MONETARY POLICY IN THE AGE OF CRYPTOCURRENCIES

Report prepared for

Ethereum Foundation – Academic Research Grant 2022

Prepared by

Binh Nguyen Thanh

binh.nguyenthanh@rmit.edu.vn

Devmali Perera

devmali.perera@rmit.edu.vn

Phong Nguyen Thanh

phong.nguyen28@rmit.edu.vn

Thai Nguyen Vu Hong

thai.nguyenvuhong@rmit.edu.vn

Tra Pham Thi Thu

tra.pham@rmit.edu.vn

Linh Nguyen Thi My

linh.nguyenthimy2@rmit.edu.vn

Tuan Chu

tuan.chu2@rmit.edu.vn

Seng Kiong Kok

seng.kok2@rmit.edu.vn

Keywords: *Blockchain, Cryptocurrency, Economic Growth, Inflation, Monetary Policy, Monetary Systems*

JEL Codes: *E31, E42, E52, O47*

Author notes:

All authors of this report are affiliated with The Business School, RMIT Vietnam.

Acknowledgement:

We are grateful to the Ethereum Foundation for providing financial support for this project (reference number: FY22-0722).

We also acknowledge the support of the research assistants in this project: Duong Nguyen Thuy, Long Nguyen Dich, Mai Phan Ngoc Uyen, Nam Le Ba Thai, Ngoc Bui Thi Hong, and Van Duong Bich.

EXECUTIVE SUMMARY

Money has been the foundational layer for economic activity throughout the history of human civilisations. Sound money that can be reliably used as a store of value, a medium of exchange and a unit of account is critical for economic development and prosperity. Many types of monetary technology have been used since humans started engaging in specialisation and trade. This current report reviews the historical instances of commodity money, commodity-backed money, fiat money and discusses the potential impact of adopting cryptocurrencies with programmatic monetary issuance schedules (e.g., Ethereum and Bitcoin) as legal tender on the economy. The report focuses on programmatic cryptocurrencies only (like Bitcoin and Ethereum) and does not discuss tokenised currencies (like stablecoins).

The report contains three chapters, with chapter 1 discussing the development of monetary technologies throughout history, monetary policies under each monetary regime standard. It compares economic growth and inflation under the gold monetary standard (commodity-backed money standard) and fiat monetary standard. Chapter 2 discusses the potential challenges and opportunities of adopting cryptocurrencies as legal tender. Moreover, chapter 3 conceptualises the difference between the monetary issuance of proof of work and proof of stake consensus rules and their potential implications for money concentration, monetary policy and economic growth. The summary of each chapter is presented below.

Chapter 1: A good is a sound monetary technology when it can hold its economic value over time (salable across time without losing its value), is widely accepted as a medium of exchange (salable across space) and can be easily used as a unit of account (salable across scale). The early primitive types of money used included commodities like salt, seashells and stones, which were then commonly replaced by various kinds of metallic money, with gold and silver being the most prominent metallic monetary technology. The main reasons the world coordinated on metallic monetary technology were mainly due to the ability of the precious metals to hold their value over time, as there was no easy way to increase the supply of precious metals without using high capital expenditure to mine them. In contrast, primitive commodities like salt, seashells or stones became abundant as soon as humans found technologies to greatly increase their supply while minimising the work input into their productions. Nevertheless, even though precious metals were widely accepted, their physicality compromise(d) their abilities to settle as a medium of exchange across geographies and be used as a unit of account.

Due to those reasons, commodity backed money replaced commodity money as the popular monetary technology when (international) trade became more important. Commodity-backed money was in essence (authenticated) papers issued by commodity custodians that allow the holders to exchange the papers into a specified amount of the underlying commodity. As commodity backed money became widely accepted, it became much easier to transfer large commodity-backed values across locations and to use it as a unit of account due to its high divisibility. The commodity backed monetary technology has greatly facilitated trade and collaborations across geographical borders. The most commonly used commodity-backed monetary technology was backed by gold and was widely used until 1971.

In the 20th century the de-facto fiat money regime started in 1971 when the US Dollar stopped to be backed by gold. Since then, fiat monies issued by central banks have replaced virtually all other types of monetary technology on a global scale. A key characteristic of fiat money is the ability of central banks to adjust the money supply to achieve specific economic goals of a country, which is commonly applied by central banks worldwide. There is a strong consensus among academics and policymakers that central banks can help to promote & stabilise economic growth through appropriate monetary policy. Fiat monetary technology is superior to the commodity-backed money in terms of its ability to serve as a medium of exchange and a unit of account. Since fiat money does not need to be backed by physical commodities, its cash settlement is the actual settlement of the economic value exchange and does not require any additional settlements of commodities between the commodity custodians. This salable across space feature was further amplified by the rise of computers and internet, which has allowed users to store and transfer fiat money in electronic form with relative ease, as no commodity settlement is ever required (even though the settlement of fiat money transactions may happen later than at the time of payment).

However, the ability of fiat money to hold its value over time was sometimes compromised in history when monetary policy tools were abused, leading to monetary inflation in various countries. While using sensible monetary policy to stabilise and stimulate the economy, when necessary, could help economic development, inflation could become a significant issue when monetary policies were incautiously implemented.

Studies analyzing the relationship between different monetary regimes and the economic development of countries are limited. A possible explanation is that the availability of

economic data for periods when actual commodity money was used is very limited. However, there are available data on economic development indicators like GDP and inflation for numerous countries for the gold-backed period of Bretton Woods system. Therefore, we conduct a descriptive analysis in this study comparing the economic development (based on GDP growth and inflation data) under the gold-backed periods of the Bretton Woods system with that of the fiat money periods. Based on a sample of economic data for high-, middle- and low-income countries, we find that the average economic growth under the gold-backed Bretton Woods system (until 1971) was higher than under fiat money (1972-2019), while inflation under the gold standard was lower for all country groups. The average inflation rates under the gold standard were lower than under the fiat money period. Moreover, middle- and low-income countries faced significant difficulties with inflation and volatility of inflation under fiat money indicating significant challenges for those countries to maintain stable price levels under fiat money.

Chapter 2: The critical foundation for the functioning of fiat money is that economic agents need to trust centralised financial institutions and the ability of the fiat money to hold value over time as well as the ease of use of fiat money as a medium of exchange and unit of account. The rise of the internet which connects all people and businesses worldwide into a borderless digital economy, has created challenges for the fiat monetary system that relies on trust in analogue centralised financial institutions. In particular, fiat money in bank accounts is not internet-native; therefore, the usage of analogue money or financial services (still) creates friction regarding cost, speed and accessibility. According to the World Bank (2022), 1.4 billion people still need bank accounts. Moreover, the trust of economic agents in the fiat monetary system has been compromised in numerous countries that experienced elevated levels of monetary inflation (e.g., Venezuela, Zimbabwe and Argentina).

The rise of cryptocurrencies like Bitcoin and Ethereum has sparked many discussions on whether cryptocurrencies are superior monetary technologies compared to fiat money. Cryptocurrency advocates often argue that cryptocurrencies could be used as money or even legal tender and might be even superior to fiat money for the economic development of a country. The fundamental differences between programmatic cryptocurrencies and fiat currencies are that cryptocurrencies (1) have programmatic monetary issuance schedule that is difficult to change, (2) are internet-native, potentially allowing more users to use them without

the need to set up bank accounts, (3) are more decentralised in their governance and (4) are inherently global.

In terms of medium of exchange, cryptocurrencies could theoretically lower financial transaction costs and increase financial inclusion due to their digital nature. Nevertheless, the prominent cryptocurrencies still face scaling issues that could induce high transaction costs and low transaction speed at the base Blockchain layer. Although layer2 developments are ongoing, it is still being determined when and if they will be ready for large-scale adoption enabling fast transactions while lowering transaction costs. For example, in the case of El Salvador which has adopted Bitcoin as a legal tender, the inception started with much international attention. However, the adoption of Bitcoin in day-to-day transactions and cross-border remittances still needs to be improved. The store-of-value function of cryptocurrencies may exist in the long term but is significantly compromised by the high volatility of cryptocurrency prices in the short and middle term. The high price volatility would induce high price-risk associated costs to households and firms when they plan their consumption, investment and engage in economic (international) trade if cryptocurrencies become legal tender and firms price goods & services in the cryptocurrencies. Moreover, the high volatility of cryptocurrency prices would also make it highly challenging if debt and credit were to be denominated in cryptocurrency terms as part of legal tender legislation, as the wild price fluctuation would substantially increase/decrease the value of the debt that needs to be served. In terms of unit of account, cryptocurrencies are theoretically almost infinitely divisible making them a great potential monetary technology in that regard. However, the high price volatility of cryptocurrencies dramatically reduces the unit-of-account function, since economic agents would need to re-calibrate prices almost daily or even hourly to denominate goods and services in cryptocurrencies to avoid the risks of making losses.

Moreover, due to the programmatic monetary issuance and the global nature of cryptocurrencies, it is difficult for governments to directly influence the money supply of cryptocurrencies within their jurisdictions making the economies that adopt cryptocurrencies as legal tender vulnerable to economic shocks, since governments would have fewer tools available to stabilise or stimulate the economy. The prominent Mundell-Flemming model suggests that a country (under fiat money) can only achieve two out of the three objectives simultaneously: independent monetary policy, stable exchange rates, and free capital movement. Each of the objectives is a potent tool for policymakers to stabilise and stimulate

the economy. Adopting cryptocurrencies as legal tender would greatly diminish a government's ability to achieve any of the three objectives resulting in no independent monetary policy, no stable exchange rates and no control of capital movements.

The potential challenges require governments to consider carefully whether adopting cryptocurrencies as legal tender is appropriate. For countries with fiat currencies that hold their values well over time and have a well-developed financial infrastructure, the challenges of adopting cryptocurrencies as legal tender could (greatly) outweigh the risks of the adoption. However, countries that do have hyperinflation consistently and do not have a well-developed financial infrastructure, adopting cryptocurrencies may be a potential alternative.

Nevertheless, the purely digital nature of cryptocurrencies has the potential to help to enhance financial inclusion and reduce financial friction if appropriately implemented. For example, some forms of tokenised fiat currencies on the Blockchain technology could be an excellent tool to enhance financial inclusion, as everyone with a mobile phone and internet could potentially use the tokenised fiat currencies for online payment and financial services without the need for bank accounts and traditional financial intermediaries. Cryptocurrency tokens like bitcoin and ether may be akin to (speculative) digital assets, but the technology network Bitcoin and Ethereum are the potent digital financial infrastructures on which governments and industry could build digital financial systems for fiat currencies that increase financial inclusion, lower financial frictions and enhance the financial markets. Moreover, it should be noted that the Blockchain-based financial infrastructure is based on decentralised software that developers and entrepreneurs are improving at a rapid pace. Therefore, over the years it is possible that tokenised fiat currencies and network tokens like bitcoin & ether can complement each other in a digital financial system built on the Blockchain networks helping to achieve financial inclusion and economic empowerment. More research on how blockchain tokens and tokenized fiat currencies can complement each other to enhance financial inclusion and economic empowerment needs to be done.

Chapter 3: We offer insights into how new cryptocurrencies are issued to the blockchain networks via the help of consensus mechanisms. Particularly, a key difference between cryptocurrency and fiat money is the extent to which the issuance of new currencies relies on the decisions of central authorities. Unlike fiat money, cryptocurrency generally does not rely on the central authorities that control the creation of new currencies. Instead, it is based on

network participants issuing new coins into the network through the various consensus mechanisms regarding the shared public ledger (i.e., the blockchain).

We discuss two popular consensus mechanisms, namely, proof-of-work (e.g., Bitcoin) and proof-of-stake (e.g., Ethereum) used to issue cryptocurrencies in various blockchain networks. The two consensus mechanisms issue new coins by rewarding participants who contribute to ensuring the operations of the blockchain networks. In proof-of-work (e.g., Bitcoin), miners devote time, energy, and computational resources to compete with each other in solving cryptographic puzzles to add a new block to the existing blockchain. The miner(s) that solve the cryptographic puzzles first receives a block reward in regarding the blockchain's native coins and transaction fees. In contrast, instead of competing with each other, network participants in the proof-of-stake mechanism, called validators, are chosen to verify transactions and add a new block to the blockchain. The validators are chosen based on the number of native tokens they stake in the Blockchain. After they successfully verify the transaction information and add a new block, the validators also receive a reward in terms of transaction fees and native coins.

While the proof-of-work and proof-of-stake mechanisms generally help assure transparency and coin scarcity and prevent the uncontrolled supply of new currencies, their highly decentralised nature might reduce flexibility in monetary policy in dealing with crises and economic shocks. Moreover, due to the programmatic scarcity of cryptocurrencies, holders tend to hold the currencies for the long term or speculation rather than as a day-to-day medium of exchange. This could impede the widespread distribution of the currencies and, in turn, lead to the concentration of currencies resulting in monetary wealth concentration. High concentrations of ownership could lead to inequality and social unrest, misallocation of resources and rent-seeking behaviours negatively affecting the economic development of a country. There is (theoretical) evidence that proof-of-stake incentivises more ownership concentration than proof-of-work, as currencies can be staked to receive new currencies lowering the need to use/sell the currencies. In proof-of-work, the holders of the currencies would need to constantly (re-)invest in capital and energy to mine more currencies which would require the holders to use/sell the currencies pressuring miners to distribute the currencies.
While the idea of having rules-based monetary policies which network participants can enforce is potent, more research needs to be done to determine what the rules for the monetary policies should be and how to distribute the (new) currencies to the households.

TABLE OF CONTENT

CHAPTER 1: HISTORICAL DEVELOPMENT OF COMMODITY MONEY AND ITS IMPACT ON THE ECONOMIC DEVELOPMENT 10
1. Money and Its Functions 10
2. Stages of Money 11
2.1. Commodity money 11
2.2 Commodity-backed money 14
2.3 Fiat money 18
3. Monetary Policy under Different Money Regimes 19
3.1. Monetary policy targets 19
3.1.1. Monetary policy targets 19
3.1.2. Monetary Policy Tools 19
3.2. Trade-off between inflation and economic growth 23
3.3. Comparison between different money regimes 26
4. Economic Development under Different Money Regimes 28
5. Conclusion 35
CHAPTER 2: CHALLENGES AND OPPORTUNITIES OF CRYPTOCURRENCY ADOPTION AS LEGAL TENDER 36
1. Introduction 36
2. Background of cryptocurrency 37
2.1. Cryptocurrency 37
2.2. Cryptocurrency, fiat money and commodity money 39
3. Monetary Policy under Cryptocurrency 42
3.1. Monetary policy tools 42
3.2. Capital controls 43
3.3. Comparison between different money regimes 45
4. Possible Economic Development under Cryptocurrency Adoption as Legal Tender 46
4.1. Volatility of cryptocurrency prices 46
4.2 Economic growth 48
5. Case studies of Cryptocurrency Adoption as Legal Tender 49
5.1. Case of El Salvador 49
5.2. Case of the Central African Republic (CAR) 51
6. Challenges and Opportunities of Adopting Cryptocurrency as a Legal Tender 52
6.1. Challenges of adopting cryptocurrency as a legal tender 52

6.2. Opportunities of adopting cryptocurrency as a legal tender 56
7. Discussion and concluding remarks 58
CHAPTER 3: IMPLICATIONS OF PROOF-OF-WORK AND PROOF-OF-STAKE ON ECONOMIC DEVELOPMENT 60
1. Background 60
2. Consensus Mechanisms 60
2.1. Proof-of-work & Consensus Mechanisms 60
2.2. Proof-of-stake consensus mechanisms 61
3. Proof-of-work, Proof-of-stake, and Monetary Policy 62
2.1. Issuance of new coin 63
2.1.1. Issuance in proof-of-work protocols 63
2.1.2. Issuance in proof-of-stake protocols 63
2.2. Control over Monetary Supply 66
2.3. Trade-off between Inflation and Growth 67
2.3.1. Proof-of-Work Implementation 67
2.3.2. Proof-of-Stake Implementation 68
3. Proof-of-work, Proof-of-stake, and Economic Development 70
3.1. Proof-of-Work Implementation 70
3.2. Proof-of-Stake Implementation 71
4. General Discussion and Conclusion 72
REFERENCES 75
Appendix 1 92

CHAPTER 1: HISTORICAL DEVELOPMENT OF COMMODITY MONEY AND ITS IMPACT ON THE ECONOMIC DEVELOPMENT

1. Money and Its Functions

There is an ongoing debate about the history and definitions of money among scholars. While anthropologists assert that money has been used as a "unit of account" in temples and palaces since the era of ancient Mesopotamia Spread (2022), economists assert that money first appeared in the era of barter exchange and served as a generally accepted "medium of exchange" (Ammous, 2018a). The notion of money has emerged in order to solve the issues in the barter system; hence, Menger (1892) attributes the origin of money to be a consequence of social institutions rather than being a consequence of state regulations. Even though there is still no consensus regarding the definition of money, the widely adopted definition of money in economics defines money based on its functions: being a medium of exchange, unit of account and store of value. The salability of a good is the most important factor in determining whether it can be freely exchanged as money on the market. The ease with which a good may be sold on the market at the lowest possible price loss whenever its owner requires it is referred to as salability (Ammous, 2018a). The suitability of any good to serve as money depends on its degree of salability across scales to function as a unit of account, across space to function as a medium of exchange, and across time to function as a store of value.

A good is salable across scales when it can be easily split into smaller units or aggregated into bigger units, hence enabling the owner to exchange it in any quantity required. Money is a typical metric for measuring the value of various goods (Cohen et al., 2019). In an economy without money, each good and service should be priced in terms of each other to determine the quantity of exchange. For example, if we want to exchange fish with rice, we need to determine the quantity of rice that we will exchange for one fish. All goods and services are valued in terms of generally recognized money. To be an acceptable medium of exchange, an item must be salable across space (Ammous, 2018a). In other words, money should be easily accepted in numerous geographical locations, transportable and transferable throughout space.

For a good to be a suitable store of value, it needs to be salable across time, i.e., a good need to retain its value into the future, thereby allowing its owners to store wealth in it (Ammous, 2018a). Money should allow one to store economic wealth in a form that will not spoil, die, disintegrate, vanish or lose significant value over time (Mankiw, 2021). For instance, commodities like fish and salt are perishable in nature. These perishable goods can be exchanged for money to preserve their exchange value, then use this money to purchase other

items that one may need in the future. For money to preserve its value in the future, it is important to have constraints on the supply of the commodity considered as money. Commodities such as seashells or stones were abundant in supply, and it was difficult to control the supply of that. However, precious metals such as gold and silver has served well as money since their supplies are quite limited, and also because it is difficult to produce such metals using man-made processes.

To summarize, money is a good purchased primarily for the purpose of exchanging with other goods (in the future) rather than to be consumed or used in the production of other goods (Ammous, 2018a). According to Mishkin (2019), money can be anything that is generally accepted as payment for goods and services or in the repayment of debts. Hence, when money is used as the medium of exchange, the double coincidence of wants of both buyers and sellers is not necessary in order to complete the exchange process. Any good that serves as well-recognized money must fulfil all three essential roles of money: medium of exchange (and saleable across space), store of value (and salable across time), and unit of account (salable across scales). In the next section, we will discuss the historical development of money under commodity money, commodity-backed money and the fiat money periods.

2. Stages of Money

Money has evolved through several stages, from barter to commodity money, paper money, and credit money (Samuelson, 1976, as cited in Focardi, 2018). In history, before money was invented, people exchanged one good or service for another using the barter system. However, this exchange was inconvenient because it required the counterparties' needs and available products to be compatible with each other, which is known as a "double coincidence of wants" (Jevons, 1875, p. 3). Even if both parties have the matching products and are willing to exchange their goods with each other, counterparties would still be reluctant to trade if both parties agree on the quantity of each product to be traded (Kregel, 2021). Therefore, early societies commenced using generally accepted commodities such as grain, cowry shells, seashells as "money" to overcome these issues in trade.

2.1. Commodity money

Commodity money means money in the form of any commodity. In early societies, commodity money was used both as a measure of value and as a means of payments. The Aztecs, during early Spanish colonization and the classical Maya of Mexico in the 16th century, used cocoa and salt as money to pay for labor and tribute (Gentle, 2021; McKillop, 2021). There are many opinions about when seashells were used as money. Gamble (2020) states that seashells have been used since 2000 BC. Seashells were polished and made into jewelry and spiritual items

and those were used to exchange for other goods. Commodities such as seashells, salt and cocoa beans performed better than grains or any other perishable agricultural commodities as a medium of exchange and store of value, because they are not quickly perishable. In addition, salt, cocoa beans, and seashells are easily counted by kilograms, meeting the unit of account function.

The use of Rai stones as money in Yap Island is another example for commodity money (Ammous, 2018a). Rai stones were limited in supply as Yapese had to quarry them from another island and shipping was costly to bring them to the island. In addition, the owner of large stones could use it for payment without moving it as these stones were not divisible or movable. Cigarettes are another example of a commodity money used during World War II. Prisoners of war utilized cigarettes as the medium of exchange, a unit of account, and a store of value to trade for different goods and services with one another in prisoner-of-war camps. Even nonsmokers were content to receive cigarettes because they knew these cigarettes could pay for other products and services (Mankiw, 2021).

With the advancement of technology, societies started inventing new forms of durable money instead of using commodities such as seashells, stones, beads, cattle and salt. The Mesopotamian human civilization evolved into a large-scale economic system based on commodities and commodity money. Around 2150 BC, the city-state of Sumer invented the shekel, a coin-like currency representing the weight of barley held in storage (Focardi, 2018). Shekels also represented precious metals such as electrum, silver, and gold. The value of a Shekel varies depending on the period, region, and government and the use of Shekels was extremely widespread. In approximately 3500 BC, the temple administrators adopted a unified accounting system in the Sumerian economy, using the silver Shekel as the fundamental monetary unit. The comparable value of a Shekel was related to barley, whereas the weight of one silver Shekel was equal to one bushel of barley. The Shekel was divided into 60 minas, and each mina represented an equivalent amount of grain. Instead of being a result of business transactions, the shekel served as a tool for court administrators to manage resources and move them across departments (Graeber, 2012).

Along with the development of money, early societies that had mastered metallurgy exchanged goods using metal ingots, silver bullion, and unmarked bars. According to anthropologists, the coins were first minted in the Iron Age kingdom of Lydia, located in the Ionian Sea, approximately 600 BC (Focardi, 2018). They also suppose that the first widespread currency was caused by enslavement and (mercenary) warriors. Lydian soldiers looted women and metals like silver, gold, and electrum. Gold and silver were mined by slaves whereas

Electrum, a naturally occurring alloy of gold and silver, was melted down and used to pay the wages of the warriors (Focardi, 2018).

Strict regulations regarding weights, sizes, values, and metal compositions were followed for producing and circulating coins made of brass, bronze, copper, silver, and gold (Focardi, 2018). At the end of the 6th century, private metal workers, who held the metal, were permitted to mint coins throughout the post-Roman Frankish kingdoms. This caused the currency to become fragmented (Fourquin, 1990, as cited in Focardi, 2018). Because the Carolingian borders were too extensive, it was a challenge for the first emperor of the post-Roman West, Charlemagne, to control and exert effective imperial power to mint coins. Besides, the massive economic disruption caused by the Viking Great Army diminished the availability of royal money. That was likely one of the factors that contributed to the rise of non-royal currency throughout France in the 880s (Focardi, 2018).

People who own metals are actually the rightful owners of coins. Hence, the issue of money distribution is relegated to the issue of metal distribution. The sovereign could charge a coinage tax (seigniorage) on the minting process to make a profit. Even if the value of the newly minted coins is same as the value of the metal, seigniorage can still be used. In case of more than two metals are used to mint a coin, the value of a coin is not necessarily correlated with the value of the metals. The weight, fineness (metal content), insignia, and nominal value of each coin to be produced are normally imposed – or attempted to be imposed – by governments or sovereigns. Regarding the organizations that mint coins, the issue mainly relates to the minting processes and the legal tender. A mint may be a government-owned institute or a business with a license from the issuing body. The ability to mint coins may be granted to the sovereign or shared with other individuals who have authority, such as nobility or high-ranking members of cults. If anyone has metal and can turn bullion into coins, then we say this place offers free minting. However, there was still a fee to pay for the cost of minting and seigniorage that should be paid for the sovereign. Coins become legal tender only if the state accepts them for payments and for repayments of any debt.

Gold, silver, iron, copper or bronze are metals with intrinsic value in the industry and used as input for creating jewelry (Focardi, 2018). These metals were more durable and valuable than other commodities and were easily divisible. Commodity money based on metal moved societies into its next phase of civilization as it eliminated the necessity for seeking an appropriate counterparty for a successful trade. Commodity money with intrinsic value has advantages in providing a tangible value and serves as a hedge against inflation. However, the bearer of the commodity money is metal forms still faced with difficulties faced while

transacting and transporting money (Kregel, 2021). For example, while commodities such as gold and silver may hold their value over time (salable across time) due to their limited supply and high production cost, they are not optimal mediums of exchange and unit of account since they are difficult to transport (not salable across space) and lacks divisibility (not salable across scale).

To address these challenges with commodity money, early societies developed a new monetary method that preserved the store of value benefits of commodity money while also enhancing its salability across space and scale characteristics. This new form of money is known as commodity-backed money (Focardi, 2018). We will discuss the evolution of commodity-backed money in the next sub-section.

2.2 ***Commodity-backed money***

Commodity-backed money means when a currency used in the country can be directly converted into a commodity. In history, the authorities issued papers such as IOUs to represent money that can be used in transactions, but the holder of that paper money could anytime convert that into the underlying commodity. It was not necessary for the bearer to carry the commodity while transacting; instead, a more practical substitute may be utilized to represent the original form of money. To be a genuine form of representative money, there must always be something valuable backing the face value of the paper money represented. Therefore, compared to commodity money, commodity-backed money was more salable across time and across space as it was easy to transport commodity-backed money. However, the supply of the commodity-backed money was limited to the availability of the metal used for coins.

Gold played a pivotal role both as commodity money and as commodity-backed money. A stable exchange rate promotes international trade and loan activities among countries. Individuals could now keep their wealth in gold at banks and use paper receipts, bills, and checks to transact of any size. This made gold-backed payments possible on any scale and integrating all key monetary salability features into the gold standard (Ammous, 2018a). Hence, the gold standard discussed below is a prominent example of commodity-backed money.

The classical gold standard system (1875 to 1914)

Before 1870s, most nations adopted a bimetallic standard based on both gold and silver. During the bimetallic period, the exchange rate between currencies was determined either based on silver or gold content in the coins. The exchange ratio between the two metals was fixed and only the metal with ample supply was used as money. Countries such as United Kingdom, United States, France, China, India, Germany and Holland were on the silver standard (Eun et

al., 2020). When more gold mines were discovered, the supply of gold increased, and governments eventually abandoned bimetallism and started using only gold in their monetary systems.

The era between 1875 and 1914 marked a golden age of rapid economic expansion and unrestricted movement of capital and labor across borders (Bordo, 1981). The gold standard was first established in Great Britain in 1821 when the Bank of England redeemed all their notes for gold. France (1850), German (1875), the United States (1879) and Russia and Japan (1897) also adopted the classical gold standard. The gold standard was a commitment of participant nations to fix the value of their domestic currencies based on a predetermined quantity of gold (Bordo, 1981). These fixed prices were maintained through nations that would purchase or sell gold at that price. Hence, the international monetary system was stable, and many nations could achieve significant growth in their economic development and international trade. The Bank of England is credited with stabilizing the gold standard systems at this time by serving as the world's last resort lender (Eichengreen & Flandreau, 1997).

