Czech University of Life Sciences Prague

Faculty of Business and Administration

Department of Economics

Bachelor Thesis

Evolution of money to CBDC: perspectives on the current state, opportunities and threats

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

BACHELOR THESIS ASSIGNMENT

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Business Administration

Thesis title

Evolution of money to CBDC: perspectives on the current state, opportunities and threats

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Objectives of thesis

Recent years we have been witnessing conceptual discussions related to Central Banks Digital Currencies and now already a number of countries are actively involved in the phase of experimentation. Their Central banks are familiarizing themselves with the essence of digital money. A number of countries have already adopted CBDCs, some countries have launched so called ”pilot” projects on CBDC implementation.

The main aim of the presented Bachelor Thesis is to disclose perspectives and threats of CBDC via in-depth analysis of evolution of money and accompanying technologies.

To reach this goal the following partial research questions will be raised and gradually answered:
1. What were the motives behind money creation?
2. What are the principal functions of money?
3. Which historical factors and events have played a significant role in shaping the contemporary financial system?
4. How has money and paying system been evolving to the current financial system?
5. What does stand for the peer-to-peer system?
6. How is that system implemented in BitTorrent and Blockchain?
7. What constitutes the fundamental nature of Bitcoin, and what are the contributing factors to its scarcity?
8. What does stand for stablecoins and how are they linked to fiat money?
9. How can the introduction and widespread use of Central Bank Digital Currency (CBDC) bring both advantages and potential challenges?
10. Is there a statistically significant relationship between CBDC adoption in certain countries and their macroeconomic indicators?

Methodology

The theoretical part of the Bachelor thesis will be mainly based on a relevant literature review (represented by printed literature, scientific articles, surveys, web sources) and the research of similar studies, using such methods as abstraction, inductive reasoning, analysis, synthesis, and deduction.

The practical part will contain descriptive statistical analysis and qualitative thematic synthesis of the main economic indicators. Own research work will be mainly based on available data analysis, comparative analysis of CBDC, stablecoin and bitcoin, along with statistical inference.

The proposed extent of the thesis

40-60

Keywords

CBDC, Money, Stablecoin, Bitcoin, Economy, SWOT analysis, logit regression

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Recommended information sources

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Publications on Central bank digital currencies (CBDC). Available online at: https://www.ecb.europa.eu/home/search/html/central_bank_digital_currencies_cbdc.en.html

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Prague on 11. 03. 2024

Declaration

I declare that I have worked on my bachelor thesis titled " Evolution of money to CBDC: perspectives on the current state, opportunities and threats" by myself and I have used only sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 15.03.2024 Faizov Rauf

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I would like to thank Mgr. Elena Kuzmenko, Ph.D. for her suggestions and advice from the start to the end of completing this thesis as well as my family and friends for the support and motivation throughout my studies.

Evolution of money to CBDC: perspectives on the current state, opportunities, and threats

Abstract

This Bachelor Thesis aims to explore the historical evolution of money from barter systems to the establishment of standardized units of account now recognized as "money". It provides insights into historical monetary policies, including the gold standard, and significant events such as the Bretton Woods convention. As part of the research a detailed examination of blockchain technology and various systems and protocols is conducted. Central Bank Digital Currency (CBDC) emerges as a significant development, marking the merging of traditional monetary systems with digital innovations.

The Practical Part of the Bachelor Thesis focuses on uncovering perspectives and threats associated with CBDC adoption. It reveals the specific relationship between macroeconomic variables and the potential for CBDC implementation. The shadow economy and broad money represent 1,117 and 1,036 (exp(B)) exponentiated coefficient (odds ratio) respectively of a predictor variable in logistic regression analysis. Another important part of the research is ESG Analysis, where environmental, social, and governance factors are considered. Additionally, the analysis proves that new blockchain networks have bigger potential for innovations than Bitcoin, for example faster transactions and the ability to build layer two networks for different solutions.

Keywords: CBDC, Money, Stablecoin, Bitcoin, Economy, ESG analysis, logit regression

Evoluce peněz k CBDC: pohledy na současný stav, příležitosti a hrozby

Abstrakt

Hlavní cíl této bakalářské práce je průzkum historického vývoje peněz, sledování jejich cesty od barterových systémů ke stanovení zúčtovacích jednotek, nyní jsou uznávány jako "peníze". Provedení analýzy vývoje a transformace peněz zahrnuje vyhodnocení jejich základní funkcí. Bakalářská práce provede Nás přes změny historické měnové politiky, včetně zlatého standardu, a významných událostí, jako je Brettonwoodská konference (Bretton Woods conference). V rámci analýzy bude proveden podrobný průzkum technologie blockchain, různých systémů a protokolů. Tento výzkum je ilustrován průnikem tradičních a moderních technologií nalezených na finanční scéně. Digitální měna centrální banky (Central Bank Digital Currency) (CBDC) je označena sloučením tradičních měnových systémů a digitálních inovací.

Praktická část bakalářské práce se zaměřuje na odhalení perspektiv a hrozeb spojených s přijetím CBDC. Ukazuje specifický vztah mezi makroekonomickými indikátory a potenciálem pro zavedení CBDC. Stínová ekonomika a široké peníze činí 1,117 a 1,036 (exp (B)) exponentovaný koeficient (poměr šancí) prediktivní proměnné v logistické regresní analýze. Další důležitou součástí výzkumu je ESG Analýza, kde jsou zohledněny environmentální, sociální a řídící faktory. Dodatečně, analýza prokazuje, že nové blockchain sítě mají větší inovační potenciál než Bitcoin, například rychlejší transakce a možnost vybudování sítě druhé úrovně pro různá řešení.

Klíčová slova: CBDC, Money, Stablecoin, Bitcoin, Economy, ESG analysis, logit regression

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Introduction

In our dynamic global landscape, the evolution of money traces its origins back to the elementary barter system. Originally conceived to exchange surplus to shortage items, this early form of trade laid the foundation for the establishment of a standardized unit of account known as "money" significantly improving the efficiency of transactions.

The contemporary digital age, noted by the worldwide use of electronic devices and the internet, brought huge changes in monetary system. In the present time, digital art or in shorter version NFT (non-fungible token) can often command higher values than traditional offline art, driven by the popularity of the teams or individuals behind their creation. In the blockchain ecosystem, coins such as Bitcoin and Ethereum represent the security and sustainability of blockchain networks and hold greater value for some individuals than traditional assets like gold or silver. The Ethereum ecosystem represents smart-contracts, decentralized finance (DeFi) that executes centralization finance (CeFi) functions and layer 2 solutions which are built over Ethereum blockchains to increase scalability. On the other hand, Bitcoin is represented to society as a digital gold, many prominent companies started using Bitcoin as a hedge for their funds due to its decentralized nature and limited quantity.

In the middle of this digital transformation, political leaders, and central banks worldwide are actively exploring the integration of new technologies into their monetary systems. This exploration includes the concept of Central Bank Digital Currency (CBDC). The CBDC represents a digital form of the country's state currency pegged 1:1, but it also entails trade-offs, such as diminishing the concept of decentralization in favor of scalability and a more centralized oversight of society.

1 Objectives and Methodology

1.1 Objectives

Recent years there has been an increase in conceptual discussions related to Central Banks Digital Currencies and now already several countries are actively involved in the phase of experimentation. Their Central banks are familiarizing themselves with the essence of digital money. Several countries have already adopted CBDCs, some countries have launched so called "pilot" projects on CBDC implementation.

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1.2 Methodology

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The practical part contains descriptive statistical analysis and qualitative thematic synthesis of the main economic indicators. Own research work is mainly based on available data analysis, comparative analysis of CBDC, Stablecoin and Bitcoin, along with statistical inference.

Pearson Correlation analysis method is adopted. Based on data found in the Practical part, the conclusion will be framed.

$$r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}} \quad (1)$$

Where:

- x: the first variable
- y: the second variable
- $\sum xy$: the sum of x and y

The Pearson correlation coefficient is used as a static that measures the strength and direction of the linear relationship between two quantitative variables. To check the statistical significance of estimated correlation coefficients a t-ratio will be used (at a common 5% significance level):

$$t - ratio = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \quad (2)$$

Where:

- r: the correlation coefficient
- n: the sample size

Table 1 Interpretation of Coefficients

Pearson correlation (r) value	Strength	Direction
Greater than 0,5	Strong	Positive
Between 0,3 and 0,5	Moderate	Positive
Between 0 and 0,3	Weak	Positive
Equal to 0	None	None
Between 0 and -0,3	Weak	Negative
Between -0,3 and -0,5	Moderate	Negative
Less than -0,5	Strong	Negative

Source: Pearson Correlation Coefficient (r) | Guide & Examples:
https://www.scribbr.com/statistics/pearson-correlation-coefficient/

Logistic Regression method is adopted. Based on theoretical findings and outcomes of the Practical part, the conclusion and recommendations will be framed.

$$\log\left[\frac{p(X)}{1-p(X)}\right] = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_p x_p \quad (3)$$

Where:

- P(x): linear function of x [1]
- X_j: The j[th] predictor variable
- β_j: The coefficient estimates for the j[th] predictor variable.

The formula on the right side of the equation predicts the log odds of the response variable taking on a value of 1. Thus, by implementing logistic regression model we can use following equation to calculate probability that a given observation takes on a value of 1:

$$p(X) = e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\cdots\beta_p X_p}/(1+e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\cdots\beta_p X_p}) \quad (4)$$

Where:

- e: exponential
- X_j: The j[th] predictor variable
- β_j: The coefficient estimates for the j[th] predictor variable.

[1] CARNEGIE MELLON UNIVERSITY. *Logistic Regression*
https://www.stat.cmu.edu/~cshalizi/uADA/12/lectures/ch12.pdf, p. 223-227

Table 2 Logistic regression assumptions

The response variable is binary.	It is assumed that the response variable can only take on two possible outcomes.
The observations are independent.	It is assumed that the observations in the dataset are independent of each other. That is, the observations should not come from repeated measurements of the same individual or be related to each other in any way.
There is no severe multicollinearity among predictor variables.	It is assumed that none of the predictor variables are highly correlated with each other.
There are no extreme outliers	It is assumed that there are no extreme outliers or influential observations in the dataset.

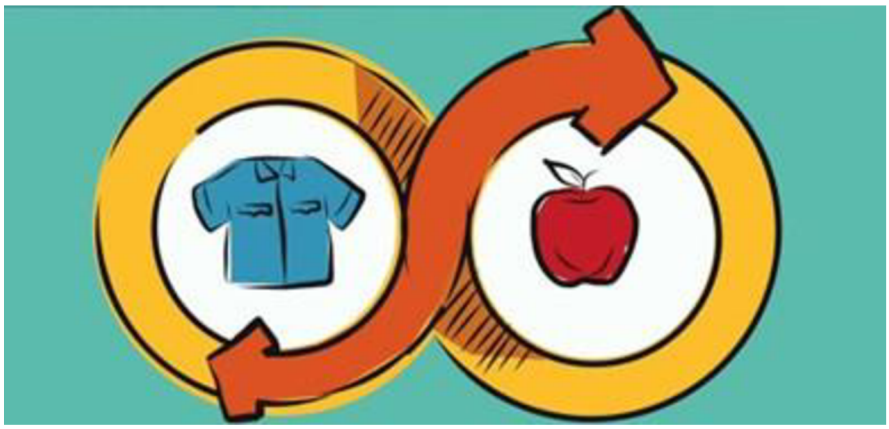
Source: Introduction to Logistic Regression: https://www.statology.org/logistic-regression/

2 Literature Review

2.1 The Evolution of Money

For centuries preceding the introduction of formal currency, societies operated within a barter economy. In this system, individuals engaged in the direct exchange of services and goods, trading what they possessed for items they needed. For instance, if one person owned 30 pounds of cow meat and another had 20 pounds of fish, a straightforward exchange of these commodities could occur between them. This barter-based method of trade played a fundamental role in facilitating transactions and meeting the diverse needs of communities before the advent of standardized currency systems.[2]

Figure 1 Barter commerce trade transaction economic concept exchange swap goods



Source: https://www.dreamstime.com/stock-illustration-barter-commerce-trade-transaction-economic-concept-exchange-swap-goods-drawing-illustration-vector-image75029629

This type of exchange system was common among Mesopotamia nations. Mesopotamia was an ancient civilization located between the Tigris and Euphrates River in the Middle East. In 14.000 BC many human societies were primarily engaged in hunting and gathering. During this time the barter system was the main means of trade, one community could exchange surplus goods and resources with another one. Over time, however, societies came to realize the limitations of barter systems.

[2] WRAY, L.R. *Introduction to an Alternative History of Money,* Levy Economics Institute of Bard College, May 2012, p.3-4

For instance, consider two producers, X and Y, where X has carrots and Y has cucumbers. If farmer X requires cucumbers from farmer Y and offers carrots in exchange, but farmer Y does not need carrots, the transaction becomes problematic. Farmer Y may reject the offer because there is no mutual need for the exchanged goods. This difficulty in finding mutually desired goods became a significant challenge. As a solution, ancient societies introduced standardized units of account, such as money, to assess the value of each product. This innovation allowed farmer X to sell his carrots, obtain units of account, and easily use them to purchase cucumbers or other desired goods.[3]

2.1.1 Commodity Money

In Mesopotamia the standardized units of account were the “shekels” of grain, which were used as a measure of value and as a debt record-keeper in 3000BC.

The "Deben" was standardized unit of measurement and money in Ancient Egypt, was used for both weight and value. It was used to measure and exchange various commodities, including grain and metals in 2500BC.

Figure 2
Mesopotamian Shekel

Source: *https://twitter.com/cmount1/status/1190569134188351488*

Figure 3
Seventy deben weigh

Source: *https://www.metmuseum.org/art/collection/search/546696*

Figure 4
Cowrie Shell

Source: *https://namtblog.com/2020/10/the-amazing-history-of-cowrie-shells.html*

[3] National Geographic Education, Encyclopedic Entry *Hunter-Gatherer Culture,* National Geographic Society, 2023, [last access: 20.01.2024], https://education.nationalgeographic.org/resource/hunter-gatherer-culture/

In ancient China, cowrie shells played a significant role as a form of money and unit of account. Cowries served as a medium of exchange and a measure of value in trade. This practice has a long history in China, dating back thousands of years.[4]

In the historical use of commodity money for transactions, a notable challenge arose. The perishable nature of certain commodities made it impractical for people to retain them for extended periods, hindering their ability to repay loans or save for future needs. In response to this issue, the innovation of coined coins emerged as an evolved version of commodity money. Coins, for example the Herodian, crafted from durable materials, not only served as a medium of exchange but also retained their original appearance over time. This characteristic addressed the previous limitation, allowing individuals to store value more effectively and use coins for various financial purposes, including loan repayment and long-term savings.

Figure 5 Herodian coin

Source: https://www.britannica.com/money/topic/coin

2.1.2 Fiat Money

The time of commodity money gives way to the age of paper money. The evolution of fiat money is linked to the practice in the 17th century where commodity money was often entrusted to "goldsmiths" for safekeeping in exchange for receipts known as "goldsmiths' notes." As an efficient alternative to physically reclaiming gold for each transaction, people began exchanging these notes, saving time and effort.

[4] POWELL, M.A. *Money in Mesopotamia*, Journal of the Economic and Social History of the Orient, Vol. 39, No. 3, Money in the Orient, 1996, p.35-55

Notably, goldsmiths realized that certain notes remained in circulation indefinitely, allowing them to safely lend the gold reserves associated with these notes or issue additional receipts as loans. This practice mirrors the principles of modern fractional reserve banking.

