UCLouvain

LOUVAIN
School of Management

Louvain School of Management

Could Decentralized Finance replace Traditional Finance?

A comparative analysis of the different components of financial systems

Authors: Devos Maxence & Nicolas Clara
Supervisor: Anh Nguyen
Academic year 2021-2022
Dissertation for the Master of Management Science

ACKNOWLEDGMENT

First, we would like to express our most sincere gratitude to our supervisor, Prof. Anh Nguyen, without whom the writing of this thesis would not have been possible. We thank him for his trust and his open-mindedness, without which the writing of this thesis would not have been possible.

We would also like to thank our respective families for their moral support and continuous encouragement. We would like to express our gratitude to our closest family members for their moral support throughout our academic career.

Finally, we would like to express our deep gratitude to the UCLouvain, the Louvain School of Management and Ichec business school. These places have allowed us to cultivate our intellectual creativity, while allowing an open and critical look at the world of tomorrow. We would like to thank all the members of the University for their dedication and for the values of excellence, inclusiveness, ethics, and solidarity that they have promoted. We will each one of us sincerely commit ourselves to actively contribute to making the world a better place and will try, during our respective lives, to advocate and defend the University values that have been transmitted to us.

LIST OF FIGURES

LIST OF TABLES

LIST OF CHARTS

LIST OF ABBREVIATIONS AND ACRONYMS

ANT	Aragon's token
APP	Application
APR	Annual Percentage Returns
APY	Annual Percentage Yields
BIS	Bank for International Settlement
BCBS	Basel Committee on Banking
BTC	Bitcoin
BTG	Bitcoin Gold
CBDC	Central Bank Digital Currency
CD	Certificate of Deposit
CEO	Chief Executive Officer
CeFi	Centralized Finance
DAO	Decentralized Autonomous Organization
DApp	Decentralized Application
DEX	Decentralized Exchange
DeFi	Decentralized Finance
DLT	Distributed Ledger Technology
EBA	European Banking Authority
ECB	European Central Bank
EIOPA	European Insurance and Occupational Pensions Authority
ERC-20	The standard Ethereum token
ERC-721	ERC-721 is a Solidity contract standard, the first standard for the representation of non-fungible digital assets
ESMA	European Securities and Markets Authority
ESRB	European Systemic Risk Board
ETH	Ethereum
EU	European Union

FED	Federal Reserve
FOMC	Federal Open Market Committee
HNWI	High Net Worth Individuals
IBFT	Istanbul Byzantine Fault Tolerance
ICO	Initial Coin Offering
IMF	International Monetary Fund
IPO	Initial Public Offering
JPM	JP Morgan Chase & Co
M2M	Machine-To-Machine
M&A	Mergers & Acquisitions
NFT	Non-Fungible Token
NBB	National Bank of Belgium
NONCE	Number Only Used Once
NYSE	New York Stock Exchange
OECD	Organization for Economic Co-Operation and Development
P2P	Peer-to-Peer
PoC	Proof-of-Concept
PoI	Proof-of-Importance
PoS	Proof-of-Stake
PoW	Proof-of-Work
SWIFT	Society for Worldwide Interbank Financial Telecommunication
US	United States (of America)
USD	United States Dollar
USDT	Tether USD

Table of Contents

INTRODUCTION

1. Choice of topic

We decided to choose this thesis topic because we considered it very relevant, very promising, and especially in direct link with our studies. Indeed, this thesis is intended to mix aspects related to finance and others to management. In a world in perpetual change, driven by constant innovations, we found it useful to put forward a completely new, innovative financial system that is an extension of the traditional financial system. Comparing the aspects of a new system to a well-established, proven and still applicable system was both an interesting and challenging task for all of us.

The world of traditional finance has, until now, met a wide variety of needs but, in our opinion, has had its limitations. These limits were mainly related to the speed of transactions, the hours of access to the stock exchanges and the control that individuals have over their financial assets. By tackling the subject of decentralized finance (DeFi), we aimed to bring a fresh and useful look at the different aspects of a new, disruptive market.

This subject was also close to our hearts because it involves, in its development, individuals driven by strong values and convictions of deep societal change. Many actors in the DeFi sector wish to be the bearers of the change that our generations must make today to face the fundamental challenges of tomorrow. Some of them defend social and environmental causes through DeFi and we also found it interesting that these aspects are not only compatible with finance, but also a pillar in its development. DeFi also has the advantage of being interoperable on an international scale. We liked it for its capacity to democratize finance in developed countries but also in less developed ones.

Finally, its security and individual management aspects also caught our attention. Indeed, the transparency of blockchains allows to highlight essential elements of our time. By being accessible to all, it is then not possible to fail in its moral duties or to deceive individuals on civic, social, and societal responsibilities. The DeFi also allows its users to constantly benefit from a right of control over their investments, their usefulness as well as to be able to hold them personally, through a hard wallet, if they so desire.

2. Research question

All the elements mentioned previously have pushed us to dig and develop a subject that seems to us to have a promising future. Although still unregulated, decentralized finance could bring major changes to traditional finance as we know it today. Its advantages, already perceptible in practice, are subject to constant daily evolution. The advances enabled today by DeFi could be carried more widely into the future and perhaps contribute to establishing a fairer, more responsible, and more sustainable alternative system for future generations.

This is how we chose as our research question: "Could Decentralized Finance replace Traditional Finance?" Although this research question seems relatively broad, it has allowed us to gain an overall understanding of the ins and outs of a broader financial system. In doing so, we were able to analyze each of the components of the two systems to understand their mechanics.

3. Structure of the thesis

Our thesis is composed of two parts which are themselves divided into chapters. The first part is devoted to a review of the literature. The objective of the literature review is to take stock of the current state of understanding of the traditional financial system as well as of DeFi. We have structured this section chronologically to better understand the evolution of the financial system.

The first chapter focuses on the traditional financial system. In it, we discuss the history of the evolution of this system by developing the notions of value and money. We also develop the components and functions of the financial system. The third section deals with the importance of trust in the traditional financial system. And we end this chapter with a recent innovation of central banks, the Central Bank Digital Currency (CBDC) which can be seen as a direct response of institutions to the rise of Bitcoin.

The second chapter focuses on understanding Blockchain technology. DeFi only exists because of this innovation, and it seemed important to understand what it entails as well as its evolution over the last few years. To do this we have developed the beginnings of the Blockchain as well as a brief explanation of the technology and its functioning. We also shed light on the different consensuses that are a necessary condition for the proper functioning of

the Blockchain. Finally, we have discussed the design of smart contracts that are essential to the DeFi.

The last chapter of this part focuses on decentralized finance itself. We have defined and analyzed an important Blockchain to the existence of the DeFi, Ethereum. We also discussed the notion of Non-Fungible Tokens and Decentralized Application Organization. Before concluding with the risks and challenges that DeFi is currently facing.

The second part is the empirical part and allows us to answer our research question based on an analysis that we have carried out. We first explain the methodology we used. It is a comparative qualitative analysis. This allowed us to analyze each component of a financial system and to compare them according to each system. The section is therefore divided into 7 chapters which are respectively money, banks, security market, mutual funds, insurance, payment service provider and supervisory and regulatory body. Each chapter is divided in the same way and includes a description of the traditional system component followed by a description of the decentralized system component. We then dedicate a section to the comparison of these two components and end with a conclusion on our analysis.

Finally, we will conclude our thesis and present its main limitations.

PART I – THEORETICAL BACKGROUND

Chapter 1. The traditional banking system

A banking system is composed of banks whose main activity is the granting of credit and the management of current accounts, as well as a central bank that maintains financial relations with each other and with non-financial agents. The central bank serves as a bank for the banks and has two main roles: issuing money and managing the banks' current accounts (Guillaumin, 2020).

A banking institution, on the other hand, is a commercial bank. The latter can be a large institution with an international presence or a smaller structure operating only locally. The banking institution is not synonymous with the banking system but is a component of it.

Section 1. History

The banking system as we know it today has largely existed in Europe since the 19th century, when it began to organize and structure itself (Hamza, 2020). The interaction between commercial banks and central banks is relatively recent, and more particularly the monopoly of money issue that central banks hold. The first central bank was born in 1668 in Sweden, the Riksbank, after the bankruptcy of the Stockholm Bank. Stockholm Bank, however, was the first bank to introduce banknotes into its economy in 1657. At first, the population reacted positively to this initiative and started to use these notes. However, the bank went bankrupt a few years later because it did not keep rigorous accounts and printed too many notes without a metal counterpart. Customers lost confidence and wanted their money back. The bank did not have enough reserves and went bankrupt a few years after its creation (Vessière, 2013). Following this failure, the Sveriges Riksbank was created as the successor to the Stockholm Bank and began issuing banknotes in 1661 (Hautcoeur, 2016). However, it did not obtain the status of Central Bank until 1897 and it was not until 1904 that it obtained the exclusive right to issue coins and notes in Sweden (www.riksbank.se).

Note that there are traces of banking activities dating back to thousands of years before Christ. The beginnings of the banking system are mainly based on bartering, but during antiquity, banking activity evolved. *Faeneratores*, interest-bearing lenders, appeared. While at the time it was customary to invest one's fortune in land, some decided to become financiers and build their fortune by lending at interest (Verboven, 2004). In addition, the organization of payments was different from today. Indeed, it was very rigid because of, among other things,

the absence of fiduciary money (a concept developed in section 1 point 2), the absence of commercial paper and bearer bonds or the predominance of cash payments (Andreau, 1977). Thus, throughout antiquity, we can say that there were bankers but not banks in the institutional sense.

Until the 11th century, the main activity of these bankers was money exchange, mainly because of the increasing number of currencies in circulation. The word bank comes from the 15th century French word "banque", which in turn comes from the Italian word "banca" meaning bench. The latter refers to the benches used by Lombard bankers in the 13th century for transactions. Lombard bankers emerged with the economic expansion that the West experienced at that time. The Lombard businessmen then started to be able to grant consumer credits. These businessmen, who became bankers, widely disseminated two major innovations for the evolution of the banking system, namely the sight account and the letter of credit. The former was made possible by the invention of accounting as we know it today (Pastre, 1997).

The institutionalization of banking evolved thanks to Italian political intervention, we can take the example of the creation of the Casa di San Giorgio in 1407 in Genoa. The city was then ruled by the aristocracy who wanted to finance themselves through financial instruments such as public debt, negotiable bonds, double-entry bookkeeping, and discounting of public and private securities. These institutions multiplied in Europe and made it possible to combine private interests with public financing needs. Over time, accounting and mathematical techniques were perfected to improve the functioning of these institutions. They managed to combine the interests of local aristocrats, the safeguarding of private savings, public financing, and the creation of a market for financial securities (Baubeau, 2021).

In the 17th century, Amsterdam was a city where most of the world's goods were transported and was also the most dynamic financial center. The creation of the Bank of Amsterdam in 1609 was a major step in the institutionalization of banking. It is a public institution that was founded based on the Venetian model developed above. This bank allowed for deposits, transfers, and endorsement of letters of credit for merchants and entrepreneurs. It promoted the economic development of the city by offering short- and long-term credits and secured transactions and investments (Bernier, 2018). It was the latter that served as the model for the public bank in the rest of North-Western Europe (Baubeau, 2021). Indeed, it was based on this model that the Bank of Sweden developed. The Bank of Amsterdam was the forerunner of the Central Bank of the Netherlands, although its primary objective was not to unify the

means of payment used in the United Provinces or to issue a fiduciary currency. Thus, during the 17th and 18th centuries, the Bank of Amsterdam could not be considered a central bank. It was not until the 19th century that it became a national bank, like the Bank of England and the Bank of Sweden, because it was then that they served as instruments of the national political unification program (Hautcoeur, 2016).

The Bank of England does not have the same history as the Bank of Amsterdam or the Bank of Sweden. It was founded in 1694 by London merchants to raise £1.2 million in public loans. The bank was both a state bank and a private bank. It was given the right to discount commercial and public bills and to issue notes convertible into metal money. However, as with the Bank of Amsterdam, it was not until the 19th century, and more particularly 1844, that the Bank of England saw its role as central banker truly asserted with the granting of a monopoly to issue banknotes throughout the country. During the industrial revolution, the growth of banks was favored by three factors: the development of fiduciary money, followed by the development of scriptural money and finally the use of securities to finance companies (Blumberg, 2021).

Finally, the history of the banking system is marked by the appearance of numerous regulations during the 20th century. The Bank for International Settlements (BIS) was founded in 1930 after the Hague Conference by the central banks of the main European states, with the status of a private bank, with the aim of depoliticizing inter-European political and financial affairs. The central bank was an idea that emerged from the Young Committee in 1929 and was born out of an intergovernmental agreement signed in The Hague. The BIS had two main purposes at its origin. The first was to facilitate the settlement of the reparations imposed on Germany following the First World War under the Young Plan. The second was to facilitate interbank relations when the 1929 crisis affected the entire financial world (Baud-Babic and Marty, 2021). One of the six BIS committees is particularly important, the Basel Committee on Banking Supervision (BCBS) established in 1974. The initiative was born in the wake of serious disturbances in the international banking and money markets, including the bankruptcy of Bankhaus Herstatt in West Germany. The BIS defines the BCBS as "the world's leading standard-setting body for prudential regulation of banks and provides a forum for regular cooperation on banking supervision issues" (https://www.bis.org/bcbs/). So far, the Basel Committee has issued 3 different agreements, the first one dates from 1988, the second from 2004 and the third from 2010. As a result of Basel II, three pillars have emerged. The first pillar defines the capital to be considered and the methods for calculating the minimum capital for

operational, credit and market risks. The second pillar defines the supervisory process for capital coverage and risk management. The final pillar concerns banks' disclosure requirements (finma, 2021).

1. The notion of value

We will develop the notion and conception of value according to economic thought and its evolution. It is an important concept but has different meanings in economics, which shows the difficulty of defining it unanimously (Berta, 2021). However, we need to understand it because currently the value of a good and any other constituent element of the economic system is intrinsically linked to its price.

The objective of this section is to understand the different conceptions of value. Indeed, since the origins of economics, the notion of value has been a shifting concept, difficult to conceptualize. We do not aim to develop this notion mathematically as this would make understanding it even more complex.

1.1.The physiocrat's vision

Physiocracy is a school of economics, but also political and legal thought that emerged in France in the second half of the 18th century. The physiocrats are considered as the founders of economic science and the precursors of economic liberalism (Touchard, 1958). The latter is based on economic freedoms as necessary for the proper functioning of the economy and implies a minimum role for the state. Economic freedoms include free trade, entrepreneurial freedom, free choice of consumption and free choice of work (Bénoit, 1978). One of the main physiocrats was Quesnay, who in 1766 proposed the Economic Table in which he simplified the nation into three classes: the productive class, the landlord class, and the sterile class. It is the productive class that generates value in the economy. He assumes that agricultural production generates value, whereas craft and commercial activities are merely the addition of labor to raw materials. Value can then be estimated through the aggregation of the value of natural products constituting the capital necessary for a production plus the value of natural products necessary for the reproduction of labor power (Deleplace, 2018). The principle of value reproduction lies in land and people (as demographic forces). Thus, for Quesnay, the reproduction of value is linked to a natural force, the land is not a power of reproduction of the identical but as the production of an excess (Markovits, 1986).

1.2.English classical economists

Several classical English economists have left their mark on history. First, we can mention Adam Smith. The starting point of Smith's thinking is the definition of wealth. According to him, wealth "consists of all things necessary and convenient for life". Thus, unlike the physiocrats, for whom wealth is land, he considered that it is produced. Therefore, to increase wealth, it is necessary to understand how to improve the productive faculties of labor. It is then that Smith states that work becomes more productive if it is divided and that everyone specializes in what he knows best. Humans have a natural tendency to specialize and divide labor and this comes from exchange. Therefore, the analysis of a society is based on the functioning of the exchange between the different protagonists. To do this, it is necessary to be able to determine the exchange value of goods, or relative value. For Smith, value can have a second meaning, namely the use value of a good, i.e., the utility of a particular object that people derive from it. Generally, use value and exchange value are very different from each other. For example, water has a very high use value while its exchange value is relatively low. Conversely, diamonds have a lower use value than their exchange value (Deleplace, 2018). To determine the exchange value, it is necessary to base it on the work ordered, the work that the possession of a good allows to buy (Berta, 2021). According to Smith, there is a difference between the real price of a good, which depends on the value of labor, and the monetary price. The latter is not invariant because if the monetary price of a good varies, it cannot be determined whether this variation is due to the change in the value of the commodity or to the change in the value of the money, which is not the case with labor as a determinant of exchange value. Thus, since labor never varies in its own value, it is the only real measure by which to determine and compare the value of any commodity. It is their real price, whereas money is the nominal price (Deleplace, 2018).

The second English classical economist whose conception of value we will analyze is David Ricardo. Ricardo's conception of value evolved over time. Indeed, he reassessed his conception of value between 1817 and 1821. Originally, he put forward the principle of labor-value according to which goods are exchanged in proportion to the quantities of labor required for their production. This principle was to be considerably modified with the introduction of capital. He would eventually consider a second cause for determining the relative value of a commodity, the level of the rate of profit. For Ricardo, commodities derive their exchange value from their scarcity and the amount of labor required to produce them. However, this is

only the case for so-called reproducible goods, for other goods it is only their scarcity that determines their value (e.g., statues, paintings, etc.). In contrast to Smith, Ricardo considers that labor-value varies both in the short term, because of supply and demand, and in the long term, because of the price of goods purchased with wages. Thus, labor-value in Ricardo's case is not the same as in Smith's case. For Smith it is the labor ordered, whereas for Ricardo it is the quantity of labor necessary for the production. Finally, Ricardo will recognize that the value of a good will also be determined by the level of the rate of profit, itself inversely proportional to wages (Deleplace, 2018).