During the gold standard, gold and local currencies were convertible in both directions at a fixed ratio, and countries were free to export and import gold. The money supply of a country was limited to the stock of gold available in that country. Gold also acted as a good store of value. In this monetary system, the misalignment of exchange rates and imbalances in the balance of payment accounts of countries would be automatically corrected via free capital flows in the form of gold between the countries. There were some limitations of this standard. First, the stock of gold is inherently limited, and it cannot be increased by man-made processes. Hence, a restricted supply makes it difficult for countries to expand their economic growth and investments. Second, there were no means of persuading countries to adhere to the gold standard. As a result, governments have the choice of abandoning the gold standard whenever it is essential to manage monetary policy in order to accomplish their economic goals.

The Interwar period (1915 – 1944)

The beginning of World War I pushed the gold standard into collapse in 1914. Following World War I, Austria, Hungary, Germany, and Russia experienced hyperinflation and financial instability, resulting in chaotic financial and monetary situations. Besides, there were international disagreements over the sizable payments for war debts and reparations. Credibility and collaboration, the two pillars that had kept the pre-war gold standard in place, began to deteriorate during this time (Eichengreen & Flandreau, 1997). First, it was a big challenge for the credibility of the system when several political and economic events upended the specific constellation of political power that had been the basis for policymaking before

1913. Second, the level of collaboration after the war was ineffective due to restrictions and international political conflicts. As a result, the administration and redesign of the gold standard system were hampered. The countries suspended the gold standard and imposed restrictions on exporting gold.

When major countries recovered from the war and stabilised their economies, the gold standard was reinstated and returned to pre-war gold prices to achieve a fixed exchange rate system again. The United States reinstated the gold standard in 1919. Despite being forewarned that the pound would become overvalued, the United Kingdom returned to gold at prewar parity in 1925. After that, France, Switzerland and other Scandinavian countries also reestablished the gold standard by 1928. By 1929, most industrialised countries had shifted back to the gold standard (Eichengreen & Flandreau, 1997). However, the Great Depression in 1929 caused the collapse of the banking system and drastically depreciated the value of the Pound. Following that, the United Kingdom, Canada, Sweden, Austria and Japan abandoned the gold standard in 1931, the United States followed suit in 1933 and France in 1936 (Eun et al., 2020).

The Bretton Woods System (1945 – 1972)

In July 1944, 44 countries gathered to design a post war monetary system that would again allow countries to maintain exchange rate stability while promoting the economic growth of their countries. In this system, USD was pegged to gold at the rate of $35 per ounce of gold and other countries fixed the par value of their local currencies to USD. All members were encouraged to establish a par value but fluctuations withing a margin of 1% were allowed. In this system, only USD was directly convertible into gold but not any other currencies. Hence, other countries could hold reserves in the forms of both gold and USD. The reserves in USD or any other strong currencies could earn interest on that whereas gold reserves did not provide such returns. In addition, countries could also save the cost of transporting gold between countries. During the time of the Bretton Woods system, the global economy expanded significantly with the support of the stable exchange rate regime.

The loss of confidence in the USD made it difficult to preserve the Bretton Woods system (Meltzer, 1991). According to Triffin (1960), Kenen (1960) and Gilbert (1968), the gold-dollar system was destined to be dynamically unstable in the long run. In order to maintain the equilibrium in this system, the United States had to maintain a deficit in their balance of payment account and supply dollars for other countries. When a country maintains a large balance of payments deficits constantly, the people lose confidence in that currency. The United States had persistent trade deficits during the late 1950s. The first crisis of confidence was the gold rush in October 1960, when speculators forced the price of gold on the London

market from $35.20 to $40 (Bordo, 1993). Growing gold shortage and rising U.S. inflation during 1960s weakened the dollar's link with gold. Midway through the 1960s, global gold output levelled off and even dropped in 1966, but private demand increased resulting in a fall in the global monetary gold stock after 1966. In 1968, a speculative attack on the world's monetary gold stock led to the demise of the Gold Pool, even though the inflation rate increase was moderate by the standards of the decade that followed (Bordo, 1993). The US monetary authorities were concerned that private speculation in the gold market would lead to official conversion demands and hence, quick corrective action was taken. The Treasury provided the Bank of England with enough gold to maintain stability, and the financial institutions of ten countries agreed not to purchase gold beyond $35.20 per ounce. It was successful in stabilizing the price of gold during the following six years, but it did not prevent the United States from gradually reducing its gold holdings (Meltzer, 1991). In addition, the International Monetary Fund (IMF) introduced Special Drawing Rights (SDR) in 1969 as a new reserve asset to cater to this problem with USD. The SDR was established by the IMF as a fractional quantity of gold equal to one US dollar (Bordo, 1993).

The depreciation of the pound forced the United States to eliminate the need for a 25 percent gold reserve against Federal Reserve notes on March 12, 1968 (Johnson, 1968). The primary outcome of these new arrangements was gold's marginal demonetization. As speculation against the dollar intensified, the reluctance of other central banks to accept dollars in settlements grew. Nevertheless, these efforts to protect the USD-based gold standard system were not successful. The USD was significantly overvalued in the foreign exchange market and the United States was unwilling to maintain the Bretton Woods System. In August 1971, the US government suspended the convertibility of USD into gold and restricted importing gold from US to the rest of the world. That marked the end of the commodity-backed money period because most countries commenced adopting floating exchange rates and adopted a fiat money system that is not backed by any commodity.

In conclusion, the commodity backed money could provide stability for the economies as the exchange rate was fixed based on the supply of commodities used for backing the money. Hence, the monetary system was less prone to inflationary or deflationary pressures. In addition, commodity-backed money has an intrinsic value deriving from the real value of the commodity and hence, gold is vulnerable to speculative attacks. For example, gold’s value is derived from both the industrial demand and the demand from those who hold gold as money. If gold's monetary premium rises, this may become difficult for industry to acquire enough gold as inputs for production. If industrial demand rises, gold becomes more valuable to the

holders of gold and more expensive to anyone who wants to buy gold (Ammous, 2018a). These limitations in commodity-backed money and the collapse of the gold standard system paved the way for the fiat currency system.

2.3 Fiat money

The end of the Bretton Woods and gold-backed monetary system created a need for another form of monetary system. This led to the creation of government money known as fiat money. There are two types of fiat money: commodity-backed fiat money and irredeemable fiat money. The commodity-backed fiat money is a government printed money that can be redeemed for gold or any other commodity. The irredeemable fiat money does not have such commodity backing granted by the government. In this monetary system, the government holds the sole authority to issue and print fiat money and has the discretion to raise the money supply whenever it is required to support economic growth or to repay the national debt. In this paper, fiat money exclusively represents irredeemable fiat money, i.e. not convertible to any commodity at a fixed rate. All subsequent discussions are focused on irredeemable fiat money.

Some authors believe that this current fiat money has no intrinsic value, which is only backed by the trust on the sovereign entity (Bjerg, 2016; Gross & Siebenbrunner, 2019; Peie et al., 2017; Perkins, 2018). The state would determine the value of fiat money based on the demand which is used as the medium of exchange to pay taxes, duties, fines and other obligations (Bjerg, 2016; Gross & Siebenbrunner, 2019; Mainelli, 2010; Perkins, 2018). However, Senner and Sornette (2019) believe that the creation of current money relies on the whole macroeconomic environment where trust occurs in society rather than just the demand from the government used to pay taxes. Specifically, the current fiat money, such as USD or EUR, is created based on the complex hierarchy of money universally claimed by society. In other words, it could be defined as the universally trusted I Owe You (IOU) (Senner & Sornette, 2019).

As fiat money no longer settles with commodities, it became more saleable across space and scale, since it can be readily split into subunits and transported. Furthermore, with advanced technology, fiat money now can be used in electronic form as well, thus furthering these two characteristics of salability (Ammous, 2018a). However, the third element "salable across time" which refers to the store of value function of the fiat money is difficult to handle. In certain ways, fiat money may be exchangable for anything for sale, including gold or other metals. Yet, exchange occurs at market price, which means that there is no fixed exchange rate between fiat money and anything in the market. As a result, the value of fiat money can fluctuate and sometimes erode over time. (Focardi, 2018).

3. Monetary Policy under Different Money Regimes

3.1. Monetary policy targets

3.1.1. Monetary policy targets

Monetary policy pertains to the various strategies employed by a nation to regulate the quantity of money available in an economy (Friedman, 1995). The two main types of monetary policies are contractionary and expansionary monetary policy. A contractionary policy aims to decrease inflation and slow down economic growth by increasing interest rates and limiting the amount of money circulating in the economy. This helps to combat the rising prices of goods and services, which can then reduce the purchasing power of money (Mallick & Sousa, 2012). In contrast, an expansionary policy seeks to stimulate economic growth by increasing the money supply at a faster rate or lowering short-term interest rates. This can encourage spending and investment in the economy. The monetary policy is controlled by the central bank of a nation; thus, it is applied to the whole domestic economy and people in that nation. However, for large economies such as the US, because of globalization and interdependence among countries, the monetary policy of a country can also affects other countries. To be specific, the expansionary money policy is applied during recession or in anticipation of a recession to stimulate consumption and investment. Besides, when the economy is growing too fast, leading to inflation, contractionary policy is applied to stabilize the price level in the economy. Overall, monetary policy assists governments in maintaining their target interest rates, asset prices, and exchange rates for currencies in order to achieve the expected level of economic growth.

3.1.2. Monetary Policy Tools

In this section, we raise the question of what monetary policy tools were adopted under each monetary system in history and the interesting implications on the ability of the authorities to control the quantity of money in circulation under each regime. Our aim is to examine the levels of flexibility in the control of money supply offered by different monies and authorities' actions, which in turn might have the ramifications of inflation or deflation in subsequent periods.

Monetary policy under fiat money relies on three primary tools: interest rates, reserve requirements, and open market operations (Mankiw, 2021). Firstly, open market operations involve buying and selling securities in the open market to regulate the money supply in the economy. When the central bank purchases securities, it has several impacts: (1) it increases the reserves of commercial banks, a basis on which they can expand their loans and investments; (2) it raises the price of government securities, which reduces their interest rates;

(3) it generally lowers interest rates, which can encourage business investment (Mankiw, 2021). Conversely, if the central bank sells securities, the effects are reversed. Secondly, the central bank can also expand the money supply directly by reducing interest rates, which can encourage households and businesses to borrow money more easily, promote consumption and investment in the economy. This can result in higher economic growth and more money circulating in the economy. Conversely, increasing interest rates can have the opposite effect. Another way to implement monetary policy is by adjusting reserve requirements. This refers to the amount of cash that banks are required to keep in the central bank as a reserve and hence, cannot lend that reserve money. When reserve requirements are high, there is less money available for lending, which decreases the money supply. On the other hand, lowering reserve requirements can stimulate the economy by increasing the amount of money available for lending.

The extent to which the impacts of the availability of money in circulation affect economic growth has attracted the researchers' attention for a long time. Some economists postulate that money supply has an active role to play in economic growth (Chaitip et al., 2015; Matres & Le, 2021). A well-regulated increase in the money supply is expected to boost an orderly economic expansion, and a contraction in the economy can be a result of a decrease or a small increase in the quantity of money (Chaitip et al., 2015). A widespread, comprehensible opinion among economists is to view the control of money supply as the most crucial aspect of monetary policy which authorities implement to meet desired performance outcomes such as boosting economic growth, cooling down the overheated economy or achieving stabilization targets (Tolley, 1957). Whittlesey (1956) goes further emphasizing the importance of changes in the money supply as the required condition rather than a mere cause for realizing growth potentials, and subsequently retaining the growth achievements.

Given the relevance of the money supply to economic growth, we must consider the role of the issuing authority in money supply management. Hence, in the following sub-sections, we summarize the monetary policy tools adopted, and the ways authorities managed the money supply under different money regimes.

Under commodity money

During the commodity money period, the use of monetary policy was relatively limited. It was challenging for governments to control the money supply because the supply of some goods such as seashells, salt, cocoa beans was unlimited in nature and can be easily exploited in everyday life. This uncontrolled supply reduces the influence of sovereign in the usage of these commodities as money, particularly as the production costs of those commodities declined. In

the example of Rai stones in Yap Island mentioned in a previous section, once an American captain named David O'Keefe had used explosives to quarry more stones and brought them into the Yap Island to exchange stones for coconut (Ammous, 2018a). This is a good example of increasing the money supply under commodity money period using advanced technology. Nevertheless, the village head has refused to accept his stones as money because it is not obtained in the traditional methods and hence, did not allow villagers to accept his stones in exchange for coconut. This proves the fact that any commodity to be considered as money should be generally accepted by everyone in that society. Hence, social acceptance acted as an important barrier to raise the money supply during this time.

When societies commenced using metals as money, that provided an opportunity for the government to involve in the monetary system to manage the money supply by mining and adopting these metals as legal tender. These metals were favored as medium of exchange due to their homogeneity, which allowed for higher and more consistent price denomination and increased salability compared to perishable commodities such as salt, cocoa beans, seashells, etc. (Ammous, 2018a). During this time, governments encouraged bullion owners to mint the metal and create more coins, but these coins will only be considered as money if the government decrees them to be money.

As mentioned previously, metals also has a limited supply in nature. In war times, it was hard for a monarch to gain a large sum of money through taxes or bonds sales. Thus, they had less choice but to debase the currency value to gain a quick supply of liquidity (Redish, 1993). A prime example of an extreme currency debasement is of the Denarius silver coin whose silver content was lowered from 90% to 2% pure silver by the Roman governments (Pense, 1992). Associating the Denarius with the pay of the army provides a primary reason for currency debasement. Hence, Denarius debasement was a quick and a simple solution to generate more coins to raise the money supply at that time (Pense, 1992). Hence, governments allowed debasing the coins, that reduces the real value of the coins but increased the money supply.

Under commodity-backed money

Adherence to the gold standard is believed to help reduce the danger of inflation by tying the hands of policymakers who may be prone to misusing monetary policy for large budget deficits or short-term benefits as the money supply was limited to the stock of the gold belonged to a country (Bernstein, 1980; Ferguson & Schularick, 2012). During the times of unexpected economic crisis that causes sudden shortage of liquidity, the authority's ability to control the money supply is of paramount importance in order to prevent the risk of insolvency (Alves et

al., 2021). This resembles the core function of central banks acting as lenders of last resort, which should act quickly to supply liquidity to distressed banks (Repullo, 2011, as cited in Alves et al., 2021). However, the role of the gold standard in avoiding political manipulation by limiting the authority's ability to expand money supply would be counterproductive and backfire during times of crisis. It is because economies are susceptible to monetary shocks that require room for flexibility in monetary policy to stabilize the shocks (Niehans, 1978). The classical gold standard, which lasted from 1880 to 1914, collapsed during World War I as a result of key belligerents embracing inflationary financing (Bordo, 1981). From this instance, one can observe that despite the inflationary hedge the monetary system offered, the authority was still in control of deciding if a country should adopt or "temporarily" suspend the gold standard in the interest of the nation.

The gold standard was reinstated in the 1920s until 1931 when Britain departed from gold, followed by the US in 1933 during the time of the President Roosevelt (Bordo, 1981). Post-World War I was the period of easy credit for economic recovery that resulted in a huge boom in stock prices, not to say economic bubbles throughout the 1920s (Eichengreen & Temin, 2000). Therefore, in January 1928, the Federal Reserve embarked on a tight monetary policy, but in an abrupt and drastic manner (Crafts & Fearon, 2010). When the implications of the FED's drastic action took a detrimental effect on the economy, efforts to change monetary policy were required to prevent the harm from deepening.

The gold standard limits one of the most powerful tools against bank runs, which is the authority's ability to act as lender of last resort by expanding the scope of liabilities (Eichengreen & Temin, 2000). According to Crafts & Fearon (2010), the absence of an aggressive policy response during the Great Depression in 1929-1931 was a principal reason for the perpetuating economic depression. Had it not been for the immediate policy reactions during the financial crisis in 2007-2008, that economic recession would have had possibly turned into "the second Great Depression" in history (Wheelock, 2010).

Under fiat money

Under the fiat money system, as mentioned in the previous section, the money supply can be controlled by the reserve requirements, interest rates and open market operations. The majority of nations maintain gold, fiat currencies issued by other nations and SDR issued by the IMF as reserves under this system. In this monetary regime, governments has direct control on the money supply. Traditionally, banks borrow from the central bank discount window and pay the discount rate as interest on these loans. In response to hyperinflation, the central bank can adjust the discount rate to modify the money supply. A higher discount rate increases the cost

of borrowing, which inhibits bankers from borrowing, thereby reducing the quantity of reserves held by the banking system and the money supply. In contrast, a lower discount rate stimulates banks to borrow from the central bank, hence increasing reserves and the supply of money (Ennis & Keister, 2008).

However, when the financial crisis occurred, asset's value sharply decreased, firms and individuals failed to pay their loans, and financial institutions faced liquidity shortages. At the time, central banks were questioned about whether traditional monetary policy was becoming inadequate or obsolete (Duarte, 2019). Due to the fact that nominal interest rates were capped at zero, and reserve requirements for banks cannot set at such a low rate due to the risk of bankruptcy (Chen & Phelan, 2022). When interest rates were nearly zero, the economy faced the risk of liquidity trap in which people are disincentivized for investments and instead choosing to hoard cash (Bordo et al., 2018). It restricts the recovery of the economy. As a result, a new unconventional monetary policy is adopted to overcome the problems of global financial crisis.

One alternative for the central bank is maintaining low interest rates for a sustained time frame. The assurance that interest rates will stay low under forward guidance may encourage investment spending even if the central bank's current objective for the interest rate cannot be lowered further (Ennis & Keister, 2008). For example, in the United States, the interest rates were kept low until nominal GDP showed significant growth, hence the consumption and investment can be recovered (Duarte, 2019). A second alternative for the central bank is conducting expansionary open-market operations through a wider range of financial instruments (Duarte, 2019). Typically, the Federal Reserve purchases short-term government bonds to engage in expansionary open-market operations. Since it enhances bank reserves, this unconventional monetary strategy is referred to as quantitative easing (Mankiw, 2021). Throughout the Great Recession, the Federal Reserve employed both forwards guidance and quantitative easing (Ennis & Keister, 2008).

In conclusion, it is apparent that the state has greater control over monetary policy under the fiat money regime. The primary goal of monetary policy is to promote economic growth and stability. The next section discusses the trade-offs that governments may encounter while implementing monetary policy.

3.2. Trade-off between inflation and economic growth

The correlation between inflation and economic growth has been the subject of ongoing interest among researchers. Earlier, economists argued that high inflation rates could only be curbed at the expense of reducing output (Gregorio, 1991). Hence, there is a tradeoff between economic

development and maintaining stable inflation rates (Easterly & Fischer, 2001). When the economy is growing rapidly as a result of expansionary monetary policy that creates more favorable financing conditions for businesses to borrow and households to invest more, inflation might be induced (Andrés & Hernando, 1997). However, for a proper assessment of the linkage between growth and inflation, it is vital to consider the time horizon over which the relationship is examined. Guitián and Mundell (1996) pointed out that in the short run, bringing inflation down requires sacrificing economic expansion, while the long run inflation rate has a minimal impact on the long run growth rate assuming that the inflation rate is not too high over the time period.

Regardless of the consideration of geographical location, it is widely agreed among economists that persistently high inflation levels will jeopardize long-term growth prospects (Guitián & Mundell, 1996). Hence, maintaining low inflation is critical for sustaining growth over the long run. Espinoza et al. (2012) show that authorities of developing countries should maintain inflation below the threshold level of 10%, above which it becomes harmful to the growth. Meanwhile, regarding the developed economies, there is no specific threshold level of inflation because inflation could hurt growth at any level. Moreover, Kemmerer (1953) illustrated that hyperinflation is often caused by unanticipated shocks such as war which causes energy and food crises, thereby raising prices in the economy. Money growth will only be the main culprit of hyperinflation under the reign of corrupt governments who excessively print money for personal gains or war funding. Under stable economic and geopolitical conditions, the three-tier relationship between inflation, money growth and GDP growth is generally managed by careful analysis before implementation.

Opinions differ about what factors constitute economic development, and whether it can be sufficiently explained by the GDP growth, GDP recovery, GDP stability or inflation control (Guru & Yadav, 2019). According to Naqvi (1993), the process of economic development is multi-faceted in nature, which comprises the elements of reducing poverty, maximizing the growth of per capita income, while maintaining macro-economic stability. It is worth noting that the causal effect from inflation to growth is mostly significant but never positive (Naqvi, 1993). Thus, inflation control has been the primary goal of monetary authorities in western economies (Andrés & Hernando, 1997). This goal is rooted in the belief that keeping inflation under control yields higher per capita income, and that the costs of hyperinflation are damaging. The materialization of the economic development cannot be left to the invisible hand given the existence of asymmetric information and market inefficiency,

but rather the government with an appropriate policy regime has a significant role in maintaining macro-economic stability (Naqvi, 1993).

It is important that the state intervenes to achieve the goals of economic development, i.e., inflation control, equitable distribution of wealth, and generation of adequate employment. Conversely, the failure of authorities in regulating financial markets, and responding to economic turbulence would result in serious implications on the economy (Guru & Yadav, 2019; Marzano, 2012). The financial crisis of 2008 driven by the mismanagement of subprime mortgage lending is a prominent example of authority's failure to manage the economy well. In the next sub-sections, we narrow down the area of research to the examination of the relationships between different types of money and three respective macroeconomic factors including the authority's control of money supply which is a tool for maintaining macro-economic stability, inflation/ deflation, and inequality.

Inflation under commodity money period

Since the governments in the commodity money regime could discretionarily expand the money supply in the similar way the central banks do under the fiat money system, the result of repeated currency debasement led to rising inflation (Bernholz, 1989). In each new debasement, the state had three main methods to increase the supply of money, including decreasing the weight of newly issued coins, lowering the levels of fineness in the coins (i.e., silver, gold) while maintaining the same weight of coins, and increasing the face value of new coins (Sullivan, 2005). Thus, the new coin entered the circulation, resulting in rising quantity of money, and subsequently increasing prices (Sussman & Zeira, 2003). In an inflation examination of France under commodity money system from 1350-1436, a study found that the demand for money is negatively affected by the low inflation rate but disappears at high inflation rates (Sussman & Zeira, 2003). When the inflation rate is high, holders of commodity money can hedge against inflation by reminting the old coins of high fineness into new coins of low fineness with the same face value (Sussman & Zeira, 2003). This method of avoiding inflation tax is unique to only commodity money assuming that different coins of the same face value were indistinguishable. When it comes to the current fiat money system, this method is less relevant because fiat money does not contain intrinsic value and cannot be melted in order to hedge inflation.

During periods of debasement, the economy regulated two types of coins with the same face value but differing intrinsic values, resulting in Gresham's law, which stated that underweight bad money drove out full-bodied good money (Sparavigna, 2014). Money was considered "bad money" when their face value determined by monetary authorities was lower

than their intrinsic value, as opposed to undervalued, full-bodied money with a higher intrinsic value. People hoarded good money and used bad money with lower fineness for payment, or even seized the opportunities to gain profit (Cho & Kasa, 2017). Experts could melt the heavy coins into metal which were then recoined to make lighter coins, thus generating profit from the difference (Dutu et al., 2005; Sparavigna, 2014).

Deflation under gold standard regime

Due to the scarce nature of gold stocks, Keynes (2010) emphasized that there is a risk of deflation when the supply of gold cannot meet the demand for money in the economy. Friedman and Schwartz (1993) claimed that one-third contraction of the US money stock from 1929 accounted for the full severity of the Great Depression. Deflation increased the debt burden as interest rates were rising at punitive levels and tampered the confidence of consumers in consumption and businesses in investment (Crafts & Fearon, 2010). People delayed consumption as they expected the prices to lower in the future. Hence, they delayed consumption into the future. Businesses didn't invest as they expected interest rates to rise in the future, hence, they delayed investing into the future (Davis, 2015).

In times of liquidity crisis, the great European banks saw the traditional gold standard as a cult, leaving them unable to assess alternatives objectively. Change in economic policy played a key role in the road to economic recovery. In the United States in 1933, Roosevelt abandoned the gold standard, followed by most countries leaving the gold standard to pave the way for a new macroeconomic policy (Crafts & Fearon, 2010). According to Eichengreen and Temin (2000), if drastic measures were not taken, such as monetary authorities realizing the need for a "change of viewpoint," the ramifications of continuing deflation were severe. Overall, the current mainstream view is that responsible monetary policy is important to help economic growth and is therefore implemented in almost every economy.

3.3. Comparison between different money regimes

This section summarizes the previous comparison of historical evolution of money under different monetary regimes.

Table 1: Monetary policy across stages of money evolution

	Stages of money evolution		
Monetary policy	Commodity money	Commodity-backed money	Fiat Money
Targets	Support economic development and combat economic crisis.		
Tools	Authorities and companies adjust the mining of commodities Sparavigna (2014).	Besides of adjusting the mining of commodities, authorities also implemented coin clipping (the act of trimming the edge of coins), decreasing the weight of newly issued coins, lowering the levels of fineness in the coins (i.e., silver, gold) while maintaining the same weight of coins. Moreover, authorities could change the nominal value of the money, e.g., could change the rates at which money can be exchanged for commodities (Mankiw, 2021).	Authorities has a variety of monetary tools including purchase/sell of securities through open market operations (OMO), change of interest rates, and change in the reserve requirement ratio. Quantitative easing and tightening have also been used in recent times (Mankiw, 2021).
Achievements	Precious metals have historically shown a good track record in terms of store of value. The medium of exchange and unit of account functions of money were limited due to the physicality of precious metals (Sparavigna, 2014).	Commodity-backed money was used frequently throughout history and remained up until 1971, when the US dollar was backed by gold. Commodity-backed money performed somewhat well as a store-of-value while it performed better as a medium of exchange and unit of account due to its IoU form (Bordo, 1993).	The Fiat money system has been widely adopted around the world since 1971. In most countries with proper monetary policies, the store-of-value function could have been maintained. The medium of exchange and unit of account functions were greatly enhanced by the fiat money system, particularly when fiat money was mapped in electronic form into computers and the rise of internet (Ammous, 2018d).
Trade-off	Utilising monetary policy can promote economic development and help countries to face economic crises, particularly under the fiat money system. However, if monetary authorities abuse the money-printing power, the trade-off will be elevated inflation in the long run (e.g., Venezuela, Zimbabwe etc.) (Rolnick & Weber, 1997).		

4. Economic Development under Different Money Regimes

While there have been extensive studies into the nexus between monetary policy and economic growth, the relationship between the two remains inconclusive due to varied results between different time periods or between developed and developing countries. Twinoburyo and Odhiambo (2018) pointed out that monetary policy is more effective in supporting economic growth in developed countries due to independent and established central banks with well-developed money. Meanwhile, the relationship tends to be less pronounced in developing economies with fragmented financial markets because central banks in those countries might lack independence in their decisions to select appropriate tools, which might result in unclear objectives for monetary policy (Daoui, 2023). Therefore, the nexus between economic growth and monetary policy and those countries gives out varying results by country, ranging from limited, negligible to crucial, positive impacts on growth (Idris, 2019). For example, the study regarding Kenya from 1997 to 2010 showed a marginal influence of monetary policy, including money supply and short-term interest rates on real output, while a study regarding Nigeria from 1981 and 2008 presented an opposite result in which increasing money supply positively boosted GDP growth (Karaman et al., 2020).