The decision to engage in goldsmith "banking" was economically rational, as the cost of writing out receipts was lower than the expenses incurred in mining gold. In essence, this strategic move aimed to reduce the overall transaction costs, leading to the gradual replacement of commodity money with paper money.

The role of goldsmiths in facilitating clearing with other goldsmiths and accommodating deposit withdrawals meant that they needed to retain some commodity money in reserve. Consequently, the issuance of paper money was closely tied to the quantity of commodity money held as reserves. Over time, certain goldsmiths specialized, marking the emergence of the modern private banking system that operates on fractional reserve deposit banking principles.

As governments entered the scene, they began competing by introducing fiat money, which could be issued either through their treasuries or central banks. Private banks were granted permission or, in some cases, required to hold this government-issued (or quasi-governmental) fiat money as reserves. Consequently, an increase in the issuance of government fiat money led to a multiple expansion of bank deposits within the fractional reserve system. This development highlights the interconnected relationship between commodity money, fractional reserve banking, and the introduction of fiat money by governments.[5]

2.1.3 The Panic in 1907 and Federal Reserve System

The Panic in 1907 is also known as “The Bankers Panic”. The Panic was the first financial crisis of 20th century that occurred in the United States. It was a serious economic downturn where the stock market collapsed and eventually played a crucial role in the development of the Federal Reserve System.

[5] WRAY, L.R. *Introduction to an Alternative History of Money,* Levy Economics Institute of Bard College, May 2012, p. 6-7

The year 1907 is known as a speculative boom in the stock and real estate markets. Most of the investors found themselves in a risky situation by high leveraging themselves, which means they borrowed a lot of money from the bank to finance their investments. "In contrast to all previous National Banking Era panics, the U.S. was officially on the gold standard during the Panic of 1907. The gold standard put constraints on the financial interventions of the U.S. Treasury to affect the stock of high-powered money, credit availability, or financial conditions more generally. Specifically, the U.S. Treasury was limited by its gold reserve balances and its surplus balances. During the Panic of 1907, the U.S. Treasury added over $40 million to the stock of high-powered money, but its ability to respond was effectively exhausted by October 25, 1907, limited by the available budget surplus."[6]

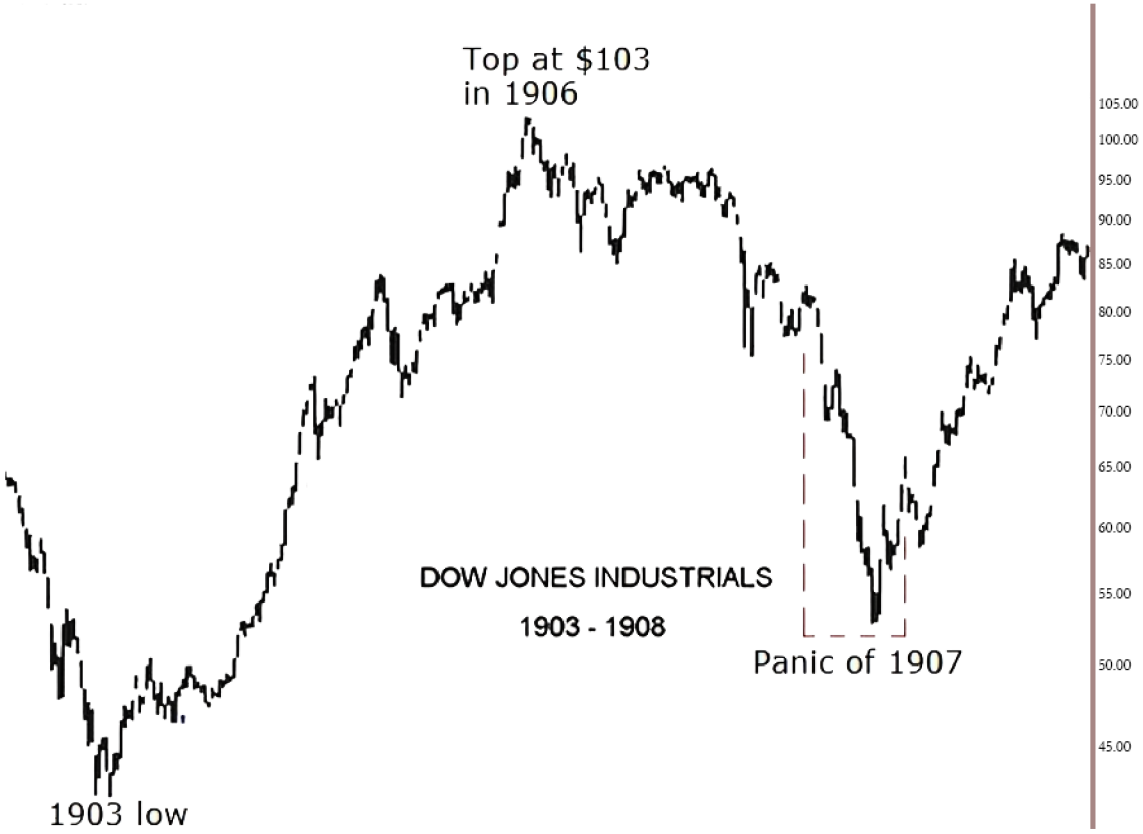
Meanwhile the group of speculators tried to corner the copper market, led by figures such as F. Augustus Heinze and Charles Morse. This unsuccessful manipulation from speculators triggered a chain reaction, eventually almost bankrupting Knickerbocker Trust Company (bank).

The inability of the Knickerbocker Trust Company to return funds to depositors in October 1907 shattered society's confidence in the banking system. This event led to a widespread panic among all bank depositors, prompting them to withdraw their funds. The panic spread beyond individual banks, affecting the stability of the entire financial system.

Within the crisis J.P Morgan became the main figure to stabilize the financial system. Recognizing the urgency of the whole situation, he organized a team of influential bankers to provide enough liquidity to struggling institutions.

[6] TALLMAN, E. *The Panic of 1907,* Routledge Handbook of Major Events in Economic History, 2012, p. 6

Figure 6 Dow Jones Industrials 3-year rally from 1903 to 1907



Source: https://ewminteractive.com/the-wave-principle-and-the-panic-of-1907

The graph above illustrates the price action in the years 1903-1908 (including The Panic of 1907) by example of Dow Jones Industrials.

As the Bank crisis and Bank runs unfolded the stock market did not remain unaffected. The stock prices collapsed by the late October 1907 and stayed in the low until the end of February 1908.

The Panic of 1907 showed the weakness of the bank system prompting reforms in financial system. The lack of general authority and any mechanism to directly provide liquidity in case of a bank shortage turned out to be a significant issue. As the result The Federal Reserve System was established in 1913. Its main purpose is to provide liquidity as a "lender of last resort" and to implement monetary policies to prevent or mitigate future financial crises.[7]

[7] Investopedia, *Bank Panic of 1907: Causes, Effects, and Importance*, THE INVESTOPEDIA TEAM, 2023, [last access: 20.01.2024], https://www.investopedia.com/terms/b/bank-panic-of-1907.asp

2.1.4 Gold standard and The Bretton Woods System

The timeline from the year 1870 to 1914 marked the rise of the gold standard, all major economies were under the rule of international monetary system. In 1871, the German Empire decided to make gold its standard and in 1873 the same decision was made by the United States. The gold was the leader in international payment among the biggest economies until World War One. World War One had a huge negative impact on the global economy. In response to the challenges after and during the war, countries started using the gold standard to peg the value of their currencies. This shift marked a transformation from the fixed exchange-rate system to a more flexible and fluctuational exchange rate regime. The war-induced economic pressures prompted nations to reevaluate their monetary frameworks, leading to changes in the international financial landscape during this period.

The challenges of post-World War One and World War Two recovery induced the leaders from Britain and the United States to design plans for monetary reconstruction. On July 1st, 1944, delegates from 44 countries gathered in Bretton Woods, New Hampshire and engaged in a month-long negotiation process, which became known as The Bretton Woods Conference. A total of 730 participants took part in this significant event. The result of the Bretton Woods Conference was the establishment of two new international institutions: the International Monetary Fund (IMF) and the International Bank for Reconstruction and Development (IBRD), now part of the World Bank Group. The United States, as the biggest power in the global financial system held a two-thirds amount of gold reserves by the conclusion of World War Two. Taking this factor into consideration, the main agreement of the conference was to peg US dollar to gold. Consequently, major economies committed to valuing their national currencies in alignment with the US dollar, solidifying the role of gold as the basis for international monetary relations.[8]

[8] COOPER. R. N., *The Gold Standard: Historical Facts and Future Prospects,* Brookings Papers on Economic Activity, Vol. 1982, No. 1, 1982

Figure 7 A diagram illustrating system of dependency between gold, US dollar and other currencies

Source: Own work

The Bretton Woods System introduced a fixed price of $35 per ounce for gold. The United States Dollar assumed a major role as the world's principal reserve currency under this arrangement. The US Dollar's stability was supported by the country's substantial gold reserves, which at the time outpaced those of other nations. As a result of this arrangement, countries with strong economies considered it profitable to collect large quantities of US dollars in reserves. The classification of the US dollar as a crucial global reserve currency aided its widespread acceptability and use in international trade. For countries seeking security and liquidity in their reserve holdings, amassing US dollars became a calculated strategy. This timeline, framed by the Bretton Woods System, was critical in shaping post-World War II international monetary relations. The dominance of the US dollar and its link to gold laid the groundwork for global economic interactions, influencing trade, investment, and financial stability for decades.[9]

After many years of settling the ground for the global economy the ruling agreement signed in Brenton Woods came to an end. As stated in the work of two American professors of economics, M. Bordo, and B. Eichengreen: "There has never existed a consensus on the causes of the breakdown of Bretton Woods. At the NBER conference, at least six distinct explanations were advanced: differences between U.S. and foreign monetary policies, differences between U.S. and foreign fiscal policies, failure of deficit countries to devalue, failure of surplus countries to revalue, a secular decline in the

[9] DOOLEY, M., *The Revived Bretton Woods System,* International Journal of Finance & Economics, Vol. 9, Issue 4, October 2004

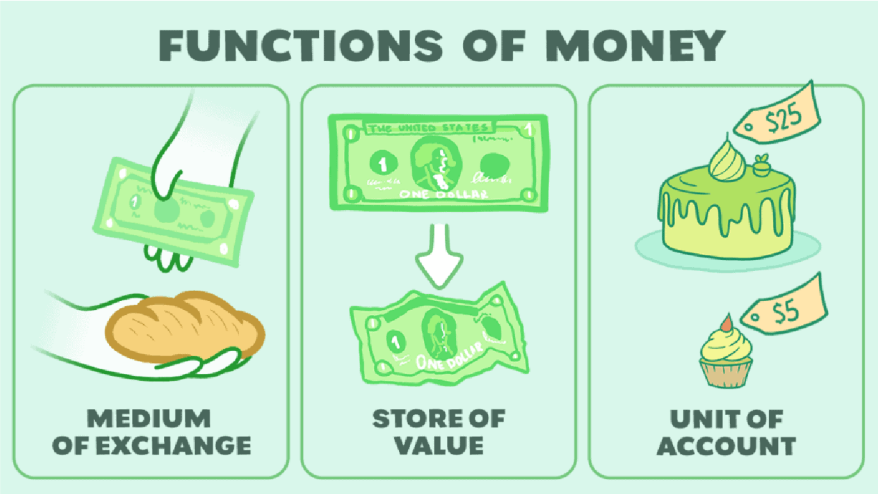
international competitive position of the United States, and flaws in the structure of the system (notably Triffin's liquidity dilemma)".[10]

Even though it could not be directly connected to a single event, on August 15, 1971, President Richard Nixon, facing a shortage of gold reserves to back the circulating supply of dollars, announced the decision to close the gold window. From that point in history, the US dollar stopped to be backed by gold and was transformed into a fiat currency. This event in the world's history became famously known as the "Nixon Shock."

2.1.5 Functions of Money

As can be seen throughout history, people have used cowry shells, Mesopotamian shekels, and salt as money. In the past centuries the most common type of money became paper money, at least up until 1971 paper money was backed by a government supply of precious metals.

Figure 8 Functions of Money



Source: https://whiteboardcrypto.com/what-is-money/

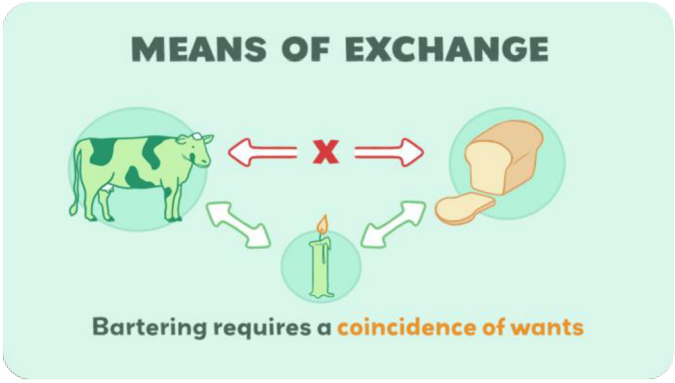
Medium of Exchange

Money serves as a medium of exchange, by providing chance to exchange good and services with stable price. In the absence of money, all trading operations would need to rely on barter, involving the direct exchange of one good or service for another.

[10] BORDO, M., EICHENGREEN, B. *A Retrospective on the Bretton Woods System: Lessons for International Monetary Reform*. January 1993, p. 624

As stated earlier, the barter system comes with limitations that impede the development of an expansive and efficient trading system within society.[11]

Figure 9 Means of Exchange



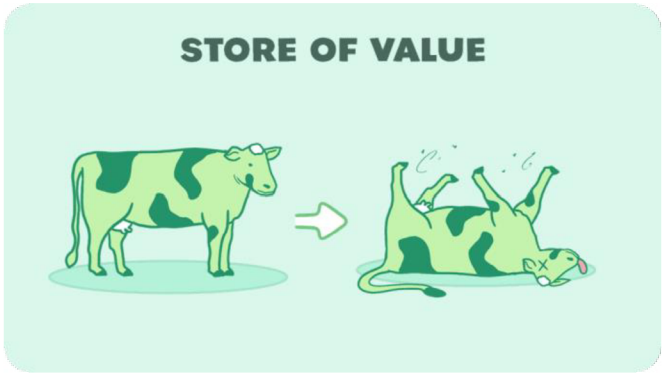
Source: https://whiteboardcrypto.com/what-is-money/

Providing this means of exchange simplifies transactions and allows the economy to function smoothly.