1.3.Value according to Karl Marx

Marx's notion of value takes three distinct forms, use value, exchange value and value. Each of these meanings depends on the conception of commodities. First, use value is since a commodity satisfies a need, but the utility of a thing does not presuppose that the thing is a commodity. According to Marx, for a thing to be a commodity, it must produce use values but also use values for others, i.e., social use values. A commodity exists only for things transferred by exchange between individuals. The utility of a commodity is relative because it exists only in the context of a relationship between two individuals. It has an appreciable qualitative character, whereas exchange value has a quantitative character but is equally a relative notion for Marx. However, the determination of exchange value does not depend on use value but on the third form of value. According to Marx, "value" is my property common to all commodities making them commensurable. It is represented by a quantity because the exchange value between two commodities can be conceived as the ratio of their values. It is also social because it only manifests itself in exchange relationships. The value of a commodity is conferred by human labor, so it has a social purpose (Deleplace, 2018).

The main distinction to be made between the work of Marx and that of Ricardo and Smith is that according to the latter, labor is only a commodity like any other. For Marx, however, labor is the origin of value, and the wage is only the part necessary for the survival of the worker and the rest is surplus value (Orléan, 2011).

The conceptions of value that we have just developed are objective conceptions because they are all based on an objective measurable criterion, i.e., work. In contrast, there are other conceptions of value, this time based on a subjective criterion that we have already mentioned, namely utility.

1.4.Value before exchange according to Étienne Bonnot de Condillac

Condillac is a French classical economist with a very different view of value than those we have listed so far. The main difference is that, according to him, value precedes exchange, in the sense that the exchange between two contracting parties is not necessary for the object of the contract to have value for each of them. He argues that value is the result of the subjective appreciation of individuals. Utility is paramount in this conception because the more useful an object seems to us, the more valuable it will be in our eyes and the less inclined we will be to exchange it. Value pre-exists the exchange and is even the reason for the exchange itself (Orain, 2007). Finally, he also considers that the value of things increases with scarcity but decreases with abundance (Pelletier, 1977).

1.5.Value for neoclassicals

Neoclassical economists, also known as marginalists, developed the concept of marginal utility. Marginal utility is the additional utility that an individual derives from consuming an additional unit of a good. A common example is the homeless person and the millionaire. If we give an extra €10 to a homeless person, his marginal utility will be very high because he has very little initially. Conversely, an extra €10 for a millionaire has little utility given his prior wealth. The two neoclassical economists whose thinking on value we have analyzed are Stanley Jevons and Leon Walras.

Jevons considers that value depends entirely on utility, but labor remains a constituent element of utility. However, once labor has been expended, it no longer has any impact on the future value of a product. Labor will affect supply which in turn will affect the degree of utility to finally determine the value or exchange ratio (Marie Henry, 2009).

Walras, for his part, also developed a theory in which utility is at the origin of value. Furthermore, according to him, the limitation of quantity, i.e., scarcity, is a key notion for understanding the notion of value. There are two elements that determine scarcity and therefore value, the first being the number or quantity of goods limited, the second being the number of people who need them. Scarcity is then simply the ratio between these two elements (Jessua, 1991).

1.6.Conclusion

Understanding the notion of value is important because in the economic system in which we live, value is intrinsically linked to exchanges between individuals and is currently materialized through money. At present, whatever conception of value we choose the commonly accepted unit for translating it is fiat money. Whether the value of a good is determined by the labor required to produce it or by the utility that an individual derives from it, its price will be the determinant of the exchange. It has not always been accepted as a medium of exchange, but individuals have had to come to terms with it and understand its value in facilitating and guaranteeing exchange.

2. The notion of money

Money is defined as "the set of means of payment immediately usable and accepted by the community for the settlement of exchanges. It therefore constitutes a means of carrying out exchanges for and between individuals" (Guillaumin, 2020).

2.1. History of money

If we pay attention to the etymology of the word money, it has always represented a means of exchange. Before money as we know it, there were other monetary instruments of which barter was the first (Bruguière 2021). Barter was only possible under certain specific conditions, which are no longer the case today, such as the limited number of exchanges in the economy or the reduced community of the individual (Narassiguin, 2004). Commodity money was therefore the first form of money. Commodities derived their value from their use as goods, their value was intrinsic. However, this form was soon replaced by metallic money.

Metallic money has its value defined in relation to a metal, which can be copper, bronze but more often silver or gold. Metallic money can be considered as a special form of commodity money. It has an intrinsic value, that of the precious metal with which it was minted. Metallic money has its value defined in relation to a metal, which can be copper, bronze but more often silver or gold. Metallic money can be considered as a special form of commodity money. It has an intrinsic value, that of the precious metal with which it was minted. The transition from bartering to the use of metallic money goes back a long way because it was an easily divisible and transportable form of payment. Initially, gold and silver circulated in pieces without any standard size or weight. Thus, for each transaction, the metal had to be weighed and its

authenticity verified. Then, to speed up transactions, the metal was given a predefined shape and weight to certify the weight of pure metal. Finally, the coin was minted by affixing its value expressed in metal weight to the piece of metal, as well as a distinctive sign to identify the minter (Delaplace, 2017). Minted coins were first issued in Lydia in the 7th century BC. King Alyattes and his son Croesus were the precursors of coinage (Hochard, 2020).

The use of metals as a medium of exchange was replaced by paper money, the representative currency. This money was directly linked to a precious metal, usually gold. For example, before the First World War, one US dollar corresponded to 1/20 of an ounce of gold. The note therefore indicated the weight associated with that note with its theoretical value (Rajca, 2017).

Finally, the last form of money that appeared is the one we are still using today, namely fiat money. This form of money is innovative because it is very different from those that humanity has known before. Etymologically, fiat money comes from the Latin word fiducia, meaning trust. Fiduciary money derives its value from the trust placed in it by its users (Guillaumin, 2020). Fiduciary money has no intrinsic value (ECB, 2015). Currently, fiat money is issued by a public entity, the Central Bank. To guarantee the use of and confidence in the currency, the state must establish legal tender, which is the obligation to accept the currency as a means of payment. However, legal tender may not be sufficient to encourage people to use money. If they do not trust it, as in the case of hyperinflation, they may decide not to use it (Guillaumin, 2020).

Money has not always had the same form as today, but its use has always been for exchange. The value attributed to money first depended on other things such as livestock, precious metals, etc. Whereas now the value of money is assigned arbitrarily by a state body which also has a monopoly on issuing it. Furthermore, the trust of individuals is a determining element for the common acceptance and use of this currency.

2.2. Functions of money

Money has three specific functions: it serves as a medium of exchange, a unit of account and a store of value.

First, money as a medium of exchange. Money is a commodity that has been commonly accepted to enable exchange. In barter economy exchanges were only possible because the

desires of two individuals appeared at the same time. It could be that someone needed something, but no one wanted what they offered in exchange. Thus, bartering cannot be considered as money. Money enables exchange because it has value and is commonly accepted by the population (ECB, 2015). Everyone will accept money as a means of exchange because he knows that he can use it himself afterwards to acquire something else.

Then, money as a unit of account. Money is a unit of account because it is used to determine the price of goods and services in an economy (ECB, 2015). It allows the respective values of goods to be compared. It simplifies the price system and thus exchange. However, although money measures the value of goods, it does not determine the value of goods (Delaplace, 2017).

Finally, the last function of money is the store of value. The amount of banknotes and coins currently used for payments, exchanges, does not correspond to the entire amount of cash in circulation (ECB, 2015). When an individual has money, he can decide when to exchange it for a good or a service, he can postpone his purchasing power. Even if he could use this money to buy precious metals or other assets that could serve as a store of value, money has certain advantages. The first is liquidity, money is perfectly liquid where it is legal tender, unlike other assets which must be sold first. The second is the absence of risk, a priori money does not lose value. To fulfil this function, money must therefore retain its value over time. This is only true when there is no inflation (Delaplace, 2017).

Section 2. The traditional financial system and its components

1. The financial system

Jean-Paul Pollin defines a financial system as "the set of rules, practices and institutions (stock exchanges, banks, etc.) that make it possible to mobilize capital to make it available to agents with financing needs". Concerning the purpose of a financial system, Lobez and Vilanova (2006) summarize it as follows: "the purpose of any financial system is to allow the transfer of savings from surplus economic agents (households) to deficit agents (firms). To do this, a financial system is traditionally structured in two poles, the pole of financial markets and the pole of financial institutions or intermediaries". This transfer of funds can be achieved in two ways: direct finance and indirect finance. Direct finance involves borrowers obtaining funds from lenders by issuing and selling securities on a financial market (see point 2. below). These securities are tradable and may represent an ownership right in the company, in the form

of shares, or a debt right, in the form of a bond (Albouy, 2021). There is also indirect finance, also called intermediated finance. In this case, borrowers do not receive funds directly from lenders but go through intermediaries (see figure 1 for an overview of the flows in the financial system).

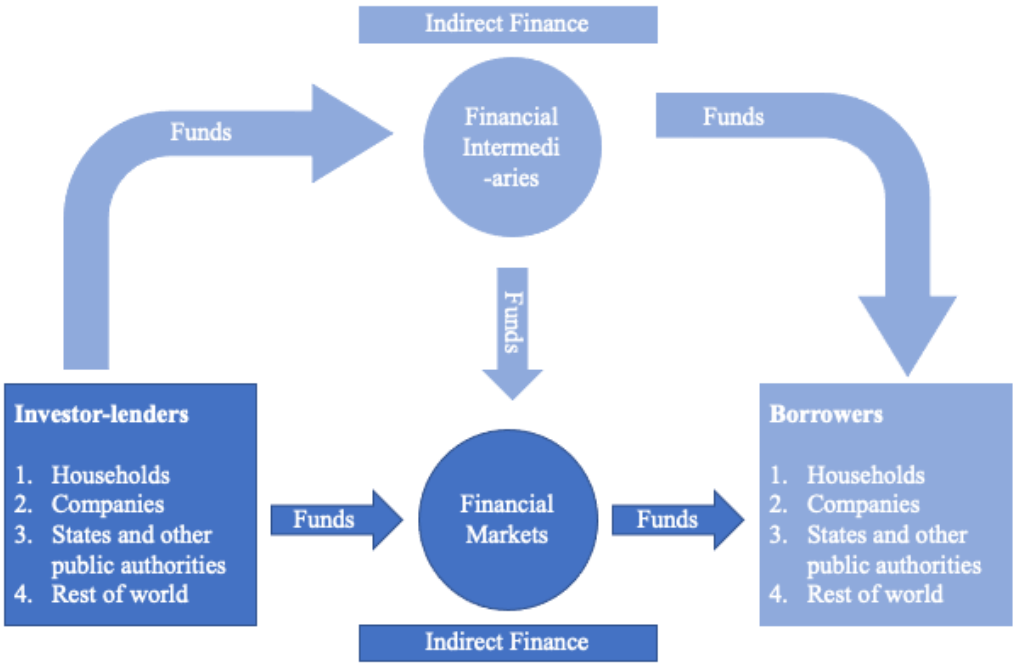


Figure 1. Flows of funds within the financial system[1]

2. Functions of the financial system

As Beitone et al. (2018) explain, a financial system must therefore fulfil five main functions. It must provide and manage means of payment. It must collect savings and help finance investment. It must transfer economic resources over time and space. It must offer risk management instruments. Finally, it must produce information to inform agents' decisions. The last two functions are particularly important for understanding their impact on exchanges between individuals and their crucial role in the dynamics of the economy.

When a capital provider and a capital seeker meet, the seeker is generally better informed than the applicant because he knows the use he will make of the capital in a precise manner, he

[1] Source: Mishkin et al., 2010.

knows the profitability of the project, etc. On the other hand, the capital provider does not always have all the information necessary to decide; he only has what the applicant agrees to provide. We can then speak of information asymmetry, and this can lead to two problems: adverse selection and moral hazard (Pollin, 2021).

Adverse selection is easily explained by an example. Suppose that an automobile insurer sets a premium. Since he does not know whether the client in front of him is a risk or not, he will set an inappropriate price. The prudent, low-risk customer will consider the premium too high, while the high-risk customer will find the premium reasonable given his profile. As a result, the insurer will attract the "bad" clients when that is what it is trying to avoid.

Moral hazard assumes that an individual who is hedged against a particular risk will behave riskier than if he or she had not been hedged.

Therefore, asymmetric information damages trade and the financial system is there to provide solutions to these problems. This financial system provides legal rules protecting the interests of investors, rules guaranteeing the quality and proper dissemination of useful and necessary information to investors, and an organization of capital markets. Financial institutions are therefore needed to produce quality information, to monitor the various projects, etc. A financial system therefore has a role that goes beyond the collection and transfer of savings (Pollin, 2021).

3. The components of the financial system

According to the IMF (2016), a financial system is composed of different actors that allow the interests of lenders and borrowers to meet. Any financial system is composed of banks, securities markets, pension and mutual funds, insurers, market infrastructure, a central bank, and regulatory and supervisory bodies. It is these actors and their interactions that allow savings to be efficiently channeled into investment and thus contribute to economic growth.

3.1.The banks

Banks are an important part of the financial system. There are four different types of banks, each with a specific role. We include the central bank in this category, although it has a very specific role.

- Commercial banks

Commercial banks are the ones we are perhaps most familiar with as individuals. Indeed, it is with this type of institution that each of us has a bank account and a savings account. Among the services offered by commercial banks, we find the provision of a bank account with related services. Commercial banks are also in charge of offering credits or loans to their clients. Finally, they oversee collecting deposits, through savings accounts. These commercial banks therefore have an intermediation role. The deposits they collect will in turn be used to lend money via bank credits.

In Belgium, the 4 largest commercial banks are Belfius, BNP Paribas Fortis, ING Belgium and KBC Group (BNB, 2020).

- Merchant banks

Merchant banks are banks that do not deal with individuals but rather with companies or high net worth individuals (HNWIs). Their main roles consist of financing activities as well as international underwriting such as investment in international companies, real estate abroad, etc. A well-known Belgian investment bank is, for example, Degroof Petercam (Clément, 2019).

- Investment banks

Investment banks are financial intermediaries that provide services to large corporations and institutions in large and complex financial transactions. They assist in fundraising, debt and equity offerings, IPOs, and M&A transactions (Dhir, 2021).

- Central banks

We have already briefly discussed the role of central banks. The bank of banks allows commercial banks to borrow money in the very short term. Indeed, customers with a current account want to be able to withdraw banknotes at the counter as soon as they want, and to do so, commercial banks must have a sufficient stock of banknotes. Since the central bank has a monopoly on the issuance of money, commercial banks must obtain banknotes from the central bank and make them available to their customers (nbb, 2021). In the European Union, the European Central Bank's main role is to manage the single currency. In addition, it is also responsible for setting the interest rates at which it lends to commercial banks in the Eurozone, thereby controlling the money supply and inflation. It also manages foreign currency reserves

and ensures appropriate supervision of financial institutions and markets by member states (Europa, 2021).

3.2.Securities markets

The securities market, also known as the stock market, is a key component of the financial system. The latter allows the meeting of two categories of economic actors, agents with a need for financing and agents with a capacity for financing. The former is, for example, companies or administrations that need capital to finance their various projects. The latter are households that have a surplus of capital after having met all their consumption needs. Companies and the State issue financial securities on the securities market, which are then subscribed directly by savers or by institutional investors managing their savings. A stock exchange makes it possible to permanently measure the future of the invested capital and the quality of the projects they finance. It is the market that is supposed to allocate resources efficiently. In this system, banks also have a role to play because they carry out commission activities, market operations and have an essential role in the derivatives market (Goyeau, 2021).

3.3.Pension and mutual funds

- Pension funds

Pension funds are schemes organized by private and public companies for the benefit of their employees. They are non-banking financial organizations collecting employee and/or employer contributions which they manage on a funded basis. When the members, i.e., the beneficiary employees, retire and claim their benefits, the pension funds pay benefits either in the form of an annuity or in the form of capital. The objective of pension funds is to encourage the building up of savings for retirement (El Mekkaoui De Freitas).

- Mutual funds

Mutual funds are collective investment schemes in securities. They pool the savings collected from their members and manage this money globally as a single portfolio. Each partner holds a share of the fund proportional to his or her stake (Balley, 2021).

3.4.Insurers

Insurers or insurance companies are a component of the financial system, they are considered financial institutions. They are dedicated to managing the risks of households and businesses. Insurance companies have two essential functions: the first is to cover the risk and the second is to recycle the savings thus generated within the economy.

To manage risks, insurance uses statistics. The basic principle is the law of large numbers. If the probability of an accident in a country is x% per year, then we know that x% of the portfolio will be affected by this damage (not necessarily every year, but on average). Finally, there is the mutualization of risk, which is the principle according to which all policyholders pay premiums so that those of them who suffer a loss are reimbursed.

3.5.Market infrastructure, securities depositories, and payment service providers

A market infrastructure is defined by the Bank for International Settlements (2012) as "a legal or functional entity established to carry out centralized multilateral payment, clearing, settlement, or recording activities and, in some contexts, may exclude participants who use the system." These infrastructures establish a set of common rules and procedures for all participants. They offer participants a centralized system for clearing, settling, and recording financial transactions among themselves or with a central counterparty. This system increases efficiency and reduces costs and risks.

Some entities in this sector such as SWIFT, Euroclear, Mastercard or Worldline are of systemic importance at the international level. The main authority of these entities is the central banks which ensure their complete functioning. The services provided by these infrastructures to their clients are clearing, settlement and custody of securities, payments, and provision of critical services (nbb, 2017).

3.6.Regulatory and supervisory bodies

Each country has its own regulatory and supervisory body for the financial and banking system. In general, the objective of these bodies is to establish macroprudential rules to ensure the stability of the system and to monitor whether these rules are properly applied by the various components of the system. The main task of macroprudential supervision is to prevent or

mitigate financial risks. On the other hand, there is also micro prudential supervision at the level of institutions such as banks, insurers, and pension funds (nbb).