In a study examining the impact of monetary policy on economic growth in a developed country (United Kingdom) and a developing country (Bangladesh), the findings show that money supply is a vital component boosting economic growth in short run and long run irrespective of the type of the nation (Islam et al., 2022). Although a hike in bank rates avert growth for both countries, the economic growth in the developed economy – the UK stands tall regardless of the rise (Islam et al., 2022). Notwithstanding the danger of inflation, both established and emerging economies benefit over the long term from a greater supply of money (Twinoburyo & Odhiambo, 2018). Moreover, monetary policy has an imperative role in supporting economic growth despite the ambiguous relationship (Karaman et al., 2020).

Studies analyzing the relationship between different monetary regimes and the economic development of countries are limited. A possible explanation is that the availability of economic data for periods when actual commodity money was used is very limited. However, there are available data on economic development indicators like GDP and inflation for numerous countries for the gold-backed period of Bretton Woods system. Therefore, we conduct a descriptive analysis in this study comparing the economic development under the gold-backed periods of the Bretton Woods system with that of the fiat money periods. This study measures economic growth as the percentage change in the real GDP values and gathered both GDP values and inflation rates from the FRED database for the period under the gold

standard (1951 – 1971) and the fiat money system (1972 - 2019). The selection of the countries for this analysis was dependent on several factors. The selection was limited by the availability of data. The GDP data are available from 1951 – 1971 whereas inflation data are available from 1960 – 2019. In July 1944, the Bretton Woods Conference was held at Bretton Woods, New Hampshire and representatives from 44 countries signed the agreement (Eun et al., 2020). This conference also led to the establishment of the International Monetary Fund (IMF) in 1945 in order to promote exchange rate stability. Hence, countries who obtained membership of the IMF during the period of 1945 – 1961 are assumed to have pegged their currencies to the US Dollar or to have started to stabilize the exchange rate with respect to the US Dollar, which imply that the countries were operating under gold standard constraints in terms of monetary policy. However, it is important to note that the pegging to the US Dollar still allowed currencies to float within +/- 1 percent of the adopted par value. Finally, it is worth noting that these countries have withdrawn from the Bretton Woods System at different time periods. The United States withdrew in 1971 and other countries followed suit and started adopting floating exchange rate systems.

Our aim is to compare the average economic growth rate and its volatility with the average inflation rate and its volatility during both gold standard period from 1951-1971 and fiat money period from 1972 – 2019. We would like to note that the calculations and discussion are descriptive only and do not imply any causality between the types of money being used and economic development. Nevertheless, the descriptive discussion could still help to provide interesting insights into the actual economic development under the two different monetary regimes.

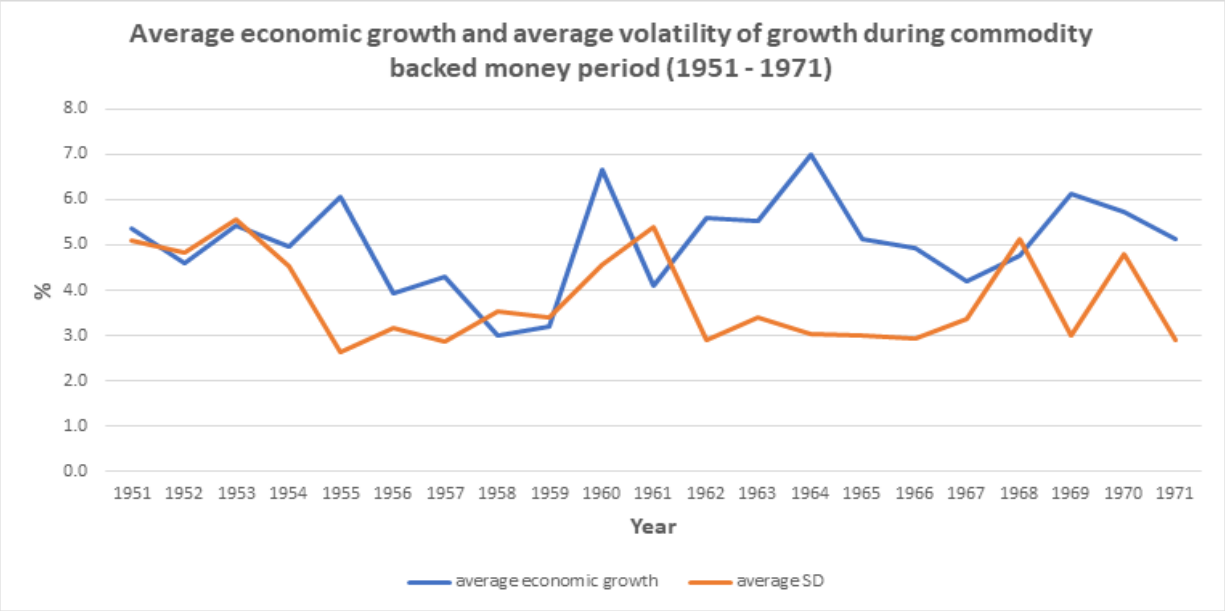

Figure 1. Average economic growth rate and volatility of growth rate during commodity-backed money period (1951 – 1971)

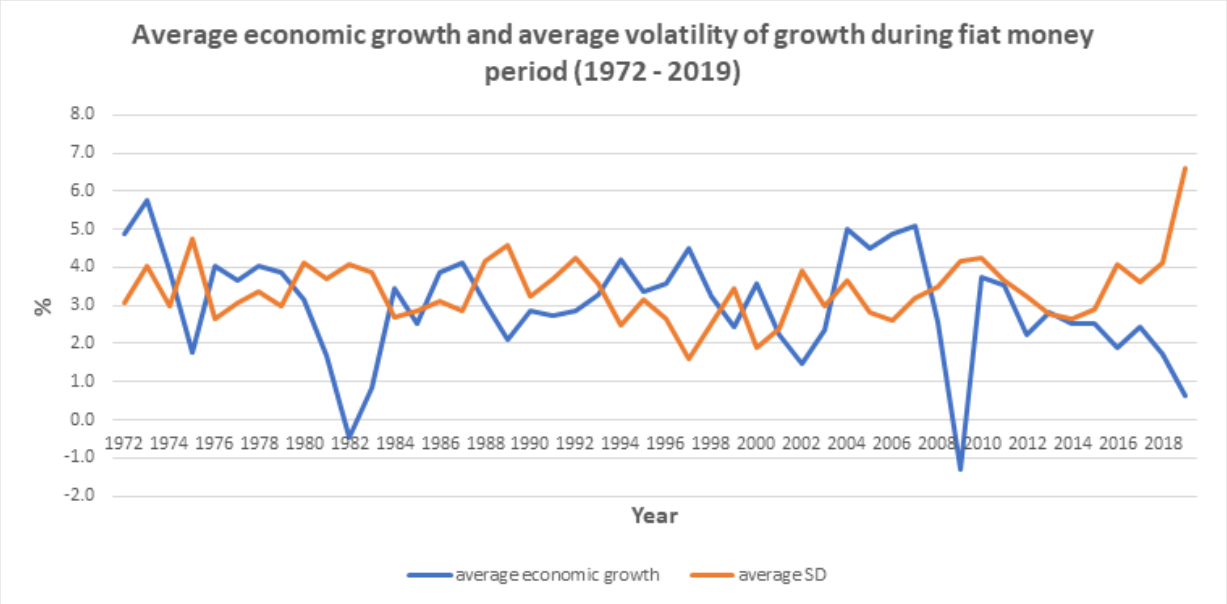

Figure 2. Average economic growth rate and volatility of growth rate during fiat money period (1972 – 2019)

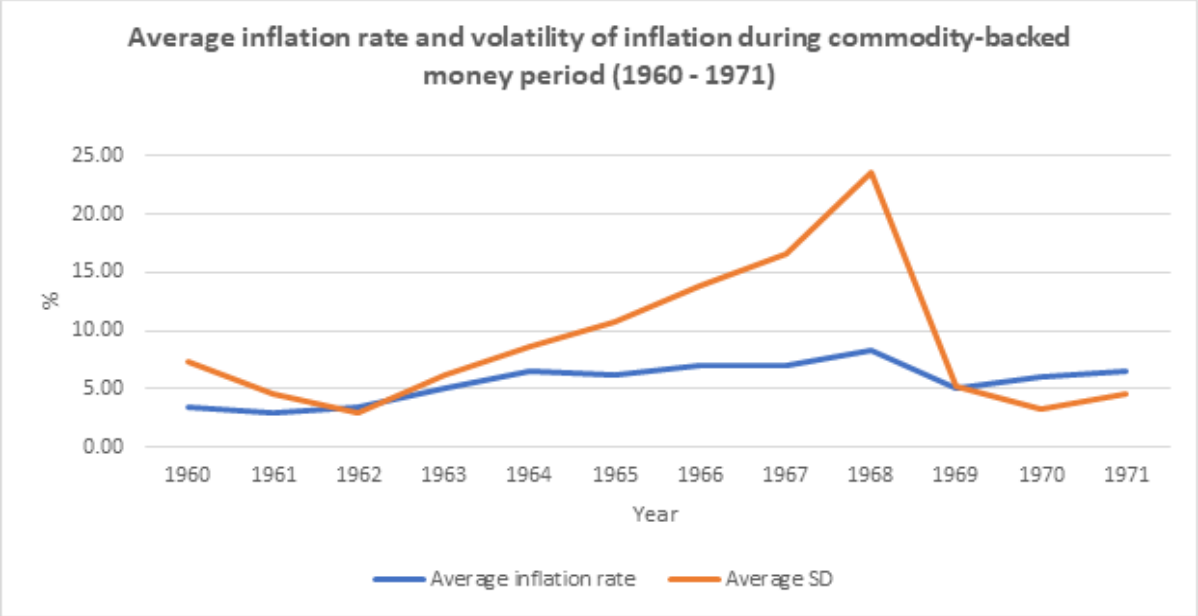

Figure 3. Average inflation rate and volatility of inflation rate during commodity-backed money period (1960 - 1971)

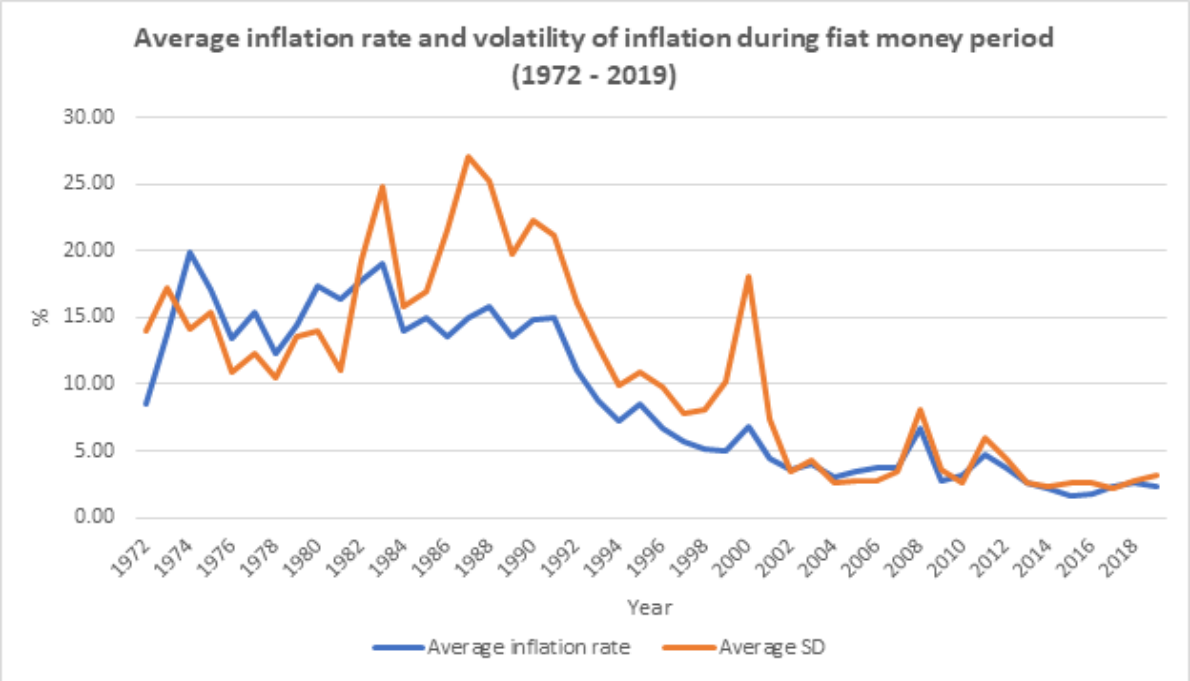

Figure 4. Average inflation rate and volatility of inflation rate during fiat money period (1972 - 2019)

Figures 1 to 4 depict the average real economic growth rate, average volatility of economic growth rate, average inflation rate, and average volatility of inflation rate of the 27 countries included in the data sample (please refer to Appendix 1 for the list of countries). Under Bretton Woods system, there was a mild recession 1960-1961, with an abrupt drop in

the GDP growth rate from 6.6% to 4.1% that led to FED's loosen monetary policy to aid the economic recovery after 1961 (Zala, 1968). Meanwhile, under the fiat monetary system, there was an economic downturn from 1980 and 1982, marked by a drastic trough in GDP growth rate from 3.2% to -0.4%. This period of recession was induced by the tight monetary policy implemented to fight against elevating inflation in the late 1970s (Ireland, 2000). However, the economy was able to rebound significantly from 1982 to 1984 when inflation was contained thanks to the FED chairman's persistence in the tight monetary policy against rising inflation (Ireland, 2000). The instances of recession under both the Bretton Woods System and the fiat monetary system suggest that monetary policy can only be adapted to the constantly changing economic environment through flexibility, however, techniques and policies implemented may be appropriate at one time but become inappropriate at another.

During 1951 – 1971 under the Bretton Woods regime, a gold-backed money system, the world recorded a substantially higher economic growth of 5% compared to the average growth of 3% from 1972 to 2019 under the fiat monetary system (Table 2). However, the economic growth has undergone less volatility (standard deviation of 3.39%) during the fiat monetary system compared to the volatility under Bretton Woods system (standard deviation of 3.81%). This might be due to the fact that governments had less control over the monetary policy during gold standard period. Moreover, there were low correlations between the GDP growth and the inflation growth under both periods, illustrated by the correlation figures of -0.19 under the Bretton Woods system and 0.02 the fiat monetary system. Hence, we do not find strong evidence for the ongoing argument on the trade-off between inflation and economic growth. In terms of inflation, the average inflation rate was higher during the fiat money time (8.9%) compared with the inflation rate during commodity-backed period (5.6%) (Table 3). This is evident because, under the fiat money system, governments have more discretion to increase the money supply whenever they deem it essential leading to higher inflation rates.

Furthermore, we analyze the economic growth rate and inflation rate under these two monetary regimes for different country groups (Table 4) (The complete list of countries and statistics is available in Appendix 1). We classify countries based on the income level using the World Bank classification in 2022. The average economic growth has declined significantly under fiat money system compared to Bretton Woods System in high income and upper middle-income countries. The economic growth has shown a slight decline only in lower middle income and lower income countries. The story of inflation is entirely opposite and provides evidence that upper middle income, lower middle income and lower income groups have undergone drastic inflationary pressures under fiat money system compared to commodity-

backed money period. From the comparison of volatility, the commodity-backed system reported a lower volatility in inflation rate than that of fiat money system, which favored greater economic growth during that period.

Although the Bretton Woods system recorded desirable macroeconomic performance in terms of GDP growth and was considered as the most stable monetary system of the past century (Cameron & Wallace, 2002), there is no sufficient data to conclude the causes of such favorable outcomes – whether it was the result of the preeminent nature of the commodity-backed system itself, whether it was thanks to absence of major shocks during this period, or whether it was contributed by the stable monetary policy of the United States, a key member of the system (Bordo & Eichengreen, 1993). As the rest of the world were tied to the United States due to the fixed exchange rate with the dollar, they were inclined to follow the US's leadership in stable financial policies, hence yielding a period of stable economic condition (Bordo, 1993). Moreover, Cameron and Wallace (2002) attribute an exceptionally favorable macroeconomic conditions after World War II as an outcome of the desirable growth under the Bretton Woods System.

While there have been extensive studies into the nexus between monetary policy and economic growth, the relationship between the two remains inconclusive due to varied results between different time periods and different monetary regimes. Regardless of ambiguous linkages, monetary policy plays a critical role in fostering economic growth in the short and long run, regardless of whether it is a developing or developed economy (Twinoburyo & Odhiambo, 2018). Fiat monies allowed authorities to appreciate or depreciate monetary units more conveniently and at faster rates compared to commodity monies (Karaman et al., 2020). In other words, fiat monies provide authorities with more flexibility in meeting economic goals, i.e., boosting economic growth, or stabilizing the economy. Thus, the fiat money regime might exert a greater influence on economic growth than the commodity-backed money regime.

In conclusion, during the commodity-backed money period, inflation was more under control as governments has less discretion over the money supply and the money supply was limited due to the inherent limitations of the commodity. The lower inflation rates under the gold standard were particularly evident in the middle- and lower income country groups. Hence, under commodity-backed money period, the world experienced a higher economic growth compared to the growth under fiat money period. However, the volatility of economic growth under fiat money was lower for the high- and middle-income country groups, whereas the low-income country group experienced higher fluctuation of real GDP growth under fiat money. Fiat money is subject to the discretion of the governments entirely and hence, the world

experienced a higher level of inflation under fiat money for all country groups. The data provides some descriptive evidence that the low-income country group faces greater challenges under fiat money as the volatility of real GDP growth, inflation and volatility of inflation were higher under fiat money. Interestingly, although the middle-income country group experienced less real GDP growth volatility under fiat money, substantially higher inflation and volatility of inflation can be observed for those countries under fiat money.

Table 2. Average economic growth rate and volatility under the Bretton Woods system (1951-1971) and the fiat monetary system (1972 – 2019)

Indicator	Bretton Woods system – a commodity-backed system 1951 - 1971	Fiat monetary system 1972 - 2019
Average Economic growth rate	5.03%	3.00%
Average Volatility of Economic Growth Rate	3.81%	3.39%

Table 3. Average inflation rate and average SD under the Bretton Woods system (1960-1971) and the fiat monetary system (1972 – 2019)

Indicator	Bretton Woods system – a commodity-backed system 1960 - 1971	Fiat monetary system 1972 - 2019
Average inflation rate	5.60%	8.90%
Average volatility of inflation rate	8.95%	10.85%
Correlation between economic growth rate and inflation rate	-0.19	0.02

Table 4. Average economic growth rate and inflation rate under different income levels

	Economic Growth Rate (%)				Inflation Rate (%)			
Country Classification	Average under BWS	Average under Fiat Money	Volatility under BWS	Volatility under Fiat Money	Average under BWS	Average under Fiat Money	Volatility under BWS	Volatility under Fiat Money
High Income	5.20	2.65	3.11	2.62	6.06	7.05	3.71	6.56
Upper Middle Income	5.78	3.71	3.13	2.98	5.17	18.57	2.83	18.90
Lower middle and lower income	4.54	4.38	3.25	4.05	2.72	8.75	3.48	7.88

Note: The country classification is based on the World Bank classification in 2022. BWS is the Bretton Woods System.

5. Conclusion

In this chapter, we explained the historical evolution of money and the characteristics of commodities that can be considered as money. Thereafter, we discussed the importance of monetary policy and how the governments adopted monetary policy under different monetary regimes. Based on this analysis, there are a few important conclusions that can be derived from this chapter. First, salability across time, across space and scale have been the salient features of successful money. Compared to commodity money and commodity-backed money backed by gold or silver, government-issued fiat money performs well in terms of salability across space and scale. Commodity money performed relatively well in terms of salability across time, particularly when precious metals were used. Commodity-backed money was less salable across time compared to commodity money but was more salable across space and scale.

Moreover, applying responsible monetary policies is critical to stimulating economic growth and preserving economic stability (Chaitip et al., 2015). It was previously thought that the government's power in regulating money supply was restrained under the commodity money system with gold and silver as the supply of these precious metals is limited. However, with the debasement of coins and the face value of the coins determined by the authorities, this monetary system was still at the discretion of the authorities (Redish, 1993). There is evidence that repeated currency debasement for funding war or gaining of seigniorage profit by the authorities, resulted in rising inflation (Pense, 1992). Nevertheless, under the fiat money system, the government has more discretion and control over the money supply to achieve macro-economic targets of a country. However, it is noteworthy that the misuse of monetary policy by the government to pay of national debt or to cover up large budget deficits can cause countries into economic crisis due to the high level of inflation (Rolnick & Weber, 1997). A recent example for the misuse of monetary policy leading to an economic crisis in the country is the situation in Sri Lanka. Therefore, maintaining the balance between economic growth and inflation is essential when a government uses its monetary policy.

With the rise of cryptocurrency and blockchain, which has facilitated financial development, there is growing interest in the usage of cryptocurrencies as legal tender, as well as the influence of cryptocurrencies on monetary policy due to their decentralized nature. In the following section, we investigate the challenges and opportunities of using bitcoin as legal tender based on the literature and in the real-life contexts of El Salvador and Central African Republics (CAR).

CHAPTER 2: CHALLENGES AND OPPORTUNITIES OF CRYPTOCURRENCY ADOPTION AS LEGAL TENDER

1. Introduction

There have been various interests and controversies about cryptocurrencies in the academic literature and the industry. Some authors argue that this innovation could be an alternative to fiat money (Carrick, 2016; Kim, 2017; Luther, 2018, 2019, as cited in Adrian & Weeks-Brown, 2021). According to a review of Bariviera et al. (2017); Bouri et al. (2018); Dyhrberg (2016); Paule-Vianez et al. (2020), as cited in Levulyte and Sapkauskiene (2021), cryptocurrency serves the same function as commodities. Other scholars criticize this type of money as purely speculative without any future promises (Bouoiyour & Selmi, 2015; Corbet et al., 2018, as cited in Levulyte & Sapkauskiene, 2021).

Cryptocurrencies use cryptography technology to secure p2p transactions between people in the network, control the supply of additional units in the system, and verify the transactions with distributed ledger technology - blockchain technology (Ferdous et al., 2021). In addition, cryptocurrency could be used as an electronic payment system based on blockchain technology that uses a network of computers to validate the transactions in that network instead of relying on third parties (like traditional financial institutions in a centralized financial system) to verify transactions (Islam et al., 2018; Perkins, 2018).

There are various types of cryptocurrencies in the market, and Bitcoin has the highest market cap among them (Islam et al., 2018). According to data from CoinMarketCap (n.d.), the market cap of Bitcoin (BTC) has reached more than 324 billion USD, followed by Ethereum (ETH) at 153,5 billion USD. Interestingly, tokenized USD account for a large fraction of the cryptocurrency market cap with Tether (USDT) having a market cap of 66 billion USD, USD Coin (USDC) 44 billion USD and Binance USD (BUSD) 16 billion USD on 8th January 2023. Additionally, based on Trading View data (n.d), Bitcoin (BTC) and Ethereum have accounted for nearly 60% of total market capitalization, in which BTC Dominance is 40.5% and ETH Dominance is 19.7% on 8th January 2023. Over the time, bitcoin has increased its prominence in the financial systems.

In this chapter, we aim to provide an overview of the cryptocurrency explaining its characteristics and comparing it with other forms of money described in chapter 1. Thereafter, we provide a discussion on how the monetary policy works when a country adopted bitcoin as legal tender with some conceptualization on possible impacts on the economic development of a country. Finally, we explore the opportunities and challenges

of adopting cryptocurrency as legal tender with the recent evidences from the case of El Salvador and Central African Republic (CAR) that has adopted bitcoin as legal tender in their countries.

2. Background of cryptocurrency

2.1. Cryptocurrency

Bitcoin was the first peer to peer payment system that facilitates the direct payment from one party to another without including any financial intermediary in this process and was introduced by Nakamoto (2008). Bitcoin has inspired many young entrepreneurs and technology enthusiasts to develop other programmable cryptocurrencies such as Ethereum. The term cryptocurrency is a combination of the words, *cryptography* and *currency*. Cryptocurrencies have no legislated or intrinsic value, but the value is determined based on the market forces. The definition of Bitcoin, Ethereum and cryptocurrency in general is continuously evolving as scholars and practitioners in the industry hold opposing viewpoints. Before proceeding further, it should be noted that this report will only address cryptocurrencies which have programmatic supply issuance schedules, such as, Ethereum and Bitcoin. Nevertheless, the report will provide a discussion on stable coins at the end of the report. Let us begin by outlining some definitions of cryptocurrency.

The Financial Crimes Enforcement Network (2013) recognizes Bitcoin as a medium of exchange that operates like a currency in some environments but does not have all the attributes of USD. The main issue faced by the regulators is that cryptocurrencies do not meet the criteria of traditional forms of money to be defined as money. The Europen Banking Authority (2014) defines virtual currencies as “a digital representation of value that is neither issued by a central bank nor public authority not necessarily attached to a fiat currency but is used by natural or legal persons as a means of exchange and can be transferred, stored or traded electronically”. According to the Reserve Bank of Australia (n.d.), cryptocurrencies are digital tokens that allow user to make direct payments to another party through an online system. Binda (2020) provides detailed evidence on different definitions of e-money and cryptocurrencies adopted by key financial institutions in the European region. According to his findings, the majority of these institutions define cryptocurrencies as virtual currencies, identified them as a digitally represented value and acknowledged the fact that cryptocurrencies are free from the control of central banks or other regulatory authorities. The need for a precise definition arises when regulators want to develop a regulatory framework for cryptocurrencies. (Hughes, 2017) synthesizes literature on the cryptocurrency related regulations in the US whereas Trozze et al.

(2022) provide a systemic review of cryptocurrency fraud and highlights the need for better consensus and clear definitions on cryptocurrencies and cryptocurrency frauds.

In addition, there is another set of scholars and practitioners that have developed different definitions of cryptocurrency adoption. Particularly, cryptocurrency adoption refers to the incorporation and usage of society to the newly developed cryptocurrency, which was heavily influenced by the trust level (Shahzad et al., 2018). The act of intentionally becoming a cryptocurrency user could be considered as adoption (Alaklabi & Kang, 2021, as cited in Chen et al., 2022). Shahzad et al. (2018) explains that adopting Bitcoin is closely related to the awareness of its technology and benefits in which the citizens could take advantage of this latest financial innovation as an alternative to the fiat currency.

The research team from Chainalysis Team (2022) has calculated the Global Crypto Adoption Index for 2022 based on the country's proportion of money invested in cryptocurrency. Primarily, this index is determined based on five sub-factors, including on-chain cryptocurrency value received at the centralized exchange, the on-chain retail value received at centralized exchanges, Peer-to-peer (P2P) exchange trade volume, the number of internet users, the on-chain cryptocurrency value received from DeFi protocols, and the on-chain retail value received from DeFi protocols. The closer the country’s final score is to 1, the higher the adoption rate. According to their findings, Vietnam, Philippines, Ukraine, India and United States are the top 5 countries in adopting cryptocurrency based on the overall index value, respectively. Interestingly, emerging markets are dominating in the adoption of cryptocurrencies whereas United States and United Kingdom are the only high-income countries included in the top 20 countries list.