Store of Value

Moreover, money serves as a store of value. It means that people can save it and use it later. If a person has 100$ today in paper money, they can spend it today or use it later by keeping it in their pocket in your bank account. This 100$ that they have today will be the same 100$ dollars tomorrow or a year later, even inflation can diminish the purchasing power.[12]

Figure 10 Store of Value



Source: https://whiteboardcrypto.com/what-is-money/

[11] SPALDING, W. *The Functions of Money; a Handbook Dealing With the Subject in Its Practical, Theoretical, and Historical Aspects.* 2023

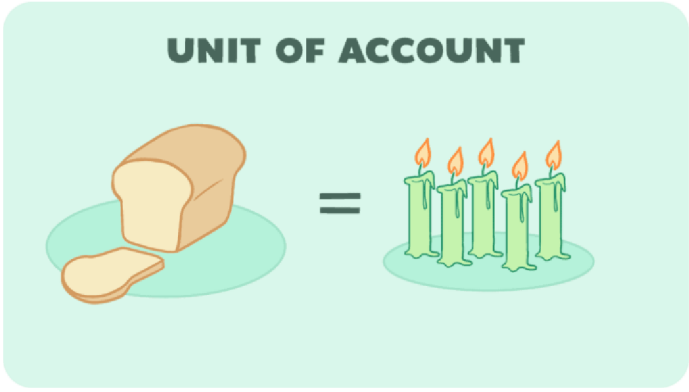
[12]GOWLAND, D. *Money, Inflation and Unemployment.* 1992

To effectively apply money as a medium of exchange, money must keep its value over time. This characteristic is essential as it acts as a reliable store of value, preventing scenarios where the price of a sold service or good doubles, or buyers end up paying twice the initial amount. The stability of money's value is pivotal for instilling trust and confidence in economic transactions, ensuring a seamless exchange of goods and services in the marketplace.

Unit of Account

Finally, money needs to function as a unit of account to offer a standardized measure for evaluating the value of goods and services during exchanges. Having knowledge of the value or price of a good enables suppliers and buyers to make decisions regarding the quantity of goods they can afford to supply or purchase.[13]

Figure 11 Unit of Account



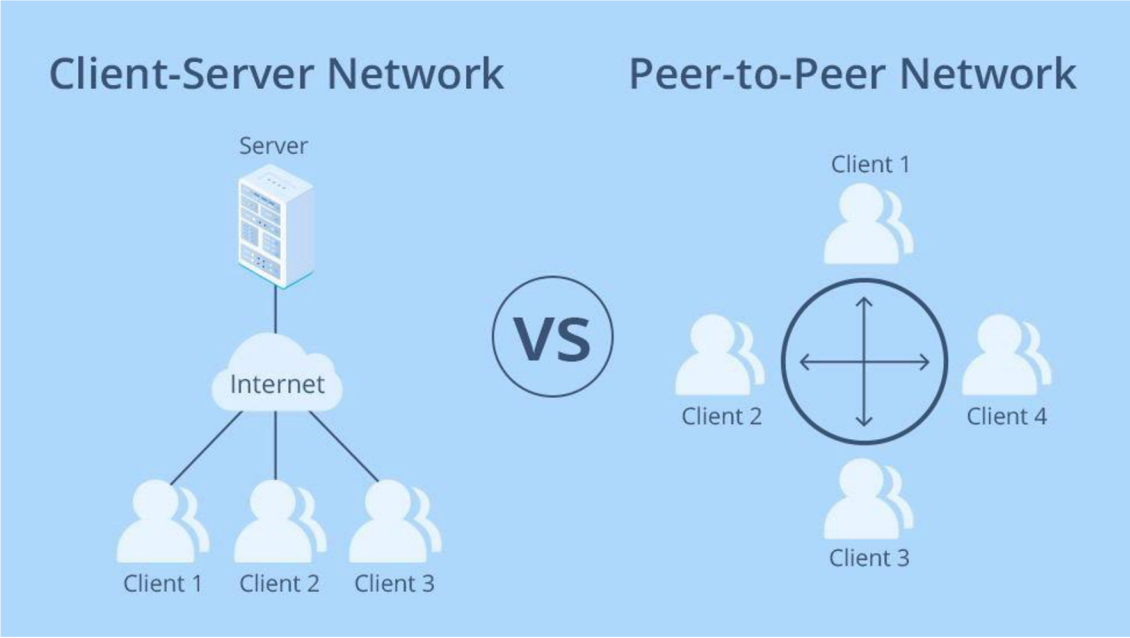
Source: https://whiteboardcrypto.com/what-is-money/

[13] SODDY, F. *The Role of Money,* 2003

2.2 Peer to Peer Protocol and Client-Server Architectures

Before talking about Blockchain Technology we need to start from understanding the peer-to-peer protocol and its differences from client server model. In the client server model, the user interacts with centralized web server, the web server is responsible for distributing content for the user or providing services to the user. On the contrast the peer-to-peer (P2P) protocol works without centralized server. Instead, users online collaborate with each other to distribute contents or provide the services to other users by making their own processors work as one of the pieces of a powerful server. In this decentralized approach there is no single server controlling all users' operations, rather the network of users collectively contributes their computer power to problem-solving.[14]

Figure 12 Comparison between client-server vs Peer-to-Peer models



Source: https://www.resilio.com/blog/whats-the-difference-between-peer-to-peer-and-client-server

[14] STEINMETZ, R, Peer-to-Peer Systems and Applications, 2005

2.2.1 BitTorrent

The first program where peer-to-peer (P2P) protocol was implemented is BitTorrent. BitTorrent was developed by Bram Cohen in April 2001 and its first version was released on July 2nd, 2001.

Figure 13 Bittorrent Logo

Source: Bittorrent

BitTorrent introduces a new method for file sharing by providing a decentralized method that allows users to share files with one another without the use of a central server. BitTorrent users, also known as "peers," participate in the system by downloading and uploading files. Rather than relying on a centralized server for file sharing, BitTorrent employs a peer-to-peer model in which users can download files while another user uploads them for them. With the release of BitTorrent, the need for centralized servers to access files was eliminated. Users can now directly upload and download files to and from other users on a distributed network.

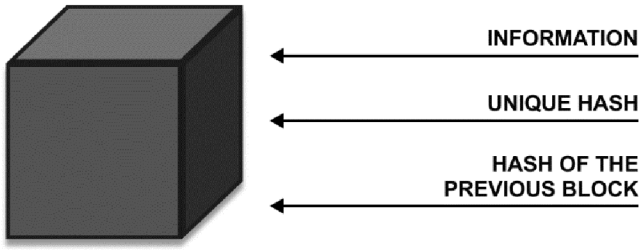
This decentralized structure not only improves the speed and efficiency of file sharing but also enhances the resilience of the network by eliminating the vulnerability associated with a single point of failure in a centralized server. BitTorrent's peer-to-peer architecture has had a transformative impact on the way large files are distributed, fostering a more collaborative and distributed approach to file sharing in the digital realm.[15]

2.2.2 Blockchain

In 2008, Satoshi Nakamoto introduced the concept of blockchain in his whitepaper titled "Bitcoin: A Peer-to-Peer Electronic Cash System." The introduction of this whitepaper marked the beginning of blockchain technology.

[15] LEI XAI. R, *REVIVED BRETTON WOODS SYSTÉM,* p.3-15

Figure 14 Information contained in each block in Bitcoin blockchain.



Source: Own work

Blockchain are built from chains of blocks where each block contains 3 unique attributes:

Transaction information

Every block contains details about the transaction, the sender's address, the recipient's address, and the amount of the tokens or coins that has been sent. The transaction information serves the purpose of publicly disclosing all activities occurring within the block.

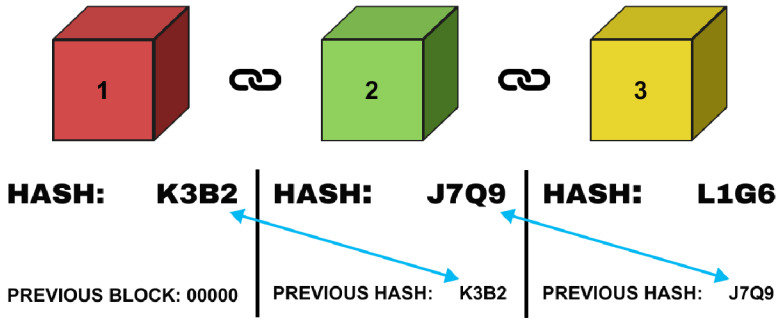
Unique hash

Represents the identity of each new block in the system to ensure the uniqueness of each block within the blockchain.

Pointer to the previous hash

As stated before, each block has a unique hash, it also has a pointer or reference to the previous block-hash which helps system to be secure.

Figure 15 Diagram illustrating how one block takes reference form the previous block.



Source: Own work

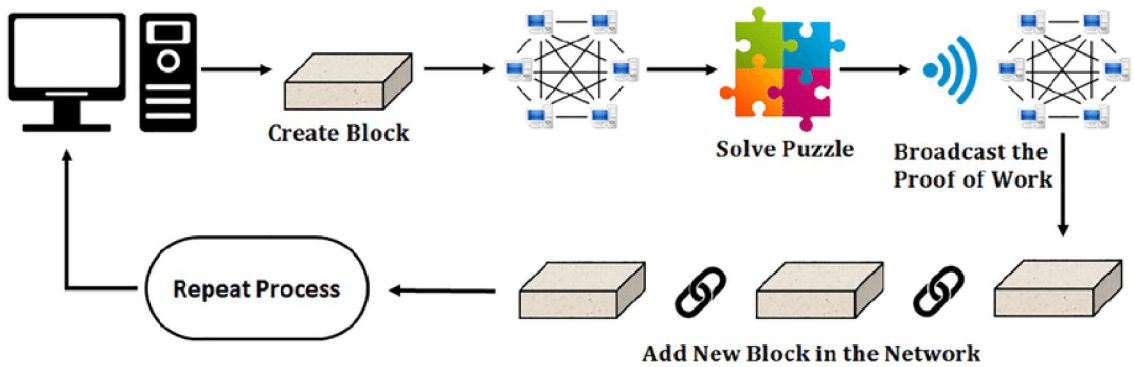
The blockchain technology functions in a fully decentralized way by using the computer power, including Graphics Processing Units (GPUs) and Central Processing Units (CPUs), contributed by users globally. This process, known as mining, involves users dedicating their computing resources to validate transactions and secure the network. In return for their active participation, users get the reward with incentives such as newly created cryptocurrency tokens or transaction fees.

Blockchain technology can operate on two different algorithms: Proof-of-Work (PoW) and Proof-of-Stake (PoS). Both algorithms were designed to demonstrate the completion of computational tasks, allowing new transaction (block) comes to the blockchain network.

Proof of Work

The Proof-of-Work (PoW) algorithm is designed to solute the double-spending problem inherent in digital transactions, where users could spend the same amount of money twice. While traditional centralized banking systems rely on a central authority for transaction verification. The PoW algorithm is the oldest and the most popular algorithm among cryptocurrencies, providing a powerful way to validate transactions and maintain the integrity of the blockchain. [16]

Figure 16 The proof of work consensus algorithm

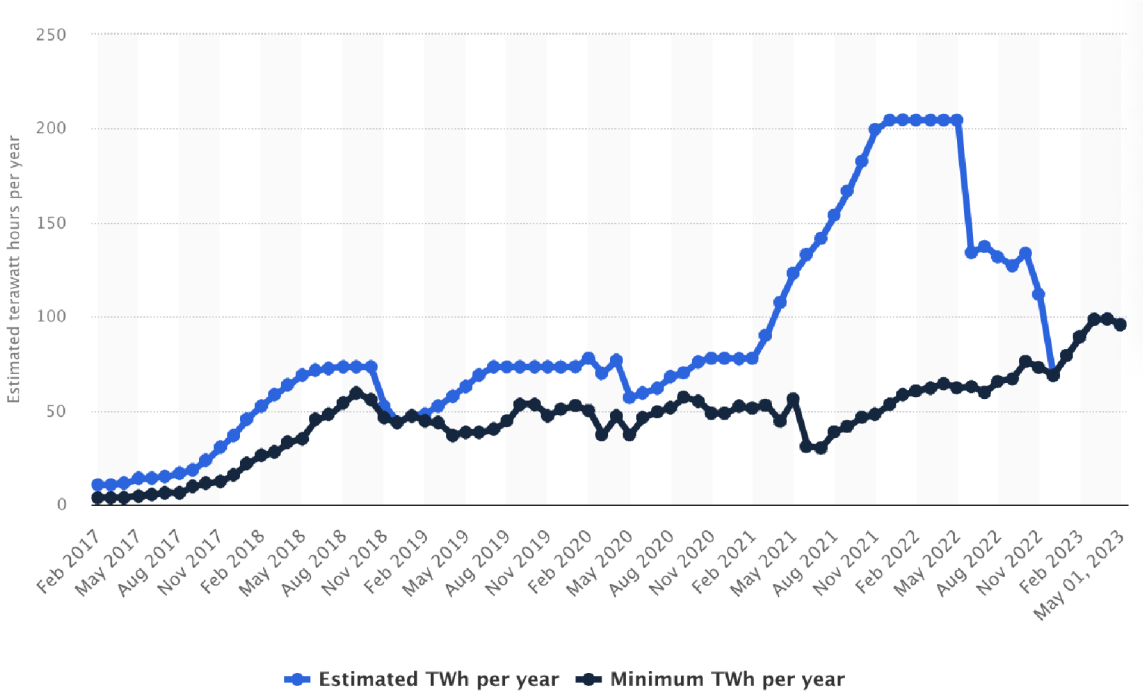


Source: https://www.researchgate.net/figure/The-proof-of-work-consensus-algorithm_fig5_353572249

[16] MYERS. R, *Proof of Work, 2023*

One of the main advantages of PoW is that it is fair and equal for all the users; at the same time this advantage can be also its biggest disadvantage: "[…], Bitcoin uses a mechanism called 'proof-of-work' to ensure that anyone (in theory, at least) can add blocks to the blockchain at a certain cadence without a central actor coordinating access or providing permission. Proof-of-work creates a fair competition between block adders who compete to add blocks. This competition consumes electricity - a lot of it"[17].

Figure 17 The maximum and minimum TWh Bitcoin Consumes from 2017-2023

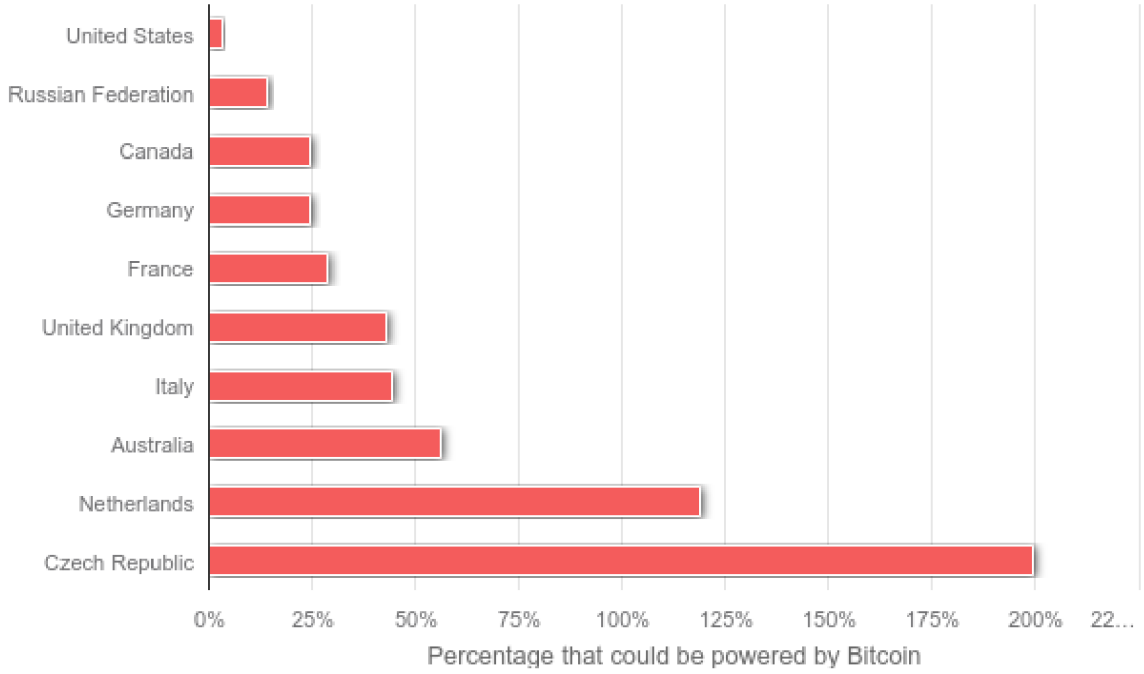


Source: https://www.techopedia.com/bitcoin-mining-and-energy-statistics

As represented in Figure 17, Bitcoin-blockchain network currently consumes approximately 100 TWh (terra watt-hours), with a peak usage of around 200 TWh. To illustrate how much it is, it could be compared to the yearly energy consumption of the entire Czech Republic - approximately 50 TWh. This data illustrates the substantial energy requirements associated with the operation of the Bitcoin blockchain network.