Section 3. The importance of trust

As Noyer (2010) says, "trust is the basis for the functioning of modern economies". An economic agent's willingness to entrust his money to a bank is simply a matter of trust. If the agent in question did not have confidence in the bank's ability to maintain his assets, he would not entrust them to the bank. In developed economies, trust in the financial system is a critical element for economic development (K. Jaward and Jihad, 2020). For Arrow (1972), trust is also at the heart of any economic relationship. According to him, virtually, every exchange, and more particularly any exchange that takes place over time, includes an element of trust between parties. As the OECD (2019) points out, financial markets are critically important for the proper functioning and well-being of the real economy as it is the main intermediation mechanism between investors and economic actors. It is then that trust is needed for markets to convert savings effectively and efficiently into productive economic growth.

The 2008 crisis allows us to understand the importance of trust and the different relationships of trust that exist within the system. Indeed, the first relationship of trust that has suffered from the crisis is not that of households towards banks. It is when loans were not repaid, the subprime, by a certain type of household that the banks lost confidence in the repayment of loans by a whole section of the population. This lack of confidence resulted in a tightening of the conditions of access to credit. Subsequently, the banks lost the confidence they had in each other. This loss of interbank confidence was reflected in the conditions of the interbank money markets with the upward trend in overnight rates. Finally, there was a loss of investor confidence in financial institutions. Given the losses that the banks were recording and the tensions that they were experiencing on their source of financing, this cast doubt on their solvency (Noyer, 2010).

Systemic risk is, in some cases, related to the confidence of individuals in the financial system. Systemic risk is defined by Cornut St-Pierre (2019) as "the probability that some event, such as the failure of a financial institution or a macroeconomic shock, could, through a domino effect, cause the collapse of the entire financial system, or even the real economy that depends on it". The erosion of confidence in the system can lead to such a collapse, as illustrated by the bank runs when savers lose confidence in their institution. If an individual hears that the bank

in which he or she has a savings account is in trouble, he or she will tend to withdraw his or her money to put it in what he or she considers a safer place. However, if all the customers of that bank have the same fear, the same loss of confidence, this can lead to a self-fulfilling prophecy, which means that a bank can fail not because of its internal problems that caused the loss of confidence, but because of mass bank withdrawals. These withdrawals then deprived the bank of the liquidity it needed to function properly, leading to its bankruptcy.

The confidence of economic agents in the financial system is therefore essential to maintain financial stability. The crisis of 2008 was a crisis that disrupted both the financial sphere and the real economy. However, the Wall Street crash of the 1990s and the bursting of the internet bubble in 2000 had little impact on the real economy, demonstrating a certain stability at these moments in history (Flouzat, 2012). Confidence must therefore be maintained to maintain financial stability to avoid systemic crises.

The best tool found so far to strengthen the confidence of economic agents in the financial system is regulation. According to Noyer (2010), this financial regulation has three goals. The first is the protection of agents, which can take several forms, the most important of which is the deposit guarantee. Indeed, if an agent hears that his bank is in trouble but knows that his deposits are guaranteed, the probability that he will empty his accounts is less than without this guarantee. The second objective of regulation is the correction of failures within the financial system, generally linked to information asymmetry. The last objective is to limit excessive risk-taking by financial institutions (Noyer, 2010). An important element that has been brought about by financial regulation and that has increased confidence in the financial system and its components is financial transparency. Transparency reduces agency costs where power is largely separated from capital ownership. It protects investors without reducing the banker's or manager's freedom of action (Duhamel, Fasterling and Refait-Alexandre, 2009).

Therefore, regulation is currently the best solution found by the system to allow the maintenance of the trust of individuals and to best guarantee economic stability. However, since trust was eroded during the 2008 crisis, it has never been fully recovered and efforts still need to be made in certain areas. According to the OECD (2019), efforts need to be made in three areas: pensions, financial consumer protection, and the governance of financial institutions.

Section 4. And after? Central Bank Digital Currency

1. What is a Central Bank Digital Currency?

In the section on the concept of money and its historical evolution (cf. section 1 point 2), we saw that currently, fiduciary money is what is used daily by individuals. We also know that since money has no intrinsic value, it must be given legal tender by the central bank so that anyone is obliged to accept it as a means of exchange. However, we have entered an era where digital technology is becoming more and more important. Solutions of this type are multiplying in all areas of daily life and even in the currency. This is especially true for the demand of individuals. For example, one out of two Europeans is more inclined to pay digitally rather than in cash and this trend has even been accelerated by the COVID-19 crisis we are experiencing (ECB, 2020).

To meet this demand and to continue the evolution, central banks have been seriously considering the creation of central bank digital currencies (CBDCs) in recent years. The Federal Reserve (2021), the central bank of the United States, defines central bank digital currency as "a generic term for a third version of currency that could use an electronic record or digital token to represent the digital form of a nation's currency. CBDC is issued and managed directly by the central bank and could be used for a variety of purposes by individuals, businesses, and financial institutions".

As Fabio Panetta (2021) recently stated, "innovations in money have challenged and altered the structure of the financial system. Time and time again, innovations have given rise to debates about the risks they pose and the rewards they bring, as well as the role of central banks in building confidence in money. Therefore, the creation of CBDCs should not be at the expense of the stability of the financial system while meeting the needs of individuals.

Note that the ECB is not the only central bank looking into the issue of a retail digital currency. In 2021, 86% of central banks worldwide responding to Boar and Wehrli's survey said they had at least done some research on the topic. The earliest research on the topic dates to 2015 when the central bank of Ecuador launched its pilot project 46 central banks have already launched design reports or prototypes (Auer and Böhme, 2021).

2. Why create a Central Bank Digital Currency?

According to the Bank for International Settlements (BIS) (2021), there are three major reasons why central banks have become increasingly interested in CBDCs over the past two years. First, we have the growing public attention to Bitcoin and other digital currencies. Second, there is the debate over stablecoins. Stablecoins are a new category of cryptocurrency. They attempt to offer some price stability and are backed by a reserved asset. This makes them significantly less volatile compared to other cryptocurrencies (Investopedia). Third, there is the entry of large tech companies into payment services and financial services in general. On this last point, we can refer to Facebook and the announcement of the launch of Libra (currently Diem). The White Papers for this project were originally published in June 2019, while Morgan Beller had been researching the topic since 2017 (Rodriguez, 2019). The idea behind the Diem cryptocurrency is to make the financial system accessible to 1.7 billion adults who are currently financially exclude because they do not have access to the financial and banking system. Along with this problem, almost every individual has access to a smartphone and the use of such a cryptocurrency could be done via only this object without having to go through a banking entity. The use of blockchain as a technology would allow to overcome different problems such as accessibility or trustworthiness (www.diem.com/en-us/white-paper). However, although the currency was supposed to launch in 2020, this was delayed as Zuckerberg told members of the Senate that Facebook's cryptocurrency would not be launched worldwide until it had received approval from the US regulator (Romm, 2019).

Ward and Rochemont (2019) also questioned the value of issuing a CBDC. They suggest that there are five main reasons, deeper than those stated by BIS. The first is to ensure public access to legal tender in the event of the phasing out of cash. Since it is a currency issued by a central bank, it would be legal tender and could be used daily by individuals. It would therefore represent a claim on the central bank. The second is to improve the efficiency of payment systems. A CBDC could make certain payments easier and faster, while making them more secure and saving money (e.g., less cash is produced). The third reason is the transition to a cashless society. The fourth reason is to have a credible competitor to the private electronic money. The monopoly of money issuance by a central bank has a social role. If privately issued e-money is the one that is most widely accepted and used, it may be that private e-money providers have an advantage over the rest of the population. The final reason is to improve the efficiency of cross-border payments.

In both cases, the reaction to emerging cryptocurrencies and gaining adherents is a fundamental reason for the creation of a potential CBDC.

3. Bitcoin as a real currency?

The historical, most popular cryptocurrency is of course Bitcoin (we will define it more fully in Chapter 2). If central banks fear crypto-currencies and Bitcoin in particular, it is because it can theoretically be considered a currency. We know that money fulfills three functions, so let's see if Bitcoin does too. According to Perrin (2019), Bitcoin meets the economic definition of money albeit imperfectly.

First, a currency is a medium of exchange. This means that for Bitcoin to be considered a currency, it must be used as a medium of exchange in transactions between two or more individuals or entities. Currently, 18,765m Bitcoin are in circulation and the total supply will reach 21m by 2140. This estimate is from 2017 based on the assumption that Bitcoin mining halves every 4 years (from Best, 2021). Only a small percentage is used for trading. If we consider the total future supply of Bitcoin, 56% is held by investors with a long-term investment goal. If we only consider the current available supply, that's 61% of Bitcoins held by investors. Investors are defined as those being "self-hosted wallets that held 75% or more of the value of all crypto-currencies they received" (Faridi, 2021). The rest is divided into three parts, about 18% of the total supply is considered lost because there has been no activity on the portfolios that hold them for 5 years or more, 11% still needs to be mined. The remaining 15% are traded frequently, mainly via trading platforms. However, more and more companies are beginning to accept the use of Bitcoin as a medium of exchange. Microsoft is an early adopter as they have been accepting Bitcoin for game and app purchases since 2014. PayPal also allows trading of Bitcoin and other cryptocurrencies. The online payment giant allows the buying and selling of cryptocurrency. Initially, they aimed to attract businesses due to their low transaction costs. Other companies that accept Bitcoin and sometimes other cryptocurrencies as payment include Etsy, Whole foods, and Starbucks. In some cases, such as Starbucks, Bitcoin is not directly accepted at the cash register like cash but can be deposited on an app and is freely available to pay via that app (Lisa, 2021). One of the most recent companies to decide to accept Bitcoins as a means of payment is Tesla, despite a certain reversal. In February 2021, Tesla CEO, Elon Musk announced that his company would accept Bitcoin for customers who wanted to buy one of his cars. However, in May 2021, Musk reversed his decision due to environmental concerns about Bitcoin mining. Given his involvement in environmental advocacy and because

of pressure from some Tesla investors, it was decided that Bitcoin would no longer be accepted until a solution was found. Finally, on July 21, 2021, at the B World cryptocurrency conference Musk announced that Bitcoin would most likely be accepted as a means of payment again (Reuters, 2021). Although some companies tend to accept the use of Bitcoin, this remains marginal. There are two reasons that may partially explain why Bitcoin is not commonly accepted outside of legal and regulatory reasons. The first is the volatility argument. Volatility is popular with traders because it allows them to make money on buying and selling assets over a short period of time. Volatility is simply the degree of variation, measured by the variance of an asset's price over a given period. The greater the volatility, the greater the price variation over a period and the more difficult it is to predict the future price. Volatility is therefore a measure of risk.

Currently, if a transaction is made in Bitcoin, it usually implies that the buyer has first purchased Bitcoin, and it is quite likely that once the transaction is completed, the seller will convert those Bitcoins into fiat currency to pay his suppliers. In this situation, since the Bitcoin price is relatively volatile, an asset can cost depending on the timing of the transaction. If we take the price of Bitcoin against the dollar, for example, since 2014 and observe the daily volatility, the latter is on average 10% and can reach 30% for some days (Baur and Dimpfl, 2021). Because of this volatility, some argue that Bitcoin is too volatile to be considered a medium of exchange. Note, however, that this volatility may only be temporary. Indeed, we are still relatively early in the adoption curve of Bitcoin by users. The rapid growth phase of the network and the increase in the number of users favor the rise in price and instability of Bitcoin (Ecoinometrics, 2021). If we measure the number of Bitcoin users or holders by the number of existing Bitcoin wallets, we can see a 25% increase from the end of 2019 to the end of 2020 bringing the current number of Bitcoin wallets to nearly 56 million (Godoy Hilario, 2021).

The second reason why Bitcoin is not currently commonly accepted as a means of payment is its scalability problem. As we will explain in the chapter on Bitcoin, the Bitcoin network is based on a set of interconnected nodes. Each of these nodes helps to ensure the reliability of transactions taking place on the Bitcoin blockchain. However, each node must approve a transaction for it to be valid, so it is impossible for the network to process many transactions in a short period of time (Poon et Dryja, 2016). For comparison, the Visa payment network can reach up to 47,000 peak transactions per second while the Bitcoin network supports less than 7 transactions per second. Thus, at present it is inconceivable that the Bitcoin network could

replace all electronic payments (Trillo, 2013). A solution was proposed in 2016 to address this scalability issue, it is the Lightning Network. The Lightning Network will create a second layer on top of the Bitcoin blockchain, which uses user-generated micropayment channels to perform transactions more efficiently. These transactions are then faster than those initially processed by the Bitcoin blockchain because they do not have to be processed by the entire Bitcoin network. The beta version of the Lightning Network was launched in 2018. Since then, the number of nodes on the Lightning Network has only doubled each year, reaching 12,675 public nodes by July 2021. Public nodes are those that are accessible by everyone, if we include private nodes, i.e., those only accessible by authorized users, then the total number of nodes is larger. However, the Lightning Network is not infallible. Indeed, it still has major security problems and is vulnerable to various attacks (CoinDesk, 2021).

Given these arguments, Bitcoin can be considered a medium of exchange in theory. Of course, there are still some barriers to overcome before it becomes one in practice, but new innovations such as the Lightning Network show us that some solutions can be considered. The problems of volatility and scalability seem to be only temporary and depend on widespread acceptance and innovative technical solutions.

The second function of money is as a unit of account, and Bitcoin does not currently fulfill this function. Indeed, although some businesses accept Bitcoin as a means of payment, it is not the one that is put forward to show the price of a good or service. The main problem Bitcoin faces in being considered as a unit of account is its volatility (Lo and Wang, 2014; Yermack, 2015). Because of this volatility, indicating prices of goods and services in Bitcoin would involve frequent price changes compared to indicating prices in fiat currency. Moreover, the regular fluctuation in the price of a certain good has a psychological cost to consumers that makes Bitcoin unsuitable as a unit of account. Unlike Bitcoin, which experiences high volatility regardless of the economic period, fiat currencies only experience high volatility during periods of hyperinflation or currency crises (Baur and Dimpfl, 2017).

The last function of money is as a store of value. The most widely used element in determining whether Bitcoin can satisfy this function is, again, volatility. Some argue that Bitcoin's high volatility does not make it a good candidate to serve as a store of value (Dezel, Liu et al., 2020; Kayal and Balasubramanian, 2021). This volatility makes Bitcoin a riskier instrument because of the greater uncertainty of its value. Moreover, in times of falling prices, people will tend to turn to assets with stable value (Kayal and Balasubramanian, 2021). On the

other hand, Baur and Dimpfl (2021) argue that although the volatility of Bitcoin at first seems to reject its use as a store of value, the long-term trend of its price is nevertheless positive. They have based themselves on various moving average prices and argue that over sufficiently long periods of time Bitcoin has store-of-value properties. Moreover, these properties are enhanced by the fact that the supply of Bitcoin is limited. They assume that if Bitcoin cannot be inflated beyond a fixed ceiling, this implies that it is possible for demand growth to exceed supply growth.

Given what has been stated above regarding the three functions of money as applied to Bitcoin, we find that Bitcoin does not meet or partially meets these functions. David Yermarck (2015) also attempted to understand whether Bitcoin is a real currency based on the three functions of currency and concluded that currently it is not. In his view, one of the requirements for Bitcoin to become a currency is for its daily value to become more stable so that it can reliably serve as a store of value and a unit of account in commercial markets. However, as Hazlett and Luther (2020) point out, this negative answer is based on the definition of money through its three functions. The standard definition of money may simply be a commonly accepted medium of exchange. To determine whether Bitcoin functions as a medium of exchange, they compared the market capitalizations of government-issued currencies with Bitcoin to estimate their respective demands. They concluded that the demand for Bitcoin is like the demand for many government-issued currencies. Of the 106 currencies with readily available data, only 6 have a higher market capitalization than Bitcoin in 2018.

One of the main obstacles that must be considered when considering Bitcoin as a currency is that it is currently not a legal tender. Thus, it can only be considered as a currency in most countries in a theoretical way. Indeed, El Salvador is the first country to have given legal tender to Bitcoin, the law was passed on 9 June 2021, and will take effect in September 2021. This decision allows El Salvador to partially emancipate itself from the United States. The country is one of the 8 sovereign states that have adopted the U.S. dollar as their official currency. The other countries are Ecuador, Zimbabwe, Timor-Leste, Palau, Panama, the Marshall Islands, and the Federated States of Micronesia. By adopting the U.S. dollar as their official currency, these countries gave up some of the tools to influence their own economies by adjusting the money supply or the exchange rate. El Salvador's innovative policy decision has been praised by several politicians in South America, Africa, and other parts of the developing world, opening new opportunities (Wintermeyer, 2021).

Although Bitcoin is not a currency from a practical point of view, there is a desire to develop a virtual currency that is legal tender. While some developing countries are thinking about following the path of Salvador, some developed countries, as explained above, have started to develop their own digital currency, Central Bank Digital Currency (CBDC). We understand that states do not want to be outdone by private cryptocurrencies or by the stablecoins that are developing. Therefore, we can think that if the central banks on one side and the states on the other side start to look at the issue of crypto-currencies or blockchain applications, it implies that there is an interest of the regulator to take measures to supervise this innovation rallying more and more adherents.

Chapter 2. Blockchain

Section 1. A brief of history and introduction to the concept of blockchain

The origins of the Blockchain go back to 1991 when cryptographic researchers Stuart Habert and Scott Stornetta published an article: "How to time-stamp a digital document", which laid the theoretical foundations for the technology (Vaudano, 2018). However, it was only in 2009, and more precisely at the time of the global systemic financial crisis that hit our societies, that it became popular thanks to the introduction of Bitcoin (BTC). Its anonymous inventor, named Satoshi Nakamoto, had the initial intention of providing, through this technology, a new digital currency with disruptive characteristics. BTC was created to address some of the weaknesses in the financial system, particularly in financial institutions. These institutions are necessary intermediaries in the system, but trust is eroded over time. Transactions are not irreversible with the involvement of banks in transactions between different parties. This uncertainty has a cost and the solution brought by Satoshi Nakamoto is the creation of "electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party" (Nakamoto, 2008).

