael, 2022).

Besides cryptocurrency market implications and transactions on the public blockchain, stablecoins prove useful also beyond digital assets. Stablecoins are used as cross-border transfers, remittance payments and as a liquidity management mechanism (Liao & Caramichael, 2022). They tend to be less regulated, borderless, operate 24/7 and potentially offer lower transactional costs than traditional banking (Macdonald & Zhao, 2022). The difference between traditional and stablecoin operations is greatly evident with cross-country transfers. While current cross-country transfers are slow and costly, the absence of intermediaries can help execute faster and cheaper peer-to-peer transactions. The transparency provided on the public blockchain ensures an efficient and faster validation process that proves especially beneficial for individuals in developing nations or countries with strict government controls (Macdonald & Zhao, 2022). The second important implication is the use of institutional stablecoins. Institutions can efficiently facilitate internal funds in the form of wholesale transactions or intraday repo transactions. This way, large banks and firms can manage operational and liquidity risk while complying with governing regulations (Liao & Caramichael, 2022).

While stablecoins provide benefits in all the above-mentioned categories, there are also dangers with a lack of monitoring and regulation. Because stablecoins are still in the developing stages they have not yet achieved their full potential. One of the arguments against predominant stablecoin trading points to greater transactional fees than initially purports by stablecoin issuers. ECB argues that fee generation depends on market congestion and the complexity of transactions. At the current state, there are no substantial differences in transactional costs between stablecoins and traditional finance payment services. While Tether and ATM transactional fees can be comparable, DAI or USDC stablecoins generate much higher fees. Other options like Solana, Tron and Avalanche may offer more competitive fees, however, one would have to trade off some other features like scalability, decentralization or security (Adachi et al., 2022).

Regardless of the current stablecoin state, there is immense growth potential with programable money, payment and financial markets and asset tokenization. The innovation can challenge the existing payment systems to provide better and more comparable payment and transfer conditions. Similarly, wider stablecoin adoption can expand to DeFi applications and smart contracts, spurring innovation also into the financial systems. The last-mentioned growth potential can be reached with asset tokenisation. The latter would transform rights to any security like real estate into digital tokens. The transparency and programmability of blockchain technology would ensure the automatization of trading and services. Finally, the growth of stablecoins can advance also to Web3 decentralized internet and further push technology to decentralized network providers (Liao & Caramichael, 2022; Macdonald & Zhao, 2022).

2.3.4 The Importance of Stablecoins in the Monetary and Banking Systems

The last part of the stablecoin discussion will elaborate on the effects stablecoins can have on banking and monetary systems. Extensive use of stablecoins could reduce bank fees and commission revenues and change the profitability of the monetary and banking sector (Li et al., 2024). Liao and Caramichael (2022) conclude that wider stablecoin endorsement and credit provision depends on the structure of stablecoin reserves. Accordingly, a narrow banking framework[10] would guarantee a stable anchor of stablecoins but at the same time pose the greatest risk to traditional banking in times of economic downturns. In the case of a two-tiered banking system[11], the system would support stablecoin issuance while maintaining the same traditional banking credit provisions (Liao & Caramichael, 2022).

Additionally, collateralized stablecoins, pose a run risks threat. When consumers trust in the stability of the asset and its collateral, tokens are perceived as safe. However, in case of major price fluctuations, social media rumours or legislative lawsuits the credibility of stablecoins can be lost. Raised doubts about future obligations can increase redemption requests. If collateral instruments are not backed with highly liquid assets to meet the demand, stablecoins can lose their value and risk a run (Dark, Rogerson, Rowbotham & Wallis, 2022; Gorton & Zhang, 2021). To prevent major collapses, stablecoins can overcollateralize their reserves or provide greater transparency with regular audit checks. The Tether lawsuits[12] which started arising in late 2019, caused great damage to crypto and the overall markets. Since then, companies aim to provide better oversight of their operations. Runs on stablecoins can have further implications, by and large because reserve assets give a direct link to the traditional financial sector (Adachi et al., 2022). Especially in times of financial distress, abrupt changes in backed reserve assets would directly affect banks that hold stablecoins and indirectly also money market funds that hold reserve assets (Dark, Rogerson, Rowbotham & Wallis, 2022).