[17] LEWIS, A. *Bitcoin and blockchains.* 2018, p. 156

Figure 18 Bitcoin Energy Consumption Relative to Several Countries



Source: https://digiconomist.net/bitcoin-energy-consumption

Despite the energy consumption concerns associated with PoW, its effectiveness in achieving decentralized consensus has been a key factor in the success of various blockchain networks, including Bitcoin.

Proof of Stake

Proof of Stake (PoS) is a relatively newer algorithm than Proof of Work (PoW), first proposed on Bitcointalk in 2011. PoS was introduced as an alternative consensus mechanism addressing the inefficiencies of PoW, particularly its high energy consumption and resource-intensive nature. In PoS, the validation of new transactions or blocks is conducted by users who hold a substantial amount of a specific cryptocurrency. This contrasts with PoW, where participants (miners) compete in solving complex mathematical puzzles to validate transactions and create new blocks. PoS aims to provide a more energy-efficient and resource-friendly approach to blockchain consensus.

For instance, miner X stakes 30 coins, miner Y stakes 50 coins, miner J stakes 75 coins, and miner D stakes 15 coins. Miner J would be given priority to write and validate the following block in this case. In contrast to the block reward in proof-of-work, Miner J will collect transaction fees, i.e. network fees.

Figure 19 Comparison Proof-of-work and Proof-of-stake

Proof-of-work vs. proof-of-stake

	Proof-of-work	Proof-of-stake
Mining/validating a block	The amount of computing work determines the probability of mining a block.	The amount of stake or number of coins determines the likelihood of validating a new block.
Distribution of reward	One who mines the block first, receives a reward.	The validator does not receive a block reward as they are paid a network fee.
Competition	Miners must compete to solve complex puzzles using their computer processing power.	An algorithm determines a winner based on the size of their stake.
Centralization	PoW solutions are increasingly designated for large-scale operations, they are centralized in nature.	An algorithm determines a winner based on the size of their stake.
Specialized equipment	Application-specific integrated circuits (ASICs) and Graphics Processing Unit (GPUs) are used to mine the coins.	A standard server-grade device is sufficient for PoS-based systems.
Adding a malicious block	To introduce a malicious block, hackers would need 51% of computing power.	Hackers would need to hold 51% of all cryptocurrency on the network.
Efficiency and reliability	PoW systems are less energy-efficient and less expensive, but they are more reliable.	PoS systems are far more cost and energy-efficient although they are less reliable.
Security	The greater the hash, the more secure the network is.	Staking helps lock crypto assets to secure the network in exchange for a reward.
Forking	Through an economic incentive, PoW systems naturally prevent constant forking.	Forking is not automatically discouraged by PoS systems.

cointelegraph.com

Source: https://cointelegraph.com/learn/proof-of-stake-vs-proof-of-work:-differences-explained

2.2.3 Bitcoin

Bitcoin is the first cryptocurrency; it was introduced in year 2009 and works on the blockchain technology. The blockchain and Bitcoin were both invented by Satoshi Nakamoto. Bitcoin as the first decentralized digital currency eliminated the need for a central server and operates based on the Proof-of-Work (PoW) algorithm. In the initial four years, miners received rewards of 50 Bitcoins for each successfully mined block. However, these rewards decrease in size approximately every four years due to a process known as „halving."

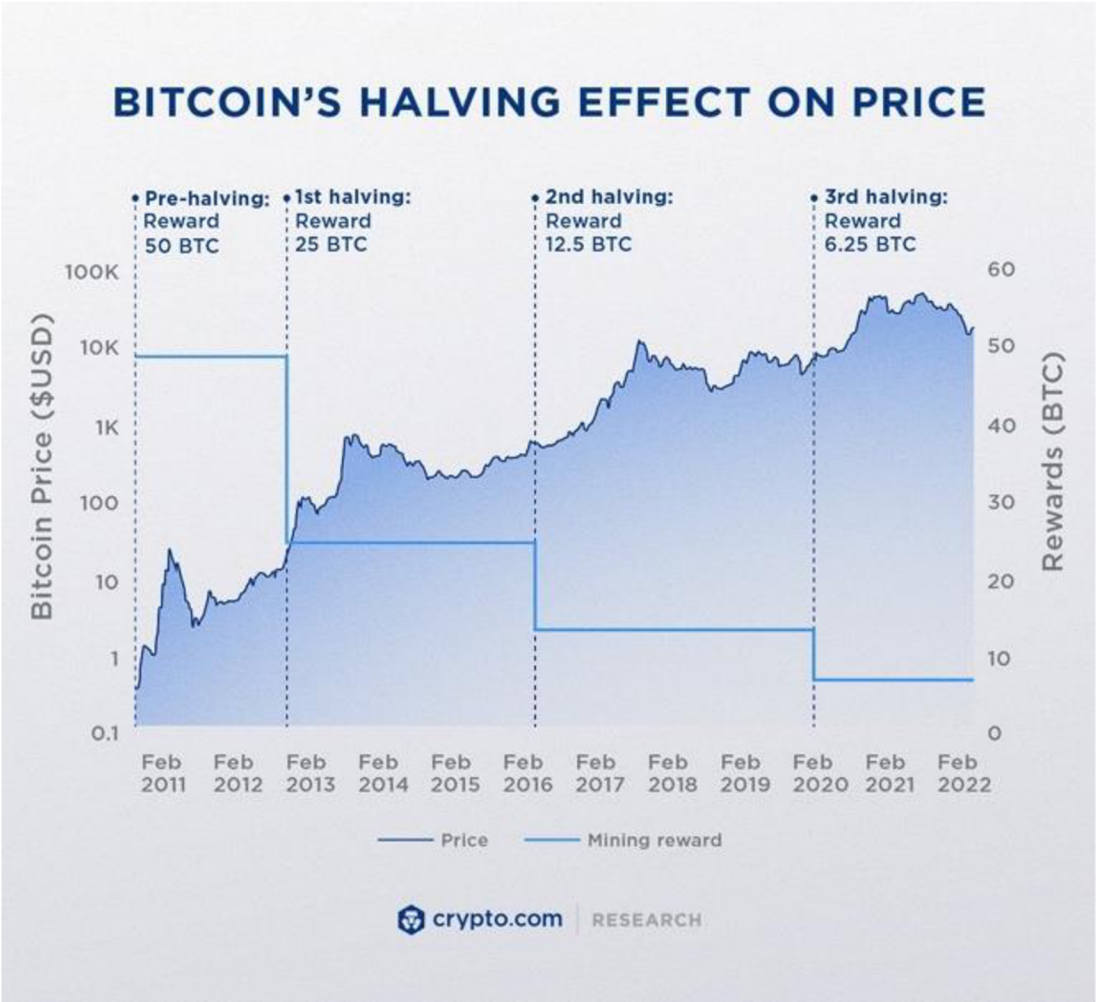
Figure 20 Bitcoin Halving Timeline

Source: https://crypto.com/university/what-is-bitcoin-halving

As of 2023, miners are eligible for a reward of 6.25 BTC, which is eight times less compared to the initial reward in 2009, equivalent to approximately 237,500 dollars. As shown on the Figure 5 each Bitcoin halving prompts Bitcoin to break its previous ATH.[18]

[18] SATOSHI, N. *Bitcoin: A Peer-to-Peer Electronic Cash System,* 2009

Figure 21 Bitcoin Halving Effect



Source: https://crypto.com/university/what-is-bitcoin-halving

Bitcoin earned its nickname "Digital Gold" due to its capped supply of 21 million coins. The algorithm dictates a reduction in the emission rate, halving it after the issuance of 10.5 million bitcoins. Subsequently, after reaching 15,750,000 Bitcoins, the emission rate undergoes another halving, and this pattern continues. The ultimate outcome is that the overall supply of bitcoins will not surpass 21 million.

Table 3 The number of bitcoins in circulation

Date	The number of Bitcoins in circulation	The growth rate for the year (%)
January 2016	14.44 million	+ 10%
January 2017	15.75 million	+ 9.1%
January 2018	16.41 million	+ 4.2 %
January 2019	17.06 million	+ 4.0%
January 2020	17.72 million	+ 3.9%
January 2021	18.37 million	+ 3.7%
January 2022	18.70 million	+ 1.8%

Source: https://www.semanticscholar.org/paper/The-Evolution-of-E-Money-Vlasov/35f5a67ff6de1134618d569bd2c6b35565e4177e

This inherent limitation gives Bitcoin a resemblance to gold in the digital realm. The scarcity of Bitcoin, much like the rarity of gold, contributes significantly to its perceived value. This unique feature distinguishes Bitcoin from traditional currencies, as its finite supply aligns with the principles of scarcity and exclusivity associated with precious metals. The analogy to gold underscores Bitcoin's potential as a store of value in the ever-expanding landscape of digital assets. Bitcoin today for some people became decentralize payment systems (DPSs).

Figure 22 Bitcoin Chart from 2015 to the end of 2023

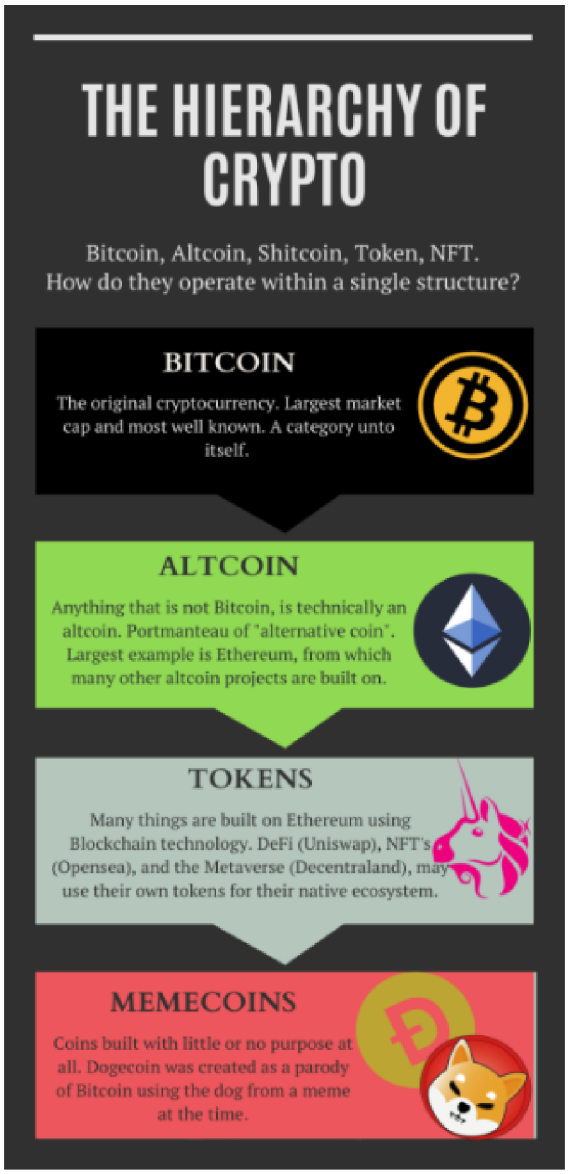
Source: own calculations based on: https://www.tradingview.com/chart/fsG5W9nf/?symbol=BYBIT%3AMNTUSDT

The current market capitalization of Bitcoin is 736 billion dollars, with its all-time high reaching 1.3 trillion dollars. This represents an increase of 47,910% from 2014 when the market capitalization was 5.72 billion dollars. This data highlights a significant surge in Bitcoin's market value over the years.

The hierarchical structure within the cryptocurrency ecosystem holds paramount significance. Bitcoin, as the inaugural and principal cryptocurrency, serves as a foundational store of value and represents the pioneering implementation of digital currency. Subsequently, Ethereum emerges as an alternative token to Bitcoin, introducing technological advancements to the digital realm. Following the successful establishment of Ethereum, a plethora of diverse tokens has been introduced onto the Ethereum blockchain, leveraging its underlying technology.

These tokens, while fundamentally aligned with the aforementioned digital currencies, diverge in their technological applications. Memecoins, a subset within this hierarchy, share the basic attributes of the tokens; however, they lack specific technological purposes. Their existence primarily revolves around cultural or humorous contexts rather than serving a substantive technological function. [19]

Figure 23 The Hierarchy of Crypto



Source: *https://richardmooneyvi.wordpress.com/2022/02/23/the-hierarchy-of-crypto-infographic/*

[19] CATON, L. *The Economics of Blockchain and Cryptocurrency*. 2022

2.2.4 Exploring Stable coins

Following the creation of Blockchain and Bitcoin over a thousand cryptocurrencies have been introduced, each serving distinct purposes. Blockchain is regarded as decentralized payment systems (DPSs). However, a significant disadvantage of Bitcoin and other cryptocurrencies (altcoins) is their volatility, which causes their effectiveness as a medium of exchange to be nonviable. This volatility is characterized by drastic fluctuations in the price of one Bitcoin, with the price surging by 200% in a single day and subsequently plummeting by 50% within a few hours.