The idea behind this technology was to create a new decentralized, more secure, and transparent environment, challenging the role of traditional intermediaries. The blockchain is a form of digital ledger, tamper-proof and decentralized, allowing the transfer of various values in the form of a peer-to-peer (P2P) network (Bamakan, Motavali et Bondarti, 2020). These values are manifold, ranging from the simple exchange of digital currencies to raw materials, supply chains and property titles. Its notable feature is that it manages to process these different values, in a secure and transparent manner, without resorting to traditional intermediaries such as financial or legal institutions (Frizzo-Barkera et al., 2020).

Blockchains can be distinguished according to who can read its content (private vs public) or according to who can modify it (permissioned vs permissionless). These notions are important to correctly classify each blockchain. Each of these aspects will be developed in the following sections (see figure 2 for an overview).

1. Types of governance

There are currently three different types of blockchains: public, private and consortium. They are subdivided into three distinct categories according to differences related to their properties. These properties are consensus determination, read permission, immutability, efficiency, nature of centralization and consensus process (Zheng et al., 2018).

1.1.Public Blockchains

Public blockchains have a much slower transaction processing rate than private blockchains. The best known can be illustrated through Ethereum (ETH) and BTC (Bouraga, 2021). The consensus mechanisms used behind Bitcoin, for example, are called "Proof-of-Work" (the latter will be detailed in section 3 of this chapter) and are slower than other mechanisms since they require the entire network to validate consensus on the progress and status of transactions. In addition, this type of blockchain has increased transparency due to its nature, making the confidentiality of its users' information more at risk (Yang et al., 2021). However, since every transaction is stored in every node of the network, it is almost impossible to tamper with a public blockchain because it means having to corrupt every single node (Zheng, Dai et al., 2018). The Bitcoin blockchain had, for example, an average of 11,364 nodes in August 2021 (Bitnode). Suppose an individual wants to change an element in a block, for example to steal the cryptocurrency of another individual whose transaction has been validated by the chain. To do this, he would have to change the information contained in the block in question but a copy of which is stored in all the nodes of the blockchain and would therefore have to change all these copies. Thus, since there are usually many nodes in a public blockchain, it is very complicated if not impossible to tamper.

Before explaining what private blockchains are, it is important to understand the notion of node that we have just denounced. It is an essential element for the proper functioning of a blockchain. Every device connected to the blockchain can be considered a node, whether it is a server, a computer, or a mobile phone. Each node serves as a validator, making it a critical component of the distributed ledger infrastructure. Depending on its type, a node can contribute to the expansion, maintenance and/or security of the data present in the network. There are two main categories, full nodes which hold a copy of the full history of the blockchain and light nodes which are connected to the full nodes to further validate the information present, they only contain a partial history of the blockchain. In addition, especially in the case of the Bitcoin

blockchain, there are mining nodes. These are only responsible for creating new blocks that will be added to the chain (Longchamp, Deshpande et Mehra, 2020). This process will be detailed in section 3 point 3 of this chapter (proof-of-work).

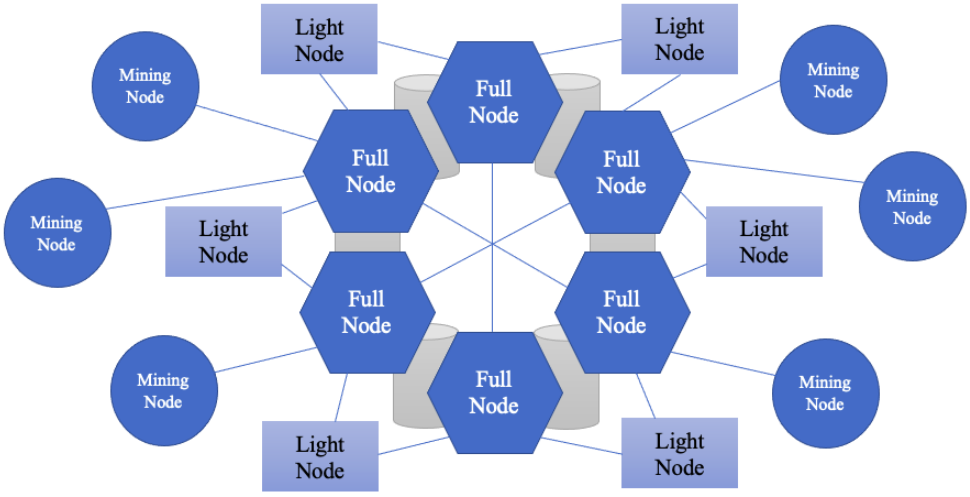


Figure 2. Different kinds of nodes[2]

1.2.Private Blockchains

Private blockchains are characterized by a much larger transaction processing than public blockchains with a much smaller number of participants. The particularity of this type of blockchain thus makes it possible to obtain a consensus for the network much faster, considerably increasing the number of processes that can be carried out in a short period of time evaluated in seconds (Yang et al., 2021). On the other hand, private blockchains are used within a single entity and can thus determine read permission as public or restricted. The nature of immutability is also different from public blockchains since it may be altered by the responsible entity. Regarding centralization and consensus processes, private blockchains also differ greatly from public blockchains. By their private nature, they are partially or completely centralized and require permissioned and certified at the node level (Zheng et al., 2018).

[2] Source: Longchamp, Y., Deshpande, S. et Mehra, U. (2020). Classification and importance of nodes in a blockchain network. *SEBA Bank*. Retrieved from: https://www.seba.swiss/research/Classification-and-importance-of-nodes-in-a-blockchain-network.

One of the best-known private blockchains is Hyperledger Fabric, the blockchain that underlies the IBM Blockchain Platform. It is an open-source project of the Linux Foundation.

1.3.Consortium Blockchains

Consortium blockchains are like private blockchains in that they are an alternative to public blockchains. We can consider this type of blockchain to be halfway between public and private blockchains. When certain aspects must be considered, public blockchains are not suitable. These aspects include: the verifiability of the data checked, the confidentiality of the data, the extensibility of the transaction volume, etc. (Dib et al., 2018). While private blockchains are used by a single organization, consortium blockchains are used by a group of organizations generally within the same industry (Bouraga, 2021). With this type of blockchains, information is visible to all but change and acceptance can only be achieved by a specific group. In this case, power is distributed among several authorities and not a single entity with absolute control. The idea is that decision-making should be collective and impartial (Bamakan et al., 2020).

Probably the best-known consortium blockchain is R3. It is a distributed ledger technology company founded in 2014 leading a consortium of over 200 companies. R3 developed Corda whose primary objective was to compete with the rise of various blockchains such as Hyperledger or Ethereum. The R3 consortium is composed of many banks including JP Morgan, Goldman Sachs, etc., which put Corda in open source in 2016. Corda is a distributed ledger technology (DLT) (see section 2 point 1 in this chapter for the definition of a DLT) specifically designed to meet the specific needs of financial institutions. Because of its specialization, its architecture is simpler than other distributed ledger technologies such as Hyperledger Fabric (Lecan, 2018; Bobée, 2019).

Table 1. Advantages and Disadvantages of Public, Private and Consortium Blockchains

	Advantage	Disadvantage
Public Blockchain	• No intermediaries • Secured • Ledger completely transparent and trustable	• Scalability issues • Energy intensive • Speed of transactions is reduced

	• User anonymity preserved • Safer, faster, and less expensive system than the traditional one	
Private Blockchain	• Highly scalable • Number of transactions per second increased • Less nodes than public blockchains • Authorizations required to perform certain actions	• Less secured compared to public blockchains • Less decentralized • Achieving trust can be difficult compared to other types of blockchains
Consortium Blockchain	• Scalability possible and more secure • More efficient than public blockchains • Technology best suited for collaboration between organizations	• Less transparent than other types of blockchains • Less anonymous compared to public and private blockchains

2. Permission models

2.1.Permissioned Blockchains

A permissioned blockchain can simply be defined as a blockchain that requires permission to access and modify data (Guadamuz, 2019). It is made up of many parts, with the main nodes pre-selected by the participants. However, the validators of permissioned blockchain do not fully trust each other (Mingxiao et al., 2017). Consequently, only individuals who have been recognized and validated in the registry are granted permission to participate in the validation of transactions (Morabito, 2017). The process is therefore a two-step process. First, participants must be authorized to join the network. Second, they can participate in network operations after revealing their identity (Xiao et al., 2020). Typically, access to a permissioned blockchain requires the permission of members of a consortium or a single entity (Wang et al., 2019).

EOS is an example of permissioned blockchain. EOS was designed to create, host, and support secure decentralized applications (dApps) and smart contracts (which will be discussed in more detail in the second chapter). Only account holders can use EOS and only someone who already has an account can issue you one (Frankenfield, 2021).

2.2.Permissionless Blockchains

A permissionless blockchain is a blockchain where it is not necessary to have a prior relationship with the ledger for a user to contribute to the processing of transactions. In addition, each vote does not depend on the identity of the owner of the vote (Morabito, 2017). This ability to be part of the blockchain and to leave it freely can only be done if the node has a valid pseudonym. The node must also be able to receive, send and validate transactions according to the rules common to the participants in the blockchain. In this type of blockchain, an incentive mechanism such as financial compensation for participation in the network is necessary for its proper functioning (Xiao et al., 2020).

LTO Network is a permissionless blockchain. It is considered a hybrid because it is a permissionless private network. This means that anyone can set up a node and participate in the network but only the hashes are shared with all the nodes in the network. The data is only shared peer-to-peer between the nodes. This blockchain therefore allows companies to take advantage of the network of a public blockchain, which generally contains many nodes while respecting the data contained private (Binance Research, 2020). Ethereum is also a permissionless blockchain but, unlike LTO Network, it is a public blockchain (just like Bitcoin).

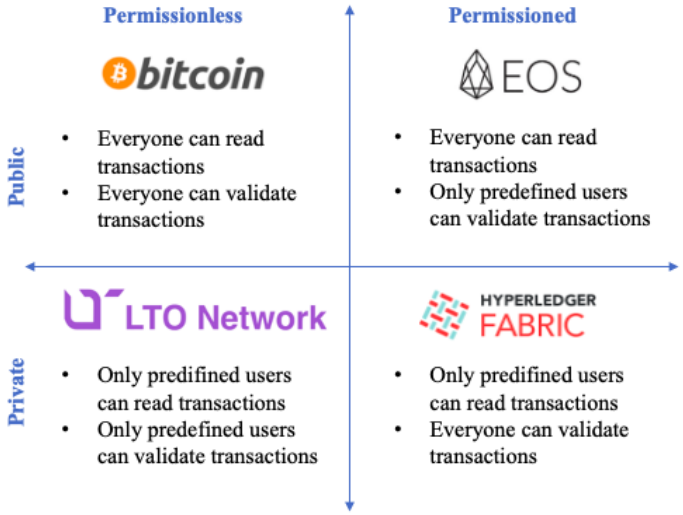


Figure 3. Relationship between governance and permission models

Section 2. Technology

1. Distributed ledger technology

Blockchain technology is a form of Distributed Ledger Technology (DLT) where transactions are digitized and decentralized (Yang et al., 2020). Therefore, all blockchains are DLTs, but not all DLTs are blockchains. A DLT is a form of database that is distributed to all members of a network who maintain and update it (Panwar et Bhatnagar, 2020). DLT allows data to be maintained only by the set of nodes, which do not need to be trusted by each other. (Bencic et Zarko, 2018). Trust in a third party is not required for DLTs. Let's take the example of a retail store that buys from different suppliers. The different parties in the supply chain must trust each other to fulfill their obligations and to build long-term relationships. But this trust is undermined when there is a lack of transparency and visibility. Let's assume that the retail store finds a better offer from a competitor and decides to buy from that new supplier. If, in the end, the retail store finds that the quality is not as good or that the delivery times are not to its liking, the original supplier will find it difficult to trust the retail store again. This risk disappears with DLTs because transparency is inherent to the technology. Thus, trust between nodes is no longer necessary to maintain and operate the system.

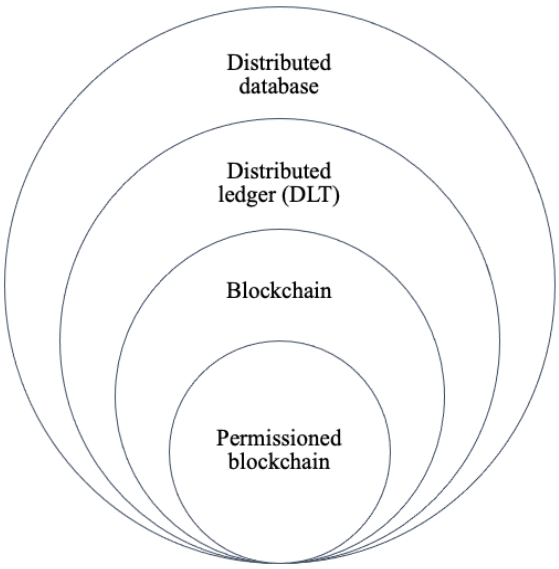


Figure 4. Relationship between DLT and Blockchain[3]

Note that currently some people do not distinguish between distributed ledgers and blockchains and use these terms to designate the same technology. The following table highlights the main differences between the two.

Table 2. Differences between Distributed Ledgers and Blockchains[4]

Characteristics	Blockchain	Distributed Ledger
Structure	Data presented in the form of a chain of blocks.	Database distributed throughout the world whose data is represented under any type of structure.
Sequence	All blocks follow a specific sequence.	Different types of DLT follow different sequences.
Consensus	Blockchain uses different types of consensuses.	DLT does not need any kind of consensus.

[3] Source: Chandler, S. (2019). What is the difference between Blockchain and DLT? *Cointelegraph*. Retrieved from: https://cointelegraph.com/news/what-is-the-difference-between-blockchain-and-dlt.

[4] Source: Panwar et Bhatnagar, 2020.

2. Centralized and decentralized ledger

As we have just illustrated (figure 1), a blockchain is intrinsically distributed. However, the ledger can be centralized or decentralized, depending on the rights that participants hold in the blockchain. If it is centralized, only certain users have rights. The identity of the latter is known, and the transactions are therefore attributable and verifiable. The system is valid because the participants are credible and trustworthy.

When it is decentralized, all users have equal rights. For example, in the case of a public blockchain, everyone has the right to validate a transaction (Sankar, Sindhu et Sethumadhavan, 2017). Of course, this does not mean that everyone will materially be able to do so. The validation of a transaction depends on the protocol used (which will be discussed in more detail in section 3 of this chapter). These rights as well as all the parameters governing the ledger are determined by a consensus algorithm to validate the information from the network entries. This consensus is necessary to maintain the integrity of the network and prevent corruption in the system (Rutland, 2017).

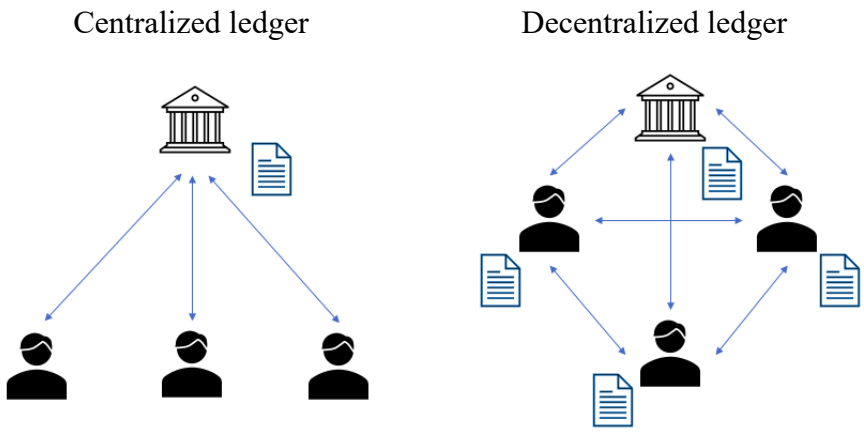


Figure 5. Centralized versus decentralized ledger[5]

3. A chain of blocks

What distinguishes DLT's blockchain technology is the block chain itself. It is a technology whose register is made up of consecutive blocks linked together by specific rules. This register

[5] Source: compiled by the authors.

is distributed and stored by all the nodes in the P2P network (Chowdhury et al., 2019). A node is typically a device such as a computer that holds a copy of the blockchain.

All transactions executed within the blockchain and recorded have an unchangeable cryptographic signature. These transactions are then grouped into blocks that are linked together by this unique signature. The latter is also called hash and makes it possible to overcome the lack of trust between members of the P2P network (Yang et al., 2020). We can see the hash as the fingerprint of each block composing the blockchain holding a certain amount of data. As we can see in figure 3, each block contains the hash of the previous block in addition to its own hash.

Each block of a blockchain is composed of a certain number of elements. First, a block has two parts: a block head and a block body (Ren, Zhu et al., 2019). The first part, block head, is composed of:

1. Previous hash: this is the element that links to the previous block. In a way, each block contains all the information of the previous block thanks to this function.
2. Timestamp: since blocks are added to each other according to when they were created, it is important to find the creation date of the block.
3. Version: This is the protocol version used by the node that supplied the block to the chain.
4. Merkle root: This is the hash value of all the transactions contained in the block.

The second part, the block body, is made up of two interconnected elements:

- Transaction: all data and transactions in the block are in this part and are the input for the next element.
- Merkle tree: this is a binary tree whose inputs are the hashed data records. These records are then arranged chronologically. The records are grouped in pairs, their hashes become a node of the tree and the process goes backwards to get the Merkle root at the end (Liang et al., 2017).