Al-Amri et al. (2019) conducted a systematic literature review from 25 articles on cryptocurrency adoption between 2014 to 2017 using both quantitative and qualitative research methods. According to them, human (ease of use, usefulness, social element and facilitating conditions) and security (perceived risk, perceived trust and perceived security and awareness) elements contribute the most to adoption decisions. In addition, countries with low trust in the banking and financial systems and a strong inflationary condition have a greater rate of adoption (Ilomäki, 2022; Ogunode et al., 2022; Saiedi et al., 2021; Stix, 2021). This could arise from the belief that cryptocurrency could be a hedge against the inflationary pressure which devaluates the national currency value (Ilomäki, 2022). As a result, cryptocurrency may become a viable currency choice in countries with a high risk of excessive inflation, as opposed to those with a stable currency environment. Before exploring the possibility of adopting cryptocurrency as legal tender, it is vital to shed light on the ongoing debate about whether we

should consider cryptocurrencies to be money or not. Hence, the next section compares the characteristics of cryptocurrency with that of the commodity money and fiat money.

2.2. Cryptocurrency, fiat money and commodity money

The debate on if cryptocurrency is money or not is still continuing with scholars having opposing views in this regard. There is an electronic version of fiat currencies nowadays, but cryptocurrencies like Ethereum and Bitcoin differ from them, as they are purely digital (internet-native) technologies that exist in the digital world only. Cryptocurrencies like Ethereum and Bitcoin are programmatic and have a predetermined monetary issuance schedule which (often) limits the total supply available. As established in Chapter 1, a good need to fulfill the functions of being a medium of exchange (salable across space), store of value (salable across time) and unit of account (salable across scale) to be considered a good form of money. There are several studies providing arguments for and against the usage of cryptocurrencies as money by examining the ability of cryptocurrencies to serve these three functions.

With respect to the function as the medium of exchange, Yermack (2015) states that there is not much adoption of Bitcoin for commercial purposes, but mostly adopted for speculation only. Claeys et al. (2018) also argue that cryptocurrencies like Ethereum and Bitcoin cannot fulfill their role as a medium of exchange owing to high transaction costs, high maintenance costs, huge demand for electricity and low processing speed. Volatility is also a problem of Bitcoin that hinders it from properly functioning as a medium of exchange since it creates more exchange rate risk for users when converting between Bitcoin and local currency (Baur & Dimpfl, 2021). Nevertheless, it is worth noting that the scalability and transaction cost concerns of cryptocurrencies are being addressed by technological development such as Blockchain layer 2s which reduce transaction cost & time. Moreover, the debate about energy consumption is more nuanced, as cryptocurrency mining could actually promote renewable energy production, act as buyer of stranded energies and stabilize the electricity grid. Furthermore, Ethereum recently transitioned to Proof of Stake consensus algorithm that cut the energy consumption of Ethereum by over 99%.

From a technical level, cryptocurrencies are purely digital, divisible (Ammous, 2018c), and borderless (Dyhrberg, 2016) which allows everyone with a telecommunication device to receive, transfer, store and use cryptocurrencies, thereby promoting financial inclusion (Vincent & Evans, 2019). While gold is highly scalable across time, it is not scalable across space owing to its physical nature, that it is “hard to carry around”. Fiat money is portable and hence more salable across space than gold, but can face challenges with respect to scalability

across time as evidenced by inflation in countries with loosed monetary policies (D'Andrea, 2022, p. 502). Nevertheless, Bitcoin inherits the scarcity of gold which makes its value appreciate as time passes, thus being salable across time without being bounded by the physical drawbacks of Rai stones or gold thanks to its divisibility along with its wide accessibility via the Internet (Ammous, 2018d). Furthermore, a cryptocurrency payment infrastructure could enable online payment and even cross-border payment relatively quickly (Nadeem et al., 2021) without the necessity to develop a proper traditional financial infrastructure with banks and intermediaries. This may help improve financial inclusion, which is one of the main reasons why El Salvador adopted Bitcoin as legal tender (Kshetri, 2022b).

Considering the unit of account function, Cryptocurrencies' high volatility remains a major drawback. The volatility of cryptocurrencies could greatly increase the price risks for consumers, producers and merchants in a country if they denominate their prices in cryptocurrencies. The percentage price change of cryptocurrencies could easily be reached over 10% in a single day and over 50% over a single year during volatile periods. Denominating prices in cryptocurrencies and using them as a unit of account would require consumers, producers and merchants to hedge against the price risks in order to make consumption, investment and trade decisions. Moreover, if debt and credit need to be denominated in cryptocurrency terms, the wild fluctuations in the market prices of the cryptocurrencies can greatly distort the debt market and value. This could lead to higher hedging costs for debtors and creditors and ultimately impair the debt market which, in turn, negatively affect the economy.

On the other hand, the ease of divisibility of cryptocurrencies allows everyone to easily quote prices with a lot of decimals if required. However, due to cryptocurrencies' relatively high pricing in terms of the US dollar, cryptocurrencies will require a large number of leading zeros for price quotation, which could be inconvenient for both buyers and sellers (Yermack, 2015).

In terms of the store of value function, prominent cryptocurrencies like Ethereum and Bitcoin have shown strong price appreciation over the long-term while exhibiting substantial price fluctuation in the short term. Ammous (2018c) argues that the limited supply is what makes Bitcoin function well as a store of value. Most individuals consider programmatic cryptocurrencies as a (speculative) store of value rather than a medium of exchange because of the limited nature of the cryptocurrencies like Bitcoin and thus its price will continue to rise as people continue to place high expectations on Bitcoin price appreciation in the future (Ammous, 2018c). Although the strong past performance of prominent cryptocurrencies in

terms of price appreciation could make cryptocurrencies good store of values over the long term, the significant short and middle term volatilities of cryptocurrencies raise the question whether cryptocurrencies are good store of values in the short and middle term.

Moreover, the security risks of cryptocurrencies render the usage of it vulnerable to hacking, which is why it may not be suited for the use as a store of wealth (Yermack, 2015). The high volatility of cryptocurrency prices makes them riskier compared to other asset types (Kubát, 2015) and also makes its price index more inflated and/or deflated (Claeys et al., 2018). Hazlett and Luther (2020) find that in terms of market capitalization, demand for Bitcoin is not substantially lower than that for fiat currencies. Hazlett and Luther (2020) suggest that bitcoin may still be used as a medium of exchange, but only in a relatively narrow domain, because they are unable to discern whether the demand for bitcoin is emerging from transactional or speculative demands.

Levulyte and Sapkauskiene (2021) found that Bitcoin and Ethereum could act as the medium of exchange, however, with wider volatility in value. The value of fiat money is inextricably linked to the government that issues this money, while cryptocurrency's value comes from its native blockchain and demand and supply forces in the open market (Cryptopedia Staff, 2022). Specifically, the issuance and governance of fiat money are determined by the central banks, while the cryptocurrency itself is controlled by the community, code of that blockchain protocol. For example, the monetary and fiscal policy decisions from the government and central bank would affect the value of the fiat currency. While most cryptocurrencies do not have a fiscal policy but are controlled by monetary policy that is programmatically embedded into the code. These mechanisms could be Proof of Work (PoW) or Proof of Stake (PoS) that is approved by the group validators rather than a single, central authority (Cryptopedia Staff, 2022). To sum up, we summarize our discussion on differences of these types of money as follows.

Table 5: Cryptocurrency, Fiat currency, and Commodity Money

	Stages of money evolution			
Basic characteristics	Commodity money	Commodity-backed money	Fiat Money	Cryptocurrency
Money supply & issuance	Abundant	Limited by the availability of the commodity	Depends on the discretion of the central bank	Limited due to programmatic nature
Governance	Uncontrollable by the state	State could have come control over the value and minting process	Controlled by the central bank	Less control by the policy makers
Financial infrastructure	No need to have a sophisticated infrastructure	Needs somewhat sophisticated infrastructure	Needs a sophisticated infrastructure	Needs a virtual infrastructure that is less costly compared to the traditional financial infrastructure
Openness & inclusiveness	Open and inclusive	Less open and inclusive	Less open and lack of inclusiveness	Open and inclusive

3. Monetary Policy under Cryptocurrency

3.1. Monetary policy tools

As mentioned above in chapter 1, government under the fiat money system can easily adopt the monetary policy to intervene the economy by changing the interest rates, using quantitative easing or adopting open market operations. Hence, the government has the discretion to increase or decrease the money supply to achieve their macro-economic targets. The monetary policy especially aims to achieve economic stability of a country because any significant expansion or contraction of money supply can have a direct impact on inflation, or it can assist mitigate possible concerns from a prolonged period of economic expansion (Friedman, 1968).

The emergence of cryptocurrencies created a completely novel form of money that is different from the traditional forms of money. Due to the nature of the cryptocurrencies, the next legitimate concern is how to maintain the monetary policy of a country with cryptocurrency being adopted as legal tender. Similar to commodity money period, a country needs to mine/receive stake reward or import more cryptocurrencies in order to implement monetary policy (this can be viewed as direct monetary policy). Since cryptocurrencies are borderless, the incentive to attract cryptocurrency flows could be implemented (this can be viewed as indirect monetary policy). A main difference between cryptocurrencies and fiat

currencies in terms of money supply is that cryptocurrencies' monetary supply issuance rate is more predictable and programmatic. According to Bailey et al. (2021), the biggest problem of inflation is that it is not foreseeable. Given the nature of blockchain, the monetary supply issuance rates of cryptocurrencies like Ethereum and Bitcoins are programmable, which can either be deflationary or inflationary. Fiat currency, the mechanism is more flexible and can be adjusted based on varied economic conditions (Hanif, 2020). Furthermore, as the government injects or withdraws money from the economy through open market operations or adjusting interest rates, a large number of entities, ranging from central banks to commercial banks, are involved. Nevertheless, bitcoin is often given as a block reward for miners or validators, or it can be removed from the market by being "burned" (i.e., sending cryptocurrency to a null address).

In addition, cryptocurrencies can act as competitors over fiat currencies, encouraging governments to be more prudent when adopting the monetary policy (Bailey et al., 2021). Even though Bitcoin's fixed quantity and scarcity make it unsuitable for replacing fiat money, programmable money whose supply is managed by algorithms can be utilized to maintain value stabilization (Fantacci, 2019). Fernández-Villaverde and Sanches (2019) proposed that in a circumstance where fiat currencies are treated equally to privately issued currencies and people are willing to hold private currencies more, it will be difficult for the government to pursue a deflationary money policy as the supply of private currencies is less likely to reduce accordingly. Furthermore, Kang and Lee (2019) showed that cryptocurrencies can really compete with government fiat currency when the inflation rate is high enough. Hence, it is worth emphasizing that the coexistence of the two forms of money results in less economic welfare due to Bitcoin's technological inefficiencies surrounding its costly and slow-moving mining procedures, which leads to fewer transaction settlements (Kang & Lee, 2019). Regarding the medium of exchange function of money, the competition between cryptocurrency and government-issued currency may turn out to be drastic. In order to maintain its monopolistic power, central bank must maintain its inflation rate at a lower rate than that of cryptocurrency. Nevertheless, the inflation rate of cryptocurrency like Bitcoin is programmed to approach zero, the central bank can only keep its inflation rate extremely low or even below zero pushing the economy to the risk of spiralling deflation (Benigno et al., 2022).

3.2. Capital controls

Capital controls are any measures imposed by a government or a central bank to limit the flow of foreign capital in and out of the domestic economy. These controls may be imposed in the form of taxes, tariffs, or any other regulatory restrictions. Under the fiat money system, the

government has the discretion to control the capital flow of a country using the monetary policy of a country. This scenario differs significantly under a monetary system based on cryptocurrency. Cryptocurrencies appear to be a great way for households or businesses to escape capital controls because of its anonymity (Árnason, 2015) and also because countries have not established any limits on how much cryptocurrency can be transferred overseas (Mundy, 2018). Cryptocurrencies can further exacerbate the issues of money laundering, tax evasion and reduce profits from seigniorage (Drakopoulos et al., 2021). With the presence of strict capital controls, people can still bypass the regulation by people having separate bank accounts in the country with capital controls and in a foreign country (Mundy, 2018). Indeed, strict capital controls are positively correlated with high crypto adoption (Alnasaa et al., 2022; Ricci, 2020). For instance, there exists demand for Argentine businesses to transact with international partners without being constrained by the cumbersome procedure of mainstream cross-border payment system and hence, Bitcoin appears to be a suitable solution here. Transaction fee is counted, but taxes, paperwork, or even the discrepancy between the applied and the official exchange rate will be removed (Serrano, 2016, as cited in Carlson, 2016). The same pattern applies to China where more than 25% of Bitcoin trading volume from 2011 and 2018 accounts for capital controls circumvention due to the uncertain economic policy established by the Chinese government (Hu et al., 2021). However, it should be mentioned that people did suffer losses when exchanging between fiat currencies via a cryptocurrency (Hu et al., 2021).

To sum up, the policy makers will lose control over their monetary policy under cryptocurrency system. Under the traditional fiat money system, the governments face a policy constraint known as the trilemma as they may not be able to achieve all three policy goals namely, a fixed exchange rate, international capital mobility and monetary policy autonomy. These three goals are mutually incompatible and policy makers can only achieve two objectives at once and must sacrifice the third objective. Unfortunately, when cryptocurrency is adopted as legal tender, policy makers may not be able to achieve any of these three goals now. As discussed above, the exchange rate cannot be controlled by the government, cryptocurrencies can be freely traded and exchanged across borders and the government lose the autonomy on the monetary policy as they cannot control the supply of cryptocurrency. When policy makers cannot control international capital flows, fix the exchange rate and use monetary policies to stimulate and fine-tune the economy, the government loses major tools that are necessary for navigating the economy.

This could be a potential big issue during times of crisis, when there are credit, solvency or liquidity issues in the financial market (e.g., during Great Financial Crisis) or severe recessions (e.g., Covid 19), and policy makers cannot use monetary policy tools to stabilize exchange rates or impose capital controls to direct the economic recovery. Hence, in section 4, we discuss the possible impact of cryptocurrency adoption as legal tender on the macro-economic performance of a country.

3.3. Comparison between different money regimes

This table summarizes and compares the monetary policy under different monetary regimes: commodity money, commodity-backed money, fiat money and now, cryptocurrency.

Table 6: Monetary policy across different monetary regimes

	Stages of money evolution			
Monetary policy	Commodity money	Commodity-backed money	Fiat Money	Cryptocurrency
Targets	Support economic development and combat economic crisis.			Decentralize the control of money supply (Tasca et al., 2016)
Tools	Authorities and companies adjust the mining of commodities (Sparavigna, 2014).	Besides of adjusting the mining of commodities, authorities also implemented coin clipping (the act of trimming the edge of coins), decreasing the weight of newly issued coins, lowering the levels of fineness in the coins (i.e., silver, gold) while maintaining the same weight of coins. Moreover, authorities could change the nominal value of the money, e.g., could change the rates at which money can be exchanged for commodities (Mankiw, 2021).	Authorities has a variety of monetary tools including purchase/sell of securities through open market operations (OMO), change of interest rates, and change in the reserve requirement ratio. Quantitative easing and tightening have also been used in recent times (Mankiw, 2021).	Inflation rate is programmable and immutable (Ammous, 2018b)
Achievements	Precious metals have historically shown a good track record in	Commodity backed money was used frequently throughout history and remained up	Authorities has a variety of monetary tools including purchase/sell of	Lower risk of unexpected money supply shocks (Bailey et al., 2021)

	terms of store of value. The medium of exchange and unit of account functions of money were limited due to the physicality of precious metals (Sparavigna, 2014).	until 1971 where US dollar was backed by gold. Commodity backed money performed somewhat good for store of value while it performed better as a medium of exchange and unit of account due to its IoU form (Bordo, 1993).	securities through open market operations (OMO), change of interest rates, and change in the reserve requirement ratio. Quantitative easing and tightening have also been used in recent times (Mankiw, 2019).	Encourage government to produce "good money" (Fernández-Villaverde & Sanches, 2019)
Trade-off	Utilizing monetary policy can promote economic development and help countries to face economic crisis, particularly under the fiat money system. However, if monetary authorities abuse the money-printing power, the trade-off will be elevated inflation in the long run (e.g., Venezuela, Zimbabwe etc.) (Rolnick & Weber, 1997).			Deflationary spiral (Benigno et al., 2022) Loosened capital control (Árnason, 2015) High volatility in exchange rate which can exacerbate economic development (Adrian & Weeks-Brown, 2021; Alvarez et al., 2022; Gorjón, 2021; Kshetri, 2022b; Read, 2022; Yussof & Al-Harthy, 2018)

4. Possible Economic Development under Cryptocurrency Adoption as Legal Tender

4.1. Volatility of cryptocurrency prices

The high volatility of cryptocurrency prices is a big challenge for economies, as volatile exchange rates make trade more difficult or costly. Import & export costs for goods, commodities could be extremely volatile. It is very difficult for (smaller economies) to stabilize the cryptocurrency prices which are at the same time the exchange rates. Denominating debt and credit in cryptocurrency terms could also lead to substantial fluctuations of values of the debt market.

Cryptocurrency faces a challenge in becoming a legal currency due to its inherent volatility. In the following we discuss the price volatility of Bitcoin but the analysis would hold similarly for the majority of other cryptocurrencies, i.e. other cryptocurrencies are similarly or more volatile than Bitcoin. According to Figure 5, Bitcoin prices and daily changes in Bitcoin price are highly volatile. The price has moved from only 434 dollars in the beginning of 2016 to its peak of more than 67000 dollars in November 2021, followed by a huge drop to around 21000 dollars in 09/03/2023. In March 2020, due to the outbreak of the pandemic, Bitcoin price has lost half of its value from nearly 10000 dollars to around 4000 dollars (Chen et al., 2020). Specifically, on 12 March 2020, Bitcoin witnessed its highest volatility of -39.14% in one day.

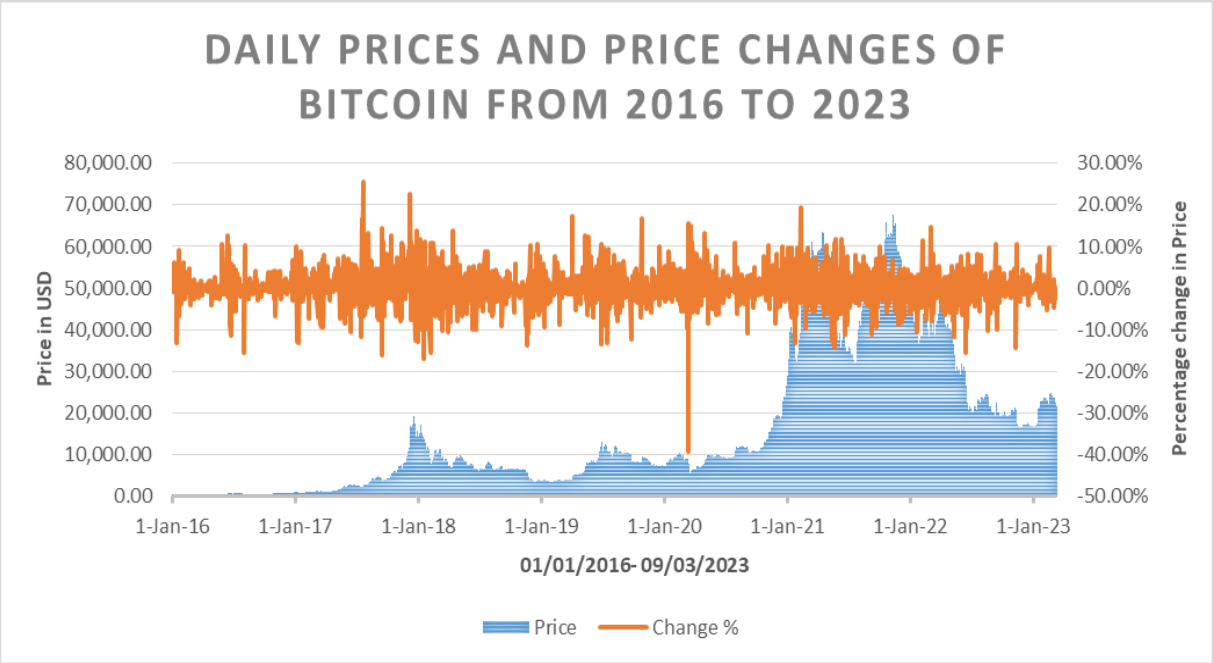

Figure 5. Daily prices and price changes of Bitcoin from 2016 to 2023

Compared to other currencies like the US dollar, Japanese yen, or euro, the volatility of Bitcoin/USD could be ten times higher (Baur & Dimpfl, 2021). This volatility is caused by the inelastic supply embedded in the protocol's code, for example, Bitcoin has a fixed supply of 21 million tokens. As a result, there is a mismatch between the quantity demanded and supplied, leading to price volatility (Claeys et al., 2018). The wide fluctuations in Bitcoin's value could hinder its effectiveness and reliability as a form of money. This restricts the adoption of cryptocurrency as a medium of exchange and unit of account, and also results in a relatively small usage network (Claeys et al., 2018). This could also lead to instability in the value of goods and services for countries that import them (Adrian & Weeks-Brown, 2021). Additionally, merchants and consumers may be hesitant to use Bitcoin as a form of payment due to the unpredictability of its value (Dark et al., 2019). A study by Baur and Dimpfl (2021) found that from January 2014 to January 2017, the daily fluctuations of Bitcoin were around 10%, making it costly for both small and large corporations to adopt it as a means of payment. With this high volatility, cryptocurrencies have been subject to speculation, rather than being used as a network for payment, making their value unsustainable in the short-term (RBA n.d).

Under the fixed exchange rate system, some microeconomic aspects could be noticeably beneficial, such as the reduction in transaction costs associated with currencies' hedging and conversion (Murray, 2000). Klein and Shambaugh (2006) suggests that

international trade would increase by 35% with a pegging system. On the other hand, a a floating exchange system leads to various negative impacts, such as a reduction in international trade, foreign investment decline, and further detrimental impacts derived from the fluctuation in national reserve value (Artus & Young, 1979). Hence, adopting highly volatile cryptocurrency as legal tender will not support a country in conducting international trade.

4.2 Economic growth

According to Leonard and Treiblmaier (2019), problems of the current debt-based monetary system stem from the fact that new money is issued by debt, which brings about 2 consequences: (i) boosted productivity, as people must work to pay their debts, but also (ii) centralized power to few entities in the economy. This pattern of money issuance is only suitable for an ever-growing economy which, in reality, is not true since maintaining economic growth forever is unachievable and also unwanted because of limited natural resources (Daly, 2005). Although these authors do not deny the current bottlenecks of Bitcoin to function efficiently as money and mostly attributed them to the volatility of Bitcoin, which will make people hesitate to adopt Bitcoin as a medium of exchange and even a unit of account.

As shown in Chapter 1, the economic growth during the gold standard era is higher than that in fiat money period, yet it is also susceptible to more variations owing to the (i) swings in gold production and (ii) fluctuations in "nonmonetary demand for gold" (Cooper et al., 1982, p. 13). Nevertheless, it is also one of the main causes leading to the Great Depression due to its constraints government to cope with hardships by exacerbating the effects of deflation since it guarantees that "thrift would be rewarded" (Eichengreen & Temin, 1997, p. 187). It is speculative to argue whether the adoption of cryptocurrencies that are akin to commodities can help to increase economic growth in the long-run.

The distribution of wealth in cryptocurrency is found to be unequal, especially among currencies with lower market capitalization (Ashish Rajendra et al., 2021). Nonetheless, Othman et al. (2020) still believe that cryptocurrency can solve the inequality problem of fiat currency thanks to its programmable inflation schedule. Cryptocurrency can also help achieve financial inclusion due to its greater accessibility via the Internet, its cost-efficiency, security and most importantly, its disintermediation nature. Cryptocurrency brings in a fairer mining mechanism for everyone, though mining is costly, it will help reduce the number of money issuers and eliminate those money first-receivers which will reap the best advantages in a fiat monetary policy.

5. Case studies of Cryptocurrency Adoption as Legal Tender

5.1. Case of El Salvador

On 9 June 2021, El Salvador became the first country to adopt Bitcoin as a legal tender by passing the Bitcoin Law qualified by a majority in the Legislative Assembly (Kshetri, 2022a). Legal tender is the payment mechanism recognized and accepted by a country's legal system allowing to extinguish debts in the same currency (Smith & Kumar, 2018). In order to facilitate this adoption, the country has created a $150 million trust fund accepted by the State Development Bank of El Salvador (BANDESAL) for two primary purposes. First, to promote the bitcoin-to-dollar conversion without any fee for the whole citizens and second, to promote the bitcoin usage in the country (Gorjón, 2021). To facilitate the adoption, the country has launched the Chivo wallet, a digital app that allows users to digitally transfer, receive and convert Bitcoin into dollar without any transaction fees (Alvarez et al., 2022). Specifically, the Chivo digital wallet with an initial US$30 value of Bitcoin is freely provided for each citizen who downloads this app (Alvarez et al., 2022). Using this app, users could transfer without fees, even for cross-border payments requiring only a mobile phone with an Internet connection (Sigalos & Kharpal, 2022). A network of 200 Bitcoin automated teller machines (ATMs) was also installed in El Salvador and in 50 major cities in the US to facilitate this adoption (Kshetri, 2022a).

This innovation became effective on 7 September 2021, with four main motivations behind it (Kshetri, 2022b). Firstly, El Salvador heavily depends on personal remittances recorded as US$5.936 billion in 2020, equaling 24.1% of the country's GDP. This adoption would save $400 million for the country's annual remittance transaction fees (Kshetri, 2022b)**.** Secondly, this change would enhance the country's financial inclusion, as 70% of the adult population in El Salvador was unbanked in 2017 (Kshetri, 2022b). Thirdly, the country's president, Nayib Bukele, also plans to transform the country into the first 'Bitcoin City' financed by US$1 billion in bitcoin-backed bonds called Volcano Bonds (Kshetri, 2022b).

Finally, adopting Bitcoin in El Salvador could reduce the country's heavy reliance on the US Dollar (Gorjón, 2021; Katterbauer et al., 2020; Kshetri, 2022b). From 1993 to 2000, El Salvador pegged their national currency to USD at the exchange rate of 8.75 colons per USD. Based on the solid macroeconomic fundamentals, stable and low inflation rate, manageable external debts, and robust banking system, the country decided to proceed with dollarization in 2001 (Andrew, 2012). Rivera-Solis (2012) stated that dollarization could rise because the country relied heavily on remittances from Salvadorians who live in the US. The US was also the leading trading partner of the country. However, the disadvantage of this system would be

the lack of control over the monetary policy, including exchange rate and interest rate adjustment, which entirely depends on the decisions of the Federal Reserve (Katterbauer et al., 2020). Additionally, the country is forced to reserve enough USD to serve the market liquidity, mainly from remittances and international borrowings (Kshetri, 2022a).