Figure 24 Different Stablecoins Labels

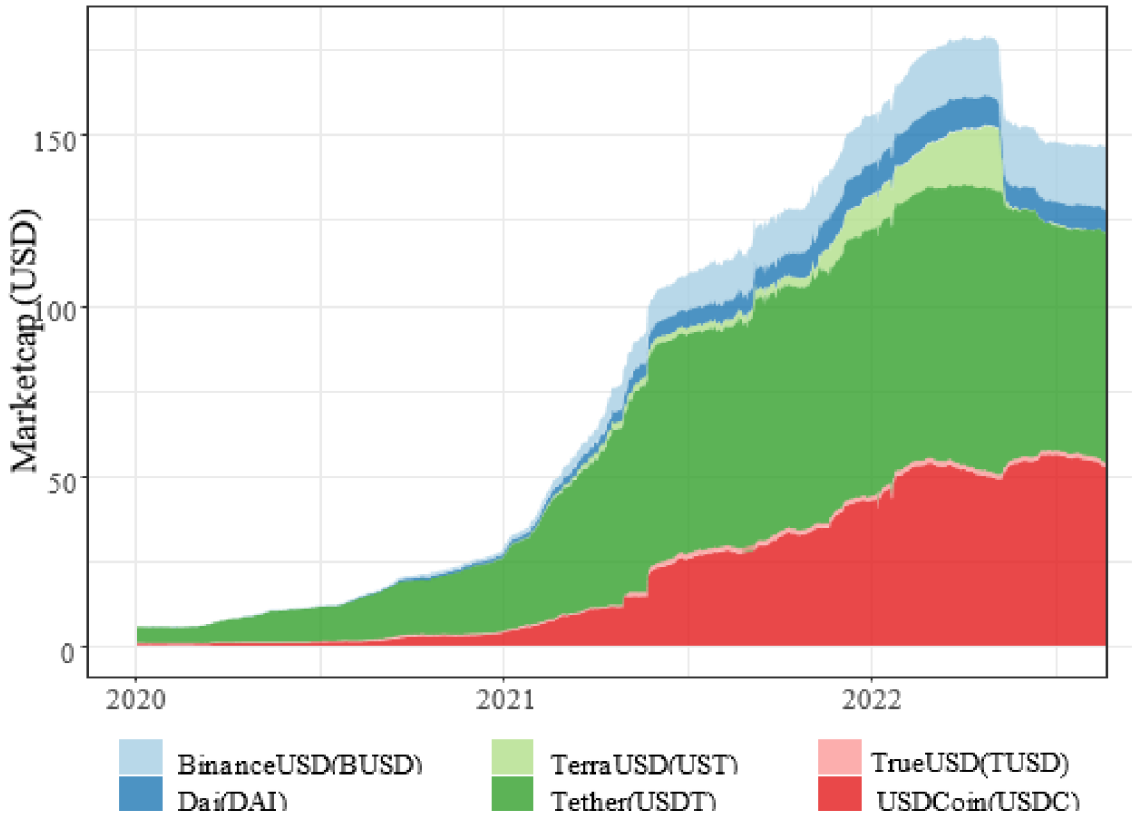
Source: https://cionews.co.in/mufg-to-issue-global-stablecoins/

The problem of volatility led to the creation of stablecoins. A stablecoin is a type of cryptocurrency designed to maintain a stable value by being fixed to the value of an external asset. This external asset is often a fiat currency like the US Dollar (1 USDT = 1 USD). The first concept of stablecoin was invented in 2010 but their rapid development started in 2020. Within 3 years their market capitalization from 5 billion dollars reached almost 200 billion USD. The four leading stablecoins: Tether (USDT), USD Coin (USDC), Binance USD (BUSD), and Dai (DAI) - issued by Tether Ltd, Circle/Paxo's, Binance, and Maker DAO, are all pegged to the value of the US dollar. Due to their stability characteristics, these stablecoins function effectively as a store of value and be medium of exchange for cryptocurrency market.

"The fast-growing adoption of stablecoins is linked to their multiple purposes in crypto markets. Their stability properties allow them to play the role of a store of value in crypto markets. Stablecoins also fuel the development of Decentralized Finance (DeFi) as collateral locked in smart contracts or borrowed to build leveraged positions"[20]. Currently, the whole supply of DeFi is 98.176 billion dollars, with stablecoins holding 70% of this amount.

[20] BARTHÉLEMY, J., GARDIN, P., NGUYEN, B. *Stablecoins and short-term funding markets*, 2023, p. 7

Figure 25 Stablecoins' market capitalization



Source: Messari. Took from work „Stablecoins and short-term funding markets ∗ Jean Barthélemy†, Paul Gardin‡, Benoit Nguyen. Version May 2023"

USDC stands as the second largest stablecoin with a market capitalization of $23 billion. It is a fiat backed stablecoin which means it's backed by reserves in the traditional financial system, signifying that every token is supported by $1 in reserve assets. The reserves backing USDC are held in US banks and consist of cash and short-term US Treasuries.

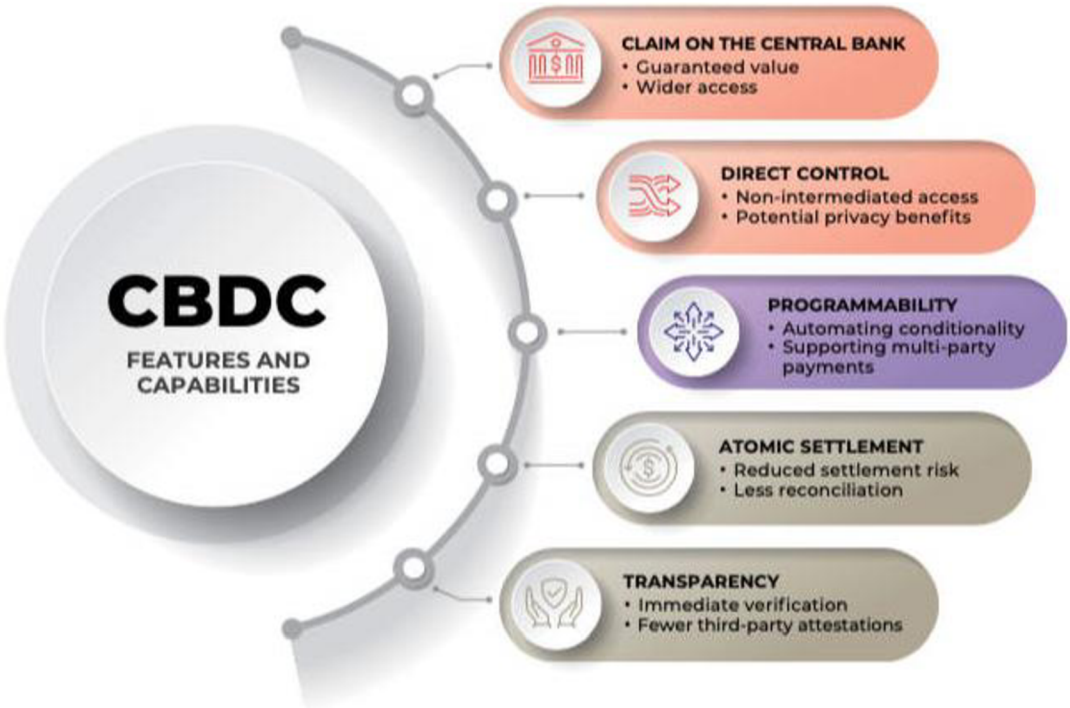
Multi-Collateral Dai (DAI), with a market capitalization of $4.7 billion, is a decentralized cryptocurrency pegged to the US dollar. It is generated by the Maker protocol, overseen by a decentralized autonomous organization (DAO) known as Maker DAO. The Maker protocol enables users to secure overcollateralized loans denominated in DAI. Initially, loans were primarily collateralized by other cryptocurrencies, but the protocol now includes various stablecoins (like USDC) and real-world assets such as US Treasuries.

2.3 Central Bank of Digital Currency

Recognizing the growing global adoption of cryptocurrencies, central banks have acknowledged the need for alternatives to traditional central bank money. Central bank digital currencies (CBDCs) represent a form of digital currency issued by central banks.

A good and clear definition of CBDC can be found in an article in the Journal of Open Innovation: Technology, Market, and Complexity - "A CBDC is an electronic variant of cash issued by a central bank, which combines cryptography and digital ledger technology to offer this digital money. It is therefore a central bank liability, which can: - Emulate the characteristics of cash (if held by the public); Serve as a central bank reserve (if held only by banks and other financial intermediaries that have access to the payment system)."[21] CBDCs will have diverse effects on financial stability and operations. Additionally, the lack of precisely modelled CBDC may create a variety of problems for the issuing central bank itself.

Figure 26 Features and Capabilities of CDBC



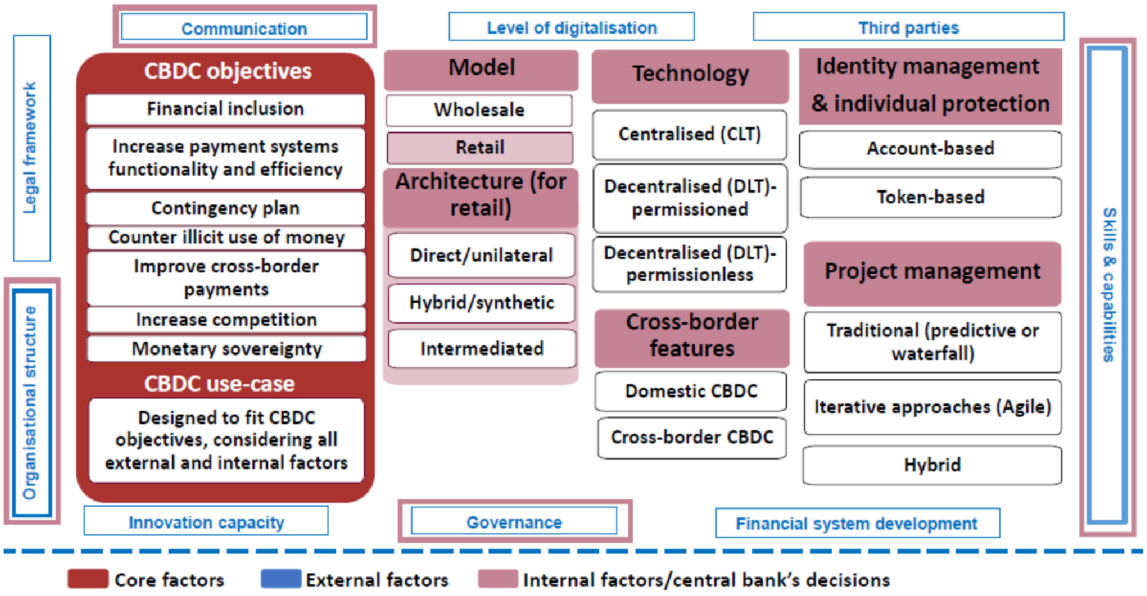
Source: https://www.ledgerinsights.com/australia-central-bank-digital-currency-cbdc-pilot-2/

[21] ALONSO, S.L.N., JORGE-VAZQUEZ, J., FORRADELLAS, R.F.R., Technology, Market, and Complexity, *Central Banks Digital Currency: Detection of Optimal Countries for the Implementation of a CBDC and the Implication for Payment Industry Open Innovation,* Journal of Open Innovation, 2021, p. 2

The fact that CBDCs themselves are issued from the Central Bank is clearly different from the existing form of cashless payment instrument for consumers. Credit transfers, direct debits, card payments, and e-money, these forms of digital transactions are liabilities for the institution that issues them. CBDCs also distinguish themselves from other types of digital money, such as crypto assets, stablecoins, and various other digital assets.

To successfully implement CBDC, central banks must consider the use case and objective of CBDC. These considerations are visualized in Figure 26.

Figure 27 Considerations for a CBDC project/model choice



Source: CBDC Task Force

2.3.1 CBDC technology and availability

CBDC technology is versatile in many ways, from the model of operation (the base of the CBDC), to the different ways of account verification (at the consumers end) it shows the many ways of its adaptability. A CBDC as a technology can run on CLT (central ledger technology) by being fully centralized or by being partly deployed on DLT (decentralized ledger technology), where database works in decentralized manner - different nodes can assign the transaction. For security purposes CBDC can also run on both these architectures. For example, transactions within one country may be centralized, however international ones may be decentralized. In some cases, CBDC can be implemented by

the government with DLT architecture, in another with CLT architecture. Payment through CBDC is also supposed to be possible in the absence of internet connection. As such, this decision needs to be assessed based on preserving confidentiality, integrity, and availability (CIA). Additionally, the method of account verification is versatile. In an account based CBDC system, users are required to provide identity verification (KYC) to access their accounts. However, in a token based CBDC system, access is facilitated using a private key.

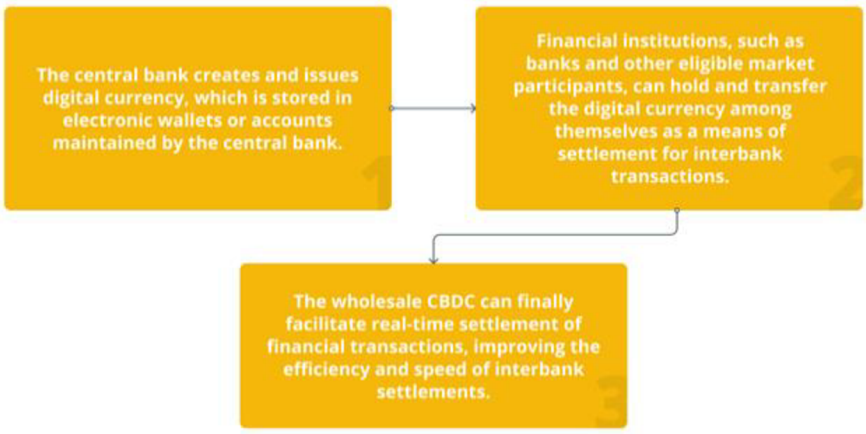
2.3.2 Wholesale Central Bank Digital Currency (CBDC)

The main purpose of wholesale CBDC is to make interbank transactions which could encompass digital assets or cross-board payment. A wholesale CBDC is restricted to use by financial institutions to settle trades in financial markets, trading bonds, stocks, and all other types of securities.

The possible workflow a wholesale CBDC:

1. The central bank creates and issues digital currency, which is stored in electronic wallets or accounts maintained by the central bank.
2. Financial institutions, such as banks and other eligible market participants, can hold and transfer the digital currency among themselves as a means of settlement for interbank transactions.
3. The wholesale CBDC can finally facilitate real-time settlement of financial transactions, improving the efficiency and speed of interbank settlements.

Figure 28 Workflow of a wholesale CBDC



Source: https://cointelegraph.com/learn/wholesale-cbdc-vs-retail-cbdc-key-differences

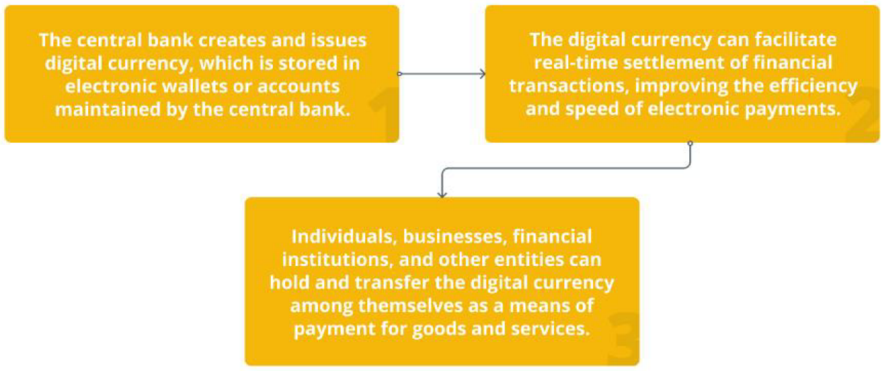
2.3.3 Retail Central Bank Digital Currency (CBDC)

Retail Central Bank Digital Currency will provide individuals and small businesses with a chance to use electronic version of fiat money that was issued by Central Bank. Unlike other cryptocurrencies, this form of digital money is fully supported by the central bank. The primary focus of a retail CBDC is to provide a user-friendly, regulated means for individuals and businesses, the financial institutions are restricted.

The possible workflow of a retail CBDC:

1. The central bank creates and puts into circulation new currency, which is then deposited and stored in wallets maintained by the central bank.
2. The digital currency can facilitate real-time settlement of financial transactions, improving the efficiency and speed of electronic payments.
3. Individuals, businesses, financial institutions, and other entities can hod and transfer digital currency among themselves as a means of payment for goods and services.

Figure 29 Workflow of a retail CBDC



Source: https://cointelegraph.com/learn/wholesale-cbdc-vs-retail-cbdc-key-differences

The Committee on Payments and Market Infrastructures states: "A retail CBDC can be seen as a sort of digital banknote that can be used by individuals and businesses (including merchants) to pay each other. A wholesale CBDC is restricted to use by financial institutions to settle trades in financial markets. In either case, it would have the full backing of the central bank."[22]

[22] Committee on Payments and Market Infrastructures, *Central Bank Digital Currencies*, 2018, p. 8

The retail CBDC is more complex and has 3 different architectures:

Direct:

In a single-tier retail Central Bank Digital Currency (CBDC) architecture, the central bank is responsible for managing all transactions between the public and businesses without any other intermediary institutions. Simultaneously, it maintains up-to-the-minute records of the direct retail holdings of all participants.