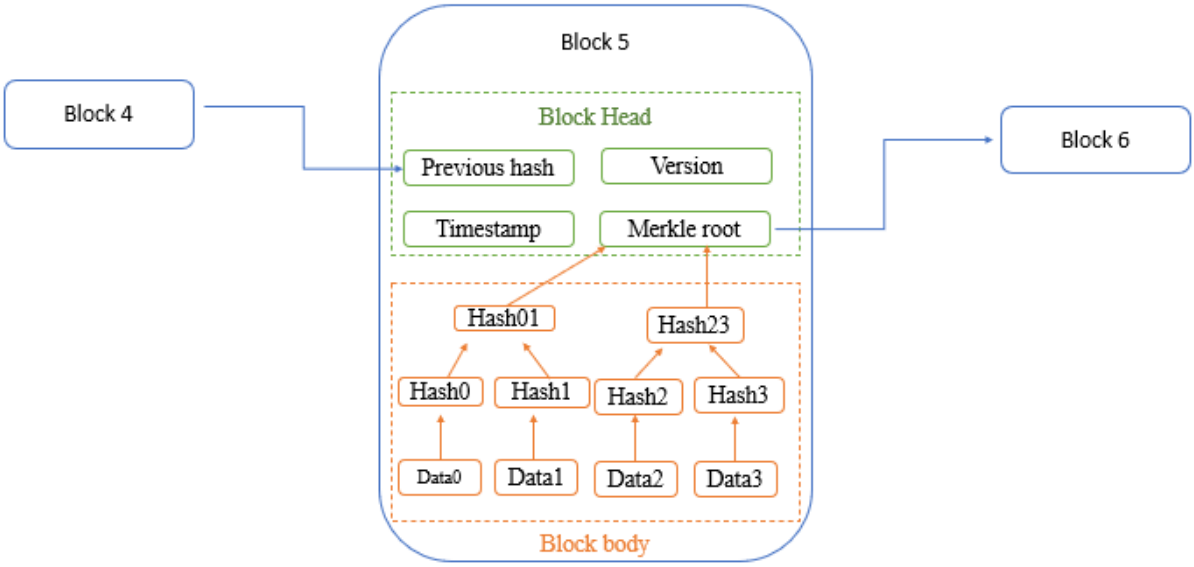


Figure 6. Simplification of a blockchain and composition of a bloc[6]

4. Characteristics of a blockchain

We can list different characteristics comamon to the different blockchains to understand their growing interest.

First, as we illustrated earlier, blockchain technology allows decentralization. When transactions take place in a centralized system, they must be verified by the central authority to be validated (Zheng, Xie et al., 2017). Decentralization thus leads to disintermediation because third parties are no longer needed for the smooth running of different transactions (Wang et al., 2019). Indeed, it is the consensus mechanisms specific to each blockchain that will maintain data consistency within the P2P network where authority is then delegated to the contributors (Hewa et al., 2020).

Furthermore, we have persistency because each transaction is validated quickly and any invalid transaction will not be accepted by honest contributors to the network (Zheng, Xie et al., 2017). In addition, since each block will be held by each node that verifies its validity, a falsification will be quickly detected (Zheng, Dai et al., 2018). However, once a block is validated, it cannot be removed from the blockchain given its irreversible side (Lohmer et

[6] Source: compiled by the authors.

Lasch, 2020). It is therefore the distribution of each block through the chain and its validation by means of a particular consensus that guarantees this immutability and irreversibility (Chowdhury et al., 2019).

Finally, transparency is also an important feature to be raised. Blockchain technology makes it possible to keep a complete history of all transactions (Lohmer et Lasch, 2020). We have even seen that each block is dated. The information is visible to all contributors and cannot be modified by a single entity (Wang et al., 2019). Each interaction between participants can also be controlled by any authorized node. All this promotes transparency and accountability (Chowdhury et al., 2019). Note that anonymity is possible using pseudonyms but is not permitted in all blockchains.

The following table shows the different properties of blockchain technology based on the type of governance (see section 1 above). The choice of the latter will have an impact on the depth of the different properties.

Table 3. Comparisons between Public, Consortium and Private blockchains

Property	**Public**	**Consortium**	**Private**
Determination of consensus	All miners	Selected set of nodes	One organization
Centralized	No	Partially	Yes
Immutability	Almost completely tamper-proof	Could be tamper	Could be tamper
Efficiency	Low	High	High
Security	Consensus mechanisms	Pre-approved participants and voting	Pre-approved participants and voting

Therefore, a public blockchain will be more decentralized than a private blockchain, but it will be less efficient. This allows us to introduce what Vitalik Buterin calls the Scalability Trilemma. The underlying idea is that it is difficult for a blockchain to be scalable, decentralized and secure at the same time. It is therefore necessary that people in the middle of

thinking about launching a project using blockchain technology ask themselves what specificities are necessary. It is necessary to determine which aspects of blockchain will optimize the project (Viswanathan et Shah, 2018).

Section 3. Different consensus mechanisms

It was necessary to find a commonly accepted method of assembling the different blocks of the blockchain to each other. Consensus algorithms therefore make it possible to validate the reliability of the blocks (Zheng et al., 2020). They allow the automatic updating of states via predefined transition rules (Buterin, 2014). As Morabito (2017) explains, "consensus provides a protocol by which new blocks can be added to the register". However, each blockchain is based on a particular consensus, such as proof-of-work, proof-of-stake, etc. (see below for a detailed explanation) which may differ depending on the blockchain used. Thus, the choice of consensus mechanism depends on the inherent design of the blockchain (Lohmer et Lash, 2020). The consensus algorithms will determine which node should store the next block and how the new block will be appended and validated by the other nodes. It is these distributed consensus algorithms that allow the automation of transactions without the intervention of a third party (Zheng et al., 2020). Consensus mechanisms are also responsible for ensuring the irreversibility of the blockchain (Lohmer et Lash, 2020).

It is thanks to the consensus mechanisms that there is no centralized authority necessary for the efficient functioning of the blockchain. Only the network participants lead and agree on the updating of the blocks through consensus. Once the next block is validated by consensus, it is added to the chain. The chain is thus made up of the oldest to the most recent block (Liu et al., 2019).

Three elements are necessary for the existence and effective functioning of consensus. First, there must be a common acceptance of the legal structure of the blockchain by all participants. Second, there must be a common acceptance of the nodes and parties applying the rules. Third, there needs to be a shared sense of equality among network members (Morabito, 2014).

Finally, we can divide the consensus algorithms in two. On the one hand, we have proof-based consensus. It is based on the idea that nodes must prove that they are more qualified than others to add a block. For example, as we will explain below, with proof-of-work, the node that will add the next block is the first to solve the puzzle. The qualification is referring to the

computational capacity that allows it to be the first and this capacity makes it the most qualified at that moment. On the other hand, we have voting-based consensus. This requires the nodes to exchange their verification result for a new block before the final decision is made. This second type of consensus is generally used in private and consortium blockchains (Nguyen et Kim, 2018).

1. Proof-of-Work

Proof-of-work (PoW) is the first variant of proof-based consensus (Nguyen et Kim, 2018). This is the traditional consensus mechanism that relies solely on computing power to mine the blocks (Chawla, 2020). Simply, participants in the networks of a blockchain use computing power to gain the right to add a block (Buterin et al., 2019). It is one of the five components of the Nakamoto consensus protocol and has been popularized by its use in the blockchain underlying the BTC (Xiao et al., 2020).

As explained before, to add a new block to the chain, a miner creates a proposed block by selecting a limited sequence of new transactions. Each miner will then try to solve the proof-of-work puzzle. The first miner to succeed in doing so broadcasts his or her block to the other nodes in the network. Each node, if the block is integrated and validated, adds the new block to its chain. The transaction is then recorded in this new approved block. Once the process is completed, the successful minor receives financial compensation (Viglianisi et al., 2020).

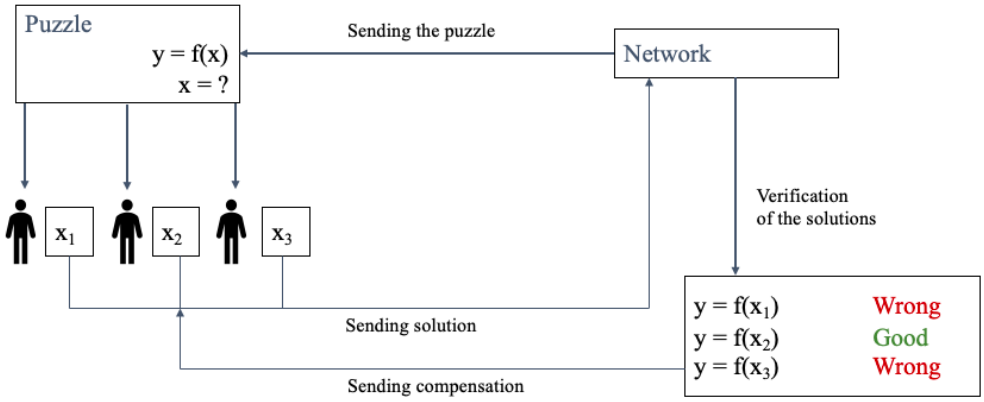


Figure 7. Simplification du fonctionnement du protocole proof-of-work[7]

[7] Source: Tar, A. (2018). Proof-of-work, explained. *Cointelegraph*. Retrieved from: https://cointelegraph.com/explained/proof-of-work-explained.

When we talk about a puzzle to be solved, we are talking about a hash puzzle of a given difficulty. It is this difficulty that makes it possible to estimate the time needed to solve this puzzle by a miner. The miner must perform hash calculations to find a “nonce”, which corresponds to an encrypted (or hashed) number in a blockchain, which when rehashed, meets the restrictions of the difficulty level. The successful miner is the first to find a nonce that satisfies them (Ren, Hu et al. 2019). For the different blocks to be linked to each other in a consistent manner, the miner, in addition to the transactions, must consider the hash of the previous block (Hazari et Mahmoud, 2019).

The PoW protocol has certain desirable properties such as anonymity which guarantees the absence of discrimination between miners within the network except for the results of their calculation (Leshno et Strack, 2019). Then, PoW is also robust to Sybil attacks and robustness to merging. These are attacks where the same entity can generate different identities at a lower cost. In doing so, this entity acquires a disproportionate influence on the network (Wang et Kangasharju, 2012). Thus, the PoW protocol ensures that it is not advantageous for a minor to pretend to be several minors at the same time. Finally, the third property assumes that a group of miners cannot increase the probability of success of the puzzle by joining forces without further calculations (Leshno et Strack, 2019).

There are, however, some major drawbacks to using this consensus mechanism. Firstly, this consensus protocol is energy intensive. Indeed, it relies entirely on the calculating power of the miners and therefore requires large investments in powerful computers and energy. Secondly, it is vulnerable to "51% attack". This type of vulnerability is a form of computer attack that can occur if hackers have more than half of the computing power of the network. Indeed, if they have more than half of the computing power, it means that they have a higher probability of solving the puzzle and thus generating the longest chain of blocks. In doing so, they impose their blockchain on the rest of the network (Li et al., 2020). As this type of attack is rare, they are not non-existent. We can take the example of the attack on Bitcoin Gold (BTG) in May 2018. The attacker was able to manipulate the blockchain ledger where all transactions are recorded. He was able to steal 388,000 BTG or almost $18 million from several cryptocurrency exchanges (Roberts, 2018). The hacker would have used a double technique to manage to hack the network. He would have used a 51% attack coupled with double spending to achieve this. The hacker deposited large amounts of BTG on trading platforms while making sure to send the same funds to his own wallet. The flaw lay in the latency that the platforms

had with respect to these simultaneously executed transactions. The platforms did not have the time to understand that the blockchain had been altered and therefore compromised and the hacker took advantage of this to withdraw from the exchanges twice the amount of funds he had initially deposited (Cimpanu, 2018). Third, consensus PoW has a low transaction throughput. There is a fixed rate of block generation as well as a maximum block size (Xiao et al., 2020).

2. Proof-of-Stake

In response to the first drawback of the PoW protocol, the high energy intensity, the proof-of-stake (PoS) protocol was created. It is therefore a more energy-efficient alternative to PoW. In this case, the possibility of proposing a block through a PoS node is no longer proportional to its computing power but to the value of its stake. In concrete terms, the more shares a node has, the greater the probability that it will undermine a new block. Note that with PoS nodes are referred to as validators and not miners as with PoW (Xiao et al., 2020). Thus, any entity with a large shareholding would be more confident. The rationale behind this idea is that a node with a share in the system is the most likely to want to maintain its security. Indeed, the value of this share would be reduced if the security of the system deteriorates (Bentov et al., 2016).

No entity will want to fraudulently attack the blockchain holding a large share of its profits (Nguyen et Kim, 2018). To carry out a 51% attack, the attacker must hold at least 51% of the cryptocurrency of the blockchain. If he decides to carry out such an attack, he takes the risk that the value will depreciate (Lee et Kim, 2020). However, the risk of a 51% attack is not null because it is always possible that a validator holds at least 51% of the shares, monopolizes the network and is ill-intentioned (Khan et al., 2020).

Although PoS appears to be more robust than PoW in some aspects, this consensus mechanism also faces some vulnerabilities. The most important one, and the one from which most of them derive, is the principle of costless simulation. Since PoS does not rely on computing power but only on trust in validators, it is possible to create updated branches without effort (Bouraga, 2021). Nothing-at-stake is a first problem related to costless simulation. A PoS validator that does not require additional effort could trade and generate a new block on several competing blockchains. This strategy is economically interesting for validators as they avoid the opportunity costs of having to be present on only one blockchain

(Xiao & al., 2020). Finally, the long-range attack is the ultimate problem related to costless simulation. An attacker can, at any given moment, use the existing state of the blockchain to create an alternative chain that is indistinguishable from the real chain. All users would then be deceived and would use the "malicious" chain (Gazi et al., 2018).

3. Proof-of- Importance

The proof-of-importance (PoI) consensus algorithm is another proof-based consensus that has been created as an alternative to PoS. In this case, each node of the system will receive an "importance score". This score is used to influence the node's chances of obtaining financial compensation when adding user transactions to the network (Bamakan et al., 2020). The primary objective of PoI, as opposed to PoS, is to address the problem of the enrichment of the rich. Validators are no longer selected based on their stake but because of their importance score. This score depends on three elements: the acquisition of rights, the transaction partner and the number and size of transactions in the previous 30 days (Hazari et Mahmoud, 2019).

- Vesting: the more coins acquired and held on an account for a minimum period, the higher the score will be.
- Transaction partner: the more transactions the node carries out, the higher the importance score.
- Number and size of transactions in the last 30 days: the more frequent and larger the transactions, the higher the importance score. Note that if several users make the same transaction between them, this will not affect their importance score.

Section 4. Smart Contracts

1. Definition

Smart contracts are part of what we call Blockchain 2.0. Indeed, while Blockchain 1.0 concerns in particular cryptocurrencies of which Bitcoin is the best known, Blockchain 2.0 concerns the innovation of smart contracts having been made possible thanks to the Ethereum blockchain in 2013 (Crypto Authority, 2018). However, the idea emerged much earlier, in the late 1990s, and was theorised by Nick Szabo (De Filippi, Wray and Sileno, 2018). He noted that computers make it possible to execute algorithms cheaply and quickly. The digital revolution therefore allows relationships to be formalised in a different way. Szabo chose the term smart contracts because he found them to be more functional than paper contracts. Smart

contracts do not rely on artificial intelligence, but on computer code in which all the promises are specified digitally. According to him, smart contracts have four main objectives: observability, verifiability, confidentiality, and enforceability. Observability is the ability to observe the execution of the contract by the counterparties. Verifiability is the ability of one of the counterparties to prove to a third party that the contract has been performed or breached. Confidentiality is the principle that knowledge and control of the content and performance of the contract should only be shared between the parties and only to the extent necessary for the performance of the contract. Finally, enforceability generally results from improved verifiability. Computer and network security can also contribute to making smart contracts self-executing (Szabo, 1996).

Smart contracts are therefore programs stored in a blockchain whose execution is automated and possible thanks to the distributed network (Viglianisi et al., 2020). The idea behind smart contracts is to have transparent machine-to-machine (M2M) transactions that eliminate the need for human intervention or that could be captured by humans to automatically enforce existing obligations (Guadamuz, 2019).

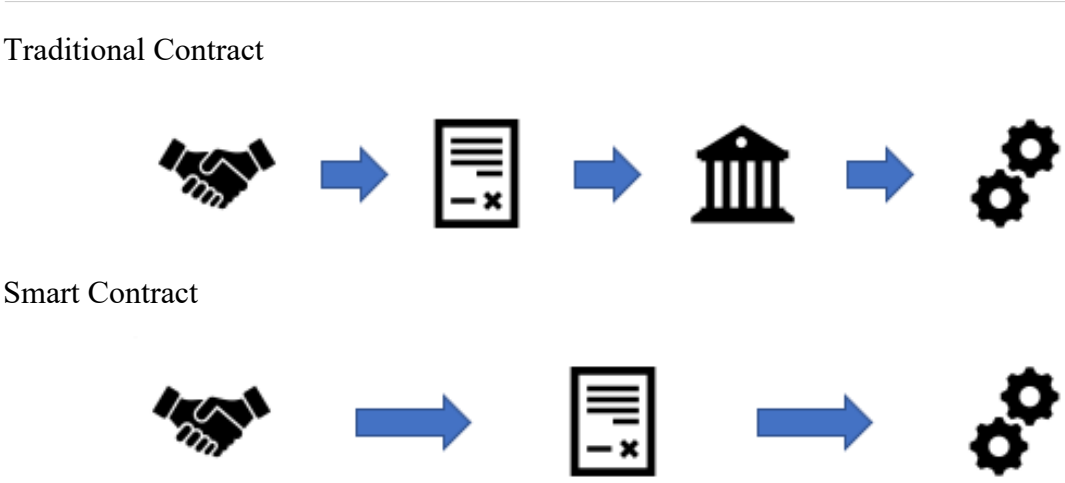


Figure 8. Primary difference between traditional contracts and smart contracts

The clauses contained in a smart contract will be automatically executed thanks to the prior definition of certain conditions (Zheng, Xie et al., 2019). These constraints are embedded in scripted languages such as Python or Solidity to execute blockchain functions.