Further we can also address concerns raised with unbacked stablecoins. From a historical point of view, Dollar was once a stable coin, backed by gold. Once the economy grew and expanded, the market needed more flexibility, which could not be provided with a gold-dollar-peg. Comparably, some believe crypto will outgrow the collateral obligations and will aim for purely algorithmic stablecoins (Dale, 2022). While inherently riskier algorithmic stablecoins are still in more theoretical development phases, some people believe they can provide substantial grounds for innovation. Not only would the implementation of algorithmically controlled mechanisms extend DeFi bounds, but it would also pose a greater threat to monetary systems. This is mostly due to stablecoin minting characteristics that

[10] Narrow banking stablecoin framework would require stablecoin to be backed by central bank reserves (Liao & Caramichael, 2022).
[11] A two-tier stablecoin framework would require stablecoins to be backed by commercial bank deposits, operating similarly to traditional fractional reserve banking(Liao & Caramichael, 2022).
[12] Tether was sued for misrepresentation of dollar reserves. Their initial claim that Tether coins are fully backed by U.S. Dollars resulted in a $41 million settlement dispute paid to U.S. Commodity Futures Trading Commission (Liao & Caramichael, 2022).

operate irrespectively of the current governmentally installed system. Wider algorithmic stablecoins adoption could decrease central banks' seigniorage revenue and force monetary policy restructuring (Macdonald & Zhao, 2022; MoreReese, 2022). Current algorithmic stablecoins like Rai already offer prominent mechanisms such as the PID-control mechanism that could be useful tools for future monetary policy design and implementation. The paper by Hawkins and others state that "the use of monetary policy rules by central banks as a form of feedback control bears a striking resemblance to … PID" (Hawkins, Speakes & Hamilton, 2015, p.11). Overall, algorithmic stablecoins are not directly tied to original financial systems. For now, they are rarely used outside of crypto markets and for that reason, they currently do not create a major systematic risk for the governmental institutions (Dark, Rogerson, Rowbotham & Wallis, 2022).

The extended digital currency chapter can draw crucial conclusions before proceeding to the case study. The technological innovation behind crypto assets has changed the informational age and transformed it into the Era of the Digital Revolution. The following has contributed to cheaper and faster payments and financial transactions. IMF's Financial Stability report claims that crypto assets are not a danger to current financial stability. However, greater adoption without proper regulations and safeguards could endanger traditional monetary systems (IMF, 2018). Additionally, the future of crypto markets depends on multiple social and economic aspects such as; wider adoptions, the user's confidence in the crypto market and direct and indirect risks between crypto and financial interconnections. The crypto currency ecosystem can be exposed to operational risk that could arise from design malfunctions. Crypto assets can expose users to cyber risk and governance risks that could come from the lack of transparency, illicit activities and challenges in cross-border transacting (IMF, 2021).

3 CASE STUDY: SILICON VALLEY BANK AND USDC

The purpose of this thesis was to dissect how different inventions in the cryptocurrency environment affect the traditional monetary system. However, a current case with the Silicon Valley bank crash has proven just how much the banking sector also influences the crypto market.

Circle Internet Financial Inc. is a global open Internet platform that offers different financial services. In September 2018, Circle launched the dollar-pegged cryptocurrency – USDC (Circle, 2023b). Currently, it is the second largest stablecoin with a market value of over $30,8 billion (CoinMarketCap, n.d.-f). USDC can be run on multiple public blockchains such as Ethereum, Avalanche, Solana etc. (Circle, 2023b). The value of USDC is in a 1:1 ratio pegged to U.S. reserves, comprising 20% cash and 80% short-term Treasury bonds. A regulated, licensed and sanctioned platform that complies with general customer requirements such as KYC, AML and CFT. The system is controlled by Centre, managed by BlackRock, custodied by Bank of New York Mellon and audited by Deloitte. All of the

above-specified features that point to regulation, transparency and compliance, work separately from Circle's operations (Circle, 2023a).