Hybrid:

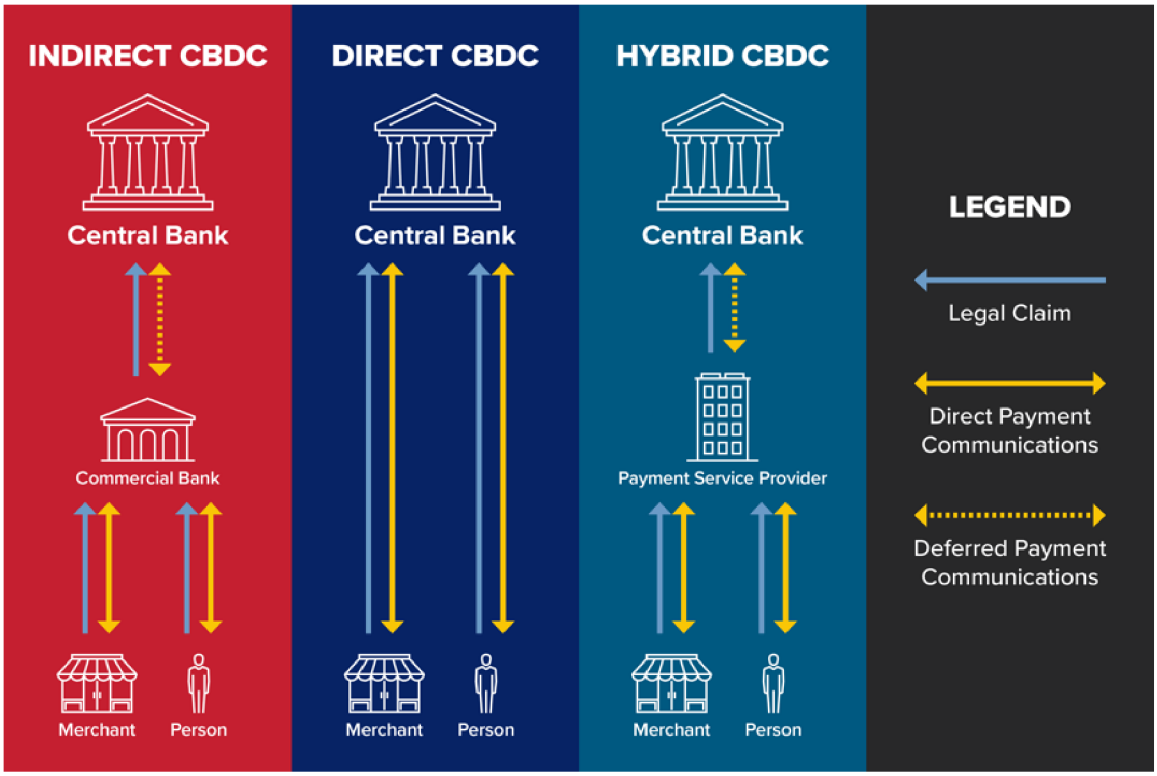
Two-tiered retail Central Bank Digital Currency (CBDC) in which intermediaries conduct know-your-customer (KYC) checks and manage real-time payments from consumers. Meanwhile, the central bank periodically records the balances held in the retail sector. This model combines the involvement of intermediaries in day-to-day operations with the central bank's oversight of retail balances at intervals.

Intermediated:

Two-tiered retail Central Bank Digital Currency (CBDC) configuration in which a notable distinction from the hybrid model is evident. In this scenario, the central bank exclusively manages the processing and recording of wholesale payments and balances. In contrast, intermediaries take on the responsibility of handling retail payments. This model emphasizes a clear division of roles, with intermediaries managing the retail front while the central bank focuses on the wholesale aspects of the CBDC system.

Figure 30 shows a schematic visualizing the differences between Indirect, Direct and Hybrid architectures, and how the issuing institution (central bank) and the receiver (user) are connected by the legal claim, direct payment communications and deferred payment communications.

Figure 30 How a CBDC could work



Source: https://www.icba.org/newsroom/blogs/main-street-matters/2021/06/03/digital-dollar-digest-what-central-bank-digital-currency-architecture-means-for-community-banks

3 Practical Part

3.1 Implementation of CBDC

This part of the analysis focuses on investigating potential triggers of CBDC adoption in various countries. What motivates particular country to start implementing CBDC as their new monetary system is based on data collected from [22, 23, 28], complemented by the paperwork issued by Central Banks, articles or briefing notes and the variables associated with them is represented in the following table (Table 4).[23,24]

To measure the density of population, a variable inhabitant per square kilometer was assigned.[25] This variable has been introduced due to challenges in offering banking services to populations in certain countries, primarily caused by geographical spread. In terms of banking service accessibility, the variable employed was the number of commercial bank branches (per 100,000 clients)[26] which made it possible to compare access to these services among the list of countries.

Increase of the banking penetration rate was measured through financial and private sector (% of GDP).[27] The justification for implementing CBDC based on the financial sector not becoming obsolete was measured through the Digital Readiness Index[28] which has seven measure components (basic needs, ease of doing business, start-up environment, technology infrastructure, business and government investment, human capital, technology adoption). All these components were summed up to obtain an overall score of the digital readiness of each country in the range of -2,5 to + 2,5.

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[23] AUER, R., CORNELLI, G., FROST, J., *Rise of the central bank digital currencies: drivers, approaches and technologies, BIS* Working Papers No 880, August 2020, [last access: 28.01.2024], https://www.bis.org/publ/work880.pdf

[24] ALONSO, S.L.N., JORGE-VASQUEZ, J., FORRADELLAS, R.F.R., Detection of Financial Inclusion Vulnerable Rural Areas through an Access to Cash Index: Solutions Based on the Pharmacy Network and a CBDC. Evidence Based on Ávila (Spain), September 2020, [last access: 28.01.2024] https://www.mdpi.com/2071-1050/12/18/7480

[25] databese.earth, *Population Density by Country in 2023*, [last access: 28.01.2024] https://database.earth/population/density/2023#:~:text=In%20the%20year%202023%2C%20the,24360.7%20people%20per%20square%20kilometer

[26] data.worldbank.org, *Commercial bank branches (per 100,000 adults),* [last access: 28.01.2024] https://data.worldbank.org/indicator/FB.CBK.BRCH.P5?most_recent_year_desc=true

[27] data.worldbank.org, *Domestic credit to private sector by banks (% of GDP),* [last access: 28.01.2024] https://data.worldbank.org/indicator/FD.AST.PRVT.GD.ZS?most_recent_year_desc=true

[28] cisco.com, *Digital Readiness Index,* [last access: 28.01.2024] https://www.cisco.com/c/m/en_us/about/corporate-social-responsibility/research-resources/digital-readiness-index.html#/

The general motivation for implementing a CBDC for consumer protection is determined by the reason that the more online commerce there is, and the bigger number of digital payments are made, the more "digital" protection consumer will need. In this case the UNCTAD B2C E-commerce Index[29] was applied as a variable.

Based on reference [29] it can be concluded that the implementation of CBDC has six different stages:

1. **Launched** - After successful testing and regulatory preparations, the central bank officially launches the CBDC for public use. From this point where the digital currency becomes available to the broader population
2. **Piloted** - A pilot program is launched to test the CBDC in a controlled environment. This phase helps identify any technical or operational issues and assesses user feedback.
3. **Development** - Once the decision is made to proceed with CBDC, the central bank enters the development stage. This involves designing the technical architecture, creating prototypes, and establishing the necessary infrastructure.
4. **Research** - Central banks begin researching and exploring the concept of CBDC. This stage involves studying the potential benefits, risks, and technical feasibility of introducing a digital currency.
5. **Inactive** - Central bank has developed and launched a CBDC but, for some reason, it is not actively being used or has minimal adoption. Reasons for inactivity could include a lack of public interest, competing digital currencies gaining more traction, or technical issues leading to a suspension of CBDC usage. In this case, the central bank may need to reassess its strategy and take steps to address the factors contributing to the inactivity.
6. **Canceled** - If a central bank decides to abandon the development and implementation of a CBDC.

[29] United Nations UNCTAD, *The UNCTAD B2C E-commerce Index 2020 Spotlight on Latin America and the Caribbean,* UNCTAD Technical Notes on ICT for Development No17, [last access: 28.01.2024] https://unctad.org/system/files/official-document/tn_unctad_ict4d17_en.pdf

In this research countries that Launch or implement Pilot project on CBDC are considered as variable 1, which means the CBDC is approved or is in its last stage. Other examples, in the stages from the points 3 – 6 (see above), are considered as a variable 0, which means countries that have not approved the CBDC.

Table 4 Triggers behind CBDC adoption and corresponding proxy variables

TRIGGERS	PROXIES
Density of population	Inhab/km^2
Banking service accessibility	Commercial bank branches (per 100,000 clients)
Increase the banking penetration rate	Financial sector credit to the private sector (% of GDP)
Financial sector does not become obsolete	Digital Readiness Index (range from -2,5 to +2,5)
Security reasons: avoid money laundering and terrorism financing	Shadow economy (% of GDP)
Consumer protection	B2C E-commerce Index
Maintain control over monetary and macroeconomic policy; Fall in use of cash (alternative)	Corresponding CB speech Broad money (% of GDP)

Source: Own work based on data from [22-28]

Examples of three countries where CBDC was partially or fully equipped:

The Bahamas take the first place as a country that first launched their own CBDC backed by Central Bank.[30] The Central Bank of the Bahamas announced via Twitter and the radio speech from John Rolle the launch of Sand Dollar.[31] Sand Dollar tokens are cryptocurrency represents the Bahamian dollar, that was issued and regulated by the country's Central Bank which makes the process of integrating them into the existing networks easier.[32] The Sand Dollar is pegged 1:1 to the Bahamian dollar, which is pegged to the US dollar.[33] The Jamaica takes the second spot; Jamaica had been working with eCurrency Mint firm to introduce CBDC in their country from 2021. The project was successfully completed and the CBDC in Jamaica was named Jamaican Digital Exchange or JAM-DEX. The main motive for the implementation was to reduce storage and handling cost of cash use [29].

China as the second highest country by GDP in the world has already conducted pilot test in 2019 called Digital Currency Electronic Payments (DCEP), later labeled e-CNY. In 2020 China started to test CBDC in its four cities by allowing commercial banks to use internal tests, such as conversions between cash and digital money, account-balance checks and payments. "China is also working on better integrating its existing payments channels with the e-CNY, and in 2023, AliPay began offering e-CNY in express payment category. In January 2023, China included e-CNY in their currency circulation calculations, and the digital yuan represented 0.13% of cash and reserves held by the central bank." [29]

[30] Atlantic Council Geoeconomics Center, Central Bank Digital Currency Tracker, [last access: 28.01.2024] https://www.atlanticcouncil.org/cbdctracker/

[31] youtube.com, @OMFIF, The Official Monetary an Financial Institutions Forum, *The Sand Dollar with John Rolle - Governor of the Central Bank of the Bahamas*, May 2021, [last access: 28.01.2024] https://www.youtube.com/watch?v=J4kI3yM5_KY

[32] Cointelegraph; The Future of Money, *Sand Dollar (Bahamas) digital currency: A beginner's guide*, [last access: 28.01.2024] https://cointelegraph.com/learn/sand-dollar-bahamas-digital-currency-a-beginners-guide

[33] GROSS, J. WEISBRODT, J., *CBDC pioneers: Which countries are currently testing a retail central bank digital currency?*, Medium, June 2020, [last access: 28.01.2024] https://jonasgross.medium.com/cbdc-pioneers-which-countries-are-currently-testing-a-retail-central-bank-digital-currency-49333be477f4

Table 5 Potential triggers behind CBDC adoption and corresponding proxy variables by country

Key points for establishing CBDC	**Density of Population**	**Security Reasons: Avoid Money Laundering and Terrorist Financing**	**Increase the banking penetration rate**	**Banking services accessibility**	**Financial Sector Not to Become Obsolete**	**Fall in Use of Cash (Alternative)**	**Consumer Protection**	**Pioneer**
Associated Variable	Inhab/km^2	Shadow economy	Financial sector credit to the private sector	Commercial bank branches	Digital Readiness Index	Broad money	UNCTAD B2C E-commerce Index	1 - CBDC implemen-tation 0 - non-existence CBDC
Unit	%	%	%	100.000	-2,5 - +2,5	%	%	0-1
South Korea	523,0	22,7	175,0	13,7	1,73	173,8	89,8	1
Canada	4,3	11,2	219	20,7	1,40	171,0	90,8	1
Brazil	26,0	33,2	71,8	17,1	-0,15	106,5	63,5	1
Ghana	150,0	35,6	11,3	11,5	-0,49	31,7	51,9	1
Ecuador	73,0	37,2	50,8	9,2	-0,28	52,3	39,5	0
China	149,0	12,7	263,6	19,8	0,23	216,0	91,8	1
Finland	18,0	14,6	93,8	6,2	1,53	60,0	93,4	0
USA	37,0	7,3	51,7	28,3	2,08	116,0	91,0	0
Estonia	30,0	22,5	57,4	7,5	1,57	67,0	90,8	0
France	117,0	13,1	115,3	33,3	0,98	62,0	90,0	0
India	480,0	39,1	50,4	14,6	-0,62	82,5	57,1	1
Ukraine	63,0	44,2	17,7	0,4	-0,13	48,2	71,2	1
Tunisia	80,0	30,4	64,0	22,3	-0,24	76,9	54,6	1
Jamaica	261,0	33,0	50,7	6,3	-0,08	66,3	55,0	1
Uzbekistan	83,0	27,2	36,7	48,0	-0,1	21,3	37,0	0
Norway	18,0	15,7	96,2	5,5	1,54	55,2	92,6	0
Russia	9,0	38,0	54,4	24,6	0,39	69,9	76,6	1
Switzerland	220,0	7,5	277	36,4	1,64	189,0	95,9	0
Trinidad and Tobago	299,0	33,0	35,0	11,0	0,04	60,4	54,9	0
Malaysia	104,0	25,3	113,3	8,7	0,46	119,2	81,3	1
Madagascar	52,0	36,2	18,5	3,0	-1,4	28,1	19,2	0
Lithuania	43,0	21,6	35,7	11,2	0,88	62,0	82,6	0
South Africa	49,0	28,8	58,7	8,0	0,06	71,4	56,5	1