A concrete example of a smart contract that is relatively easy to understand is one implemented by the insurer Axa in 2017, Fizzy. This was a smart contract implemented in the Ethereum Blockchain to buy insurance against airline delays and cancellations. Let's say you have bought a Paris-New York flight ticket and you know that a flight delay or cancellation is possible. To cover yourself, you decide to buy insurance and a friend advised you to use Fizzy. Once you have entered your flight details on the Fizzy website, the platform gives you a quote of what you would have to pay for the insurance as well as the compensation you would receive in the event of a delay of more than 2 hours or cancellation. This quote is calculated using an algorithm with 8 years of historical data and the pricing depends mainly on the risk of delay and cancellation for a Paris-New York flight with the chosen airline. So far, nothing innovative and the presence of blockchain and smart contracts does not add any value. However, let's assume once again that you have taken out this insurance 6 months before your departure and that on the day of your trip your flight lands 3 hours late in New York. You don't have to do anything. As soon as the plane lands, you will receive your compensation directly into your bank account, without having to make a claim or fill in any additional paperwork. The smart contract will determine whether the conditions for compensation have been met, based on the prior information and flight tracking (Clement, 2019).

Furthermore, it should be noted that one of the main characteristics of smart contracts is their inherent immutability (Lohmer & Lasch, 2020). Therefore, even if a programming error in a smart contract is detected after it has been implemented in the blockchain, the miscalculation(s) are frozen forever in the blockchain. For this reason, extensive testing is conducted on smart contracts to detect programming errors before they result in erroneous transactions (Viglianisi et al., 2020).

2. DApps

2.1.What is a Decentralized Application?

The introduction of programmability on the blockchain with the application of smart contracts has enabled the development of decentralized applications or DApps (Taş and Tanrıöver, 2019). Therefore, thanks to this programming possibility, many developers have started to develop blockchain-based decentralized applications (Xu, 2020). dApps can be defined as applications built on a decentralized network (a blockchain) combining back-end code (smart contract) with a front-end user interface (e.g., a website) (Doyle, 2021). For those who have no computer skills or programming knowledge, the term front-end refers to the user

interface. It is everything that is visible to the user of a website or application such as the menu, buttons, pages, links, etc. The backend refers to the programming for the server, the application itself and the database (concepta, 2019). The emergence of dApps allows us to understand the full potential of blockchain technology because in the eyes of the user it is like an application that we all know but based on a blockchain with all its implications. Some even consider that dApps are the breaking point between web 2.0 and web 3.0 (see figure 9 for the evolution of the web).

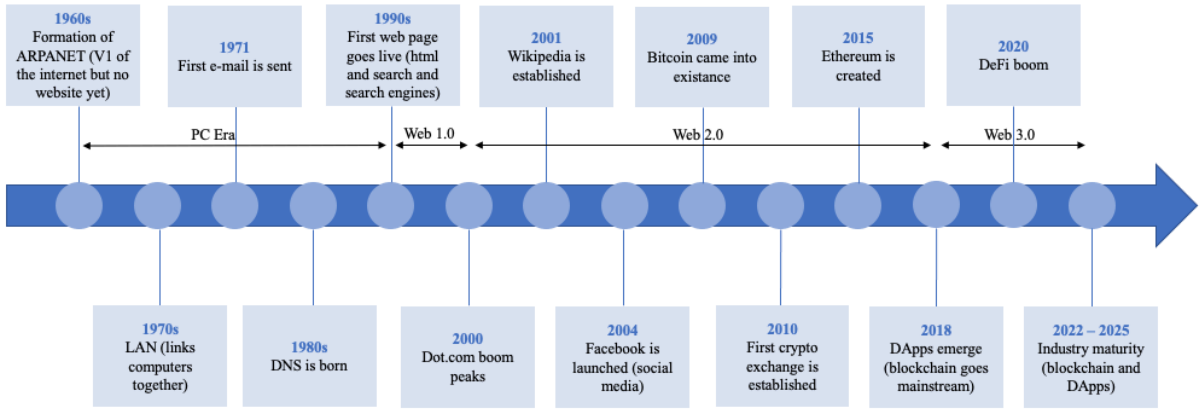


Figure 9. The Evolution of the Web[8]

2.2.Difference between App and dApp

Apps or applications have been commonly used daily for many years on both smartphones and computers. Apps are easy to download, convenient to use and offer many features. Moreover, since 2017, decentralized applications are becoming more and more popular. However, from the user's point of view, the differences seem imperceptible. Indeed, at the functional level dApps are like Apps in that they also provide services ranging from simple games to financial transactions (Goldann, 2019).

Technically speaking, the major difference between Apps and dApps lies in the back end. Indeed, since the user experience is similar, the front-end is identical, with a few exceptions. The back end of an App consists of a centralized architecture where one or more servers are

[8] Source: Doyle, M. (2021). Building A Decentralized Future With dApps. *The World Create*. Retrieved from: https://theworldwecreate.net/insights/building-a-decentralized-future-with-dApps

used to maintain the entire application. Conversely, the back end of a dApp is a blockchain network composed of hundreds and thousands of machines.

This difference has two important consequences for users today, but both are closely related to user data. At a time when most applications are free, they are profitable thanks to user data. This data is collected and stored on servers. However, the centralized architecture of applications where everything is saved on one or more servers makes them vulnerable to hackers. All they must do is interrupt the hosting service to access the data and jeopardize the privacy of the users.

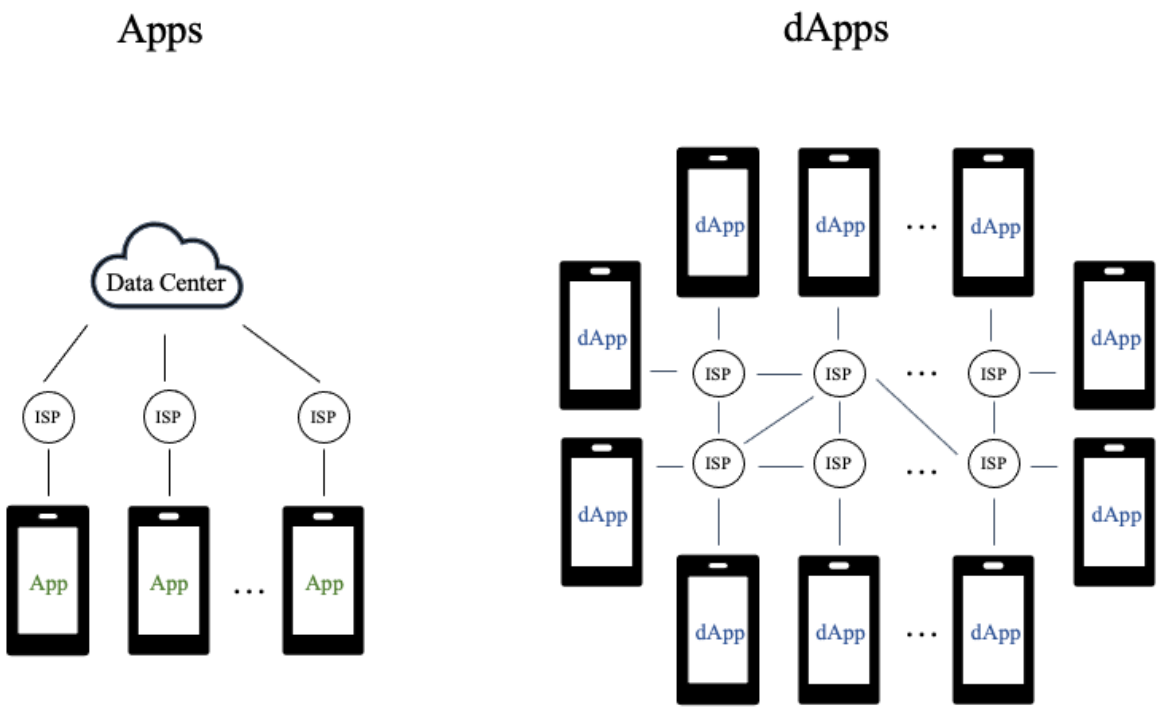


Figure 10. Apps vs dApps[9]

This difference has two important consequences for users today, but both are closely related to user data. At a time when most applications are free, they are profitable thanks to user data. This data is collected and stored on servers. However, the centralized architecture of applications where everything is saved on one or more servers makes them vulnerable to

[9] Source: Ray, S. (2018). What is a DApp? *Towards data science*. Retrieved from: https://towardsdatascience.com/what-is-a-dapp-a455ac5f7def.

hackers. All they must do is interrupt the hosting service to access the data and jeopardize the privacy of the users. In the case of a dApp, it is virtually impossible to take it down because it would involve the hacker taking down all the distributed hosting nodes (Sharma, 2018).

We can take the example of the Facebook-Cambridge Analytica data hijacking scandal. In 2018, it was revealed that 87 million Facebook accounts were harvested. The data of its users was then used for political and commercial purposes. The collected data was used to manipulate the opinion of the people involved (Meredith, 2018). This example shows us that the data collected by these applications can be used directly against the consumer without him even realizing it. A decentralised application therefore allows user data to be used for unknown purposes without being hacked.

The second consequence concerns applications involving a third party like Uber or Airbnb. When you order an Uber ride, the price paid by the customer will remunerate both the driver and the platform. In the same way, for Airbnb, the price paid includes an administration fee that is used to pay the application. The application serving as an intermediary plays an important role in mediating transactions between two parties. This intermediation role is then remunerated by taking a percentage of the price paid by the client. This is the most common way to manage transactions between two parties who do not know each other, so that the trust between them is not necessary for the successful completion of the exchange. Indeed, the third parties guarantee the integrity of the transaction by verifying the identity of each party, and then the transfer is carried out in complete security. However, with the emergence of smart contracts that are integrated into DApps, these counterparties are no longer necessary because the decentralized application and the underlying smart contracts can themselves verify the identity of the parties, the fact that the payment has taken place, etc. (Toronto reference library, 2019).

Obviously, dApps are still far from being as popular as traditional applications in terms of number of users. For example, Facebook has 1.9 billion daily active users (Statista, 2021) while if we group all dApps under ETH there are a total of 90,000 daily users (State of the dApps, 2021). However, the number of dApps created has been increasing since 2015 (see table 4) as well as the investments in them showing the growing interest by developers and users for this type of products. It has been estimated that the dApps "market size is projected to reach USD 21,070.2 million by the end of 2025" (Semeney, 2021).

Table 4. Evolution Total Number of dApps[10]

Date	# of dApps	% Growth
Aug. '15	60	n.a.
Aug. '16	202	70%
Aug. '17	547	63%
Aug. '18	1,637	199%
Aug. '19	2,723	66%
Aug. '20	3,268	20%
Aug. '21	3,614	11%

2.3.Features of dApps

There are 4 main characteristics necessary for a software to be considered a decentralized application.

- Open Source

By making a dApp code open source, it implies that all participants in the network have access to the history of what happened. Not only one entity or person can modify the code but the whole network approves and follows the changes. The code of a dApp should be available to anyone who wants to see it. This feature allows to gain the trust of the users because they can know all the implications underlying the use of the dApp. It is a proof of transparency that developers offer by making the code available to users (Raval, 2016; Sharma, 2018).

- Token based

For a traditional app, the remuneration of developers and other contributors to its creation is based on different elements such as transaction fees, advertising revenues, commissions, etc. However, for dApps this type of remuneration is not used because it would imply that it is

[10] Source: https://www.stateofthedApps.com/fr/stats, consulted on September 19, 2021

specified in the underlying code and visible to all, thus reducing the trust of users. However, for dApps this type of remuneration is not used because it would imply that it is specified in the underlying code and visible to all, thus reducing the trust of users. The alternative method of remuneration that has been found is the use of tokens allocated to the scarce resources of the network.

Before developing the concept of remuneration in the context of dApps in more detail, it is important to understand what a token is and the notion of tokenization. A token can be defined as "a unit of value that an organization creates to self-govern its business model and empower its users to interact with its products while facilitating the distribution and sharing of rewards and benefits to all its stakeholders" (Mougayar, 2017). A token can be understood as a means of exchange within an ecosystem such as a dApp. Tokenization is then the process of encapsulating values in the form of a token. Once tokenized, any value can be managed as a digital asset whose unit of account is represented by the token (Freni, Ferro et al., 2020).

The users of the dApps need to own tokens of the dApp to use it and the owners of the rare resources of the network are paid in tokens as well. The rare resources can be anything if it has been defined beforehand by the creators of the dApp. Let's take the example of Bitcoin, the owners of the scarce resources are the miners, and the scarce resources are the computing power. When the dApp is created, the total number of tokens that will be put into circulation is decided beforehand. If the number of users will grow but that the supply of tokens is limited, this implies that the value of each token will increase with time (Raval, 2016).

- Decentralized consensus

In the case of an app, to be able to modify it or perform a transaction on it, the organization behind it must make the modifications and make them available to users via an update. In the case of a dApp, it is not a central authority that decides if these modifications or transactions are accepted but all the nodes that are part of the network. The validators of the network are then paid in tokens for having contributed to the evolution, the improvement, or the good functioning of the dApp (Sharma, 2018).

- No central point of failure

We can say that there is no central point of failure for the dApps which are not on a single centralized server but distributed on the network. The data contained in a dApp is then distributed over the whole network through each node that makes it up. Each node is

independent of each other which means that if one node is corrupted the other nodes will not be affected and the network will continue to function normally (Pratap, 2018).

dApps and more particularly the principle of tokenization allowing the remuneration of developers introduce a conception of value. The value of something rare can then be nested within a token whose value is commonly accepted thanks to the well-known principle of supply and demand. Furthermore, there are many kinds of dApps such as games but also financial dApps such as exchanges. This last point allows us to introduce the next and last chapter of this literature review which concerns decentralized finance.

Chapter 3. Decentralized Finance

Section 1. Definition

Peter Wall, CEO of mining company Argo Blockchain sees DeFi as "an umbrella term that is meant to define a financial system that functions without third-party intermediaries like banks." Decentralized finance is a system by which the various existing financial products become accessible on a public decentralized blockchain network. This system, devoid of intermediaries, grants the possibility to every person to use a financial service without having to resort to a bank or a brokerage company. DeFi does not require any documentation such as a social security number or an identity card to be used by individuals around the world. DeFi represents a system by which actors: buyers, sellers, lenders, borrowers, etc. can interact with each other, without the need for a third-party institution to broker the transaction. The trusted intermediary is strictly tied to the software and no longer depends on a centralized institution (Sharma, 2021).

Decentralized Finance relies on various open and composable frameworks and open-source software, allowing any person in the world to practice financial services. These services are performed in a totally transparent and secure way, without the need for traditional trust intermediaries. The goal of DeFi is to bring about a new, more global, and inclusive financial system (Defirate, 2021).

1. Role and purpose

To operate and perform transactions, decentralized finance uses dApps as well as open protocols. These are managed and powered by smart contracts, serving as independent substitutes for traditional financial intermediaries (Daily, Hanson, et al., 2021). Thus, rather than carrying out financial transactions such as lending, borrowing, etc. through a financial intermediary, transactions can be carried out directly between the different participants of the network. One of the major assets that DeFi brings to its users is its open eco-system. It offers the possibility of access to financial services to individuals who do not have access to traditional financial systems such as banks (Sangwan, 2020).

Section 2. Ethereum

1. What is Ethereum

Ethereum is a decentralized public blockchain with its own crypto currency called ETH or Ether. It is based on a computer programming language open to all, Solidity (Frankenfield, 2021). This blockchain was created in 2015 by Vitalik Buterin (Haar, 2021). This Russo-Canadian writer and programmer was already known to the blockchain community in 2011 as he wrote articles for Bitcoin magazine (cointelegraph, 2021). His decentralized network allows users around the world to enjoy a multitude of peer-to-peer uses. For example, they can exchange crypto currencies, borrow, or lend to earn interest, conduct simple transactions, or exchange and store non-fungible tokens via its network. Other uses are also being developed, such as social networks and video games (cointelegraph, 2021).

Ethereum offers the possibility to create and use smart contracts and dApps, scalable and completely independent from third parties. Developers can thus develop their own IT conditions to ensure the security of their applications, prevent fraud or even control by third parties, while remaining completely independent and decentralized (Reiff, 2020).

To make its smart contracts work, Ethereum developed the "ERC-20" standard in 2015. This standard defines a common list of rules that the token must follow and implement. Developers then have the possibility to program the circulation of new tokens based on the Ethereum ecosystem. This is used by most exchanges dedicated to crypto-currencies and has become popular thanks to the participatory financing of companies and DAOs via ICOs (Ethereum).

2. Features of Ethereum

According to ConsenSys, there are 11 benefits of using Ethereum:

- **Data coordination**: The decentralized infrastructure of the protocol allows blockchain participants to not have to depend on a centralized intermediary entity to make use of the various possible applications and transactions.
- **Rapid deployment**: Companies and users using Ethereum can easily manage and set up private blockchain infrastructures without having to code them from scratch. The platform works like a SaaS.

- **Permissioned networks**: Open-source protocol layers developed by some companies allow other companies or users to rely on Ethereum networks, whether they are public or private. By going through layers, users are guaranteed to get a solution that meets regulatory requirements.
- **Network size**: The Ethereum network operates with millions of users and relies on a mainnet, relying on hundreds of nodes. A mainnet refers to a fully developed and operational blockchain protocol. Transactions made in crypto currencies are then verified, disseminated, and recorded on the ledger (Ifegwu, 2021). Current competitors to Ethereum currently have far fewer nodes, making their networks far less large and viable.
- **Private transactions**: Companies using the Ethereum network can provide a service that respects the privacy of their users. Indeed, the confidentiality of data is ensured through the network, which itself can be chaperoned by private transaction layers. Thus, the private and confidential information of the users is never revealed to the different users of the network. The different data are then systematically encrypted and only reach the parties directly involved in the transactions.
- **Scalability and performance**: Consortia networks developed on Ethereum can surpass the characteristics of the main public network. Indeed, the number of transactions per second can be increased depending on the network configuration. All this is made possible thanks to the proof-of-authority consensus, the gas limit, or the custom block duration.
- **Finality**: Ethereum, like other blockchains, uses consensus algorithms. These guarantee the security of transactions by making them tamper-proof. Transactions are recorded and consensus mechanism such as IBFT guarantees the completion of transactions. Istanbul Byzantine Fault Tolerance (IBFT) means that a network can continue to operate properly even if some nodes have been compromised or hacked. When a blockchain is hacked, some hackers may try to offer invalid blocks that can harm other users. This system makes it possible to reduce the infrastructure required compared to the algorithm used for the Proof of Work.
- **Incentive layer**: The different layers linked to the Ethereum crypto economy allow to set up a reward or punishment system according to the mechanisms developed in its health. Indeed, the activities that ensure the authenticity of transactions allow users to

benefit from rewards. On the other hand, harmful or fraudulent activities penalize users or companies in bad faith.