The collapse of Silicon Valley Bank (SVB), in March 2023, was the second largest bank failure after the Washington Mutual Bank collapse in 2008 (Son, 2023). The SVB initially operated as a venture capital lending institution. However, in their forty operating years they have extended services from commercial and investment banking to private wealth management. In 2021, SVB marked historically high deposit growth. Growth of the technology sector was related to extremely low-interest rates and Covid-19 government stimulus checks (Silicon Valley Bank, 2023a, 2023b). To increase profits, SVB invested a sizeable number of deposits in long-term U.S. Treasury securities (Helmore, 2023; Politi & Fedor, 2023). This resulted in the highest inflation rate spikes since 1990 (Silicon Valley Bank, 2023a). To fight inflation, Fed increase interest rates, which devalued long-duration securities (Jiang, Matvos, Piskorski & Seru, 2023). With rising inflation, depositors demanded higher returns to meet their liquidity needs. SVB was forced to sell long-term securities at a $1.8 billion loss (after tax). To acquire additional capital, the bank announced to raise "$2.25 billion between common equity and mandatory convertible preferred shares" (Silicon Valley Bank, 2023b). The peak was reached with a bank run that happened on March 9th. Depositors decided to withdraw $42 billion from SVB, which forced the U.S. Government to seize the bank on March 10th (Son, 2023).

This event is important as it loops cryptocurrency and the traditional bank world together. In the past, financial stocks were to a great degree connected to poor design features of crypto assets like Terra/Luna tokens or illicit crypto activities that led to the FTX exchange collapse. This case is quite different as the banking sector introduced risk to the crypto markets not the other way around. Circle held reserves in six different commercial banks. One of those, was SVB securing $3.3 billion of Circle's $40 billion cash reserves. Although the stake amounted to only 8% of total Circle reserves, the collapse of SVB caused USDC stablecoin to temporarily de-peg. On March 11th the price overnight fell to $0.8774, are regained the original peg by the end of March (CoinMarketCap, n.d.-f). The fascinating point is that value of USDC fell to record low amounts, not due to collateral inefficiency but because it was linked to the insolvent bank. The market crashed on March 9th and forced FDIC to shut down the bank early Monday March 10th. It is important to acknowledge the difference between held assets. While funds locked with banks were not retrievable, depositors that staked their money in USDC were able to trade, but with a 12.3% discount.

While the SVB crisis is in some way similar to the 2008 Crisis, they differ immensely. For one, the current crisis had a strong social media presence. The instant trade of information on social platforms has caused a loss of $42 billion in a matter of hours, while "bad debt" piled up since 2007 until it resulted in a market crash in 2008 (Son, 2023; Tatar & Burniske, 2018). Another difference is the SVB user base and type of deposits. Based on S&P Global data, more than 93% of all holdings in the SVB represented uninsured deposits (Gilbert, Fowers, Bogage & Wolfe, 2023). SVB provided accounts for tech startups and venture

capitalists, which held much greater amounts than the $250,000 FDIC deposit insurance amount. Having the Government not intervened, all the accounts holding more than the standard deposit insurance amount would be lost. The USDC devaluation stopped when the US authorities announced complete deposit insurance for all SVB depositors (McCaul, 2023).

Overall, unprecedented SVB collapse, exhibits how the theoretical part of this thesis coincides with the actual world events. Though the exact importance of fully backed stablecoins, in times of banking crisis, cannot be indicated at this point, many theoretical questions arise. For example, whether fully backed stablecoins that hold liquid assets, tend to respond better in economic crises, than banks with fractional reserve systems. Additionally, we can also consider regulations on stablecoins and wonder whether the government could disentangle stablecoins from banks by banning banks as reserve holders.

4 METHODOLOGY

The extended literate review discussed the main topics of this master thesis. The goal was to identify and relate the most relevant scholarly publications to gather greater knowledge about cryptocurrencies and their applications in traditional economies. Academic databases used in this thesis are Science Direct, Springer Link, Elsevier, ECB, BIS and IMF. The scientific papers were created by academic institutions, economists and other industry leaders. The theoretical part is elevated with interview conclusions gathered as a form of primary qualitative research. Because cryptocurrencies are a fairly new phenomenon, conducting interviews with industry experts seemed the most adequate type of methodology. The main goal was to acquire views and opinions on digital currencies and their economic ramifications. This master thesis uses semi-structured and unstructured interview questions. Questions were designed to cover both traditional economics and digital currency aspects of this master thesis. The research was conducted with three different industry professionals: MSc Anja Blaj, PhD Oliver Beige and Blaž Hribar. Anja Blaj is a chair of the Blockchain Think Tank Slovenia and the policy expert for the European Crypto Initiative (EUCI). Oliver Beige is an economist and industrial engineer for Polycentric. He is also active as a strategy advisor for WarrenBrandeis and innovation strategist for the Center for Deep Tech Innovation. Last but not least interviewee was Blaž Hribar. He is a Board Member at Pokojninska družba A and a Head of Research for the NLB Funds.