Key points for establishing CBDC	Density of Population	Security Reasons: Avoid Money Laundering and Terrorist Financing	Increase the banking penetration rate	Banking services accessibility	Financial Sector Not to Become Obsolete	Fall in Use of Cash (Alternative)	Consumer Protection	Pioneer
Associated Variable	Inhab/km^2	Shadow economy	Financial sector credit to the private sector	Commercial bank branches	Digital Readiness Index	Broad money	UNCTAD B2C E-commerce Index	1 - CBDC implemen-tation 0 - non-existence CBDC
Unit	%	%	%	100.000	-2,5 - +2,5	%	%	0-1
Sweden	26,0	13,7	132,4	11,4	1,95	83,8	90,8	1
Uruguay	20,0	31,7	26,4	9,6	0,48	52,1	56,6	0
Bahamas	77,0	39,0	46,2	24,6	1,23	60,0	55,7	1
Algeria	19,1	17,5	21,1	5,3	-0,54	82,9	52,2	0
Angola	29,4	39,7	8,4	8,2	-1,24	21,3	26	0
Australia	3,4	9,9	133,9	24,1	1,49	134,2	90,6	1
Austria	108,5	8,8	89,6	12,3	1,1	80	88.8	1
Azerbaijan	125,9	37,1	18,3	6,5	0,08	32,0	60	0
Czechia	135,9	14,5	50,5	17,3	0,83	87,7	85,8	1
Georgia	53,65	46,5	63,6	31,3	0,5	52	73,6	1
Greece	79,04	27,1	52,6	16,8	0,42	80	79,2	1
Guatemala	168	48,8	36,8	24	-0,43	59,1	36,8	1
Hungary	112,8	23,5	36	22,4	0,36	65,3	81,3	0
Ireland	73,9	12,4	26,2	16,1	1,54	120	93,4	0
Japan	327	9,6	196,1	33,9	1,35	286,1	88,7	1
Kazakhstan	7,26	32,1	25	13,1	0,23	33,1	68,2	1
Kenya	94,88	32,8	31,5	4,4	-0,57	37,7	49	0
Latvia	29,4	25,1	28,8	6,6	0,77	95	77,8	1
Mexico	65,56	29,4	34,3	12	-0,04	41,7	46,8	0
Philippines	391	34,4	48,9	9	-0,25	85,9	44,7	0
Poland	133,98	22,5	39,7	23,2	0,73	68,1	82,2	0
Portugal	111,4	20,4	90,1	30,7	0,8	145,6	77,5	0
Romania	86,46	23,8	24,8	21,7	0,35	42,8	75	0
Serbia	93	31,4	40,3	26,4	0,22	56,9	75,3	0
Slovenia	105	24	41,1	22,6	0,83	23,78	78,8	0
Spain	94,59	21,5	90	37,4	1	77,31	84,9	0
United Arab Emirates	133,99	20,5	66	7,6	1,26	91,5	78,2	1

Key points for establishing CBDC	Density of Population	Security Reasons: Avoid Money Laundering and Terrorist Financing	Increase the banking penetration rate	Banking services accessibility	Financial Sector Not to Become Obsolete	Fall in Use of Cash (Alternative)	Consumer Protection	Pioneer
Associated Variable	Inhab/km^2	Shadow economy	Financial sector credit to the private sector	Commercial bank branches	Digital Readiness Index	Broad money	UNCTAD B2C E-commerce Index	1 - CBDC implementation 0 - non-existence CBDC
Unit	%	%	%	100.000	-2,5 - +2,5	%	%	0-1
Singapore	8806	9,2	129	7	2,37	148,9	94,4	1
Luxembourg	252	10	101,5	56,5	2,22	120	78,4	0
Denmark	139	15,3	143,4	17,5	1,82	61,4	94,5	0
Israel	423	21	70,2	15,2	1,31	103,7	83,9	1
Cyprus	136	27,3	75,6	28,3	0,99	59	78,1	0
Malta	1698	27,8	72	23,5	0,94	49	72,9	0
Qatar	234	16,7	100,8	8,5	0,73	83,1	72,1	0
Turkey	111	31,4	54,5	15	0,22	55,5	68,8	1
Armenia	97,5	39,4	52,6	24,3	0,16	51,9	49,9	0

Source: Own calculation

3.1.1 Person's Correlation

Person's Correlation illustrates the relationship between two variables. The general purpose of this analysis is to define the strength of that relationship. A correlation coefficient, ranging from -1 to +1, a positive correlation which is over 0 signifies positive correlation, while a negative correlation - below 0 indicates that variables are negative related. A correlation coefficient of 0 indicates that there is no relationship between variables.

Table 6 Person's Correlation

Name	Inhabit.	Shadow economy	Financial sector credit to the private sector	Commercial bank branches	Digital Readiness Index	Broad money	UNCTAD B2C E-commerce Index
Inhabit.	1						
Shadow economy	0,105	1					
Financial sector credit to the private sector	0,079	-0,607	1				
Commercial bank	0,132	-0,249	0,277	1			
DRI	0,024	-0,742	0,528	0,252	1		
Broad Money	0,046	-0,59	0,796	0,202	0,473	1	
B2C	-0,058	-0,745	0,578	0,158	0,848	0,528	1

Source: Own elaboration by using SPSS 29

When correlation between two variables is close to 1 or -1 it is an indicator of a strong positive or strong negative relationship respectively. A correlation coefficient close to 0 indicates a weak relationship between two variables, which indicates that one variable is weak in relation to another.

A strong positive relationship in the table is highlighted with green color and strong negative relationship is highlighted with orange. As a result, it is visible that The Digital Readiness Index (DRI) represents strong negative correlation with three variables (Shadow economy, Broad Money, Consumer Protection (B2C), Financial sector credit to private sector). A strong positive relationship is represented between Broad Money and Financial sector credit to private sector. Consumer Protection (B2C) shows a strong positive relationship as well, with Digital Readiness Index (DRI).

Table 7 Statistical significance (t-ratio) of correlation coefficient

Name	Inhabit.	Shadow economy	Financial sector credit to the private sector	Commercial bank branches	Digital Readiness Index	Broad money	UNCTAD B2C E-commerce Index
Inhabit.	/						
Shadow economy	0,797	/					
Financial sector credit to the private sector	0,599	-5,77	/				
Commercial bank	1,005	-1,941	2,179	/			
DRI	0,181	-8,354	4,670	2,964	/		
Broad Money	0,348	-5,522	9,54	2,554	4,066	/	
B2C	-0,439	-8,478	5,33	2,210	12,369	4,674	/

Source: Own calculation

After finding the result of the Pearson's Correlation calculation, a statistical verification of correlation should be conducted; the critical t-value of 2.001. The significant correlation coefficient is highlighted with a green color and insignificant with orange (Table 7). Consequently, it is visible that most correlation coefficients are significant with just 7 being classified as insignificant.

3.1.2 Logistic Regression

Logistic regression is a type of statistical model used for classification and predictive analytics. Logistic regression estimates the probability of an event occurring. In this case the goal is to predict which of the explanatory variables can explain an increase in probability of CBDC implementation by taking sample size of 59 countries. Seven explanatory variables were chosen, as explained earlier, to capture potential key factors influencing the CBDC adoption. The response variable, labeled 'Pioneer,' is designed for binary classification, categorizing countries based on whether they have implemented CBDC (coded as 1) or not (coded as 0).

Table 8 Logistic Regression Model (1)

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Inhab_km2	-.003	.003	.979	1	.322	.997
	Shadow_economy	.236	.080	8.790	1	.003	1.266
	Financial_sector_cr	.004	.011	.122	1	.727	1.004
	Commercial_bank	-.106	.050	4.414	1	.036	.900
	DRI	-.339	.931	.132	1	.716	.713
	BROAD_MONEY	.044	.017	7.018	1	.008	1.045
	B2C	.085	.049	3.028	1	.082	1.088
	Constant	-13.670	4.908	7.757	1	.005	.000

a. Variable(s) entered on step 1: Inhab_km2, Shadow_economy, Financial_sector_cr, Commercial_bank, DRI, BROAD_MONEY, B2C.

Source: Own calculation in SPSS 29

In the initial analysis, all explanatory variables were tested against the response variable. Variables with high p-values were excluded, resulting in the selection of “broad money” and “shadow price”. These two variables met our criteria of having p-values < 0,05 (Sig.) and displaying a negative Pearson’s Correlation with each other.

Table 9 Logistic Regression Model (2)

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Shadow_economy	.111	.040	7.836	1	.005	1.117
	BROAD_MONEY	.036	.011	9.794	1	.002	1.036
	Constant	-5.831	1.770	10.857	1	<.001	.003

a. Variable(s) entered on step 1: Shadow_economy, BROAD_MONEY.

Source: Own calculation in SPSS 29

Considering "shadow economy" coefficient of 0,111, it can be concluded that the odds of CBDC implementation are predicted to grow to about 1,117 (Exp (B)). Consequently, if there is a 10-percentage-point difference in the shadow economies of two countries, the country with the higher shadow economy is anticipated to have odds of CBDC implementation approximately $1{,}111^{10}$ or 3,02 times larger than those of the country with the smaller shadow economy. Meanwhile, the broad money has a smaller intensity coefficient of 0,036 which signifies that odds of CBDC implementation are predicted to grow about 1,036 (Exp(B)). If the broad money of two countries differs by 2-percentage-points, the country with a higher share of broad money has predicted odds of CBDC adoption of 1,036 * 1,036 or 1,073.

Table 10 Confusion Matrix

			Predicted		
			Pioneer		Percentage Correct
	Observed		Not Accepted	Accepted	
Step 1	Pioneer	Not Accepted	27	5	84.4
		Accepted	8	19	70.4
	Overall Percentage				78.0

a. The cut value is .500

Source: Own calculation in SPSS 29

Confusion Matrix is one of the existing tools for postestimation analysis which checks how successfully the logistic regression model predicts outcomes. The model properly predicted 27 out of 32 countries where CBDC was not accepted - which is 84,4 percent

of all the cases. Meanwhile countries where CBDC was accepted post-estimation analysis predicted to be 19 out of 27 - which is 70,4 percent.

Table 11 Hosmer-Lemeshow test

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	10.323	8	.243

Source: Own calculation in SPSS 29

Hosmer and Lemeshow Test represents how well the model fits the data. Chi-square value is supposed to be insignificant, which means its p-value should be greater than a conventional significance level of 0.05. In the result there is a high Chi-square value of 10.323 and p-value of 0,243 (Sig.), which means there is not enough evidence to reject the null hypothesis of the Hosmer and Lemeshow Test. Therefore, the model fits the observed data.

3.2 ESG perspectives

Another important part that must be considered is the environmental, social, and governmental aspects of cryptocurrency and CBDC. The environmental issue is usually the main concern regarding cryptocurrencies; however, the thesis shows their impact on the environment is significantly smaller than what the consensus seems to be. The social aspect consists of many factors, one of them being the public opinion on the digital currency matter. Cryptocurrencies can be easily manipulated and there is also a concern regarding their security – these reasons are still the root of the public's distrust in digital currencies. On the other hand, the implementation of CBDC in developing countries where financial institutions are still lacking, (together with widespread adoption of online banking and electronic devices) can be a major aid for the said country's economy. The governance factor seems to be the most controversial one, as centralizing digital currencies would make them no longer autonomous and anonymous, but at the same time many finances related crimes could be avoided. This analysis is especially important after official acceptance of eleven Bitcoin ETFs by US SEC regulator in Jan 10, 2024, which makes Bitcoin trades more open to institutional investors.[34]

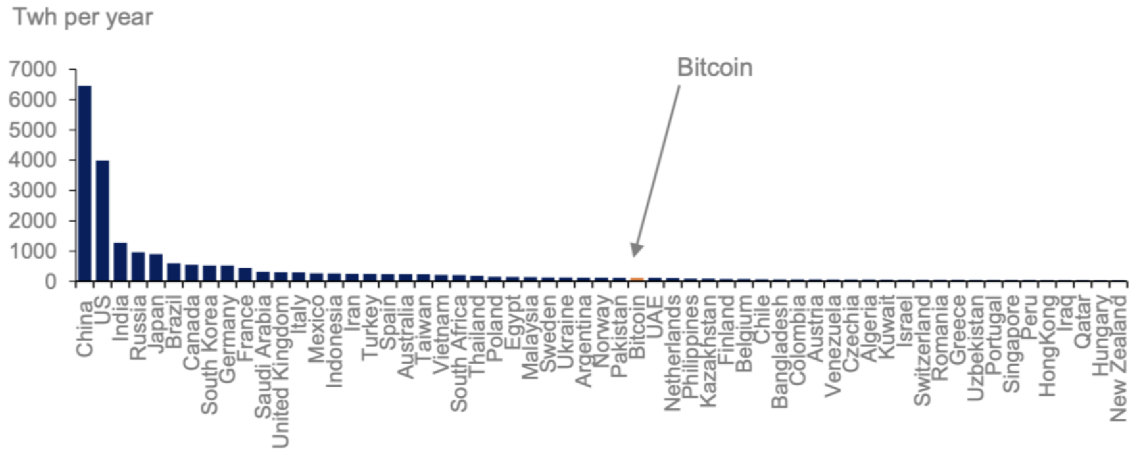
3.2.1 Environmental

The environmental impact of private cryptocurrency like Monera, Dash, Zcash is complicated[35]. The fundamental architectural design of leading private cryptocurrencies, such as Blockchain, is computationally intensive and demands substantial energy input, surpassing the energy consumption of mineral mining for copper, aluminum, or gold to generate equivalent market value. Research suggests that the energy consumption associated with the mining process, particularly for Bitcoin, has experienced a significant increase over the years, now rivaling the annual electricity consumption of entire countries, as it is shown in the graph in Figure 30.

[34] LANG, H., MCGEE, S., *US SEC approves bitcoin ETFs in watershed for crypto market*, Reuters, January 2024, [last access: 29.01.2024], https://www.reuters.com/technology/bitcoin-etf-hopefuls-still-expect-sec-approval-despite-social-media-hack-2024-01-10/

[35] GRAVES, S., *Privacy Coins Monero, Zcash, Horizen 'At Risk' of Delisting by Binance*, Decrypt, January 2024, [last access: 29.01.2024], https://decrypt.co/211717/privacy-coins-monero-zcash-horizen-at-risk-of-delisting-by-binance

Figure 31 Country ranking, annual electricity consumption



Source: University of Cambridge

This energy consumption trend escalates in tandem with the rising cryptocurrency market valuation, posing a heightened concern, particularly with recent substantial price increases. But it is important to know that energy consumption of blockchains does not affect climate change. Renewable energy sources like wind and solar, characterized by their lack of greenhouse gas emissions, contribute to carbon-neutral energy production. Furthermore, several of the new cryptocurrencies address environmental concerns by adopting alternative Blockchain designs, transitioning from the traditional proof-of-work to a more sustainable proof-of-stake approach, as has been made in Ethereum blockchain in the recent update. This shift enhances transaction speed, reducing energy consumption and the scalability of cryptocurrency usage of transactions per second and comparison it to old cryptocurrencies which is presented in Table 12.[36]

European Central Bank (ECB), and Bank of England (BoE) have stated in their public statements, it is increasingly important to consider environmental impact when designing CBDC. Requirement 7b (R7b): Environmentally friendly. The design of the digital euro should be based on technological solutions that minimize its ecological footprint and improve that of the current payment ecosystem.[37]

[36] GRECHINO, N., *Transactions Per Second (TPS),* November 2023, DEV, [last access: 29.01.2024], https://dev.to/fromaline/transaction-per-second-tps-3f8b
[37] ECB, *Report on a Digital Euro*, October 2021.