- **Tokenization**: The Ethereum network allows any business to be able to tokenize an asset if it has been stored in a digital format. Tokenization allows these assets to be split and develop new business models. This is notably the case for real estate, previously monolithic, or rare works of art. Other applications such as data management by the public are also possible through tokenization.
- **Standards**: It is possible to develop many projects and initiatives through the Ethereum ecosystem and each of them is usually accompanied by a native token. These mainly use the ERC-20 token standard to benefit from the native framework that extends Ethereum. ERC-20 is at the origin of many tokens such as stablecoins or security tokens (standard token allowing companies and issuers to tokenize stocks, bonds, or physical assets).
- **Interoperability and open source**: The Ethereum network are fully capable of working with other systems both in terms of implementation and unrestricted access. Consortia are not locked into the computing environment of a single provider.

3. From ETH to ETH 2.0

In November 2020, the beginning of the transformation from Ethereum 1.0 to Ethereum 2.0 started. One of the main goals of this transformation is to change the consensus mechanism from Proof-of-Work to Proof-of-Stake. This new Eth2 allows more scalability and less transaction costs. This transformation which should allow the switch between proof-of-work and proof-of-stake is composed of 4 phases:

Phase 0: This phase started on December 1st, 2020. For it to start, the Eth network had to gather 16,000 nodes of 32 ETH or more than 524,000 ETH. Once these ETH are blocked and made available to this new chain, the phase 0 called Beacon Chain could start. This is the chain that will synchronize and manage the entire Ethereum network in the future.

Phase 1: This phase is currently scheduled to start in 2022, it is the Shard Chain. The changes do not really concern the users. In addition to the Beacon Chain that orchestrates the entire ETH network, there will be other nodes that will be implemented in different shards, up to 64. The Beacon Chain will oversee distributing the different transactions between the shards to guarantee their execution.

Phase 1.5: This is the merge. We will start to see a real migration and mixing between the two technologies, ETH 1.0 and ETH 2.0. The two protocols, Proof-of-Work and Proof-of-Stake will be merged. At this moment, the network is hybrid. The operation of the two networks must cooperate.

Phase 2: This is when mining is no longer relevant. Miners will have to migrate to another network because ETH 2.0 will only work via Proof-of-Stake. The network of validators on ETH 2.0 will then be fully functional. The smart contracts will not be executed by the Proof-of-Work miners anymore but by this new ETH network.

4. Why are most DeFi projects done on ETH?

4.1.ETH, a cryptocurrency

First, the Ethereum blockchain has its own cryptocurrency, ETH. It is the second largest, after BTC with a current market cap of $465m (coinmarketcap, December 3, 2021). During the month of September 2021, each day there were on average more than 1.2m transactions involving the ETH network. It is the cryptocurrency with the highest average daily number of transactions, well ahead of the second, BTC which had an average volume of over 250k for the same period (statista).

4.2.Smart contracts

As we have seen before, smart contracts have been born with the arrival of Ethereum. Thanks to these, digital currencies are programmable and go beyond the simple storage and exchange of value. This programmability allows to lend and borrow crypto currencies, to program payments or to invest in index funds (Ethereum.org). All this is very similar to what is possible in the traditional financial system. A cryptocurrency that can only be bought and traded is not enough to make it a financial system. However, if we can hold this crypto currency, exchange it, lend it, borrow it, etc., it looks more like a complete system.

4.3.An ecosystem

ETH's founder, Vitalik Buterin, has explicitly stated that ETH's goal goes beyond the ability to trade crypto-currencies and help with token creation. Buterin hopes that Ethereum projects will encourage and serve the public good by enabling the creation of a DeFi ecosystem where the various components can be interconnected (Rapoza, 2021).

The fact that Ethereum was for some time the only blockchain capable of supporting smart contracts has enabled the development of several DeFi projects. Therefore, if all DeFi projects are based on the same language, the interaction between the different services provided by the different actors of the same ecosystem is more obvious.

However, some developers are currently turning to competitors of ETH for the development of their DeFi project. Indeed, the costs are more and more important on the ETH network (gas fees) which incite the developers to find less expensive solutions.

5. Main competitors of ETH

5.1.Solana

Solana is a decentralized blockchain for building scalable and decentralized applications. It is the fastest blockchain in the world and is the fastest growing ecosystem in the crypto currency sphere. Solana is the 5th largest crypto with a current market cap of $58M (coinmarket cap). There are more than 400 projects based on Solana covering DeFi but also NFTs and many others. One of the particularities of Solana is its low transaction cost. Its scalability guarantees that the cost of a transaction will never exceed $0.01 for both developers and users. Currently, the average cost of a transaction is $0.00025. For comparison, during the month of November 2021, the lowest transaction cost for the ETH network was $36, which is well above Solana's maximum level.

Solana uses the proof-of-stake protocol to verify transactions, manage the supply of coins and create new coins. In addition, this blockchain also uses another protocol, proof-of-history (PoH), in parallel which is the one that makes this blockchain the fastest. Indeed, it is the second primordial characteristic of Solana, the speed, a block can be built in 400 milliseconds. As its name indicates, proof-of-history allows to validate a transaction by checking its history. To put it simply, when you take a photo of yourself holding the newspaper of the day, you prove that the photo was taken after the publication of the newspaper in question. With PoH it's a bit the same principle, you can create a historical document proving that an event happened at a given time.

5.2.Cardano

The second main competitor of ETH is Cardano. It is a proof-of-stake blockchain developed based on a peer-to-peer search system. Cardano's developers are working closely

with the academic community to create a system that combines security and sustainability for applications and decentralized systems. ADA, the crypto currency of the Cardano network, is the 6th largest with a current market cap of $45M (coinmarket cap).

Like Solana, the main differences with Ethereum are the consensus used and the fees to be paid when using the network. Indeed, Cardano is based on the proof of stake, ensuring an increased speed of the transactions compared to Ethereum, still based on a Proof of Work. The PoS consensus used by Cardano is called Ouroboros. It is the first blockchain consensus based on peer-reviewed research. To build a block, a leader is randomly selected in proportion to the number of tokens he or she has. The larger your initial stake, the more tokens (ADA in this case) you hold, the greater your chances of being selected as a leader. Ouroboros uses formal methods as evidence to research, answer challenges and create mathematical models. These are then independently audited by the rest of the network.

Section 3. Non-Fungible Tokens

1. What is a NFT?

An NFT is an acronym for "non-fungible token" representing a class of cryptographic assets integrated to the blockchain. The particularity of these assets is that they have unique identification codes and metadata, distinguishing them from each other.

The uniqueness of NFTs makes them irreplaceable by others. By way of comparison, conventional banknotes can be exchanged against each other. A 5-euro bill can be exchanged for another 5-euro bill. The same is true for a Bitcoin, because one Bitcoin can be exchanged for another Bitcoin. The holder will not know the difference.

Concerning the development of non-fungible tokens (NFT), they were first developed on Ethereum. The ERC-721 standard was the first to be defined. This was created as a Solidity contract standard and represents the first existing standard for the representation of non-fungible digital assets. (Ethereum, 2021).

2. The characteristics of an NFT

NFTs have several key characteristics:

- **Non-interoperable**: An NFT from any collection cannot be used in a collection that does not belong to it. For example, NFTs from the Bored Apes Yacht club collection cannot be used as a character in a Metavers or in a game like CryptoKitties.
- **Indivisible**: unlike a cryptocurrency like Ethereum or Bitcoin, NFTs are not divisible and therefore cannot be traded in fractions.
- **Indestructible**: NFTs are indestructible by nature. They are the result of smart contracts and are therefore registered on the blockchain. They cannot be destroyed or copied either since their ownership is linked to a unique identification code.
- **Verifiable**: NFTs are traceable since their inception. Exchanges can be numerous, but the traceability will always remain the same, allowing to authenticate the authenticity of the coins.

3. NFTs and DeFi

The use and reason for the existence of NFTs in decentralized finance can be explained through the marketing of digital products and services. There are many examples, but the most common one is Ethereum. The Ethereum blockchain introduced the ERC-20 tokens to enable the use as well as representation of digital assets. The proof of ownership on which the blockchain is based allows artists and content creators to enjoy a range of benefits.

The value of NFTs is mainly defined by the supply and demand behind the goods and services offered. This is notably the case for works of art, but there are other applications such as collateralization of NFTs as collateral for other DeFi domains. Collectibles or NFTs, once their value is established by the market, can be used as collateral as it is already the case in the traditional market (Iredale, 2021).

Section 4. Decentralized Autonomous Organizations

1. Definition of a DAO

A DAO (Decentralized Autonomous Organization) is a decentralized organization whose governance rules are automated and immutably and transparently recorded in a blockchain.

2. How does a DAO work?

DAOs are organizations managed collectively by members and not by management based on a hierarchical structure. Leadership is therefore not central but rather governed by bottom-up decisions articulated around rules defined and enforced by a blockchain.

DAOs are based on smart contracts that are executed if specific criteria are met. They are the core of DAOs as they define the voting rights of the members that constitute them. The governance aspects of these decentralized digital enterprises are thus based on decisions that are collectively defined and accepted by most of the members constituting a DAO.

3. Example of DeFi DAO

3.1.Aragon

Aragon is a decentralized application (dApp) that runs on the Ethereum blockchain. It allows anyone to create and manage a decentralized organization.

The company wants to create a form of digital jurisdiction where anyone can organize themselves in a free and sustainable way. Inclusiveness and respect for all is also a central concern of the company. To implement its vision, this DAO provides the various digital tools available to anyone who would like to start their own digital structure.

The project is completely open source and includes a token: ANT. This token grants different voting rights and allows the community to make decisions about the future development of Aragon. The goal of the Aragon team is to create a completely decentralized organization so that any individual or entity can create their own digital decentralized organization.

3.2.Aragon's token, ANT

Aragon's crypto-currency, ANT, allows users to have an influence on the future of their ecosystem. ANT holders assist in driving the protocol, voting on proposals to determine changes in the Aragon network. The Aragon team created ANT with the idea that the protocol would be owned and operated by its users. In addition, ANT tokens can be used to acquire ANJ coins, which are required for users to participate in resolution services provided by Aragon Court. This DAO inherent to Aragon, deals with subjective disputes requiring human intervention.

Section 5. Risks and Challenges

1. Technical risk

The first technical risk refers to a risk inherent to the contracts and the underlying blockchain protocol on which DeFi platforms depend. Fraudulent or erroneous transactions are irreversible on the blockchain and constitute a technical risk.

These errors are directly linked to the computer code written to run the blockchain on which DeFi operates. This code is extremely important since it must consider both the parameters of the present but also anticipate future technical possibilities and future improvements that can be integrated. These codes are difficult to write, and the resulting technical bugs are still difficult to identify since the technology is still very new and there are no standardized procedures to identify possible false or erroneous transactions.

These technical errors have been particularly costly for some DEX. Indeed, millions of dollars have been stolen and often not returned due to technical flaws exploited by malicious hackers (Grigo, Hansen, et al., 2020).

The second technical risk encountered occurs when certain protocols become too congested. The Ethereum blockchain experienced transaction problems when its networks were too congested. When a network is overloaded, a transaction can remain in a queue or simply be cancelled. This risk is often related to liquidity risk and leads to market inefficiency (Daily, Hanson, et al., 2021).

2. Compliance risk

The compliance risk in DeFi is directly linked to the lack of regulations in the sector. Since it is still a very young and growing industry, the entities working on its development are outside the traditional regulatory structures. Such an environment creates uncertainty due to the absence of trusted intermediaries. The anonymity of certain transactions is also considered a form of risk as actors are not subject to clear guidelines from nationally and internationally recognized regulatory bodies. DEXs and DeFi platforms are, however, subject to legal obligations but are still quite abstract and confusing compared to the traditional financial sector. (Daily, Hanson, et al., 2021).

3. Liquidity risk

The liquidity risk is also very important because insufficient liquidity weakens the sustainability of the system and therefore does not allow for optimal pricing in the industry. This risk is strongly related to the technical risk explained above since the lack of liquidity can result from technical congestion of the network used. During previous cryptocurrency crashes, some networks were unable to process all requests simultaneously. This was the case on the Ethereum network where market makers and liquidity providers could not maintain similar prices on the different DEX and existing platforms. An event like this creates liquidity holes and questions the confidence of the players, thus leading to a sudden drop or a crass (Grigo, Hansen, et al., 2020).

PART II – EMPIRICAL ANALYSIS

The empirical part is the last part of our thesis before our conclusion. The latter will allow us to analyze the different elements to answer our research question which is to know if decentralized finance can replace traditional finance as we know it today.

We will first explain the methodology used to carry out our empirical analysis.

Then, we will devote a chapter to each component of the financial system for which we will conduct a comparative analysis. Each of the chapters will end with a conclusion that will serve as a basis for the conclusion of our study.

Methodology

Our empirical analysis will be based on a comparative analysis of the components of the financial system. We will compare the different components of the system on the one hand for the traditional system and on the other hand for the decentralized finance system known under the acronym DeFi.

The comparative analysis tool, or benchmarking, is widely used in management and particularly at the level of companies to allow them to situate themselves in relation to their competitors. Generally, a given company will compare itself to the leader in its sector to note the differences and try to understand why the leader has this position and implement actions to improve. This management tool is relatively recent as its first definition dates to the early 1990s, which is also when managers started to use it within their companies (Beaulieu and Boisvert, 2014). According to Moriarty and Smallman (2009), it is an essential tool in the current environment. Indeed, the number of companies is growing, and it is increasingly necessary to do everything possible to perform better against these competitors to keep or even gain market share. We consider that using benchmarking to answer our research question is a good analysis tool because it allows us to compare the performance of two entities to determine the potential improvements to implement. Our benchmark will then be the traditional financial system component because it is the one that has been established for the longest time and is, currently, the most widespread and commonly accepted among consumers. The DeFi component will then be compared to highlight the points that need to be improved to determine if it could one day dethrone the current leader.

The purpose of this in-depth study will be to highlight the different possibilities, advantages and disadvantages conferred by the two systems. The aim of this study is to

determine if the DeFi can, in the long run, replace the financial system that we currently know or if the two systems will coexist in symbiosis. To do this, we will try to pose and explain, in a theoretical and practical way, the different components of these systems. The objective of our approach will be to demonstrate and compare the different advantages that decentralized finance has over the classic financial system.

We will therefore divide our study by illustrating each component of the two financial systems with diagrams and numerical examples, to best reflect the objective reality of each element. We will first discuss the components of the two systems to start from a solid base and to have a global vision of their functionalities and attributes. These components are those mentioned previously in our thesis (see chapter 1 section 2 point 3). To these we have added money as an additional component because, as explained in the first chapter, it is an essential concept for any financial system.

To select the most representative and comparable examples for each component of the financial system, we will base ourselves on the most capitalized example in its category. Using this filter, we select the example that currently has the most members. When capitalization is not available, we will select the example based on another element that defines its number of users. For each selected entity with a stock or a crypto currency listed, we will also reproduce the evolution of its price graphically from the listing of the most recent entity of the two that are part of the same component.

The first component of the system we will analyze is the currency. We will try to compare the reference and haven currency at the global level: the US dollar (USD). In terms of decentralized finance, we will focus our research and presentation on the most capitalized and used stablecoin in the crypto sphere: Tether (USDT).

We will then approach the concept of banks where we will compare two types of banks. The first type of banks analyzed are those we call the banks of the banks, the central banks. From the traditional point of view, the FED has been selected while there is no specific example taken for decentralized finance, we will detail the reason for this absence. The second type of bank concerns the lending and borrowing solutions for individuals and companies. We will illustrate this through the most capitalized American commercial bank: JP Morgan Chase. On the DeFi side, we will focus our research on the decentralized liquidity market protocol Aave.

The third necessary component of any financial system is the security market. For traditional finance, we chose the NYSE. Since stock exchanges are not listed entities, we selected the NYSE based on the number of IPOs in the past year. We have selected the market where the most IPOs have been launched. For decentralized finance, we chose Uniswap which is the DeFi exchange with the largest capitalization.

We will then discuss mutual funds. We have chosen BlackRock on the one hand and Mudrex on the other. As Mudrex is a DeFi protocol that does not have a token, we have based our selection mainly on the assets under management. Note that this is an extremely recent solution in DeFi and that competitors are very limited.

Next comes he insurance component. Ping An Insurance Group is the leading insurance company in this field. It is the first traditional non-US company in our study. On the decentralized finance side, it is Nexus Mutual.

The penultimate component concerns payment service providers. Although Amazon and Apple have launched their own payment service providers with Amazon Pay and Apple Pay, this is only a small part of their business. We therefore chose the most capitalized company that is solely focused on this area, Paypal. This one will be compared to the DeFi protocol, Metamask.

Finally, the supervisory and regulatory body is the last element of a financial system. Central banks are not a supervisory body as such. The European Union, for example, has an entire supervisory system divided into 4 distinct entities. Of course, this is not a single entity, but this complete system will be developed to understand its exact role. On the side of decentralized finance, there is no such body, and we will re-explain the stakes of this one on the DeFi.

Chapter 1. Money

Section 1. US Dollar (USD)

The most widely used fiat currency in the world is the USD, although the reserve of this currency held by central banks is decreasing. According to International Monetary Fund data, 59% of total currency held in reserve in Q2 2021 was in USD. This is the lowest level in 25 years. Analysts believe that this downward trend illustrates the declining role of the USD in the global economy (Arslanalp and Simpson-Bell, 2021).