In the primal stages, I conducted an introductory phone call with field experts to present compatible information about my research and to establish personal contact. Interviews were conducted in a form of an email with open-ended questions. This proved to be the best type of interview because experts were able to provide their views and extended knowledge even beyond the scope of this thesis. Based on the gathered research I identified the main points, which will be in more detail elaborated in the discussion part that follows.

5 DISCUSSION OF RESEARCH QUESTIONS

As already mentioned in the introduction, this master thesis is trying to answer the four main research questions. The initial analysis derived from the in-depth literature review is compared with interview responses that seem confirmative with the underlying analysis.

The first research question examines whether cryptocurrencies/digital currencies can replace fiat money. This paper elaborates on three cryptocurrencies: Bitcoin, Ethereum and stablecoins. Bitcoin is mainly used as a speculative investment vehicle. It cannot function as a currency because it is not backed by any debt or equity claim nor can it be exchanged for any other commodity (Senner & Sornette, 2019). The constant price volatility, scalability and regulation concerns remain crucial barriers when thinking about Bitcoin as a legal tender. Yu and Villaverde conclude that while a purely private market with limited aggregate stock would ensure stationary equilibrium, the equilibrium would be inefficient and socially suboptimal. Sener and Sornette point to the lack of a dynamic monetary perspective that requires new forms of money for economic growth. Constrained supply reflects suboptimality and outdates economic theories (Senner & Sornette, 2019). Besides Bitcoin, this thesis also touches on Ethereum and stablecoins. Ethereum is in this discussion less relevant because the network primarily aims to develop a wide variety of programable features with smart contracts and decentralized applications. For that reason, it does not compete as a fiat currency alternative. The last category includes stablecoins. While fiat-backed stablecoins present the biggest threat, they fail to exist as independent currencies. Tether (USDT) for example, fulfils the static features of money as the central authority issues IOU claims to users. However, the value of assets is linked to traditional financial currencies, showing the inability for their replacement (Senner & Sornette, 2019). In the current state, we conclude that cryptocurrencies/ digital currencies cannot replace fiat money. Cryptocurrencies fail to meet currency demands in a traditional sense because they lack stability (achieved through a unit of account measure), wider acceptance and governance mechanisms.

Hribar also conveys the same conclusion. He claims that initial promises to change fiat currency, investments, payment systems and monetary policy were not realized. That is especially due to the absence of regulation and lack of oversight. Only countries with weak currencies and no monetary power, such as El Salvador, could decide to implement Bitcoin as their legal tender. For others, the crypto substitution of fiat currency would reflect the inability to stimulate the economy and the loss of the power of monetary policy. Beige provides a conclusion through a different lens. He points to currency price stability features, that can be ensured only if an asset can be exchanged, stored and accounted for. To achieve price stability governments, require “major bureaucratic undertaking to monitor price fluctuations in the market and aggregate them into consumer and producer price indices and inflation metrics”. He concludes that for that reason none of the crypto projects undertake this effort. While the high volatility of Bitcoin creates a productive financial asset that

departs from non-productive currency features, stablecoins and private payment technologies are dependent on stability provided by public actors.

The second research question is considering whether Monetary policy can be effective in the world without central banks. This master thesis recognises multiple historical system like; the commodity-based system, the Free Banking Era in U.S. or more than a decade-long Scottish decentralized monetary system, that operated without central banks. Although historical evidence especially in the last-two-mentioned periods showed some degree of efficiency even without complete control, we have to consider what institutions would replace central banks. The monetary policy would fall in the hands of crypto assets. With a regard to the first research question, we can conclude that decentralized systems are not developed enough to undertake such an important and global role. The crypto ecosystem suffers from architectural faults, scalability fragmentations and the absence of reliable nominal anchors that make the crypto monetary system insufficient (BIS, 2022b).

Beige explains that currency is implemented as an accounting and transactional instrument because it provides the most accountability and the greatest value-creation for investors and economic activities. While he is not averse to the idea of private provisions of currency, he affirms that privately issued money falls short to provide an instrument with greater price stability without reliance on the public agency groundwork. Hribar on the other hand, turns his attention to pre–FED American financial system that existed without central banks. He claims that "decentralized systems were inclined to greater boom and bust financial cycles. Concluding that with central banks and banking regulation the volatilities are less severe and further apart". Hribar also affirms that none of other alternatives like commercial banks or cryptocurrencies could sufficiently replace central banks. The stability and value of currencies can be guaranteed only by the state as it can create rules and laws and simultaneously enforce them through legal institutions.