The situation in El Salvador after the adoption

a) Remittances are not affected as much as their initial expectation

The expectation of improving the remittance volume of the country by adopting the Chivo wallet used to send and receive remittances without fees is far from reality (Kshetri, 2022b). Only 2% of remittances was transferred by using the Chivo wallet in January 2022 which might resulted from the four-times higher cost of transfers compared to the traditional way (Kshetri, 2022b). Especially, Salvadorans need to convert their fiat money to Bitcoin and bear the costs of conversion rate and bid-ask spread in the centralized exchanges, namely Coinbase, Kraken and Binance (Kshetri, 2022b). For example, exchanging USD 200 Bitcoin for fiat money would cost them, on average, USD 2.99 to 7.67. In addition, sending Bitcoin from a centralized exchange to a Chivo wallet also incurs a network fee of approximately USD 3 for the miner (Kshetri, 2022b). Vázquez (2022) also report that sending remittance using Bitcoin would cost trading fees from Western Union or other intermediaries, as El Salvador is no longer considered a dollarized economy. The citizens are required to have the technical knowledge to execute, especially when the Bitcoin value is highly volatile. This makes them reluctant to adopt this new payment method and instead rely on the informal broker to implement this complex task (Sigalos & Kharpal, 2022).

b) Financial inclusion: some progress with the Chivo wallet download

Over the first week of October 2021, there were 3 million Chivo digital wallet downloads, which equals 46% of the population. Comparing this figure to only 30% of Salvadorans having bank accounts would be considered a successful strategy (Kshetri, 2022b). This considerable achievement comes from the less cumbersome procedures to open an account on Chivo compared to traditional banking (Kshetri, 2022b). Besides, the primary stimulus for this massive download is the free USD 30 Bitcoin value offered. This is significant compared to the average hourly wage range of USD 1 to 1.5 in El Salvador (Kshetri, 2022b). It also equals 0.7% of their annual income per capita (Alvarez et al., 2022).

However, Kshetri (2022b) and Alvarez et al. (2022) find less enthusiasm to continue engaging in the Chivo app from Salvadorans after they cash out their USD30 grant. The number of downloads was huge on its first launch in September 2021, which equals 40% of the total download, while no new download was recorded in 2022 (Alvarez et al., 2022), 75% of the

interviewees mentioned that they would not download the digital app if there were no $30 incentives (Alvarez et al., 2022). Only 20% of 1800 interviewees used Bitcoin as their payment method, while 50% of surveyed households only intended to claim the reward of USD 30 (Alvarez et al., 2022). Only 14% of 337 companies have revealed implemented Bitcoin transactions since September 2021- a survey from the country's Chamber of Commerce and Industry.

Although the quick adoption of Salvadorans with the Chivo app can be considered an early success, the subsequent adoption and usage of Bitcoin still face challenges that need to be addressed. It is not surprising that such a radical embrace of a new monetary technology needs time to be adopted.

C) Risk of deficits

After nine months since the adoption day, the El Salvador government has spent nearly $375 million USD, including $150-million trust fund for Bitcoin-USD conversion, $120 million for $30 incentive in each Chivo wallet, and a rough amount of 104 million USD for purchasing Bitcoin (Sigalos & Kharpal, 2022). However, the launch of US $1-billion Bitcoin fund backed by the Volcano Bond has seen no progress which continues to delay (Kshetri, 2022b). According to Fitch Ratings (2022), the country has fall into the risk of fiscal deficit including USD800 million Eurobond repayment which would expire in January 2023 leading to downgrade from “B-” to “CCC”. Besides, the debt-to-GDP ratio has reached 87% in 2022, sparkling the risk that this country could not meet their debt obligations over the medium term (Fitch Ratings, 2022). The adoption of Bitcoin has raised the economic uncertainty and policy unpredictability which could hinder the possibility that IMF could subsidize for the further support program (Fitch Ratings, 2022).

5.2. Case of the Central African Republic (CAR)

After El Salvador, the Central Africa Republic (CAR) is the second country that adopts Bitcoin as the legal tender and national reserve currency (Kshetri, 2022a). The CAR aims to utilize cryptocurrency for economic development and to facilitate new cryptocurrency-associated industries by establishing a legal and regulatory framework for cryptocurrencies (Katterbauer et al., 2020). However, the details of the adoption strategy in the CAR have not been disclosed clearly (Kshetri, 2022a). Besides, this adoption could act as the alternative currency to the current CFA franc, which France established under the General de Gaulle decree in 1945 (Sylla, 2018). Currently, the CFA franc currency is still used in two regions: The central African Economic and Monetary Community (CEMAC) by six

countries (in which CAR is a member) and the West African Economic and Monetary Union (WAEMU) by eight countries (Sylla, 2018). It is still very early in the adoption of Bitcoin as legal tender in CAR and more data are needed to evaluate the progress and effectiveness of the adoption.

Table 7. The characteristics of money in relation to Bitcoin adoption as legal tender in El Salvador and CAR

Characteristics of money	Countries that adopt Bitcoin as legal tender	
	El Salvador	Central African Republic
As a unit of account	According to Chartalism, Bitcoin acts as a unit of account by being endowed with a value which it could be used to pay tax and outstanding debts in El Salvador (Alvarez et al., 2022).	According to Katterbauer et al. (2020), article 6 of the law states that cryptocurrency might be used to pay taxes. Hence, Bitcoin in CAR has served as the unit of account with value.
As a medium of exchange	Under Bitcoin law, Bitcoin is accepted as the means of exchange for all national transactions. Specifically, with the Chivo wallet, citizens could send and receive Bitcoin within the national network without any fees (Alvarez et al., 2022).	According to (Kshetri, 2022a), Bitcoin has become the legal currency in CAR along with the current currency-CFA franc. This allows Bitcoin to be used as a medium of exchange for goods and services (Katterbauer et al., 2020).
As a store of value	According to Gorjón (2021), Bitcoin is not considered as the storage of value due to its fluctuations in value. It could rather act as the facilitator for financial inclusion in El Salvador	The fluctuation of Bitcoin value makes it become an unsecured legal tender which would violate the CAR's economy (Odeh, 2022). Hence, it could be considered the storage of value

6. Challenges and Opportunities of Adopting Cryptocurrency as a Legal Tender

Based on our analysis on literature, we found that there are various challenges and opportunities emerged from those countries that have been adopting cryptocurrency as legal tender. Low transaction fees and monetary independence are the most mentioned opportunities, while technical issues and inequality are the most mentioned challenges.

6.1. Challenges of adopting cryptocurrency as a legal tender

Losing the policy control

One of the potential challenges associated with accepting cryptocurrency as a legal form of payment is the possibility of forfeiting control of three major macroeconomic objectives from the impossible trinity (Marthinsen & Gordon, 2022). The idea of the impossible trinity stems

from the Mundell-Flemming model, which suggests that a country can only achieve two out of the three objectives simultaneously: independent monetary policy, stable exchange rates, and free capital movement (Aizenman et al., 2013).

The International Monetary Fund (IMF) has expressed concerns about the effectiveness of El Salvador's monetary policy since the country's adoption of Bitcoin as legal tender, as sovereign monetary policies would be surrendering to external influence. Additionally, a greater dependence on unpredictable international capital flows when adopting this type of money could significantly increase volatility for goods and services' domestic price (Gorjón, 2021). The adoption would weaken the ability of central bank to stabilize the economy against recession or liquidity shortages (Marthinsen & Gordon, 2022).

Price fluctuations

Another challenge is the Bitcoin price volatility which imposes more risks for households and enterprises (Adrian & Weeks-Brown, 2021; Alvarez et al., 2022; Gorjón, 2021; Kshetri, 2022b; Read, 2022; Yussof & Al-Harthy, 2018). The price fluctuations will make them waste more time and resources choosing between currencies to hold (fiat or Bitcoin/cryptocurrency). It can also negatively affect government revenue and increase exchange rate risk (Adrian & Weeks-Brown, 2021; Gorjón, 2021) because taxes are quoted in cryptocurrency, and government spending is denominated by the local currency (Adrian & Weeks-Brown, 2021). The denomination of debt and credit in cryptocurrency terms could lead to substantial fluctuations in in the value of the debts negatively affecting the debt market which, in turn, could impair economic growth.

Centralization

The adoption of cryptocurrency as a new legal tender will require a specific technical setup which grants more control to private entities over the monetary system (Ojha et al., 2021). Since regulatory requirements to set up a cryptocurrency exchange are cumbersome, legitimate exchanges in this market are of a moderate amount, making it less competitive and more centralized. Furthermore, technical barriers of decentralized wallets remain high for newcomers, making them rely more on custodial wallets ', thereby raising the risk of security once these centralized entities are attacked (Böhme et al., 2015). More importantly, centralizing the mining capacity of a Proof-of-Work system similar to Bitcoin will make it more vulnerable to a sudden regional energy shortage. Hence, this creates network congestion, drives transaction fees upward and adds more cost burden on the network users (Scharnowski & Shi, 2021).

Lack of education

Insufficient education can also hinder the popularity of cryptocurrency. Some El Salvadorans still think Bitcoin is the same as the Chivo wallet (Trigueros-Argüello & de Trigueros, 2021, as cited in Kshetri, 2022b). The El Salvadoran government, particularly president Bukele and other Bitcoin promoters in El Salvador, keep emphasizing the merits of Bitcoin cannot help persuading people to accept it but urging them to use it to experiment with it. This is not possible as the price volatility of this asset is one of the most significant barriers to entry for new users. Also, they claim misleading facts about Bitcoin's technology and the trustless environment of Bitcoin. Still, the truth is Bitcoin's anonymity can also bring in the dark side of illegal payment (Vázquez, 2022).

Energy consumption

Similar to the concerns of general cryptocurrency adoption, unsustainable energy consumption is also discussed when a government wants to adopt it as a legal tender (Adrian & Weeks-Brown, 2021). It can be infeasible for a country to find alternative energy sources to mine new Bitcoin (Ojha et al., 2021). The amount of energy required for a Proof-of-Work system like Bitcoin can cause extensive pollution. At the same time, its efficiency still lags behind the current payment systems with only seven transactions per second, rather than the

Legal issues

Legal issues such as jurisdiction-based problems arise due to the variety of nodes' locations (Katterbauer et al., 2020) and taxation (Katterbauer et al., 2020; Ojha et al., 2021). For taxation, collecting and mapping all cryptocurrency transactions with their owner's identity is challenging due to the cryptocurrency's pseudonymity (Hassan & Azhar, 2022; Liedel, 2018). Complying with international monetary obligations (Adrian & Weeks-Brown, 2021) is also considered when discussing the challenges of cryptocurrency adoption as a legal tender.

There are concerns that Bitcoin be used as a tool for money laundering and terrorism financing due to its anonymity (Adrian & Weeks-Brown, 2021; Blundell-Wignall, 2014; Katterbauer et al., 2020; Kedem et al., 2022; Taylor, 2022; Teja, 2022; Yussof & Al-Harthy, 2018). Nevertheless, there are still Bitcoin mixing services used to preserve the anonymity of Bitcoin transactions (Möser et al., 2013). These services have been implementing new off-chain tactics to make it more difficult for regulators to detect money laundering transactions by solely relying on the traceability of the Bitcoin blockchain (See, 2022).

High transaction costs

While it is believed that payment using blockchain is cheaper than traditional systems regarding the relative value between the transacted amount and the fees, in absolute terms, the opposite is true (Alvarez et al., 2022). According to the experience of El Salvador, when remittance

transfer is about four times more expensive than traditional payment methods due to network fees and exchange fees outside the Chivo wallet (Kshetri, 2022b). Transaction costs can rise higher due to the increase in Bitcoin's price (Ammous, 2018a) or when the network is congested, and people are impatient to wait for transaction confirmation, which adds up to the cost of uncertainty for users (Tsang & Yang, 2021).

Slow speed

In fact, the transaction time of the Layer1 Blockchains which can amount to half an hour, which is inconvenient for businesses (Read, 2022). Furthermore, the international transfer of cryptocurrency can encounter problems when an exchange ban user from a specific country. Dorofeyev et al. (2018) stated that payment using cryptocurrency is not any quicker than the current electronic payment system in the condition of insufficient support for depositing and withdrawing cryptocurrency to and from the traditional financial system.

Inequality

Regarding the inequality issue, the lack of Internet access is a considerable barrier to entry, especially for the poor and unbanked population (Alvarez et al., 2022; Katterbauer et al., 2020; Kedem et al., 2022; Namcios, 2022; Ojha et al., 2021; Taylor, 2022). In El Salvador's experiment, most adopters are the people who are banked and more familiar with the Internet as well as mobile devices (Alvarez et al., 2022; White et al., 2022). On some occasions, the distribution of cryptocurrencies is "lopsided", leaving room for economic inequality (Buterin, 2021, as cited in Apostólicas & Nayar, 2021). Although it is deemed that cryptocurrency has the potential to promote financial inclusion (Vincent & Evans, 2019), more needs to be done to achieve that.

Technical issues

Technical issues are another challenge for cryptocurrency users. Users may forget passwords or encounter issues when using Bitcoin (Alvarez et al., 2022; Namcios, 2022; Read, 2022; Vázquez, 2022). Data privacy and network security are significant concerns (Katterbauer et al., 2020; Ojha et al., 2021; Yussof & Al-Harthy, 2018). Moreover, due to the lack of KYC (know-your-customer) control as well as technical flaws (Gorjón, 2021) within the Chivo Wallet app, more than 2,000 cases of identity theft related to the wallet were reported by mid-October 2021 (Kshetri, 2022b). Countries that adopt cryptocurrency as a legal tender may lack infrastructure (Namcios, 2022) for deployment, especially for enterprises to accept cryptocurrency as a

medium of payment (Read, 2022). Furthermore, there is a paradox that a custodial wallet[1] is used in CAR to prevent people from losing their private keys, which contradicts the decentralization nature of Bitcoin (Teja, 2022).

6.2. Opportunities of adopting cryptocurrency as a legal tender

Financial Inclusion

Since the invention of Bitcoin and blockchain technology, a new form of mechanism for international settlement that does not rely on third parties has been established (Ammous, 2018a). This distributed ledger technology (DLT) allows every participant in the network to create and validate transactions eliminating the role of middle banks (Lai, 2021). Moreover, combined with an e-wallet or e-payment systems, blockchain-based cryptocurrencies could revolutionize the digital payment sector allowing users to transfer money without the need of physical infrastructures (Khando et al., 2023). Moreover, blockchain technology could let any individual send their own money without any permission, without revealing their identity, and store their Bitcoin on their own private key to carry it at ease (Ammous, 2018a). Bitcoin's comparative advantage as a digital currency may not be in replacing cash payments for small, in-person transactions, which can be conducted through a variety of methods such as cash, barter, credit cards, and checks. Instead, Bitcoin's advantage lies in allowing for the final settlement of large payments over long distances and national borders, bringing the speed and security of cash settlement to the digital world (Ammous, 2018a). Consequently, adopting cryptocurrencies as legal tender could easily be scalable without the need to heavily invest in financial and fintech infrastructures. Everyone with a mobile phone and internet can potentially use cryptocurrencies and access inter-native financial services.

Economic independence

Regarding the independence aspect, Bitcoin adoption as a legal tender can help Euro- or dollarized economies such as CAR and El Salvador to reduce the influence of other countries (Apostólicas & Nayar, 2021; Namcios, 2022). Adopting Bitcoin can help CAR to reach the international markets more easily without dealing with dependence on France within the CAR Franc system (Namcios, 2022).

[1] There are 2 commonly used wallets in the cryptocurrency market: custodial versus non-custodial (decentralized) wallet. While non-custodial wallets let users store their own private keys used to sign transactions, custodial wallets manage their user's private key and make transactions on the blockchain on behalf of users Gomzin, S. (2022). How to Choose the Wallet. In *Crypto Basics* (pp. 165-182). Springer.

Potential low transaction fee

Another benefit of adopting cryptocurrency as a legal tender is its potential to lower financial transaction fees owing to its disintermediation nature (Yussof & Al-Harthy, 2018). Further, it can also improve the technology in the future (Till et al., 2017), especially if we consider it in relative terms. The transaction fee rates of cryptocurrency networks could be still lower than that of the traditional payment system. For example, Mastercard or Visa transaction cost is 1.7 - 3.5%, still higher than the rate of a transaction fee of Bitcoin of 0.1% in 2017 (Tsang & Yang, 2021). Such low cost of blockchain can benefit young startups as it reduces their cost for investors and companies due to the less reliance on intermediaries to solve the problem of information asymmetry (Ahluwalia et al., 2020). Besides, lower transaction costs can allow for lower prices, thereby enhancing the quality of life of less affluent people (Massaro et al., 2020) or even microcredits as they can raise funds at a lower transaction cost and conversion fees (Holtmeier & Sandner, 2019). Other Blockchains and Layer2 solutions could be even faster and cheaper.

High speed

Other opportunities expected from cryptocurrency adoption are high transaction speed arising due to decentralization (Yussof & Al-Harthy, 2018) and greater privacy due to cryptography (Yussof & Al-Harthy, 2018). Concerning the transaction speed, Bitcoin payment can process within 10 minutes, and the network operates 24/7 compared to the traditional payment system, which only has a few clearing sessions a day and does not work on holidays or weekends (Dabrowski & Janikowski, 2018). This attribute of cryptocurrency can reduce the time required for cross-border money transfers compared to the traditional system currently being used (Ng & Griffin, 2018).

Regarding privacy, such expectation is not accurate because the Bitcoin network and most public blockchain networks are pseudonymous, neither anonymous nor private. The difference here is that privacy is "hiding the context", while anonymity is "hiding the owner of it" (Bradbury, 2014, as cited in Khalilov & Levi, 2018). The bitcoin blockchain is not anonymous to ensure its transparency property (Protect Your Privacy, 2016, as cited in Khalilov & Levi, 2018). Also, privacy is not an inherent feature of the Bitcoin blockchain. The users themselves can only protect their privacy by ensuring their transactions are not linked together (Khalilov & Levi, 2018).

Traceability

Meanwhile, the traceability of cryptocurrencies are useful in tackling the money laundering issue (Yussof & Al-Harthy, 2018). Indeed, by mapping the cryptocurrency pathway with the

crypto-to-fiat portal (i.e., centralized exchanges), the identity of one can still be discovered. However, some tools can help money launderers protect their identity when transferring their funds using cryptocurrency (Dupuis & Gleason, 2020). The supply chain industry can take advantage of this traceability of blockchain with IoT (Internet-of-Things) technology to promote transparency and security of the system and reduce counterfeit products (Abu-elezz et al., 2020). However, there are still difficulties in utilizing this benefit because of the bugs in the irreversible smart contracts, insufficient standardization guidelines to integrate blockchain and allow all stakeholders to work fluently together (Feng et al., 2020).

Non-reversibility

Non-reversibility is another benefit of cryptocurrency that can help avoid chargeback fraud (Yussof & Al-Harthy, 2018). Chargeback fraud occurs once a customer requests a refund after receiving the products or services, resulting in losses for merchants regarding online transactions (Kher et al., 2021), especially those in the e-commerce industry (Dumitrescu, 2017). Reduction in chargeback fraud can also help small businesses avoid being penalized as only 1% of their charges being classified as chargebacks is enough for them to be eliminated from the network of Visa or MasterCard (Harper 2014, as cited in Brito, 2014).

At the same time, this may add up the cost for users (Ma, 2017). If a fraudulent transaction occurs, the victim can never claim their money back (Mabunda, 2018). Therefore, a higher level of trust is required among network participants (Chenguel, 2023) to ensure that their money is spent properly.

Rules-based monetary policy

More importantly, cryptocurrencies are less susceptible to unexpected changes in monetary policy due to its programmatic supply (Yussof & Al-Harthy, 2018). It also means that the government will lose the control of its monetary policy (Adrian & Weeks-Brown, 2021; Blundell-Wignall, 2014; Gorjón, 2021) to ensure its economic stability because cryptocurrency is not designed to capture important macroeconomic indicators such as Consumer Price Index or unemployment rate, yet (Buterin, 2021, as cited in Apostólicas & Nayar, 2021).

7. Discussion and concluding remarks

There have been only two countries that have adopted cryptocurrency as legal tender so far in history. El Salvador has low growth rates, high poverty rates, and a chaotic social and economic background (*The World Bank In El Salvador - Overview*, 2022). The economic condition is even worse in CAR, whose economy remains one of the poorest in the world. Its people are

severely deprived of education and social security due to the conflicts for power between factions in the country (*The World Bank in Central African Republic - Overview*, 2022).

Besides these similarities in the social and economic situation, El Salvador and CAR face the same problem of lack of currency autonomy. El Salvador has had a dollarized economy for 20 years (Díaz & Rumbea Pavisic, 2022), and the CAR has had its currency being highly affected by France, i.e., the monetary colonialism aforementioned (Canac & Garcia-Contreras, 2011). This may be why they adopt Bitcoin – a so-called decentralized currency – as a legal tender to escape the undesired impact of other countries' economic issues. As seen from the example of El Salvador, if a country plans to adopt cryptocurrency as a legal tender, sufficient knowledge about the underlying technology and technical preparation should be guaranteed for all businesses and households within that country. However, other uncontrollable factors, such as volatility in crypto-currency price and transaction fees, can limit the adoption of cryptocurrency and, in turn, lead to a waste of time and resources for both the government and its people. Thus, finding a solution that will satisfy the benefits of cryptocurrency and blockchain while preserving its decentralization nature can be the topic for future research about cryptocurrency adoption.

According to Bhimani et al. (2022) there is no correlation between GDPs per capita and cryptocurrency adoption, however, there is a negative linkage between economic freedom, democracy, control over corruption, and human development vis-à-vis cryptocurrency adoption. Meanwhile, adoption is more well-promoted among countries that have higher income inequality among their people. This may explain why more developed economies, which tend to have higher economic freedom (Brkić et al., 2020), democracy (Acemoglu et al., 2019), better control over corruption (Gründler & Potrafke, 2019), and greater human development (Gründler & Potrafke, 2019), have not adopted cryptocurrency as their legal tender because the cost to replace their current efficient system would be higher.

CHAPTER 3: IMPLICATIONS OF PROOF-OF-WORK AND PROOF-OF-STAKE ON ECONOMIC DEVELOPMENT

1. Background

The idea of a purely digital payment system first emerged in the early 1980s and witnessed significant development until the late 1990s. During that time, experts were exploring the creation of new forms of money that were more secure and private than the traditional forms of payment. One of the earliest breakthroughs was the concept of "blind signatures" proposed by Chaum (1983) proposing the creation of a digital cash that could be spent anonymously. Further developments of the concept were proposed by Law et al. (1997) where users can create anonymous bank-issued digital coins by sending encrypted transactions to the bank. However, both approaches require a central authority, the bank, to issue and operate cryptographic key pairs and monitor the entire process.

Later attempts at digital currencies and digital tradable goods were proposed to make the issuance and balance validation processes more independent and inefficient in the late 1990s and early 2000s. Most notable of which were B-money (Dai, 1998), Reusable proof-of-work (Finney, 2004), and Bit Gold (Szabo, 2005), proposing that users can become digital gold miners by solving cryptographic puzzles. What the three approaches had in common was that they all proposed techniques to make the process of issuance and transacting more independent and user-centric using proof-of-work, a concept proposed and implemented in Hashcash (Back, 2002). Proof-of-work is a mechanism used to combat spam emails and DoS (Denial of Service) attacks using a system that requires email senders to perform computational tasks and generate tokens in other to be able to send the emails; the recipients then can verify the authenticity of the received emails by looking at those tokens (Back, 2002). However, all three approaches still in one way or another required a central authority to maintain the balance of all users, putting trust in one place.

2. Consensus Mechanisms

2.1. Proof-of-work & Consensus Mechanisms

Inspired by more than 20 years of research on cryptography-based digital currencies, the first successful instance of a purely digital payment system, known as Bitcoin, was proposed, and implemented by Nakamoto (2008). Bitcoin's unique innovation was the creation of a tamperproof network with security, anonymity, and consistency (Zhang et al., 2020) where the ownership records of all users and transactions were stored on a distributed public ledger, the

integrity of which was constantly validated by a network of worldwide computers. This technique eliminated the need for a central authority, such as the bank, since validating the ledger does not require any pre-defined chosen groups of participants (Jutla, 2021). Nakamoto (2008) proposed an elegant solution to the Byzantine Generals problem of a distributed ledger system using a proof-of-work-based consensus mechanism that leverages incentives among participants. Nakamoto's solution achieves consensus by creating a setting of trust, dictated by open-source protocol rules, where a group of actors, known as miners, devote computational power to solve cryptographic puzzles in order to be able to make changes to the public ledger. These actors receive newly minted coins called bitcoins in return only if these changes are confirmed to be valid by other network participants (Nakamoto, 2008). The process above is called a proof-of-work consensus mechanism. In other words, a consensus mechanism is a set of operational governance rules to ensure all participants can eventually agree on a single state of the network in an environment where there is no pre-defined authority to trust (Nguyen et al., 2019).

2.2. Proof-of-stake consensus mechanisms

Nakamoto's proof-of-work consensus mechanism has paved the way for the development of methods for achieving consensus in blockchain systems. Based on the initial design, King and Nadal (2012) published their invention of another consensus mechanism called proof-of-stake, an alternative consensus mechanism where validators are chosen to make changes to the public ledger based on the amount of stake they hold in the network (Goldberg & Moore, 2019; Jutla, 2021). Instead of creating new blocks through the mining, this new approach replicates the process by assigning the right to add new blocks to the blockchain to the stakeholders of the network and consensus is achieved as all participants keep adding new blocks to the longest chain (Buterin & Griffith, 2017; Deirmentzoglou et al., 2019). This approach is known as chain-based proof-of-stake. However, due to its technical nature inherited from proof-of-work, chain-based proof-of-stake only allows a blockchain to achieve probabilistic finality, not deterministic finality (Buterin & Griffith, 2017; Deirmentzoglou et al., 2019). This technical characteristic implies that in chain-based proof-of-stake, the addition of a block into the public ledger is not "truly" final, but rather probabilistic and there is a slight chance that it may be reverted.

The other approach to proof-of-stake consensus, known as Byzantine Fault Tolerance (BFT) consensus, fixes this problem. In BFT-based consensus, the algorithm chooses validator nodes as leaders to propose new blocks, then requires at least two-third of the network participants to agree on accepting this new block (Deirmentzoglou et al., 2019). BFT-based

consensus is currently used to achieve consensus in many of today's most celebrated proof-of-stake algorithms, including Ethereum's Casper the Friendly Finality Gadget (Buterin & Griffith, 2017), Cardano's Ouroboros (Cardano, n.d.,), Polkadot's GRANDPA (Pewtrouski, 2019), and Cosmos's Tendermint (Tendermint, n.d.). Although some protocols like Polygon's Heimdall and Bor (Polygon, n.d) are still using a hybrid approach of both chain-based and BFT-based consensus, chain-based proof-of-stake was more commonly used among the early pioneers such as Peercoin (King & Nadal, 2012) and Blackcoin (Vasin, 2014).

Though acknowledging the existence of many consensus mechanisms, we identify proof-of-work and proof-of-stake as the two most common mechanisms in blockchains. As there are many variants of how proof-of-work and proof-of-stake are implemented in protocols, the scope of this section will focus on the more widely studied consensus mechanisms, which are Nakamoto's proof-of-work, used in Bitcoin, and BFT-based proof-of-stake as mentioned by scholars such as Bentov et al. (2016), Chaudhry and Yousaf (2018), Goldberg and Moore (2019), and Deuber et al. (2020).

3. Proof-of-work, Proof-of-stake, and Monetary Policy

The objective behind consensus mechanisms is to allow network participants the opportunity to agree on a single truth and/or a particular network state in a trustless environment (Chaudhry & Yousaf, 2018; Nguyen et al., 2019). This is achieved by asking participants to validate and add new information to the blockchain while devoting economic expenditure.in exchange, for such resources, network participants receive rewards for every new bundle of transactions, called a block, attached to the ledger's history.