Table 12 Comparison of old blockchains and POS blockchains by TPS

Old Blockchains	TPS (Transaction per second)	New Blockchains	TPS (Transaction per second)
Ethereum	57	Polkadot	127
BSC	89	Atom	340
Zcash	26	Solana	804
Monera	23	Optimism	150
Bitcoin	9,87	Polygon	166
Litecoin	10	Arbitrum	174
Tron	92	Hedera	3001

Source: Own research based on data in reference [35]

3.2.2 Social

The social dimensions of cryptocurrencies present inherent uncertainties. The high price volatility and the potential for significant investor losses should not be underestimated. Given that transactions often occur in regulatory gray areas, plus the high manipulation of the cryptocurrencies even on Bitcoin (Figure 31). In years 2015-2019 over 1 billion of dollars was administered to the crypto market, from American Express (AXP), Bain Capital, Deloitte, Goldman Sachs (GS), MasterCard (MA), the New York Life Insurance Company, the New York Stock Exchange.[38] In addition there are also retail investors who were investing in ICO boom on Ethereum blockchain[39]. Resulting from this news the price of one bitcoin surged to ATH (all time high) in 2017. In 2018, the sharp drop in Bitcoin price can largely be attributed to a combination of various factors. Firstly, regulatory crackdowns by governments across the world created uncertainty and skepticism among investors. Countries like China and South Korea imposed strict regulations on cryptocurrency trading, leading to a decrease in demand. Additionally, concerns about security breaches and hacking incidents plagued the market, undermining trust in cryptocurrencies. Furthermore, the bursting of the initial coin offering (ICO)

[38] PAGLIERY, J., *Record $1 billion invested in Bitcoin firms so far*, CNN Business, November 2015, [last access: 29.01.2024], https://money.cnn.com/2015/11/02/technology/bitcoin-1-billion-invested/

[39] nfttech.com, *Comparing the ICO Boom of 2017/18 and the NFT Boom of 2021*, January 2022, [last access: 29.01.2024], https://www.nfttech.com/newsroom/comparing-the-ico-boom-of-2017-18-and-the-nft-boom-of-2021

bubble significantly affected investor sentiment. Many projects launched during the ICO craze failed to deliver on their promises or turned out to be scams, causing a loss of faith in the entire industry. Moreover, as traditional financial institutions started embracing blockchain technology and launching their own cryptocurrencies or tokenized assets, some institutional investors withdrew from Bitcoin due to increased competition. This loss of institutional support further contributed to the decline in price throughout 2018. Overall, these combined factors created a negative feedback loop that led to a significant downward trend in Bitcoin's value during that year. Libra, a global virtual currency project initiated by Facebook – has been the subject of many controversial discussions since its announcement in June 2019.[40]

Figure 32 Price evolution of Bitcoin

Source: Own research based on [37-41]

Figure 31 visualizes the price evolution of Bitcoin in relation to significant events that heavily influenced Bitcoin's fluctuation.

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In the beginning of 2021 Elon Musk publicly announcement his total investment of 1,5 billion of dollars into Bitcoin.[41] The end of 2021 and beginning of 2022 was a strictly negative time for all crypto community because of two significant events.

Firstly, the second biggest crypto exchanger FTX has collapsed due to mismanagement of funds, lack of liquidity and the large volume of withdrawals.[42] Secondly, the Terra-LUNA (Terra Luna is a Layer 1 blockchain with a native token Luna, which was providing backing of stablecoin UST) crash in May 2022. Its collapse was triggered by the depeg of the ecosystem's stablecoin UST.[43]

Additionally, cryptocurrency users face challenges related to the security of their digital asset accounts, known as 'wallets'. While the elimination of settlement institutions aims to decentralization, it can become a disadvantage if accounts are compromised or passwords are forgotten, potentially impacting an individual's wealth.[44]

The social perspectives look better as the way to adopt CBDC technology to unbanked people or society with limited access to financial services. The widespread adoption of smartphones and online services would make it easier to set up digital currency accounts, which could be implemented by a Central Bank. This argument holds especially true in emerging and developing nations, where financial infrastructure is less improved than in developed countries, and establishing a bank account may necessitate a consistent income stream. However, the argument can also be reversed: the extensive adoption of digital currency could further disadvantage a segment of society without access to electronic devices and reliant on cash if digital money were to replace cash, whether explicitly or implicitly.

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3.2.3 Governance

Putting aside the recent news about acceptance of the Bitcoin ETF, there are several private cryptocurrencies and unknown answers from governance if the alternative cryptocurrencies (altcoins) are considered as commodity or security. Table 13 represents what by US SEC would be considered as security for the governance based on the Bitcoin example which was officially accepted as a commodity. By the words of Gary Gensler "everything other than Bitcoin is a security"[45]. The first aspect that represents any cryptocurrency as commodity is mining - when computer power is used to obtain a coin or a token.[46]

The private round/sale is the aspect that raises questions from the government, what rules were applied for investors, for the team to organize private round by the juridical side.[47] Airdrop is a way to distribute coins or tokens of new project to community which performs certain tasks on the early stage. It raises questions from regulation authorities if all crypto accounts (wallets) were purely random and not a part of the team builders.[48]

Crypto staking is locking your liquidity to earn rewards, which can be considered as security asset, as a dividend program.[49] Burning supply is the act of effectively removing tokens from the available supply, which decreases the number in circulation, which influences the price of a digital asset.

When it comes to the public round, the question of what kind of digital assets public users were paying to exchange one digital asset for another and if it was legal in a particular country becomes significant.

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[45] LIAN, A., *SEC chair Gensler confirms "everything other than Bitcoin" is a security: Implications and analysis*, CryptoSlate, February 2023, [last access: 29.01.2024], https://cryptoslate.com/sec-chair-gensler-confirms-everything-other-than-bitcoin-is-a-security-implications-and-analysis/

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Table 13 The main criteria for cryptocurrency for being a security

NAME	MINING	PRIVATE ROUND	AIRDROP	STAKING	BURN SUPPLY	PUBLIC ROUND
BTC	X					
XCH (CHIA)	X	X				
DYDX		X	X			
DOT		X		X		X
BNB		X	X	X	X	X

Source: Own research based on 5 different cryptocurrencies

From a governance standpoint, the implementation of CBDC, as opposed to cryptocurrencies, coupled with the integration of Blockchain technology, presents several advantages. The inherent risks of governance deficits could be mitigated through enhanced transparency and traceability in CBDC transactions. These attributes could empower governments or central banks with increased control over money transfers to both citizens and businesses. Money transfers could be aligned with specific purposes or integrated with "smart contracts" – self-executing contracts with terms encoded directly into lines of code. In essence, monetary and fiscal policies could become more targeted and, consequently, more efficient. This approach would also contribute to the increased difficulty of tax evasion, criminal activities, or the financing of terrorism.

4 Results and Discussion

This paragraph sums up the information collected in the Bachelor Thesis in the form of answers to the ten main questions regarding this paper.

1. What were the motives behind money creation?

Initially in the history of money, barter system was the first system allowing the exchange of goods to services or vice versa, but without attribute of „medium of exchange".

The lack of this attribute was a major flaw in the system, which prompted the creation of such "medium of exchange" to make international and internal trade more accessible, improve economic efficiency, promote growth and development and facilitating savings and investment. Moreover, the governments of each country started to create their own mediums of exchange to stabilize the economy and fix financial systems.

2. What are the principal functions of money?

Medium of exchange – money functions as a means of exchange and by that it provides a way to exchange goods or services at a stable price.

Store of value – money functions to save some value for the future. Fiat money is often able to effectively maintain its value over time. For instance, if a person has $100 today, they can expect that the same $100 will maintain its value in five years, without considering inflation. By looking back in history, some commodity money did not have this ability, some of it would dissolve after only a few months.

Unit of account – money functions as a unit of account to offer a standardized measure for evaluating the value of goods and services during exchanges.

3. How has the money and payment system been evolving to the current financial system?

Barter System - before the introduction of any formal currency, societies relied on barter systems where goods and services were simply directly exchanged. However, this system had

its limitations. Making complex transactions was complicated because of no practical way to measure the value. That is what led to the introduction of standardized units of account.

Commodity Money – various commodities such as shells, grain, and metals were used as the first way to standardize the unit of account. Over time the coins representing a specific value were introduced.

Fiat Money – governments began issuing fiat money, its value was based on the trust and authority of the issuing government, rather than any internal value. Fiat money has become the dominant form of currency globally, facilitating economic transactions and serving as a medium of exchange, store of value, and unit of account.

Electronic Payments – the development of electronic payment systems, including credit cards, debit cards, and electronic fund transfers, revolutionized the way transactions are conducted. These systems offer convenient, fast, and secure ways of making transactions, reducing reliance on physical money.

Digital Currencies and Blockchain Technology - the issuance of digital currencies, such as Bitcoin and Ethereum, introduced decentralized payment systems built on blockchain technology. These currencies offer the potential for borderless transactions, increased privacy, and reduced reliance on traditional financial intermediaries.

4. Which historical factors and events have played a significant role in shaping the contemporary financial system?

The Panic of 1907 was one of the first major financial crises of the twentieth century in the United States. This crisis occurred during a speculative boom in the stock and real estate markets, with investors heavily leveraging themselves, exposing vulnerabilities in the financial system. The Panic of 1907 exposed flaws in the banking system, resulting in widespread panic and "bank runs" as trust in banks eroded. J.P. Morgan helped to stabilize the financial system by providing liquidity to struggling institutions. This crisis visualized the need for financial reforms, which eventually led to the formation of the Federal Reserve System in 1913.

Additionally, the adoption of the gold standard and the subsequent Bretton Woods System significantly influenced the global financial scene. The gold standard (from 1870 to 1914) pegged major economies' currencies to gold, providing stability in international monetary

relations. However, the economic challenges of World War I and World War II caused the nation to rethink their financial managements, leading to the Bretton Woods Conference in 1944. This conference resulted in the establishment of the International Monetary Fund (IMF) and the International Bank for Reconstruction and Development (IBRD), and the agreement to peg currencies to the U.S. dollar, which was backed by gold at a fixed price. The Bretton Woods System facilitated global economic interactions but eventually collapsed in 1971 with the "Nixon Shock," when President Richard Nixon abandoned the gold standard, transitioning the U.S. dollar to a fiat currency.

These two main historical events have had the biggest impact on the structure and functioning of the contemporary financial system, shaping international monetary relations and financial regulations.

5. What does the peer-to-peer system stand for?

Peer-to-peer system works without a centralized server. Instead, users online collaborate with each other to distribute content or provide services to other users by making their own processors work as one of the pieces of a one powerful server. In this decentralized approach there is no single server controlling all users' operations, instead the network of users collectively contributes their computer power to problem-solving. This technology was first successfully implemented by Bram Cohen in BitTorrent and then in different blockchains.

6. How is that system implemented in BitTorrent and Blockchain?

BitTorrent was the first program where peer-to-peer system was successfully implemented by Bram Cohen in April 2001. BitTorrent used peer to peer protocol to introduce file sharing in a decentralized way. It allows users to successfully share their files between each other without a centralized organ. The individual users in BitTorrent peer to peer protocol were considered as small pieces of one huge file.

In 2008, a person (or group of people) named "Satoshi Nakamoto" introduced the concept of blockchain in their whitepaper titled "Bitcoin: A Peer-to-Peer Electronic Cash System." The main achievement that they reached was to successfully transfer Bitcoin from one electronic

wallet to another by using the peer-to-peer protocol. Afterwards, many blockchains have implemented this technology, e.g. Polkadot, Solana, Ethereum.

7. What determines the fundamental nature of Bitcoin, and what are the contributing factors to its scarcity?

The fundamental nature of Bitcoin is to be decentralized and non-controlled by the governments. As what Satoshi Nakamoto stated in their whitepaper about Bitcoin: "A purely peer-to-peer version of electronic cash would allow online payments to be sent directly from one party to another without going through a financial institution". The limitation of Bitcoin makes it a scarce resource; the total number of Bitcoin coins is 21million. Moreover, every four years in the Bitcoin blockchain happens a limitation known as "halving", which reduces the annual issuance rate of Bitcoin by 50%.

8. What are stablecoins and how are they linked to fiat money?

Initially, stablecoins were created due to high cryptocurrency volatility, this prompted the market to create standardized unit of account which is tied to the value of traditional state currency. The direct link to fiat money is the fact that each stablecoin that is issued to the market is backed by state currency 1:1.

9. How can the introduction and widespread use of Central Bank Digital Currency (CBDC) bring both advantages and potential challenges?

CBDC is a new technology which changes the way of how the fiat money is considered because of a different way the users can interact with it. The potential threat of CBDC is the question in what hands or group of people or country is it going to be facilitated, due to its nature to be centralized. The government of a particular country has full access to all clients' data and can influence the percentage rate to their personal interest.

The potential advantage of a widespread CBDC is that it is a faster and easier way to transfer money from one country to another. The wired transaction as the way to purchase goods can be more open, countries with high volatile currency can be more regulated and protected by the government.

10. Is there a statistically significant relationship between CBDC adoption in certain countries and their macroeconomic indicators?

The main goal of the Practical Part of this Bachelor Thesis is to illustrate the direct connection between the shadow economy and broad money and the CBDC adoption. Logistic regression analysis proves that the more broad money and unregulated state currency exist in a particular country the more potential there is for a sooner adoption of CBDC.

Additionally, ESG analysis shows that fully decentralized networks, such as Bitcoin, consume a significant amount of electricity. Simultaneously, most cryptocurrencies do not face any regulations from leading countries. This results in their high volatility in the price.

5 Conclusion

This Bachelor Thesis focuses on illustrating the path of money evolution from commodity money, which was not friendly-to-use and lacked universal acceptance, to cryptocurrency like Bitcoin which has an actual value due to the limitation of supply. Simultaneously with that the payment system was also researched, tracing its origins from barter system to modern blockchain technology, eventually reaching the central bank of digital currency (CBDCs).

The most significant historical events which influenced the current monetary system were observed. The Panic of 1907, which led to the creation of the Federal Reserve System in 1913. The abandonment of gold standard in 1971 gave the United State of America power to print their state currency in enormous amounts.

Peer-to-peer protocol was first implemented in BitTorrent by Bram Cohen, to provide decentralized way of file-sharing. Afterwards, blockchain technology was invented by Satoshi Nakamoto to provide a decentralized way of purchase and money transfer.

Stablecoins was observed as a next developing step for crypto-world and crypto society, due to high-volatility of different cryptocurrencies and manipulation in the market. Stablecoins were invented as a little island of freedom for crypto enthusiasts, they let them exchange their high-volatile cryptocurrency to stablecoins. Simultaneously, keeping themselves confidential and not occupied by centralized bank systems.

The potential threats and perspectives are an important factor to consider before taking any steps towards implementation of CBDC. Both factors vary depending on the perspective, on one hand the government power over financial transactions will increase which consequently minimizes the risk of tax evasion, criminal activities, or the financing of terrorism. On the other hand, societies with limited access to electronic devices might become even more excluded in the case of full transition into the use of digital currencies. Additionally, the analysis proves that new blockchain networks have bigger potential for innovations than Bitcoin, for example faster transactions and the ability to build layer two networks for different solutions.

In conclusion, the CBDC technology is an alternative way for society to explore in the present time. While some people want more freedom and to keep themselves anonymous, the Central Bank of Digital Currency provides a more manipulative and controlled way of citizens' financial activity.

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7.3 List of abbreviations

- PoW… Proof of Work
- PoS… Proof of Stak
- USDT… Tether
- USDC… USD Coin
- BUSD… Binance USD
- UST… TerraUSD
- TUSD… TrueUSD
- IBRD… International Bank for Reconstruction and Development
- FRS… The Federal Reserve System

- IMF… International Monetary Fund
- NBER… National Bureau of Economic Research
- P2P… Peer To Peer
- GPU… Graphics Processing Units
- CPU… Central Processing Units
- TWh… Terra Watt-Hours
- DPS… Decentralize Payment Systems
- DLT… Distributed Ledger Technology
- KYC… Know Your Customer
- CLT… Central Ledger Technology
- CIA… Confidentiality, Integrity, Availability
- TPS… Transaction per second