The third research question examines whether the Digital euro could strengthen the monetary policy. We can conclude that if the digital euro is designed prudently, it can ensure better system efficiency, easier payment transmissions and electric facilitation of national sovereignty. ECB would have direct control over money circulation which would allow them to better and more promptly respond to economic downturns. Additionally, with a decreasing demand for fiat currencies, the digital euro could be the only option to generate publicly available money even in the digital future. Although the digital euro portrays many benefits, it also raises various considerations for the banking sector with the deposit disintermediation, increased reserves requirements and wider political influence with consumer privacy and data surveillance. The second stage of the digital euro will be reached in the autumn of 2023, which will determine the design features and regulations for the central banks' digital currency. The following decisions could more accurately determine the true effect of the digital euro. At this time, the third research question is therefore inconclusive.

While Blaj believes that Digital Euro Project has the potential to benefit overall economy and consumers, she also points to behaviour patterns, identification of consumers and

potential political influence that can be problematic. The untraceable data gathering that could benefit the economies can be challenged by the design features of the digital euro. “The most recent discussion does not envision DLT utilization or heavy inscription nor does ECB provide greater research and information regarding privacy concerns”. Blaj affirms that “cross-referencing and data merging could install unwarranted surveillance or data exploitation”. Further she claims that technical solutions can only be sufficiently installed with “robust safeguards, transparency and legal frameworks that explicitly protect user privacy and prevent misuse or unauthorized access to transactional data”. Hribar also recognizes similar problems. Besides avoiding intermediaries Hribar is rather hesitant about digital euro benefits. Mostly due to theoretical claims for user privacy and lower transactional costs.

In the last research question, we discuss whether the broader world beyond the digital asset ecosystem can beneficiary implement stablecoins. The nature of fiat-backed stablecoins ensures a degree of stability that has been beneficial for multiple non-crypto services such as cross-border transactions with remittance payments and institutional liquidity risk management (Liao & Caramichael, 2022). Besides listed services, stablecoin innovation is still majorly limited to the crypto-decentralized ecosystem. Nonetheless, stablecoins portray a great growth potential that could develop to the point, that they could credibly and more efficiently compete with existing bank deposits or cash instruments. The following could be a springboard for the progressive replacement of existing payment systems, large financial asset tokenization and other stablecoin technological advancements. Regulatory frameworks like MiCA will be crucial in determining the level of changes in the financial and monetary systems (Liao & Caramichael, 2022; Macdonald & Zhao, 2022).

Blaj recognises stablecoins as payment mechanisms where invoices can be issued for stablecoin services aligned with accountants and tax authorities. However, she also states that regardless of the use cases, the “notion of stablecoins widely intervenes with the notion of nation state sovereignty and monetary/fiscal policy. For these reasons, acceptance, compliance and legitimacy of such payments may be continuously discussed and examined”.

CONCLUSION

Advancements in technology, especially with blockchain and distributed ledger technology are fostering innovation in financial and payment systems. Digital assets started developing in 1990 with early attempts like eCash, HashCash and Bitgold. The initial research led to the development of revolutionized cryptocurrency networks like Bitcoin and Ethereum. The pseudonymous inventor, Satoshi Nakamoto, created a decentralized peer-to-peer network that could potentially replace existing payment systems. While Ethereum with smart contracts and decentralized applications (DeFi) is not a direct threat to payment systems, it has the potential to redesign intermediary services for multiple industries such as finance, real estate, insurance, corporate governance etc. The exponential growth of privately owned digital assets has sparked interest from many investors. Based on the analysed literature we

show that current digital assets serve mainly as speculative investments. Their extreme volatility features enable them to serve as a reliable medium of exchange and a unit of account. For that reason, we conclude, that at the current state, cryptocurrencies are unable to serve as a substitute for traditional currencies.

Such conclusions were crucial in further discussions regarding central banks. Central banks are responsible for preserving the value of money and ensuring the efficiency of the payment systems. This thesis examines whether central banks hold too much power and whether a decentralized system could benefit the wider economy. To solve these questions, this thesis, recognises multiple historical systems like; the commodity-based system, the Free Banking Era in U.S. or more than a decade-long Scottish decentralized monetary system, that operated without central banks. Pointing that the above-mentioned system existed and even offer some sort of control but was still prone to greater economic vicissitudes. Based on the literature review we conclude that the potential for radical changes and new alternative systems with decentralized assets proves to be farfetched. Decentralized systems lack nominal anchor, structural faults and scalability fragmentations, which makes cryptocurrency systems an insufficient alternative to traditional monetary systems (BIS, 2022b).