In a proof-of-work setting, the economic expenditure is computational power generated by energy-intensive hardware and electricity consumption (Berg et al., 2019). Participants of a proof-of-work protocol, called miner nodes, need to use their computational power to compete to solve a cryptographic puzzle. The first miner to solve the puzzle is granted the right to propose a new block, containing validated transactions. The block proposer then broadcasts the new block to all nodes on the network. The nodes validate the block's integrity and then express their acceptance by creating new blocks that contain the block's unique hash in the block header (Nakamoto, 2008). The protocol then credits the block proposer with native coins from the transaction fees and the block reward.

In contrast, in a proof-of-stake setting, the economic expenditure is the "buy-in" stake in the form of a protocol's native tokens (Jutla, 2021) held by network participants, called validators. To become a validator, a participant is required to deposit a certain amount of the

network's native coins and set up a validator node with the necessary software and hardware requirements. These requirements are different from network to network. Like proof-of-work, a validator's main functions are to put together new transactions to propose a new block, then validate and attest to a new block proposed by other validators. For every new block, a block proposer is chosen among validators based on their stake to become a block proposer that adds a new block to the public ledger. Once the block is accepted, the block proposer is rewarded with transaction fees and block rewards in the protocol's native coins. Overall, having discuss the design characteristics of proof-of-work and proof-of-stake, in the next sections, we discuss the link between these two consensus mechanisms and issues related to monetary policy: issuance of new coin (section 2.1), control over money supply (section 2.2), and trade-off between inflation and growth (2.3).

2.1. Issuance of new coin

2.1.1. Issuance in proof-of-work protocols

The issuance of new coins in proof-of-work consensus mechanisms is carried out through block reward function - a function implemented in a protocol that decides the number of coins to be issued if a new block is created. A constant block reward function is a function that determines a protocol's block reward value to remain fixed over a long period of time (Goldberg & Moore, 2019; Nakamoto, 2008). For instance, Bitcoin's block reward function dictates that the network's reward for each block will be reduced by half every 4 years (210,000 blocks to be specific), starting with 50 bitcoins rewarded for block 0. It is worth noting that while a constant block reward function is not an essential feature of proof-of-work consensus mechanisms, it is used in practice by the most celebrated proof-of-work protocols such as Litecoin (Litecoin, n.d.) or Zcash (Zcash, n.d.). In these protocols, the distribution process of new supply relies solely on a pre-defined constant block reward function. This suggests that the supply of new native cryptocurrencies in proof-of-work protocols operate in a block-based unchanged uniform manner throughout the timeline of their respective blockchains.

2.1.2. Issuance in proof-of-stake protocols

Proof-of-stake protocols, on the other hand, operate far more complex reward structures and the initial supply distribution method is done externally to the blockchain. In this subsection, we discuss the initial supply, issuance rate, and burning mechanisms from proof-of-stake protocol.

Initial supply

In specific, the original paper by King and Nadal (2012) suggested that the initial supply of its proof-of-stake protocol is to be distributed in a process that is similar to an IPO, known as

Initial Coin Offering (ICO), where the original developers of a project issue an initial number of coins in the first block of the blockchain and offers these coins to the public in exchange for some forms of money – fiat and/or digital. For instance, 4.72% of the max supply of the Avalanche protocol was offered to the public in 2020 in exchange for bitcoin, ether and certain stablecoins (ICO Drops, n.d.). Although being a proof-of-work protocol at the time of initial issuance, Ethereum also issued its initial supply in this manner, offering 72 million coins to the public in exchange for bitcoins.

Bentov et al. (2016) highlights that the initial issuance of new coins via an IPO-like manner is unfair, and such a method of issuance implies the centralization of the money supply which can later result in large stakeholders manipulating the market. The authors argue that original proof-of-work solves this problem elegantly through its fair distribution per block. However, Jutla (2021) on the other side, argues that proof-of-work's method of initial issuance also provides an unfair advantage to early participants. The author points out that early participants acquired the coins with ease as they did not have many competitors and this phenomenon will result in such coins becoming highly speculative, granting disadvantages to later acquirers.

Issuance of supply after the first block

In proof-of-stake, for every block besides the first block, one or more validators are selected at random to be involved in the block creation process. For every block created, these validators are rewarded with newly minted coins. However, this process is different between blockchains. For example, some systems choose the validators at random by looking at the protocol coins, like Cardano (Cardano, 2022) and Avalanche (Buttolph et al., 2020), and hence, the more coins a validator possesses, the more likely that validator gets chosen. If there were no external economic resources to enter this closed economy, the network of validators suffers from a compounding effect where the rich validators get richer. Ethereum's proof-of-stake (Ethereum, 2022) limits all the validators to a max threshold of stake, which is 32 ETH. Any amount that surpasses this threshold is not accounted for when the algorithm picks its group of validators. The newly minted reward coins for validators are also locked until a future update of the network. While this mechanism still leaves space for compounding effects, where validators use their reward to run new validator nodes, the feedback loop is much slower, like the phenomenon in proof-of-work where miners sell their reward coins to buy new mining equipment.

Additionally, the block reward functions of proof-of-stake protocols also consider other varying parameters, such as the total number of active validators (Ethereum, 2022).

Issuance rate in comparison to proof-of-work

At the date of writing, the current supply of bitcoin is at approximately 19,280,000 bitcoins and is growing at an annualized rate of Bitcoin is currently at approximately 1.7% (6.25 bitcoins per block, 144 blocks per day). This growth rate is expected to be reduced by half every 4 years (210,000 blocks) as the block reward is reduced by half. Ethereum recently switched from a proof-of-work based to a proof-of-stake-based consensus mechanism[2] resulting in changes in the supply issuance rate. Calculation by Ethereum Foundation (2023) shows that prior to the transition, the Ethereum network's annualized issuance rate was at approximately 4.61%; after the transition, this number was reduced by nearly 90% to an annualized rate of approximately 0.52%. Although each network has its own supply issuance schedule designed differently based on distinctive rationales, it is worth noting that in Ethereum's case, the transition to proof-of-stake has resulted in the network's supply issuance rate to have been reduced significantly.

Burning mechanisms

Burning mechanism refers to a process through which a protocol's native coins are permanently removed from circulation. The implementations of burning mechanisms imply that the depletion rate of a protocol's native coin supply is higher in times of high network traffic. Although a burning mechanism is not a technically essential feature for distributed systems to achieve consensus, it is observed when analyzing the top proof-of-work and proof-of-stake protocols[3] that burning features are widely adopted by proof-of-stake protocols. Out of the total of six proof-of-stake protocols, except for Cardano, five protocols have been exercising a coin-burning mechanism where either burn functions are implemented natively in the protocols' source codes or burning programs are manually performed by the development entity on a periodic basis (Binance, 2021; Buttolph et al., 2020; Ethereum Foundation, 2023; Polygon Labs, 2022). Additionally, Cardano (2022) mentioned in a development note published in March 2022 that Cardano developers were finalizing an implementation that enabled coin-burning capabilities on the Cardano blockchain. Burning mechanisms implemented by proof-of-stake protocols are observed to be associated with the protocols' fee structure per transaction in the sense that for every transaction, a portion (e.g., Ethereum blockchain) or all (e.g., Avalanche blockchain) of the fees paid by users is burned.

[2] Ethereum was recently transitioned to using a proof-of-stake consensus mechanism at block 15537393 on 15th September 2022 (Ethereum Foundation 2022)

[3] We analyzed the top 20 protocols on CoinMarketCap (2023) with the highest total market capitalization. Among the 20 protocols, the 6 protocols that use proof-of-stake consensus mechanisms are Ethereum, BNB, Cardano, Polygon, Avalanche, and Tron.

2.2. Control over Monetary Supply

A central feature that differentiates cryptocurrency from base fiat money is the way in which new money is created (Danielsson, 2019). In the fiat money system new money is being create mainly through physical printing, credit creation and open market operations. For cryptocurrency system, new coins are generated by a computer algorithm at a fixed rate that are owned by private entities (Danielsson, 2019).

The fiat system has a built-in safety valve, the elastic and adjustable supply of money allows the central bank to quickly respond to liquidity crises and to act as a lender of last resort to safeguard price stability. With fiat money, central banks can make changes to a range of instruments, when they deem it necessary, to keep inflation rate under control, such as short-term interest rate changes, asset purchases or credit creation (Claeys et al., 2018).

Furthermore, there is no absolute limitation on the amount of currency in circulation. By virtue of negligible marginal costs of printing new cash, central banks can produce it endlessly, as long as that has no consequence on the monetary system (Tomić et al., 2020).

In contrast, cryptocurrencies have no monetary authority to set interest rates but, in most cases, a pre-determined fixed supply or mechanisms to assure coin scarcity (Dong, 2022; Farell, 2015). As a result, cryptocurrency might experience, in the digital realm, the same issue faced by gold and silver coins: limited resources restrain the ability to expand money supply in the face of economic distress.

Whilst monetary authorities in the commodity system can either adjust the ratio of metals by which coins are minted or modify the coin's face value (Redish & Weber, 2011), it is not that simple in blockchain networks, where the supply is even more inelastic. The protocol serves as the single tool to control the creation of new blocks and thus the release of underlying coins. Mining difficulty adjustment is encoded into Bitcoin's source code such that a new block is appended to the blockchain on average every 10 minutes, ensuring the pre-determined steady issuance of new coins into the system (Nakamoto, 2008). A supply cap change is technically feasible with the modification of the underlying protocol (Kostal et al., 2018), nonetheless, it is exceptionally hard for any change to truly happen to Bitcoin software due to its decentralized nature, especially when a raised or unlimited supply would destroy the investment thesis for Bitcoin – its scarcity (Ammous, 2018b). Accordingly, cryptocurrencies built on the same inelastic supply philosophy as Bitcoin, can hardly increase their supply beyond the pre-determined rate to respond to demand shocks and fulfil the lender of last resort function. Hence, most cryptocurrencies cannot effectively serve as both a form of currency and an investment.

Additionally, while cryptocurrencies help prevent policy makers from abusing their money creating privilege to favour individual self-interests over the common welfare (Danielsson, 2019), their decentralized governance could be counterproductive during crises that require flexibility in monetary policies. Decentralized networks strongly resist changes, much more than coercive centralized networks whose members are forced to adhere to unilateral decisions of the central authority (Ammous, 2018a). Even when cryptocurrency developers can modify the underlying protocols, those changes might not result in expected outcomes. Radical changes to a cryptocurrency's core protocol, such as a change to its issuance model, require the consent of the overwhelming majority of nodes to migrate simultaneously to the new software implementation and actively sell the coins on the old implementation (Ammous, 2018a). If any of nodes reject the changes, a hard fork will occur. Notably, it is hard to coordinate among disparate nodes and miners without a central authority (Ammous, 2018a). Ultimately, the algorithmically determined issuance of cryptocurrencies increases transparency and predictability of their monetary policy but takes away agility and flexibility to deal with economic shocks.

2.3. Trade-off between Inflation and Growth

Several studies have observed the possibility of deflationary pressure in blockchain networks implementing either proof-of-work (PoW) or proof-of-stake (PoS) as consensus mechanism (Barber et al., 2012; Ciaian et al., 2018; Deuber et al., 2020; Kapengut & Mizrach, 2022; Kostal et al., 2018; Peters et al., 2015). We discuss this in detail in the following subsections.

2.3.1. Proof-of-Work Implementation

Unlike physical metal commodities, which are in unknown total supply, most of PoW-based cryptocurrencies are designed with a pre-set finite cap on the supply of native tokens, which will be gradually introduced following a predetermined issuance schedule (Farell, 2015). The fixed cap aims to assure scarcity but has been accused of triggering deflation in blockchain networks. At the end of the mining phrase, that is once its hardcoded upper limit is reached, the total coin supply would stop growing or even decrease if a non-trivial portion of coins was irreversibly lost due to theft, electronic storage corruption or damage to physical storage (Peters et al., 2015). As real outputs continue to rise irrespective of the stagnating monetary supply, the overall price level would be continuously declining. The 'zombie coins' whose private keys were lost or destroyed also contribute to accelerate deflation (Deuber et al., 2020). In other words, while central banks can increase the amount of money in circulation to accommodate economic growth, the only outlet for growth in blockchain economy would be the appreciation

of the native token. Additionally, characterized by capped supply, diminishing issuance rate and energy intensive mining, PoW-based cryptocurrencies are broadly regarded as high-yield investments. Users are hesitant to trade their coins, fearing a sudden frenzied surge in the coin value. This could form a vicious cycle where hoarding of appreciating coins further exacerbates the deflationary problem (Deuber et al., 2020).

Bitcoin, in the common definition of deflation, is deflationary as its purchasing power increases over time. Although imposing no hard cap supply but a positive annualized inflation rate to allow a requisite growth of money supply, the issuance schedule of subsequent PoW-based cryptocurrencies remains fixed and predictable. From the perspective of an unknowable future, a predetermined variation in money stock is unlikely to match the real demand for liquidity (Malherbe et al., 2019).

Advocates of PoW protocol believe that deflation is a virtue that preserves the value of Bitcoin and its variants, making them a better store of value compared to inflationary fiat currencies. Nonetheless, as proof-of-work cryptocurrencies come into real-world implementation, their artificial scarcity, inelastic supply and wild volatility features would incentivize hoarding and promote deflation, which might result in a major depression, albeit not as immediately and blatantly as inflation. Ametrano (2016) stressed that 'if high inflation is money's heart attack, persistent deflation is money's cancer' (p. 6). With a fatal deflationary bias, proof-of-work cryptocurrencies have established themselves more as digital gold than currency in daily transactions.

2.3.2. Proof-of-Stake Implementation

Like proof-of-work cryptocurrencies, the majority of proof-of-stake coins have either a hard cap or a burning mechanism to make the supply deflate over time. By examining all PoS cryptocurrencies with market capitalization above $1 billion, Dong (2022) has found 12 out of 13 coins exercising a deflationary tokenomics model[4]. The only inflationary coin, MINA, has the smallest market cap, suggesting that cryptocurrency investors favour deflationary coins. This implication is particularly important to PoS-based networks as they must induce a large number of users to buy and hold stake to be secure. Besides, it is worth noting that the deflationary attribute of PoS cryptocurrencies also comes from their minting mechanism.

[4] Tokenomics refers to the structure of a particular cryptocurrency's economy, covers all elements that determine the supply and demand characteristics of the token, including but not limited to token issuance and distribution, its supply, utility and incentive mechanisms, creating incentives for investors to buy and hold tokens. A cryptocurrency's tokenomics is often outlined in its white paper.

Deuber et al. (2020) holds that pure PoS-based approach inevitably incentivizes coin hoarding as the participants maximize their utility by holding stake instead of trading. A large quantity of coins taken out of circulation undoubtedly inhibits the smooth exchange of goods and services in a crypto economy, leading to declining prices and deflation of coins. Furthermore, owning to minimal operation costs, as the PoS algorithm does not involve consuming quantum of electricity, there is no need to supply as many new coins, in the form of block reward, to motivate validators to sustain a preferred level of security (Kostal et al., 2018). Lower issuance rate means suppressed inflationary effect. Consequently, in addition to deflationary pressure inherent in token design and hoarding incentivizing characteristic, there might be an ineluctable deflation in PoS-based systems.

The removal of the block reward has indeed significantly slowed the minting of new Ether since the Beacon chain merge (Kapengut & Mizrach, 2022). Eating further into the supply are burnt fees, which have been introduced since the EIP-1559 protocol upgrade in August 2021. The burn rate can, in principle, exceed the issuance rate, eroding Ether's advantage as a disinflationary currency while adding some deflationary pressure (Félez-Viñas et al., 2021; Kapengut & Mizrach, 2022).

Even though proof-of-stake cryptocurrencies might widely vary in total supply and issuance schedule, deflation remains a considerable threat to these digital currencies as their consensus algorithm invariably incentivizes coin hoarding and lowers issuance rate. Ultimately, pre-set hard supply cap, asymptotically approaching zero money growth rate, energy intensive mining (PoW-based approach) or coin hoarding incentivizing (PoS-based approach) undoubtedly hinder the long-term viability of cryptocurrencies as currencies that can be used in day-to-day transactions. The implementation of a deflationary legal tender could disincentivize consumer spending and business investment, increase debt burden, reduce business profits, and hence destroy job creation in the process (Doumenis et al., 2021).

Several novel consensus algorithms have been proposed to mitigate power consumption and coin hoarding such as proof-of-importance (PoI), proof-of-cooperation (PoC) (Ferdous et al., 2021). However, unless the mining or minting of new coins is decoupled from the consensus, whether a particular consensus mechanism is associated with deflation will critically hinge on the native token's supply and issuance schedule which directly influence the purchasing power. Deuber et al. (2020) advocated for moderate steady inflation as a countermeasure against the stagnation of money, a deterrent to money hoarding and an incentive for trading. However, there is yet no unified formula for an exactly right inflation rate in blockchain networks.

3. Proof-of-work, Proof-of-stake, and Economic Development

The wealth is reallocated in cryptocurrency networks according to the consensus mechanism, from coin issuance to distribution of the underlying coins to the system's maintainers in the form of block rewards. While egalitarian cryptocurrencies based on proof-of-work and/or proof-of-stake claim to bring fairness to real-world economies, their algorithmically driven free-market implementation may eventually incentivise wealth concentration, and hence increase inequalities (Dong, 2022; Li et al., 2022; Li et al., 2020; Sus, 2022).

3.1. Proof-of-Work Implementation

In matters of coin issuance and distribution, proof-of-work-based cryptocurrency networks are dynamic computational meritocracies, in which miners are compensated for computational power devoted and winners of block rewards constantly vary (Sus, 2022). Although miners might earn a large number of cryptocurrency units, a great portion of their proceeds must be sold to cover operating expenses including electricity bills, rent and amortization of ASICs, thereby distributing newly mined coins to other users (Kuśmierz & Overko, 2022). Hence, proof-of-work, in the idealized view, is egalitarian: the discovery of a block is random as the information diffuses instantaneously throughout the network, and thus everyone can contribute equally according to their computational power which is 'natural' and cannot be exclusively owned. However, the folklore belief has been called into question by scholars who suggested that larger wealth resulted in more than proportional rewards in proof-of-work-based networks. Mining might increase wealth disparity with the accumulation of extra-protocol factors: mining cartelization, early or even exclusive access to specialized mining hardware (Li et al., 2022; Li et al., 2020).

The miner of a newly mined block will be the first to receive its own block, thus gaining an advantage in the race to mine the next block. The previous block advantage encourages miners to coalesce into pools and form peering relationships to obtain a more advantageous position in the mining network (Long et al., 2022). In fact, proof-of-work mining is now essentially an all-pay tournament to win, with the majority of mining activities carried out in large purpose-built warehouses with dedicated mining rigs. The industry is dominated by mining pools that are groups of miners sharing computational resources to increase the probability of winning a block and reduce the variance of block rewards (Schinckus, 2020). As of 2018, approximately 70% of cryptocurrencies with the largest capitalization were already controlled by a handful of major computational nodes (Kalinin & Berloff, 2018). Notably,

while mining pools are supposed to operate independently, scholars detected mining cartels among major miners in some of the most popular PoW-based cryptocurrency networks (Li et al., 2022; Li et al., 2020). Members of mining cartels might secretly share the information about newly mined blocks in advance in order to relay the blocks more quickly among them. In other words, miners in a cartel gain a previous block advantage whenever another cartel member mines a block, resulting in an abnormally high probability of consecutively discovering blocks by miners in the same cartel (Long et al., 2022).

Additionally, miners in mining pools and cartels might benefit from early or even exclusive access to advanced mining hardware. The argument that computational power cannot be exclusively owned might be misguided in the case of an oligopoly, where internal parties mutually agree to halt the availability of new mining rigs irrespective of external demand. This may happen to Bitcoin network as more than 50% of total hash power has passed into the hands of just four mining pools, one of them is owned by a major computer and mining hardware manufacturers (Savolainen & Soria, 2019). Constraints in acquiring specialized mining equipment further disturb the egalitarianism of PoW-based systems.

3.2. Proof-of-Stake Implementation

Pure proof-of-stake implementation is broadly criticized for its inherent problem of wealth compounding, which may eventually lead to wealth disparity and inequalities similar to those observed in the real world (Dong, 2022; Sus, 2022).

Owning to proof-of-stake's intrinsic initial supply requirement, cryptocurrency networks implementing pure stake-based protocol need to pre-mine a quantity of native coins at the genesis block for the purpose of initial staking of the foundation nodes. Those pre-mined coins already bear a degree of inequality. Early participants, the first to receive a prodigious quantity of coins from the pre-mining phrase and the centralized initial distribution, are originally wealthier with regard to the network's total supply (Sus, 2022). More importantly, in a PoS-based configuration, stakeholders are not rewarded for computational work but wealth. The odds of receiving block rewards are directly proportional to the number of coins participants own and stake. While Goldberg and Moore (2019) and proponents of proof-of-work hold that proof-of-stake induces 'rich getting richer', whereby wealthier nodes are more likely to get elected, hence reap the block reward and become even wealthier, Saleh (2021) and Rosu and Saleh (2021) prove the contradiction. Reconciling arguments in prior studies, Dong (2022) claims that proof-of-stake incentivizes wealth concentration through the expected liquidity need: in the long run, whoever can afford to save a larger fraction of their wealth get

a larger share in the networks. Accordingly, often the wealthy can save more in illiquid assets (staked coins), hence continue receiving more coins for 'free', realizing the 'rich getting richer' phenomenon.

Additionally, considering PoS's stake-based selection mechanism and negligible costs of locking up capital, there is no natural selling pressure on the recipients of block rewards. On the contrary, minters are incentivized to reinvest their proceeds into staking perpetually due to the plutocratic and oligopolistic system. The lack of incentive for coin distribution causes more capital to become illiquid, eroding the winning chances of small stakeholders, which further encourage wealth concentration (Dong, 2022; Xiao et al., 2020). Notably, major stakeholders might constitute a closed group to exert control over the availability of native coins to outsiders (Karakostas et al., 2019). There is no possibility that a person without coins can participate in the process of securing the network and earning rewards.

Even though wealth concentration exists in both proof-of-work and proof-of-stake systems, the coin centralizing force in PoS is argued to be stronger than the hash rate centralizing force in PoW (Dong, 2022). As an attempt to achieve a fair and wide distribution, several PoS cryptocurrencies utilize PoW for their initial distribution of wealth.

4. General Discussion and Conclusion

Consensus mechanisms namely proof-of-work and proof-of-stake are seen to potentially have an adverse impact on economic growth due to their deflationary tendency and wealth concentration issue. Scholars anticipated a long-term deflationary tendency in blockchain networks relying on proof-of-work and/or proof-of-stake as underlying consensus mechanism. The majority of PoW-based cryptocurrencies are designed with a fixed supply of native tokens to provide artificial scarcity. However, once the hard cap reached its upper limit, PoW-based networks would face ineluctable deflation as the economy continues to grow. The anticipated deflation might be accelerated with irreversible loss or speculative hoarding of coins**.** For PoS-based cryptocurrencies, the deflationary attribute comes from their monetary issuance protocols and minting mechanisms. PoS coins incentivize stake hoarding and lower issuance rate. Coupled with a hard cap and/or a burning mechanism, there might be a deflation in PoS-based networks. Implementation of a deflationary legal tender can potentially discourage consumer spending and delay business investment, which might impede economic growth and job creation.

Either proof-of-work or pure proof-of-stake implementations are susceptible to the effects of wealth concentration and power concentration. These issues could potentially

exacerbate inequality and decrease financial inclusion, which can in turn hinder economic growth. Wealth concentration may occur in PoW-based networks due to the formation of mining pools and cartels with early or exclusive access to specialized mining hardware. Meanwhile, PoS implementation faces criticism for its inherent wealth compounding issue, rooted in proof-of-stake's intrinsic initial supply requirement and stake-based selection mechanism. It is worth noting that the coin centralizing force in PoS-based networks is believed to be stronger than the hash rate centralizing force in PoW-based networks.

Implementing a legal tender that encourages wealth concentration could exacerbate existing inequalities. Groups of wealthy miners or validators could make the network high barriers to entry and force the participants with little holdings to exit the network, resulting in decreased financial inclusion and social mobility (Bains, 2022). Notably, the impact of inequality on economic growth has been highly debatable. Partridge (1997) found American states with high inequality grew relatively faster, implying that unequal distribution of income encouraged economic activities and growth. Advocates of a positive nexus argue that high inequality fosters aggregate savings, as the rich have a higher propensity to save, and provide incentives for individuals to work harder and invest for higher wages (Ciaian et al., 2018; Kennedy et al., 2017). Some studies yielded inconclusive findings where the nexus is positive or insignificant among high-income countries but negative among low-income countries (Barro, 2000; Castelló-Climent, 2010; Fawaz et al., 2014). Also, Halter et al. (2014) found that the nexus changed over time, that is, high inequality enhanced economic growth in the short run but slowed down and hampered growth in the long run. However, a large number of studies reported negative results on the inequality-growth nexus (Cingano, 2014; Iyke & Sin-Yu, 2017; Panizza, 2002; Wan et al., 2006). The one key channel through which inequality lowers economic performance is lowering investment opportunities (either in physical or human capital) of the poorer segments of society. Besides, high concentration of wealth can incentivize rent-seeking behaviors, which lowers economic efficiency through misallocation of resources. In extreme cases, it may fuel social dissatisfaction, raising the threat of political instability and social unrest (Kennedy et al., 2017). While the effects of inequality on economic growth remain open to debate, it has been widely acknowledged that development is much more than economic indices and that blockchain technology is a key enabler of the sustainable development goals (Jiang et al., 2022). Hence, the implication of proof-of-work or proof-of-stake cryptocurrencies need to be thoroughly considered when designing economic policies. Strategies that help to increase the distribution of the new currencies into the economy need to

be implemented if prominent cryptocurrencies (both proof-of-work and proof-of-stake) are to be adopted as legal tender.

Nevertheless, the purely digital nature of cryptocurrencies has the potential to help to enhance financial inclusion and reduce financial friction if appropriately implemented. For example, some forms of tokenised fiat currencies on the Blockchain technology could be an excellent tool to enhance financial inclusion, as everyone with a mobile phone and internet could potentially use the tokenised fiat currencies for online payment and financial services without the need for bank accounts and traditional financial intermediaries. Cryptocurrency tokens like bitcoin and ether may be akin to (speculative) digital assets, but the technology network Bitcoin and Ethereum are the potent digital financial infrastructures on which governments and industry could build digital financial systems for fiat currencies that increase financial inclusion, lower financial frictions and enhance the financial markets. Moreover, it should be noted that the Blockchain-based financial infrastructure is based on decentralised software that developers and entrepreneurs are improving at a rapid pace. Therefore, over the years it is possible that tokenised fiat currencies and network tokens like bitcoin & ether can complement each other in a digital financial system built on the Blockchain networks helping to achieve financial inclusion and economic empowerment. More research on how blockchain tokens and tokenized fiat currencies can complement each other to enhance financial inclusion and economic empowerment needs to be done.