Following the successful establishment of cryptocurrencies, countries and users are looking for a compromise between the stability of the traditional system and the flexibility of the cryptocurrency market. While the public sector is introducing CBDC, the private sector has been working on stablecoins. The latter represents a crypto asset that maintains a stable value. They are designed to operate as a trading and payment mechanism for the crypto market. The goal of this thesis was to discuss stablecoin applications beyond the crypto market. This thesis concludes that stablecoins can benefit the broader world beyond digital assets as they can offer faster and more affordable cross-border transactions with remittance payments and institutional liquidity risk management with intraday repo transactions (Liao & Caramichael, 2022). However, the role outside of the crypto is still fairly limited. The wider adoption in the future can present a greater danger for the nature of money and central banks. For that reason, CBDC projects have been a top priority for governments around the world. The development of CBDCs offers a governmentally backed currency available in a digital form. While some countries like China have already implemented their digital yuan, Europe is still in the research phase. The impact of the digital euro and other CBDCs will greatly depend on the design choices. This thesis works to discuss if Digital Euro can strengthen monetary policy. We conclude, that while adoption can allow CBDC to compete with existing payment services to offer more affordable and efficient cross-border transactions, enhance financial inclusion and allow faster implementation of monetary policy tools, they simultaneously can negatively affect bank intermediation and user privacy.

The purpose of this master thesis was to explain the effects of cryptocurrencies on the monetary system. We can conclude, that at this point in time, decentralized networks cannot compete with the existing centralized systems. However, rapid growth and increasing

popularity can become important, especially in the future. To ensure the stability of the monetary systems and wider user protection, countries should aim to implement effective rules and regulations. The first cornerstone in crypto regulation was already established with European MiCA. A wider adoption could contribute to a resilient, robust and efficient cryptocurrency market on a global level.

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APPENDIX

Appendix A: Povzetek (Summary in the Slovene language)

Razvoj tehnologij ima širok vpliv na naš način življenja. Od uvedbe Bitcoina in tehnologije veriženja blokov leta 2009, so kripto valute postale eden najzanimivejših tehnoloških dosežkov. V novembru 2021 je globalna tržna kapitalizacija kripto valut dosegla rekordno vrednost približno 3 bilijone dolarjev, kar lahko primerjamo z vrednostmi svetovne avtomobilske industrije ali ene najuspešnejših tehnoloških delnic na svetu, družbe Apple (CoinGecko, n.d.; Ngrave, 2022). Od takrat je trg kripto valut doživel številne cenovne skoke in padce, ki so maja 2023 globalno tržno kapitalizacijo znižali na 1,1 bilijona dolarjev. Cilj digitalnega premoženja je bil ustvariti decentraliziran finančni sistem, ki bi deloval brez reguliranih posrednikov (The White House, 2023). Za investitorje so zaupanje, varnost in hitrost transakcij ter decentralizacija in njegova nestanovitnost poglavitne, saj ustvarjajo priložnost za visoke donose. Kljub priljubljenosti in obljubi po finančni revoluciji so nedavni dogodki, kot npr. zlomi nekaterih kripto valut, nezakonite dejavnosti in agresivni vladni ukrepi, omajale zaupanje v trg kripto valut (Yaffe-Bellany, 2023). Namen moje magistrske naloge je bil analizirati učinek kripto/digitalnih valut na denarni sistem. Svojo radovednost glede kriptovalut sem želela povezati z ekonomskim in finančnim znanjem, ki sem ga pridobila v času študija. S tem magistrskim delom sem želela razširiti svoje znanje o gibanju digitalizacije, da ga bom lahko uporabila na svoji nadaljnji karierni poti.

Digitalizacija in globalizacija se prepletata že dalj časa in nič drugače ni z denarnim sistemom. Denar je eden najpomembnejših človeških izumov (Arvidsson, 2019). Skozi čas je koncept denarja obstajal v številnih oblikah, od kovanih kovancev do papirnatih bankovcev, kreditnih kartic in digitalnih denarnic. Ne glede na mehanizem plačila pa je vedno služil kot sredstvo menjave. Naraščajoče digitalne tehnologije in pandemija covid-19 so pospešile spremembe pri načinu plačevanja in uporabe denarja. Vedno bolj se uveljavlja težnja po brezgotovinskih družbah (Arvidsson, 2019). Taka sprememba lahko potencialno postavi pod vprašaj prihodnjo naravo denarja in tudi vlogo centralnih bank. Centralne banke po vsem svetu predstavljajo glavni denarni instrument, katerega cilj je doseči gospodarsko rast in finančno stabilnost ob nizki in stabilni inflaciji (International Monetary Fund [IMF], n.d.). Žal je zaradi številnih finančnih kriz in večkratnega reševanja finančnih institucij veliko ljudi izgubilo zaupanje v subjekte pod državnim nadzorom. Vse večja skepsa in nove zahteve uporabnikov so spodbudile nove inovacije, temelječe na tehnologiji veriženja blokov, ki je prinesla uvajanje digitalnih valut, kot so npr. Bitcoin, Ethereum in stabilni kovanci (He, 2018). Decentralizirana tehnologija veriženja blokov deluje kot varno in odprto omrežje brez posredovanja tretjih oseb ali nadzora centralnih bank. Čeprav digitalno premoženje trenutno ne ogroža obstoječih finančnih storitev, bi lahko zaradi velikega potenciala rasti premoženja, kot so npr. stabilni kovanci, v prihodnosti prišlo do pomembnih implementacij (Financial Stability Board, 2022). Vlade si zato, da bi ohranile svojo moč, prizadevajo vzpostaviti ustrezne predpise, ki bi uredili poslovanje in upravljanje z digitalnim premoženjem, vzporedno pa centralne banke razvijajo svoje digitalne valute (CBDC).

Cilj te magistrske naloge je analizirati spremembe, ki nastajajo z uvedbo digitalnega denarja. V sklopu naloge želim ugotoviti, ali se bodo digitalni sistemi ohranili, v kolikšni meri bodo spremenili naše življenje in kakšen vpliv bodo imeli na obstoječe tradicionalne sisteme. Odgovore sem poiskala in analizirala skozi štiri ciljna raziskovalna vprašanja:

1. Ali lahko kripto valute/digitalne valute nadomestijo fiat denar?
2. Ali je denarna politika v svetu brez centralnih bank lahko učinkovita?
3. Ali lahko digitalni evro okrepi denarno politiko?
4. Ali ima lahko širši svet zunaj kripto ekosistema digitalnega premoženja koristi od uvedbe stabilnih kovancev?

V magistrski nalogi sem uporabila kvalitativno metodo raziskovanja. Teoretični del temelji na raziskavi sekundarnih podatkov, ki predstavi glavne teme iz več akademskih člankov in revij. V praktičnem delu sem izvedla empirično raziskavo, ki temelji na polstrukturiranih in nestrukturiranih intervjujih. Intervjuje sem opravila z mag. Anjo Blaj, predsednico društva Blockchain Think Tank Slovenija, ekonomistom in industrijskim inženirjem dr. Oliverjem Beigom ter s članom uprave Pokojninske družbe A, Blažem Hribarjem. Njihova znanja in izkušnje pokrivajo vse vidike moje magistrske naloge, od kripto valut, regulacije do ekonomije in monetarnih sistemov. Cilj uporabe primarnih podatkov je bilo oblikovanje zaključkov in povezav v okviru vsebine magistrske naloge.

Magistrska naloga ima dva vsebinska sklopa. V prvem delu sem obravnavala denarne sisteme in njihovo vlogo v hitro razvijajočem se svetu digitalnih valut. Dotaknila sem se funkcij, ki so si jih pridobile centralne banke skozi čas in poiskala nekatere odgovore glede denarnih politik. Prvi del magistrske naloge se zaključi z analizo digitalnih valut centralnih bank (CBDC) s poudarkom na digitalnem evru. V drugem delu magistrske naloge sem se osredotočila na ekspeditivni svet decentraliziranih tehnologij z Bitcoinom, Ethereumom in stabilnimi kovanci. Po poglobljeni analizi vlog, aplikacij in značilnosti omenjenih kripto valut sem preučila tudi primer Silicon Valley Bank in USDC kovanca, ki prikazuje povezanost med tradicionalnim bančništvom in kripto kovanci. Zadnji del magistrske naloge je empirični del, ki vključuje metodologijo, razpravo o raziskovalnih vprašanjih in sklep.