REFERENCES

Abu-elezz, I., Hassan, A., Nazeemudeen, A., Househ, M., & Abd-alrazaq, A. (2020). The benefits and threats of blockchain technology in healthcare: A scoping review. *International journal of medical informatics (Shannon, Ireland)*, *142*, 104246-104246. https://doi.org/10.1016/j.ijmedinf.2020.104246

Acemoglu, D., Naidu, S., Restrepo, P., & Robinson, J. A. (2019). Democracy Does Cause Growth. *The Journal of political economy*, *127*(1), 47-100. https://doi.org/10.1086/700936

Adrian, T., & Weeks-Brown, R. (2021). Crypto Assets as National Currency? A Step Too Far. *IMFBlog, International Monetary Fund, July*, *26*.

Ahluwalia, S., Mahto, R. V., & Guerrero, M. (2020). Blockchain technology and startup financing: A transaction cost economics perspective. *Technological forecasting & social change*, *151*, 119854. https://doi.org/10.1016/j.techfore.2019.119854

Aizenman, J., Chinn, M. D., & Ito, H. (2013). The "Impossible Trinity" Hypothesis in an Era of Global Imbalances: Measurement and Testing. *Review of international economics*, *21*(3), 447-458. https://doi.org/10.1111/roie.12047

Al-Amri, R., Zakaria, N. H., Habbal, A., & Hassan, S. (2019). Cryptocurrency adoption: current stage, opportunities, and open challenges. *International journal of advanced computer research*, *9*(44), 293-307. https://doi.org/10.19101/IJACR.PID43

Alnasaa, M., Gueorguiev, N., Honda, J., Imamoglu, E., Mauro, P., Primus, K., & Rozhkov, D. (2022). Crypto-assets, corruption, and capital controls: Cross-country correlations. *Economics letters*, *215*, 110492. https://doi.org/10.1016/j.econlet.2022.110492

Alvarez, F. E., Argente, D., & Van Patten, D. (2022). *Are Cryptocurrencies Currencies? Bitcoin as Legal Tender in El Salvador*.

Alves, N., Bonfim, D., & Soares, C. (2021). Surviving the perfect storm: The role of the lender of last resort. *Journal of financial intermediation*, *47*, 100918. https://doi.org/10.1016/j.jfi.2021.100918

Ametrano, F. M. (2016). Hayek money: The cryptocurrency price stability solution. *Available at SSRN 2425270*.

Ammous, S. (2018a). *The bitcoin standard : the decentralized alternative to central banking* (1st edition ed.). Wiley.

Ammous, S. (2018b). Can cryptocurrencies fulfil the functions of money? *The Quarterly review of economics and finance*, *70*, 38-51. https://doi.org/10.1016/j.qref.2018.05.010

Ammous, S. (2018c). Digital Money. In. John Wiley & Sons, Incorporated.

Ammous, S. (2018d). Digital Money. In *The bitcoin standard : the decentralized alternative to central banking*. John Wiley & Sons, Incorporated.

Ammous, S. (2018e). Government Money. In *The bitcoin standard : the decentralized alternative to central banking*. John Wiley & Sons, Incorporated.

Ammous, S. (2018f). What Is Bitcoin Good For? In *The Bitcoin Standard: The Decentralized Alternative to Central Banking*. John Wiley & Sons, Incorporated.

Andrés, J., & Hernando, I. (1997). Inflation and economic growth: some evidence for the OECD countries. Monetary Policy and the Inflation Process-BIS Conference Papers,

Andrew, S. (2012). Official Dollarization in El Salvador as an Alternative Monetary Framework. In *Central America, Panama, and the Dominican Republic*. International Monetary Fund.

Apostólicas, P., & Nayar, J. (2021). EXPLAINING ETHEREUM INTERVIEW WITH VITALIK BUTERIN. *Harvard International Review*, *42*(4), 50-57.

Árnason, S. L. (2015). *Cryptocurrency and Bitcoin. A possible foundation of future currency: why it has value, what is its history and its future outlook*

Artus, J. R., & Young, J. H. (1979). Fixed and Flexible Exchange Rates: A Renewal of the Debate (Taux de change fixes et taux de change flexibles: reprise du débat) (Tipos de cambio fijos y tipos de cambio flexibles: Reanudación del debate). *Staff papers - International Monetary Fund*, *26*(4), 654-698. https://doi.org/10.2307/3866966

Ashish Rajendra, S., Jim, B., & Andrew Le, G. (2021). Characterizing Wealth Inequality in Cryptocurrencies. *Frontiers in blockchain*, *4*. https://doi.org/10.3389/fbloc.2021.730122

Back, A. (2002). Hashcash-a denial of service counter-measure.

Bailey, A. M., Rettler, B., & Warmke, C. (2021). Philosophy, politics, and economics of cryptocurrency I: Money without state. *Philosophy compass*, *16*(11), n/a. https://doi.org/10.1111/phc3.12785

Bains, P. (2022). *Blockchain consensus mechanisms: A primer for supervisors*. International Monetary Fund.

Barber, S., Boyen, X., Shi, E., & Uzun, E. (2012). Bitter to Better — How to Make Bitcoin a Better Currency. In (pp. 399-414). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-32946-3_29

Barro, R. J. (2000). Inequality and Growth in a Panel of Countries. *Journal of economic growth (Boston, Mass.)*, *5*(1), 5-32. https://doi.org/10.1023/A:1009850119329

Baur, D. G., & Dimpfl, T. (2021). The volatility of Bitcoin and its role as a medium of exchange and a store of value. *Empirical economics*, *61*(5), 2663-2683. https://doi.org/10.1007/s00181-020-01990-5

Benigno, P., Schilling, L. M., & Uhlig, H. (2022). Cryptocurrencies, currency competition, and the impossible trinity. *Journal of international economics*, *136*, 103601. https://doi.org/10.1016/j.jinteco.2022.103601

Bentov, I., Gabizon, A., & Mizrahi, A. (2016). Cryptocurrencies without proof of work. Financial Cryptography and Data Security: FC 2016 International Workshops, BITCOIN, VOTING, and WAHC, Christ Church, Barbados, February 26, 2016, Revised Selected Papers 20,

Berg, C., Davidson, S., & Potts, J. (2019). *Understanding the blockchain economy: An introduction to institutional cryptoeconomics*. Edward Elgar Publishing.

Bernholz, P. (1989). Currency Competition, Inflation, Gresham's Law and Exchange Rate. *Journal of institutional and theoretical economics*, *145*(3), 465-488.

Bernstein, E. M. (1980). Back to the Gold Standard? *The Brookings Bulletin*, *17*(2), 8-12.

Bhimani, A., Hausken, K., & Arif, S. (2022). Do national development factors affect cryptocurrency adoption? *Technological forecasting & social change*, *181*, 121739. https://doi.org/10.1016/j.techfore.2022.121739

Binance. (2021, 22 March). Introducing BNB Auto-Burn: a new Protocol for the Quarterly BNB Burn. https://www.binance.com/en/blog/ecosystem/introducing-bnb-autoburn-a-new-protocol-for-the-quarterly-bnb-burn-421499824684903205

Binda, J. (2020). Cryptocurrencies – problems of the high-risk instrument definition. *Investment management & financial innovations*, *17*(1), 227-241. https://doi.org/10.21511/imfi.17(1).2020.20

Bjerg, O. (2016). How is Bitcoin Money? *Theory, culture & society*, *33*(1), 53-72. https://doi.org/10.1177/0263276415619015

Blundell-Wignall, A. (2014). The Bitcoin question: Currency versus trust-less transfer technology.

Böhme, R., Christin, N., Edelman, B., & Moore, T. (2015). Bitcoin: Economics, Technology, and Governance. *The Journal of economic perspectives*, *29*(2), 213-238. https://doi.org/10.1257/jep.29.2.213

Bordo, M. (1993). *The Gold Standard, Bretton Woods and other Monetary Regimes: An Historical Appraisal*. National Bureau of Economic Research.

Bordo, M. D. (1981). The classical gold standard: some lessons for today [compares United States and United Kingdom economic performance under the gold standard]. *Review - Federal Reserve Bank of St. Louis*, *63*(5), 2-17.

Bordo, M. D., Cochrane, J. H., & Seru, A. (2018). Three: Lessons from the Quiet Zero Lower Bound. In. Hoover Institution Press.

Bordo, M. D., & Eichengreen, B. J. (1993). *A Retrospective on the Bretton Woods system lessons for international monetary reform*. University of Chicago Press. https://doi.org/10.7208/9780226066905

Brito, J. (2014). Benefits and Risks of Bitcoin for Small Businesses. *Testimony before the House Committee on Small Business, Mercatus Center at George Mason University, Arlington, VA*.

Brkić, I., Gradojević, N., & Ignjatijević, S. (2020). The Impact of Economic Freedom on Economic Growth? New European Dynamic Panel Evidence. *Journal of risk and financial management*, *13*(2), 26. https://doi.org/10.3390/jrfm13020026

Buterin, V., & Griffith, V. (2017). Casper the friendly finality gadget. *arXiv preprint arXiv:1710.09437*.

Buttolph, S., Moin, A., Sekniqi, K., & Sirer, E. (2020). *Avalanche Native Token ($AVAX) Dynamics*. Retrieved 22 March from https://assets.website-

files.com/5d80307810123f5ffbb34d6e/6008d7bc56430d6b8792b8d1_Avalanche%20Native%20Token%20Dynamics.pdf
Cameron, G., & Wallace, C. (2002). Macroeconomic Performance in the Bretton Woods Era and After. *Oxford review of economic policy*, *18*(4), 479-494. https://doi.org/10.1093/oxrep/18.4.479
Canac, P., & Garcia-Contreras, R. (2011). Colonial Hangover: The Case of the CFA. *Journal of Asian and African studies (Leiden)*, *46*(1), 54-68. https://doi.org/10.1177/0021909610388476
Cardano. (2022). *Cardano Roadmap: Status Update*. https://roadmap.cardano.org/en/status-updates/update/2022-03-18/
Cardano. (n.d.,). *About Ouroboros BFT*. https://docs.cardano.org/cardano-sidechains/basics/ouroboros-description
Carlson, J. (2016). Cryptocurrency and capital controls. *Available at SSRN 3046954*.
Castelló-Climent, A. (2010). Inequality and growth in advanced economies: an empirical investigation. *Journal of economic inequality*, *8*(3), 293-321. https://doi.org/10.1007/s10888-010-9133-4
Chainalysis Team. (2022). The 2022 Global Crypto Adoption Index: Emerging Markets Lead in Grassroots Adoption, China Remains Active Despite Ban, and Crypto Fundamentals Appear Healthy. https://blog.chainalysis.com/reports/2022-global-crypto-adoption-index/
Chaitip, P., Chokethaworn, K., Chaiboonsri, C., & Khounkhalax, M. (2015). Money Supply Influencing on Economic Growth-wide Phenomena of AEC Open Region. *Procedia economics and finance*, *24*, 108-115. https://doi.org/10.1016/S2212-5671(15)00626-7
Chaudhry, N., & Yousaf, M. M. (2018). Consensus algorithms in blockchain: Comparative analysis, challenges and opportunities. 2018 12th International Conference on Open Source Systems and Technologies (ICOSST),
Chaum, D. (1983). Blind Signatures for Untraceable Payments. In (pp. 199-203). Springer US. https://doi.org/10.1007/978-1-4757-0602-4_18
Chen, W., & Phelan, G. (2022). Should monetary policy target financial stability? *Review of economic dynamics*. https://doi.org/10.1016/j.red.2022.08.002
Chen, X., Miraz, M. H., Gazi, M. A. I., Rahaman, M. A., Habib, M. M., & Hossain, A. I. (2022). Factors affecting cryptocurrency adoption in digital business transactions: The mediating role of customer satisfaction. *Technology in society*, *70*, 102059. https://doi.org/10.1016/j.techsoc.2022.102059
Chenguel, M. B. (2023). Blockchain and Cryptocurrency: Development Without Regulation? International Conference on Business and Technology,
Cho, I.-K., & Kasa, K. (2017). Gresham's Law of Model Averaging. *The American economic review*, *107*(11), 3589-3616. https://doi.org/10.1257/aer.20160665

Ciaian, P., Rajcaniova, M., & Kancs, d. A. (2018). Virtual relationships: Short- and long-run evidence from BitCoin and altcoin markets. *Journal of international financial markets, institutions & money*, *52*, 173-195. https://doi.org/10.1016/j.intfin.2017.11.001

Cingano, F. (2014). *Trends in income inequality and its impact on economic growth* (Vol. 163). OECD Publishing. https://doi.org/10.1787/5jxrjncwxv6j-en

Claeys, G., Demertzis, M., & Efstathiou, K. (2018). *Cryptocurrencies and monetary policy*.

Cohen, D., Shin, F., & Liu, X. (2019). Meanings and Functions of Money in Different Cultural Milieus. *Annual review of psychology*, *70*(1), 475-497. https://doi.org/10.1146/annurev-psych-010418-103221

CoinMarketCap. (n.d.). *Today's Cryptocurrency Prices by Market Cap*. CoinMarketCap. Retrieved January 8 from https://coinmarketcap.com/

Cooper, R. N., Dornbusch, R., & Hall, R. E. (1982). The Gold Standard: Historical Facts and Future Prospects. *Brookings papers on economic activity*, *1982*(1), 1-56. https://doi.org/10.2307/2534316

Crafts, N., & Fearon, P. (2010). Lessons from the 1930s Great Depression. *Oxford review of economic policy*, *26*(3), 285-317. https://doi.org/10.1093/oxrep/grq030

Cryptopedia Staff. (2022). *Fiat Money vs. Cryptocurrency*. https://www.gemini.com/cryptopedia/fiat-vs-crypto-digital-currencies

D'Andrea, F. M. (2022). Book Review: The Fiat Standard: The Debt Slavery Alternative to Human Civilization. In (Vol. 25).

Dabrowski, M., & Janikowski, L. (2018). Virtual currencies and central banks monetary policy: challenges ahead. *depth analysis. Monetary Dialogue July*.

Dai, W. (1998). B-money. In.

Daly, H. E. (2005). Economics in a full world. *IEEE engineering management review*, *33*(4), 21-21. https://doi.org/10.1109/EMR.2005.27010

Danielsson, J. (2019). Cryptocurrencies: Policy, economics and fairness. *Systemic Risk Centre Discussion Paper*, *86*, 2018.

Daoui, M. (2023). Monetary Policy and Economic Growth in Developing Countries: A Literature Review. https://doi.org/10.48550/arxiv.2303.03162

Davis, J. S. (2015). The asymmetric effects of deflation on consumption spending: Evidence from the great depression. *Economics letters*, *130*, 105-108. https://doi.org/10.1016/j.econlet.2015.03.016

Deirmentzoglou, E., Papakyriakopoulos, G., & Patsakis, C. (2019). A Survey on Long-Range Attacks for Proof of Stake Protocols. *IEEE access*, *7*, 28712-28725. https://doi.org/10.1109/ACCESS.2019.2901858

Deuber, D., Döttling, N., Magri, B., Malavolta, G., & Thyagarajan, S. A. K. (2020). Minting Mechanisms for (PoS) Blockchains.

Díaz, J. P., & Rumbea Pavisic, J. F. (2022). The determinants of interest rate spreads in dollarized economies. *Applied economics letters*, *ahead-of-print*(ahead-of-print), 1-8. https://doi.org/10.1080/13504851.2022.2098234

Dong, L. B. T. T. (2022). On the limiting distribution of shares in Proof-of-Stake. *Available at SSRN*.

Dorofeyev, M., Kosov, M., Ponkratov, V., Masterov, A., Karaev, A., & Vasyunina, M. (2018). Trends and prospects for the development of blockchain and cryptocurrencies in the digital economy. *European Research Studies*, *21*(3), 429-445.

Doumenis, Y., Izadi, J., Dhamdhere, P., Katsikas, E., & Koufopoulos, D. (2021). A Critical Analysis of Volatility Surprise in Bitcoin Cryptocurrency and Other Financial Assets. *Risks (Basel)*, *9*(11), 207. https://doi.org/10.3390/risks9110207

Drakopoulos, D., Natalucci, F., & Papageorgiou, E. (2021). Crypto boom poses new challenges to financial stability. *International Monetary Fund. Obtenido de https://blogs. imf. org/2021/10/01/crypto-boom-poses-new-challenges-to-financial-stability*.

Duarte, C. B. (2019). Alternative Monetary Targets, Instruments and Future Monetary Policy Frameworks. *Review of political economy*, *31*(4), 582-601. https://doi.org/10.1080/09538259.2020.1730606

Dumitrescu, G. C. (2017). Bitcoin – A Brief Analysis of the Advantages and Disadvantages. *Global economic observer*, *5*(2), 63-71.

Dupuis, D., & Gleason, K. (2020). Money laundering with cryptocurrency: open doors and the regulatory dialectic. *Journal of financial crime*, *28*(1), 60-74. https://doi.org/10.1108/JFC-06-2020-0113

Dutu, R., Nosal, E., & Rocheteau, G. (2005). The tale of Gresham's law. *Economic commentary (Cleveland)*, 1.

Dyhrberg, A. H. (2016). Bitcoin, gold and the dollar – A GARCH volatility analysis. *Finance research letters*, *16*, 85-92. https://doi.org/10.1016/j.frl.2015.10.008

Easterly, W., & Fischer, S. (2001). Inflation and the Poor. *Journal of money, credit and banking*, *33*(2), 160-178. https://doi.org/10.2307/2673879

Eichengreen, B., & Temin, P. (1997). *The Gold Standard and the Great Depression*. National Bureau of Economic Research.

Eichengreen, B., & Temin, P. (2000). The gold standard and the great depression. *Contemporary European History*, *9*(2), 183-207.

Eichengreen, B. J., & Flandreau, M. (1997). *The gold standard in theory and history* (2nd ed.). Routledge. https://doi.org/10.4324/9780203978870

Ennis, H. M., & Keister, T. (2008). Understanding monetary policy implementation. *Economic quarterly-Federal Reserve Bank of Richmond*, *94*(3), 235-263.

Espinoza, R., Leon, H., & Prasad, A. (2012). When Should We Worry about Inflation? *The World Bank economic review*, *26*(1), 100-127. https://doi.org/10.1093/wber/lhr043

Ethereum. (2022). *Proof-of-Stake Rewards and Penalties*. https://ethereum.org/en/developers/docs/consensus-mechanisms/pos/rewards-and-penalties/

Ethereum Foundation. (2023). *How The Merge impacted ETH supply*. https://ethereum.org/en/upgrades/merge/issuance/#how-the-merge-impacts-ETH-supply

Eun, C. S., Resnick, B. G., & Chuluun, T. (2020). *International Financial Management* (Ninth edition, International student edition. ed.). McGraw-Hill Education.

Europen Banking Authority. (2014). *EBA Opinion on 'virtual currencies'*. https://www.eba.europa.eu/sites/default/documents/files/documents/10180/657547/81409b94-4222-45d7-ba3b-7deb5863ab57/EBA-Op-2014-08%20Opinion%20on%20Virtual%20Currencies.pdf?retry=1

Fantacci, L. (2019). Cryptocurrencies and the Denationalization of Money. *International journal of political economy*, *48*(2), 105-126. https://doi.org/10.1080/08911916.2019.1624319

Farell, R. (2015). An analysis of the cryptocurrency industry.

Fawaz, F., Rahnama, M., & Valcarcel, V. J. (2014). A refinement of the relationship between economic growth and income inequality. *Applied economics*, *46*(27), 3351-3361. https://doi.org/10.1080/00036846.2014.929624

Félez-Viñas, E., Foley, S., Karlsen, J. R., & Svec, J. (2021). Better than Bitcoin? Can cryptocurrencies beat inflation? *Can cryptocurrencies beat inflation*.

Feng, H., Wang, X., Duan, Y., Zhang, J., & Zhang, X. (2020). Applying blockchain technology to improve agri-food traceability: A review of development methods, benefits and challenges. *Journal of cleaner production*, *260*, 121031. https://doi.org/10.1016/j.jclepro.2020.121031

Ferdous, M. S., Chowdhury, M. J. M., & Hoque, M. A. (2021). A survey of consensus algorithms in public blockchain systems for crypto-currencies. *Journal of network and computer applications*, *182*, 103035. https://doi.org/10.1016/j.jnca.2021.103035

Ferguson, N., & Schularick, M. (2012). The "Thin film of gold": monetary rules and policy credibility. *European review of economic history*, *16*(4), 384-407. https://doi.org/10.1093/ereh/hes006

Fernández-Villaverde, J., & Sanches, D. (2019). Can currency competition work? *Journal of monetary economics*, *106*, 1-15. https://doi.org/10.1016/j.jmoneco.2019.07.003

Financial Crimes Enforcement Network. (2013). Application of FinCEN's regulations to persons administering, exchanging, or using virtual currencies. *United States Department of the Treasury*, *March*, *18*.

Finney, H. (2004). Reusable proofs of work (rpow). *URL: http://web. archive. org/web/20071222072154/http://rpow. net/*, *Abruf am*, *11*(01), 2019.

Fitch Ratings. (2022). *Fitch Downgrades El Salvador's Long-Term IDR to 'CCC' from 'B-'*. https://www.fitchratings.com/research/sovereigns/fitch-downgrades-el-salvador-long-term-idr-to-ccc-from-b-09-02-2022/dodd-frank-disclosure

Focardi, S. M. (2018). *Money : What It Is, How It's Created, Who Gets It, and Why It Matters*. Taylor & Francis Group.

Friedman, M. (1968). The Role of Monetary Policy. *The American economic review*, *58*(1), 1-17.

Friedman, M. (1995). *The role of monetary policy*. Springer.

Friedman, M., & Schwartz, A. J. (1993). *A monetary history of the United States, 1867-1960* (Course Book ed.). Princeton University Press. https://doi.org/10.1515/9781400829330

Gamble, L. H. (2020). The origin and use of shell bead money in California. *Journal of anthropological archaeology*, *60*, 101237. https://doi.org/10.1016/j.jaa.2020.101237

Gentle, P. F. (2021). Cocoa as an Early form of Money in the Economic Sense: Satisfying Store of Value, Unit of Account and Medium of Exchange Requirements. *SocioEconomic Challenges*, *5*(4), 90-97. https://doi.org/10.21272/sec.5(4).90-97.2021

Gilbert, M. (1968). THE GOLD-DOLLAR SYSTEM: CONDITIONS OF EQUILIBRIUM AND THE PRICE OF GOLD. *Essays in international finance*.

Giorgioni, G. (2019). The CFA Franc Zone: a political re-evaluation twenty years after the advent of the Euro. *Journal of contemporary African studies*, *37*(4), 379-403. https://doi.org/10.1080/02589001.2018.1481280

Goldberg, I., & Moore, T. (2019). Compounding of Wealth in Proof-of-Stake Cryptocurrencies. In (Vol. 11598, pp. 42-61). Springer International Publishing AG. https://doi.org/10.1007/978-3-030-32101-7_3

Gomzin, S. (2022). How to Choose the Wallet. In *Crypto Basics* (pp. 165-182). Springer.

Gorjón, S. (2021). The role of cryptoassets as legal tender: the example of El Salvador. *Banco de Espana Article*, *35*, 21.

Graeber, D. (2012). *Debt: The first 5000 years*. Penguin UK.

Gregorio, J. d. (1991). *The Effects of Inflation on Economic Growth: Lessons from Latin America*. International Monetary Fund.

Gross, M. M., & Siebenbrunner, C. (2019). *Money creation in fiat and digital currency systems*. International Monetary Fund.

Gründler, K., & Potrafke, N. (2019). Corruption and economic growth: New empirical evidence. *European Journal of Political Economy*, *60*, 101810. https://doi.org/10.1016/j.ejpoleco.2019.08.001

Guitián, M., & Mundell, R. A. (1996). *Inflation and growth in China : proceedings of a conference held in Beijing, China, May 10-12, 1995*. International Monetary Fund.

Guru, B. K., & Yadav, I. S. (2019). Financial development and economic growth: panel evidence from BRICS. *Journal of Economics, Finance and Administrative Science*, *24*(47), 113-126. https://doi.org/10.1108/JEFAS-12-2017-0125

Halter, D., Oechslin, M., & Zweimüller, J. (2014). Inequality and growth: the neglected time dimension. *Journal of economic growth (Boston, Mass.)*, *19*(1), 81-104. https://doi.org/10.1007/s10887-013-9099-8

Hanif, M. (2020). Developing a fair currency system. *ISRA international journal of Islamic finance*, *12*(3), 325-345. https://doi.org/10.1108/IJIF-02-2019-0024

Hassan, S., & Azhar, T. (2022). CURRENT CHALLENGES OF CRYPTOCURRENCIES FACED BY GOVERNMENTS. *Journal of Research and Reviews in Social Sciences Pakistan*, *5*(1), 13.

Hazlett, P. K., & Luther, W. J. (2020). Is bitcoin money? And what that means. *The Quarterly review of economics and finance*, *77*, 144-149. https://doi.org/10.1016/j.qref.2019.10.003

Holtmeier, M., & Sandner, P. (2019). The impact of crypto currencies on developing countries. *Frankfurt School Blockchain Center Working Paper*.

Hrnjic, E., & Clarke, G. (2022). National study on central bank digital currency and stablecoin in the Maldives.

Hu, M., Lee, A. D., & Putniņš, T. J. (2021). Evading capital controls via cryptocurrencies: Evidence from the blockchain. *Available at SSRN 3956933*.

Hughes, S. D. (2017). Cryptocurrency Regulations and Enforcement in the US. *W. St. UL Rev.*, *45*, 1.

ICO Drops. (n.d.). Avalance. https://icodrops.com/avalanche/

Idris, M. (2019). Monetary policy and economic growth in developing countries: evaluating the policy nexus in Nigeria. *Journal of Business and Economics Research*, *8*(5), 290-300.

Ilomäki, M. M. S. (2022). Impact of Public Speculation on Cryptocurrencies. A Study Between Early and Late Adopting Countries.

Ireland, P. N. (2000). Interest Rates, Inflation, and Federal Reserve Policy Since 1980. *Journal of money, credit and banking*, *32*(3), 417-434. https://doi.org/10.2307/2601173

Islam, M. R., Nor, R. M., Al-Shaikhli, I. F., & Mohammad, K. S. (2018, 2018). Cryptocurrency vs. Fiat Currency: Architecture, Algorithm, Cashflow & Ledger Technology on Emerging Economy: The Influential Facts of Cryptocurrency and Fiat Currency.

Islam, M. S., Hossain, M. E., Chakrobortty, S., & Ema, N. S. (2022). Does the monetary policy have any short-run and long-run effect on economic growth? A developing and a developed country perspective. *Asian Journal of Economics and Banking*, *6*(1), 26-49. https://doi.org/10.1108/AJEB-02-2021-0014

Iyke, B. N., & Sin-Yu, H. O. (2017). Income Inequality and Growth: New Insights from Italy. *Economia internazionale*, *70*(4), 419.

Jevons, W. S. (1875). Money and the Mechanism of Exchange. *The numismatic chronicle, and journal of the Numismatic Society*, *15*, 337.

Jiang, S., Jakobsen, K., Bueie, J., Li, J., & Haro, P. H. (2022). A Tertiary Review on Blockchain and Sustainability With Focus on Sustainable Development Goals. *IEEE access*, *10*, 114975-115006. https://doi.org/10.1109/ACCESS.2022.3217683

Johnson, H. G. (1968). THE STERLING CRISIS OF 1967 AND THE GOLD RUSH OF 1968. *Nebraska journal of economics and business*, *7*(2), 3-17.

Jutla, C. S. (2021). Inflation-Tracking Proof-of-Work Crypto-Currencies. *Cryptology ePrint Archive*.

Kalinin, K. P., & Berloff, N. G. (2018). Blockchain platform with proof-of-work based on analog Hamiltonian optimisers. https://doi.org/10.48550/arxiv.1802.10091

Kang, K.-Y., & Lee, S. (2019). *Money, cryptocurrency, and monetary policy*. SSRN.

Kapengut, E., & Mizrach, B. (2022). An Event Study of the Ethereum Transition to Proof-of-Stake. https://doi.org/10.48550/arxiv.2210.13655

Karakostas, D., Kiayias, A., Nasikas, C., & Zindros, D. (2019). Cryptocurrency Egalitarianism: A Quantitative Approach. https://doi.org/10.48550/arxiv.1907.02434

Karaman, K. K., Pamuk, Ş., & Yıldırım-Karaman, S. (2020). Money and monetary stability in Europe, 1300–1914. *Journal of monetary economics*, *115*, 279-300. https://doi.org/10.1016/j.jmoneco.2019.07.007

Katterbauer, K., Syed, H., & Cleenewerck, L. (2020). The impact of the legalization of Bitcoin in the Central African Republic–a legal analysis. *Cuadernos de Economía*, *713*, 746.

Kedem, S., Thomas, D., & Dietz, C. (2022). Central African Republic adopts bitcoin as legal tender: As the Central African Republic becomes the second country in the world to adopt Bitcoin, Shoshana Kedem investigates what it means for the country, the region and the cryptoverse. *African business*(494), 48.

Kemmerer, D. L. (1953). Inflation: The First World War. *Current history (1941)*, *24*(141), 281-287. https://doi.org/10.1525/curh.1953.24.141.281

Kenen, P. B. (1960). International Liquidity and the Balance of Payments of a Reserve-Currency Country. *The Quarterly journal of economics*, *74*(4), 572-586. https://doi.org/10.2307/1884352

Kennedy, T., Smyth, R., Valadkhani, A., & Chen, G. (2017). Does income inequality hinder economic growth? New evidence using Australian taxation statistics. *Economic modelling*, *65*, 119-128. https://doi.org/10.1016/j.econmod.2017.05.012

Keynes, J. M. (2010). *Economic possibilities for our grandchildren*. Springer.

Khalilov, M. C. K., & Levi, A. (2018). A survey on anonymity and privacy in bitcoin-like digital cash systems. *IEEE Communications Surveys & Tutorials*, *20*(3), 2543-2585.

Khando, K., Islam, M. S., & Gao, S. (2023). The Emerging Technologies of Digital Payments and Associated Challenges: A Systematic Literature Review. *Future internet*, *15*(1), 21. https://doi.org/10.3390/fi15010021

Kher, R., Terjesen, S., & Liu, C. (2021). Blockchain, Bitcoin, and ICOs: a review and research agenda. *Small business economics*, *56*(4), 1699-1720. https://doi.org/10.1007/s11187-019-00286-y

King, S., & Nadal, S. (2012). Ppcoin: Peer-to-peer crypto-currency with proof-of-stake. *self-published paper, August*, *19*(1).

Klein, M. W., & Shambaugh, J. C. (2006). Fixed exchange rates and trade. *Journal of international economics*, *70*(2), 359-383. https://doi.org/10.1016/j.jinteco.2006.01.001 (Journal of International Economics)

Kostal, K., Krupa, T., Gembec, M., Veres, I., Ries, M., & Kotuliak, I. (2018, 2018). On Transition between PoW and PoS.

Kregel, J. (2021). The economic problem: from barter to commodity money to electronic money. *Levy Economics Institute, Working Papers Series*.

Kshetri, N. (2022a). Bitcoin's Adoption as Legal Tender: A Tale of Two Developing Countries. *IT professional*, *24*(5), 12-15. https://doi.org/10.1109/MITP.2022.3205528

Kshetri, N. (2022b). El Salvador's Bitcoin Gamble. *Computer (Long Beach, Calif.)*, *55*(6), 85-89. https://doi.org/10.1109/MC.2022.3164265

Kubát, M. (2015). Virtual Currency Bitcoin in the Scope of Money Definition and Store of Value. *Procedia economics and finance*, *30*, 409-416. https://doi.org/10.1016/S2212-5671(15)01308-8

Kuśmierz, B., & Overko, R. (2022). How centralized is decentralized? Comparison of wealth distribution in coins and tokens. https://doi.org/10.48550/arxiv.2207.01340

Lai, P. C. (2021). Towards an Ultimate Cashless Society and Potential Collaboration Between Blockchain and E-Payments. In (pp. 176-195). IGI Global. https://doi.org/10.4018/978-1-7998-9035-5.ch011

Law, L., Sabett, S., & Solinas, J. (1997). How to make a mint: the cryptography of anonymous electronic cash. *The American University law review*, *46*(4), 1131.

Lawson, B., Smith, J., Fourie, T., & Burford, V. R. (2022). *The Central African Republic announces bitcoin as legal tender*. S&P Global Intelligence. Retrieved 20 March from https://www.spglobal.com/marketintelligence/en/mi/research-analysis/the-central-african-republic-announces-bitcoin-as-legal-tender.html

Leonard, D., & Treiblmaier, H. (2019). Can cryptocurrencies help to pave the way to a more sustainable economy? Questioning the economic growth paradigm. *Business Transformation through Blockchain: Volume II*, 183-205.

Levulyte, L., & Sapkauskiene, A. (2021). Cryptocurrency in context of fiat money functions. *The Quarterly review of economics and finance*, *82*, 44-54. https://doi.org/10.1016/j.qref.2021.07.003

Li, S.-N., Campajola, C., & Tessone, C. J. (2022). Twisted by the Pools: Detection of Selfish Anomalies in Proof-of-Work Mining. https://doi.org/10.48550/arxiv.2208.05748

Li, S.-N., Yang, Z., & Tessone, C. J. (2020, 2020). Proof-of-Work cryptocurrency mining: a statistical approach to fairness.

Liedel, D. A. (2018). THE TAXATION OF BITCOIN: HOW THE IRS VIEWS CRYPTOCURRENCIES. *Drake law review*, *66*(1), 107.

Litecoin. (n.d.). *What is Litecoin?* https://litecoin.org/

Long, S., Basu, S., & Sirer, E. G. (2022). Measuring Miner Decentralization in Proof-of-Work Blockchains. https://doi.org/10.48550/arxiv.2203.16058

Ma, D. (2017). Taking a byte out of Bitcoin regulation. *Alb. LJ Sci. & Tech.*, *27*, 1.

Mabunda, S. (2018). Cryptocurrency: The new face of cyber money laundering. 2018 International Conference on Advances in Big Data, Computing and Data Communication Systems (icABCD),

Mainelli, M. (2010). The eternal coin - made from real money: risks in fiat currencies. *Journal of Risk Finance*, *11*(1), 111-116. https://doi.org/10.1108/15265941011012723

Malherbe, L., Montalban, M., Bédu, N., & Granier, C. (2019). Cryptocurrencies and Blockchain: Opportunities and Limits of a New Monetary Regime. *International journal of political economy*, *48*(2), 127-152. https://doi.org/10.1080/08911916.2019.1624320

Mallick, S. K., & Sousa, R. M. (2012). REAL EFFECTS OF MONETARY POLICY IN LARGE EMERGING ECONOMIES. *Macroeconomic dynamics*, *16*(S2), 190-212. https://doi.org/10.1017/S1365100511000319

Mankiw, N. G. (2021). *Principles of Economics*. Cengage Learning Asia Pte Limited. https://books.google.com.sg/books?id=c3u4zQEACAAJ

Marthinsen, J. E., & Gordon, S. R. (2022). Hyperinflation, Optimal Currency Scopes, and a Cryptocurrency Alternative to Dollarization. *The Quarterly review of economics and finance*, *85*, 161-173. https://doi.org/10.1016/j.qref.2020.12.007

Marzano, F. (2012). Globalization, poverty, economic development. *Angelicum*, *89*(2), 547-577.

Massaro, M., Dal Mas, F., Chiappetta Jabbour, C. J., & Bagnoli, C. (2020). Crypto-economy and new sustainable business models: Reflections and projections using a case study analysis. *Corporate social-responsibility and environmental management*, *27*(5), 2150-2160. https://doi.org/10.1002/csr.1954

Matres, J. d. O. G., & Le, T. V. (2021). The Impact of Money Supply on the Economy: A Panel Study on Selected Countries. *Journal of Economic Science Research*, *4*(4).

McKillop, H. (2021). Salt as a commodity or money in the Classic Maya economy. *Journal of anthropological archaeology*, *62*, 101277. https://doi.org/10.1016/j.jaa.2021.101277

Meltzer, A. H. (1991). U.S. policy in the Bretton Woods era. *Review - Federal Reserve Bank of St. Louis*, *73*(3), 54.

Menger, K. (1892). On the origin of money. *The Economic Journal*, *2*(6), 239-255.

Mishkin, F. S. (2019). *The Economics of Money, Banking, and Financial Markets*. Pearson. https://books.google.com.sg/books?id=SAP-swEACAAJ

Möser, M., Böhme, R., & Breuker, D. (2013, 17-18 Sept. 2013). An inquiry into money laundering tools in the Bitcoin ecosystem. 2013 APWG eCrime Researchers Summit,

Mundy, S. (2018). India's cryptocurrency traders scramble after RBI crackdown. *FT.com*.

Murray, J. (2000). Why Canada needs a flexible exchange rate. *The North American journal of economics and finance*, *11*(1), 41-60. https://doi.org/10.1016/S1062-9408(00)00027-9 (The North American Journal of Economics and Finance)

Mursa, G. (2014). EURO – ADVANTAGES AND DISADVANTAGES. *CES working papers*, *6*(3), 60-67.

Nadeem, M. A., Liu, Z., Pitafi, A. H., Younis, A., & Xu, Y. (2021). Investigating the Adoption Factors of Cryptocurrencies—A Case of Bitcoin: Empirical Evidence From China. *SAGE open*, *11*(1), 215824402199870. https://doi.org/10.1177/2158244021998704

Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. *Decentralized business review*, 21260.

Namcios. (2022). Bitcoin Magazine: Making Bitcoin Legal Tender In Africa: How CAR Can Find Financial Freedom. In: Newstex.

Naqvi, S. N. H. (1993). Economic development and development economics. *The Pakistan Development Review*, *32*(4), 357-386.

Ng, D., & Griffin, P. (2018). The wider impact of a national cryptocurrency. *Global Policy*, 1.

Nguyen, C. T., Hoang, D. T., Nguyen, D. N., Niyato, D., Nguyen, H. T., & Dutkiewicz, E. (2019). Proof-of-Stake Consensus Mechanisms for Future Blockchain Networks: Fundamentals, Applications and Opportunities. *IEEE access*, *7*, 85727-85745. https://doi.org/10.1109/ACCESS.2019.2925010

Niehans, J. (1978). *The theory of money*.

Odeh, M. K. (2022). The Political Economy of the'Bitcoin'Experiment in the Central Africa Republic. *AfronomicsLaw Blog [https://www. afronomicslaw. org/category/analysis/political-economy-bitcoin-experiment-central-africa-republic]*.

Ogunode, O., Iwala, A., Awoniyi, O., Amusa, B., Omosebi, T., Kassim, S., & Akintoye, R. (2022). Cryptocurrency and Global Practices: Lessons for Nigeria. *South Asian Journal of Social Studies and Economics*, 7-28.

Ojha, M. K., Sharma, C. P., Arya, S., & Kumar, D. R. (2021). Crypto Currency As New Legal Tender: A Theoretical Outlook. *Ilkogretim Online*, *20*(1), 6788-6798.

Othman, A. H. A., Musa Alhabshi, S., Kassim, S., Abdullah, A., & Haron, R. (2020). The impact of monetary systems on income inequity and wealth distribution: A case study of cryptocurrencies, fiat money and gold standard. *International journal of emerging markets*, *15*(6), 1161-1183. https://doi.org/10.1108/IJOEM-06-2019-0473

Panizza, U. (2002). Income Inequality and Economic Growth: Evidence from American Data. *Journal of economic growth (Boston, Mass.)*, *7*(1), 25-41. https://doi.org/10.1023/A:1013414509803

Partridge, M. D. (1997). Is Inequality Harmful for Growth? Comment. *The American economic review*, *87*(5), 1019-1032.

Peie, N., Mohamed, S., Yusoff, N. S. M., Joreme, A. A., & Rosli, M. A. (2017). Can gold dinar replace fiat money as currency? *Journal of Emerging Economies and Islamic Research*, *5*(3), 63. https://doi.org/10.24191/jeeir.v5i3.8831

Pense, A. W. (1992). The decline and fall of the roman denarius. *Materials characterization*, *29*(2), 213-222. https://doi.org/10.1016/1044-5803(92)90116-Y

Perkins, D. W. (2018). Cryptocurrency: The economics of money and selected policy issues. *Washington DC: US Congressional Research Service*.

Peters, G. W., Panayi, E., & Chapelle, A. (2015). Trends in crypto-currencies and blockchain technologies: A monetary theory and regulation perspective. https://doi.org/10.48550/arxiv.1508.04364

Pewtrouski, J. (2019). *Polkadot Consensus Part 2: GRANDPA*. Polkadot. https://polkadot.network/blog/polkadot-consensus-part-2-grandpa

Pilling, D. (2022). Central African Republic's adoption of bitcoin is mostly about geopolitics. *FT.com*.

Pokharel, A., & Dahal, K. (2022). Crypto Inheritance Planning For HODLers: Methods To Safely Transfer Digital Assets To Beneficiaries. *Available at SSRN 4183803*.

Polygon. (n.d). *Polygon PoS Architecture*. https://wiki.polygon.technology/docs/home/architecture/polygon-architecture/

Polygon Labs. (2022). *Burn, MATIC, Burn!* Polygon. https://polygon.technology/blog/burn-matic-burn

Read, C. L. (2022). Bitcoin's Global Reach. In *The Bitcoin Dilemma* (pp. 273-280). Springer.

Redish, A. (1993). Anchors Aweigh: The Transition from Commodity Money to Fiat Money in Western Economies. *The Canadian journal of economics*, *26*(4), 777-795. https://doi.org/10.2307/135820

Redish, A., & Weber, W. E. (2011). COIN SIZES AND PAYMENTS IN COMMODITY MONEY SYSTEMS. *Macroeconomic dynamics*, *15*(S1), 62-82. https://doi.org/10.1017/S1365100510000593

Reserve Bank of Australia. (n.d.). *Digital Currencies*. https://www.rba.gov.au/education/resources/explainers/pdf/cryptocurrencies.pdf?v=2023-03-27-22-15-42

Ricci, P. (2020). How economic freedom reflects on the Bitcoin transaction network. *Economia e politica industriale*, *47*(1), 133-161. https://doi.org/10.1007/s40812-019-00143-9

Rivera-Solis, L. E. (2012). Dollarization in El Salvador: Revisited.

Rolnick, A. J., & Weber, W. E. (1997). Money, Inflation, and Output under Fiat and Commodity Standards. *The Journal of political economy*, *105*(6), 1308-1321. https://doi.org/10.1086/516394

Rosu, I., & Saleh, F. (2021). Evolution of Shares in a Proof-of-Stake Cryptocurrency. *Management science*, *67*(2), 661-672. https://doi.org/10.1287/mnsc.2020.3791

Saiedi, E., Broström, A., & Ruiz, F. (2021). Global drivers of cryptocurrency infrastructure adoption. *Small business economics*, *57*(1), 353-406. https://doi.org/10.1007/s11187-019-00309-8

Saleh, F. (2021). Blockchain without Waste: Proof-of-Stake. *The Review of financial studies*, *34*(3), 1156-1190. https://doi.org/10.1093/rfs/hhaa075

Sandner, P. G., Gross, J., Grale, L., & Schulden, P. (2020). The digital programmable euro, Libra and CBDC: Implications for European banks. *Libra and CBDC: Implications for European Banks (July 29, 2020)*.

Savolainen, V., & Soria, J. (2019). Too Big to Cheat: Mining Pools' Incentives to Double Spend in Blockchain Based Cryptocurrencies. *Available at SSRN 3506748*.

Scharnowski, S., & Shi, Y. (2021). Bitcoin blackout: Proof-of-work and the centralization of mining. *Available at SSRN 3936787*.

Schaupp, L. C., Festa, M., Knotts, K. G., & Vitullo, E. A. (2022). Regulation as a pathway to individual adoption of cryptocurrency. *Digital Policy, Regulation and Governance*.

Schinckus, C. (2020). The good, the bad and the ugly: An overview of the sustainability of blockchain technology. *Energy Research & Social Science*, *69*, 101614. https://doi.org/10.1016/j.erss.2020.101614

See, K. (2022). The Satoshi Laundromat: A Review on the Money Laundering Open Door of Bitcoin Mixers.

Senner, R., & Sornette, D. (2019). The Holy Grail of Crypto Currencies: Ready to Replace Fiat Money? *Journal of economic issues*, *53*(4), 966-1000. https://doi.org/10.1080/00213624.2019.1664235

Shahzad, F., Xiu, G., Wang, J., & Shahbaz, M. (2018). An empirical investigation on the adoption of cryptocurrencies among the people of mainland China. *Technology in society*, *55*, 33-40. https://doi.org/10.1016/j.techsoc.2018.05.006

Sigalos, M., & Kharpal, A. (2022). El Salvador's bitcoin experiment: $60 million lost, $375 million spent, little to show so far. *CNBC*. https://www.cnbc.com/2022/10/13/el-salvadors-bitcoin-holdings-down-60percent-to-60-million-one-year-later.html

Smith, C., & Kumar, A. (2018). CRYPTO-CURRENCIES - AN INTRODUCTION TO NOT-SO-FUNNY MONEYS: CRYPTO-CURRENCIES - AN INTRODUCTION. *Journal of economic surveys*, *32*(5), 1531-1559. https://doi.org/10.1111/joes.12289

Sparavigna, A. C. (2014). Some notes on the Gresham's law of money circulation. *International Journal of Sciences February*.

Spread, P. (2022). *Economics, Anthropology and the Origin of Money As a Bargaining Counter*. Taylor & Francis Group.

Stix, H. (2021). Ownership and purchase intention of crypto-assets: survey results. *Empirica*, *48*(1), 65-99. https://doi.org/10.1007/s10663-020-09499-x

Sullivan, N. (2005). Gresham's law, fact or falsehood? . *Student Economic Review*, *19*, 9. https://www.tcd.ie/Economics/assets/pdf/SER/2005/Noel_Sullivan.pdf

Sus, V. (2022). Proof-of-Stake Is a Defective Mechanism. *Available at SSRN 4067739*.

Sussman, N., & Zeira, J. (2003). Commodity money inflation: theory and evidence from France in 1350–1436. *Journal of monetary economics*, *50*(8), 1769-1793. https://doi.org/10.1016/j.jmoneco.2003.01.003 (Journal of Monetary Economics)

Sylla, N. S. (2018). The CFA franc: French monetary imperialism in Africa. *London: London School of Economics, Firoz Lalji-Centre for Africa, Africa at LSE blog*.

Szabo, N. (2005). Bit gold. *Recuperado de https://nakamotoinstitute. org/bit-gold/TVer página*.

Tasca, P., Aste, T., Pelizzon, L., & Perony, N. (2016). Decentralized Banking: Monetary Technocracy in the Digital Age. In (pp. 121-131). Springer International Publishing AG. https://doi.org/10.1007/978-3-319-42448-4_7

Taylor, I. (2019). France à fric: the CFA zone in Africa and neocolonialism. *Third world quarterly*, *40*(6), 1064-1088. https://doi.org/10.1080/01436597.2019.1585183

Taylor, L. (2022). Will the Central African Republic's bitcoin experiment flop? *New scientist (1971)*, *254*(3386), 12-12. https://doi.org/10.1016/S0262-4079(22)00826-0

Teja, N. (2022). CAR faces same issues as El Salvador with bitcoin adoption. *International Financial Law Review*.

Tendermint. (n.d.). *Tendermint Core*. https://tendermint.com/core/

Till, B. M., Peters, A. W., Afshar, S., & Meara, J. G. (2017). From blockchain technology to global health equity: can cryptocurrencies finance universal health coverage? *BMJ global health*, *2*(4), e000570-e000570. https://doi.org/10.1136/bmjgh-2017-000570

Tolley, G. S. (1957). Providing for Growth of the Money Supply. *The Journal of political economy*, *65*(6), 465-485. https://doi.org/10.1086/257983

Tomić, N., Todorović, V., & Čakajac, B. (2020). The potential effects of cryptocurrencies on monetary policy. *European journal of applied economics*, *17*(1), 37-48. https://doi.org/10.5937/EJAE17-21873

Triffin, R. (1960). *Gold and the Dollar Crisis: The Future of Convertibility*. Yale University Press. https://books.google.com.sg/books?id=Za2YkRY_uzkC

Trozze, A., Kamps, J., Akartuna, E. A., Hetzel, F. J., Kleinberg, B., Davies, T., & Johnson, S. D. (2022). Cryptocurrencies and future financial crime. *Crime science*, *11*(1), 1-1. https://doi.org/10.1186/s40163-021-00163-8

Tsang, K. P., & Yang, Z. (2021). The market for bitcoin transactions. *Journal of international financial markets, institutions & money*, *71*, 101282. https://doi.org/10.1016/j.intfin.2021.101282

Twinoburyo, E. N., & Odhiambo, N. M. (2018). Monetary Policy and Economic Growth: A Review of International Literature. *Journal of Central Banking Theory and Practice (Podgorica)*, *7*(2), 123-137. https://doi.org/10.2478/jcbtp-2018-0015

Vasin, P. (2014). Blackcoin's proof-of-stake protocol v2. *URL: https://blackcoin. co/blackcoin-pos-protocol-v2-whitepaper. pdf*, *71*.

Vázquez, E. (2022). The Technical Fix: Bitcoin in El Salvador. *The South Atlantic quarterly*, *121*(3), 600. https://doi.org/10.1215/00382876-9826018

Vincent, O., & Evans, O. (2019). Can cryptocurrency, mobile phones, and internet herald sustainable financial sector development in emerging markets? *Journal of transnational management*, *24*(3), 259-279. https://doi.org/10.1080/15475778.2019.1633170

Wan, G., Lu, M., & Chen, Z. (2006). The inequality–growth nexus in the short and long run: Empirical evidence from China. *Journal of Comparative Economics*, *34*(4), 654-667. https://doi.org/10.1016/j.jce.2006.08.004 (Journal of Comparative Economics)

Wheelock, D. C. (2010). Lessons learned? comparing the federal reserve's responses to the crises of 1929-1933 and 2007-2009. *Review - Federal Reserve Bank of St. Louis*, *92*(2), 89-107. https://doi.org/10.20955/r.92.89-108

White, K., Buonocore, C., Goel, A., & Waliczek, S. (2022). *The Macroeconomic Impact of Cryptocurrency and Stablecoins*. W. E. Forum. https://www3.weforum.org/docs/WEF_The_Macroeconomic_Impact_of_Cryptocurrency_and_Stablecoins_2022.pdf

Whittlesey, C. R. (1956). Relation of Money to Economic Growth. *The American economic review*, *46*(2), 188-201.

The World Bank in Central African Republic - Overview. (2022). https://www.worldbank.org/en/country/centralafricanrepublic/overview

The World Bank In El Salvador - Overview. (2022). https://www.worldbank.org/en/country/elsalvador/overview#1

Xiao, Y., Zhang, N., Lou, W., & Hou, Y. T. (2020). A Survey of Distributed Consensus Protocols for Blockchain Networks. *IEEE Communications surveys and tutorials*, *22*(2), 1432-1465. https://doi.org/10.1109/COMST.2020.2969706

Yermack, D. (2015). Is Bitcoin a real currency? An economic appraisal. In *Handbook of digital currency* (pp. 31-43). Elsevier.

Yussof, S. A., & Al-Harthy, A. M. H. (2018). Cryptocurrency as an alternative currency in Malaysia: issues and challenges. *ICR journal*, *9*(1), 48-65.

Zala, J. (1968). 1958—1967: THE ECONOMIC TRENDS OF A DECADE. *Acta oeconomica*, *3*(2), 133-144.

Zcash. (n.d.). *Glossary - Zcash Documentation 5.4.2 documentation*. https://zcash.readthedocs.io/en/latest/rtd_pages/glossary.html

Zhang, Z., Zargham, M., & Preciado, V. M. (2020). On modeling blockchain-enabled economic networks as stochastic dynamical systems. *Applied network science*, *5*(1), 1-24. https://doi.org/10.1007/s41109-020-0254-9

Appendix 1

	Economic Growth Rate (%)				Inflation Rate (%)			
Country Classification	Average under BWS	Average under Fiat Money	Volatility under BWS	Volatility under Fiat Money	Average under BWS	Average under Fiat Money	Volatility under BWS	Volatility under Fiat Money
High income								
Australia	4.55	2.99	3.26	1.50	2.90	5.22	1.60	4.04
Brazil	7.43	3.33	2.82	4.01	2.89	3.60	1.40	2.99
Canada	4.81	2.69	2.59	2.03	2.62	4.03	1.24	3.25
France	5.26	2.12	1.40	1.62	4.12	4.14	1.31	4.10
Germany	6.19	1.93	2.85	1.97	2.72	2.58	1.07	1.86
Greece	7.00	1.35	3.81	3.83	2.16	9.62	1.52	8.32
Iceland	5.25	3.44	5.61	3.36	10.69	16.75	6.19	19.41
Italy	5.82	1.70	2.39	2.31	3.90	6.28	1.82	6.03
Japan	9.06	2.38	2.57	2.57	5.47	2.43	1.21	4.36
Luxembourg	2.95	3.70	3.29	3.34	2.57	3.44	1.42	2.79
Netherlands	5.22	2.28	2.77	1.81	4.21	3.12	1.98	2.55
New Zealand	3.93	2.53	4.80	2.46	4.08	5.85	2.63	5.54
Norway	4.00	2.81	1.56	1.79	4.28	4.51	2.60	3.42
Panama	7.27	4.96	4.39	4.05	1.23	3.04	0.96	3.44
Portugal	5.76	2.45	2.48	3.14	5.00	9.02	3.02	8.79
Spain	6.94	2.53	4.90	2.36	5.86	6.59	3.46	6.05
Sweden	3.85	2.16	1.62	2.02	4.34	4.37	1.85	4.01
The UK	2.72	2.21	1.85	2.11	4.26	5.39	2.21	5.33
The US	3.93	2.80	2.53	1.97	2.79	3.95	1.77	2.95
Uruguay	2.02	2.56	4.75	4.10	45.14	37.14	35.00	31.92
Upper middle-income								
Colombia	4.93	3.83	2.36	2.19	10.68	15.29	6.35	9.70
Costa Rica	6.89	4.13	4.31	2.93	2.28	13.96	1.59	13.99
Ecuador	4.88	3.67	2.48	3.30	4.58	21.65	1.79	21.64
Mexico	6.40	3.21	3.39	3.50	3.14	23.39	1.58	30.27
Lower middle income and low income								
El Salvador	5.01	2.37	2.56	3.36	0.59	8.94	1.57	7.99
India	4.01	5.55	3.26	2.77	5.63	7.87	4.76	4.98
Ethiopia	4.60	5.22	3.93	6.03	1.95	9.44	4.11	10.67