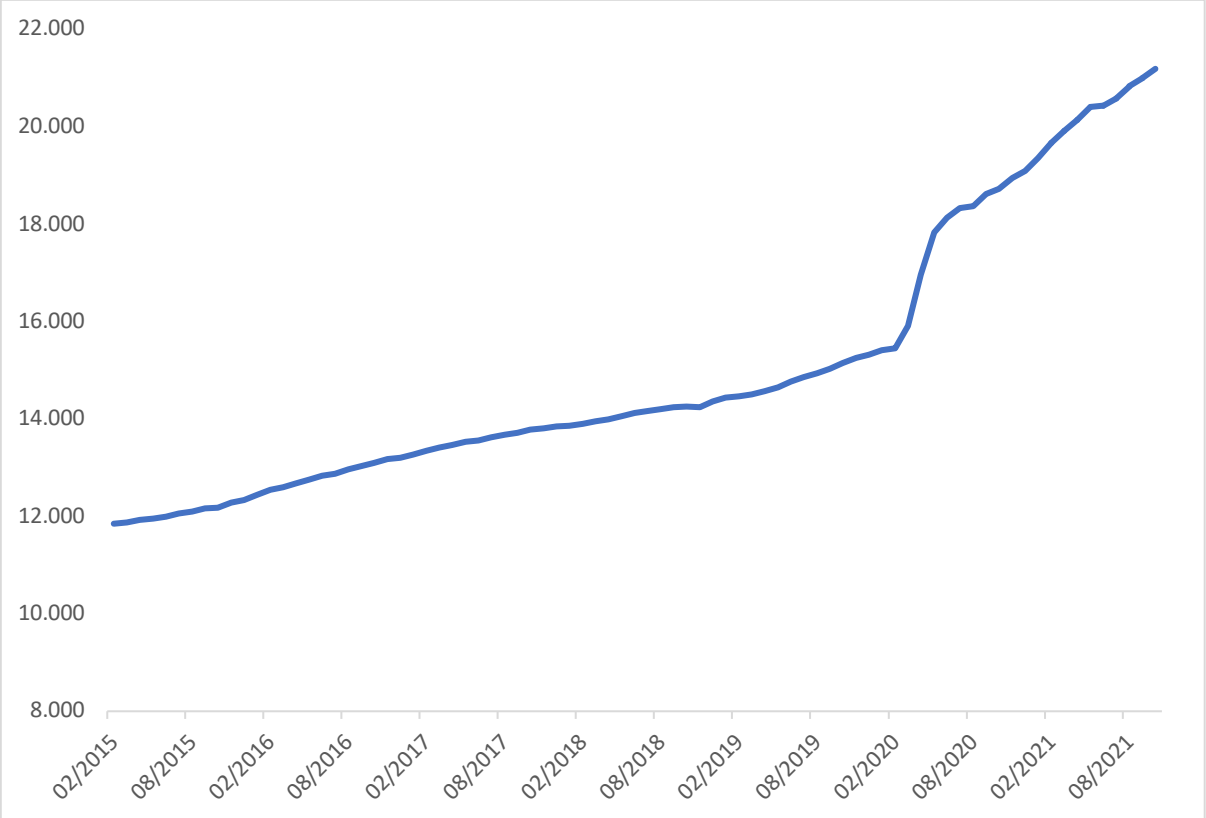


Chart 1. Evolution Money Supply in billion USD from Feb. 2015 to Oct. 2021[11]

Chart 1 represents the evolution of the money supply measured in billion dollars since February 2015. We can see a strong jump around March 2020 corresponding to the quantitative easing put in place by the Fed to offset the effects of the Covid-19.

[11] Source: Fed, https://fred.stlouisfed.org/series/M2SL, consulted on December 3, 2021

Section 2. Tether (USDT)

1. Introduction

Tether is a digital token called a "stablecoin" backed by the traditional US dollar (USD) issued by the company Tether Limited. It is active on various blockchains and is collateralized entirely by reserves in the accounts of Tether Ltd. $1 USD from the traditional world is thus equivalent to $1 USDT (Lars, 2017). It is the first stablecoin with a current market cap of $76M (coinmarketcap).

Note that stablecoins can be classified into three categories, fiat-collateralized, crypto-collateralized, and non-collateralized. USDT is part of the first category since it is backed by the USD.

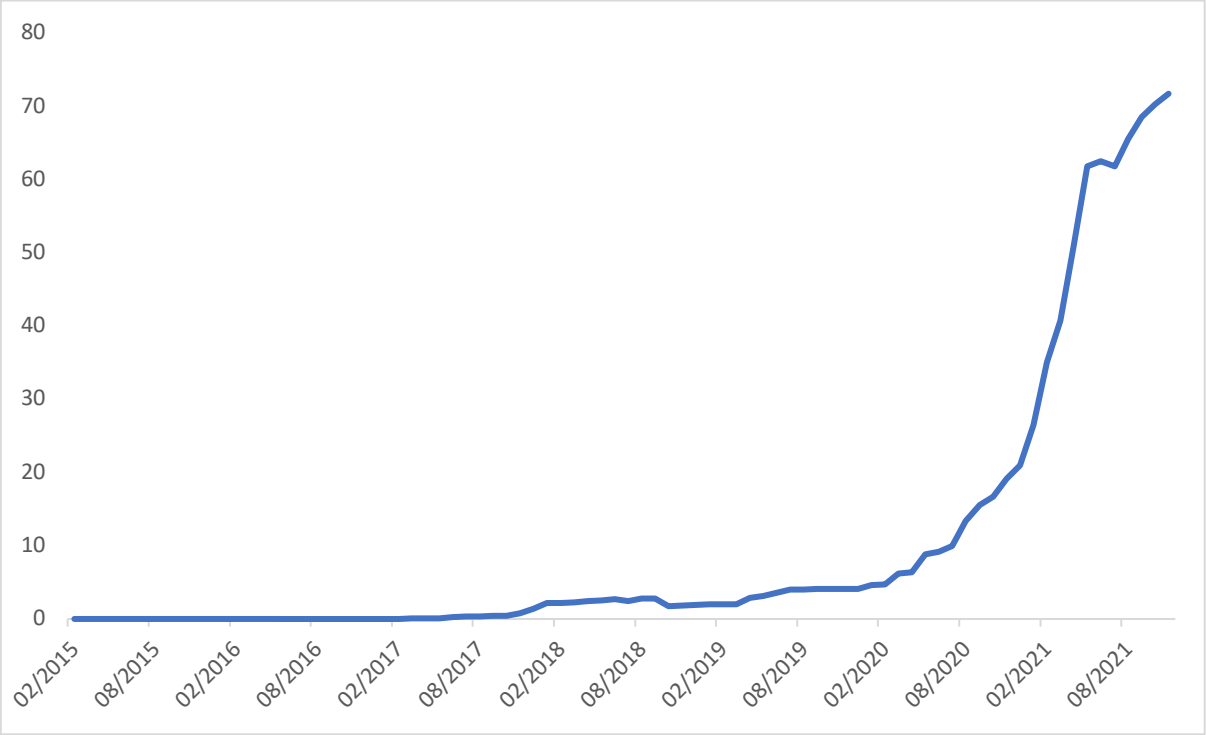


Chart 2. Evolution Market Capitalization USDT in billion USD from Feb. 2015 to Nov. 2021[12]

[12] Source: Statista, https://www.statista.com/statistics/1277906/Tether-daily-market-cap/, consulted on December 3, 2021

2. Functioning

As in most markets, the price is defined by a balance established between supply and demand. This balance is therefore the result of a trust established between the market and the company. Cryptocurrency investors can moreover consult, in a completely transparent way, the information relating to the management and issuance of USDT as well as the audits carried out on the website of Tether Ltd.

3. Utility and characteristics

USDT is an effective way for investors to hold cash in the blockchain world. As in the traditional world, USDT provides a way for investors to hold cash and hedge against excessive bullish or bearish movements. USDTs thus serve as an exchange currency capable of reducing a risk of exposure when cryptocurrency market conditions are too volatile or uncertain.

Tether is a stablecoin created specifically for Internet. As such, it offers a variety of services for the different tokens present on cryptocurrency exchange platforms. Tether also reduces transaction costs and increases the speed of transactions since it does not go through traditional trusted intermediaries such as financial institutions. This stablecoin is also transparent and can therefore be exchanged in a matter of moments anywhere in the world. Finally, Tether holders are the custodians of their own funds and thus eliminate the risk associated with exchange custody.

Section 3. Comparative analysis between USD and USDT

First, it is important to keep in mind that the USD and the USDT are intrinsically linked. Indeed, without the USD, the USDT cannot exist since the former is used to back the latter. However, the correlation between the two is not perfect and stands at 86% if we use the previous data above, i.e., over the last 5 years.

Furthermore, an important difference lies in the total value in circulation of the two respective currencies. In October 2021, there were 21.187bn USD in circulation, at the same time there was $70.3bn USDT in circulation, which is 1/300th of the total value of the USD supply. Of course, one of the main reasons and explanations for this difference is the length of time the two currencies have been in existence. On the one hand, the first US dollar was printed in 1914 following the creation of the Federal Reserve Bank (Best, 2021). On the other hand,

Tether was founded in 2014 by Brock Pierce, Craig Sellars and Reeve Collins. So, there is a century separating these two events. However, if we calculate the CAGRs for the period October 2016 to October 2021, Tether's is much larger. Indeed, its CAGR for the last 5 years is 488% while that of the USD is 10%.

We can explain this difference via the increase in popularity of crypto currencies in recent years. Indeed, stablecoins are widely used for crypto-to-crypto exchanges. These are primarily an advantage for trading platforms due to the regulations regarding the transfer and storage of fiat currency. Thus, thanks to stablecoins, platforms can have access to USD without having to hold it directly. Therefore, most of the crypto currency trading platforms do not allow to directly exchange USD for any crypto currency, it must first be converted into USDT before the exchange can be made. Tether is also of interest to traders because it allows them to hedge against the volatility of traditional crypto currencies without having to sell the crypto currencies back and convert them into fiat. Indeed, in some countries as soon as you sell your cryptocurrency and convert it into fiat, you are taxed on your capital gain.

The third difference finally concerns the use of the two currencies. The main and only use of Tether is currently the two mentioned above. The US dollar, meanwhile, also allows to invest via the stock and bond market, for example, but also allows consumers to consume. The main nature is therefore different even if in both cases it is a medium of exchange. However, since Tether is not a legal tender, merchants have no obligation to accept it as a means of payment. That doesn't mean they don't have the right to do so. In fact, some businesses have started to accept cryptocurrencies as payment methods including Tether. You can, for example, pay in USDT at Travala.com, an online platform for booking hotels and flights. The same goes for the famous Time magazine as well as other brands and online businesses (nowpayments.io, 2021). Of course, this acceptance of the use of Tether as a means of payment is not the norm but the number of acceptors is growing. Thus, we can think that a currency is one not when a government gives it legal tender but rather when most individuals consider it as such. Once consumers, traders and producers are aligned to consider a currency as such, it can serve as a medium of exchange.

One last important thing to mention about Tether is the fact that it is backed by the USD, so the value of Tether depends only on the value of the USD. When an exchange takes place, on Travala.com for example, both parties therefore see Tether as a form of substitution for the classic USD. The intrinsic value of this stablecoin is dependent on the value of the USD and

therefore does not provide a hedge against current inflation. To overcome this weakness, there are other stablecoins that are not collateralized by a fiat currency but by another cryptocurrency. DAI is such a stablecoin, it has a current market cap of $6.5bn (coinmarketcap) and is 27th in the ranking of cryptocurrencies by market cap. The purpose of this section is not to explain how DAI is built and how its stability is maintained but only to show that dependence on a fiat currency such as the USD is not something impossible to overcome.

Section 4. Conclusion

Can Tether substitute for USD? It would appear not at this time. This conclusion has two main explanations. First, since stablecoin is not legal tender, no one is forced to accept it as currency and so it is by dint of individual actions that Tether is considered a currency. Second, since it is backed by the USD itself, it is dependent on it and cannot exist without it.

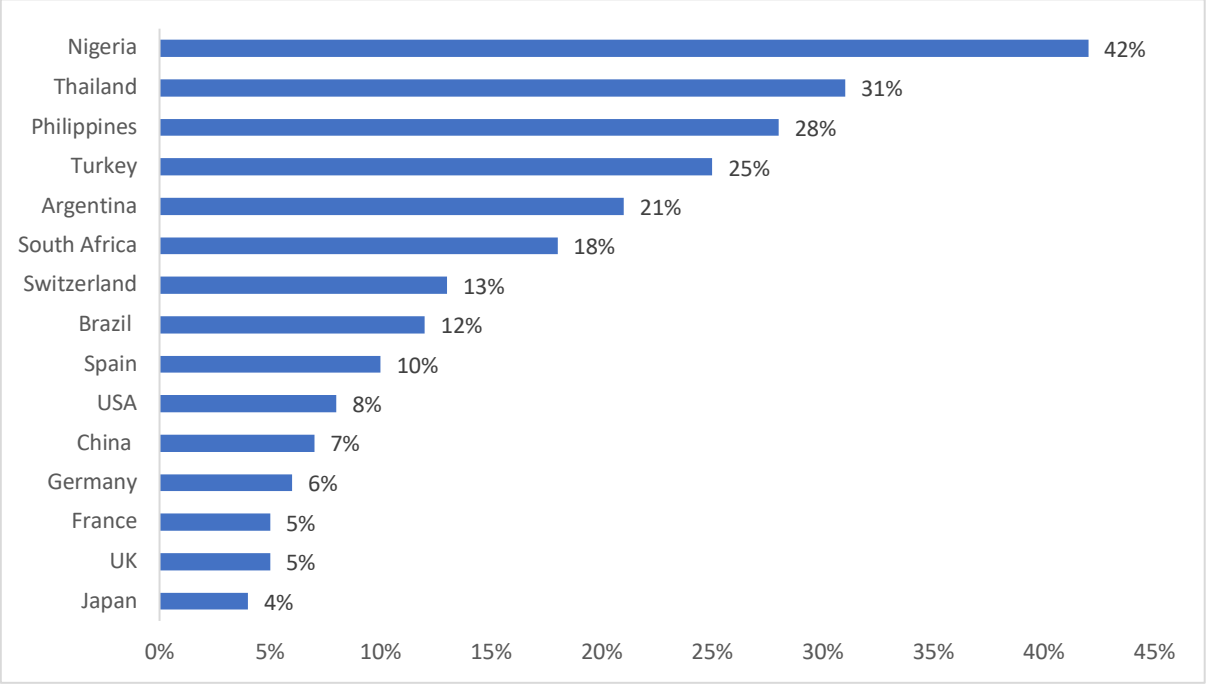


Chart 3. Adoption of Crypto Currencies around the world in 2021[13]

[13] Source: Statista, https://fr.statista.com/infographie/15440/utilisateurs-cryptomonnaies-par-pays/, consulted on December 3, 2021

It is, however, interesting to note that Tether's popularity has increased over the past few years demonstrating the increased interest in crypto currencies from individuals. The underlying reason for this interest is unclear but given the countries in which crypto currencies have the most users, we can assume that this goes beyond speculation.

Chapter 2. Banks

Section 1. Central Bank

1. Federal Central Bank (Fed)

Although there is no market cap for central banks as they are not public, it is easy to consider the US Federal Reserve, the Fed, as the central bank par excellence. It is the most influential central bank in the world as 80% of the world's transactions are conducted in US dollars (Jeulin).

On the Fed's website, we can find the 5 functions it performs to promote the efficient functioning of the national economy and the broader public interest.

- It conducts national monetary policy to ensure maximum employment, stable prices, and moderate long-term interest rates.
- It actively monitors and invests to promote the financial system and minimize systemic risks.
- It promotes the safety and soundness of individual financial institutions, including monitoring their impact on the overall financial system.
- It promotes the efficiency and security of payment systems by providing services to facilitate US dollar transactions and payments.
- Finally, it conducts consumer-focused research and analysis to promote consumer protection and community development.

The 3 tools of monetary policy are controlled by the Federal Reserve, they are the open market operations, the discount rate, and the bond reserves. The discount rate and bond reserves are managed by the Board of Governors of the Federal Reserve System, which consists of 7 members who are appointed by the President and confirmed by the Senate. Their term of office is 14 years. Open market operations are managed by the Federal Open Market Committee (FOMC) within the Fed. The FOMC is composed of 12 members, 7 members of the Board of Governors of the Federal Reserve System, the President of the Federal Reserve Bank of New York and 4 of the 11 other Reserve Bank presidents, who serve one-year terms on a rotating basis.

2. Central Bank in DeFi?

We cannot say that there is a central bank in the case of DeFi. The whole point of decentralized finance is that there is no central entity governing the market. The aim is that the decentralized system can regulate itself by combining different complementary service providers whose execution is automated thanks to smart contracts.

3. Conclusion

Since this element disappears with the DeFi, there is no comparative analysis to be made of the "central bank" component itself. The central bank is a crucial component of the traditional financial system because it guarantees the stability of the system. However, the decisions are in the hands of a concentrated number of decision-makers since at the Fed, only 12 people have the decision-making power to choose the way monetary policy will be conducted. This will have a real impact on the population since it influences inflation, interest rates, the value of money compared to others, etc. The system is therefore maintained by the confidence of the population in these 12 people. If the trust erodes, the whole system could falter.

Section 2. Commercial Bank

1. JP Morgan Chase

1.1. Description

JP Morgan Chase & Co is an American multinational bank headquartered in New York. The company as we know it today was born in 2000 with the merger of Chase Manhattan Corporation and JP Morgan & Co. However, the history goes back much further, to 1799.

It is the most capitalized commercial bank, with a current market cap of $476M. The commercial banking business accounts for 57% of revenue, 15% comes from core transactions, 15% from asset management, 8% from investment banking and the last 5% is labeled as other revenue. The largest portion of revenue is net interest income, which alone accounts for 46% of revenue (JP Morgan, annual report 2020).

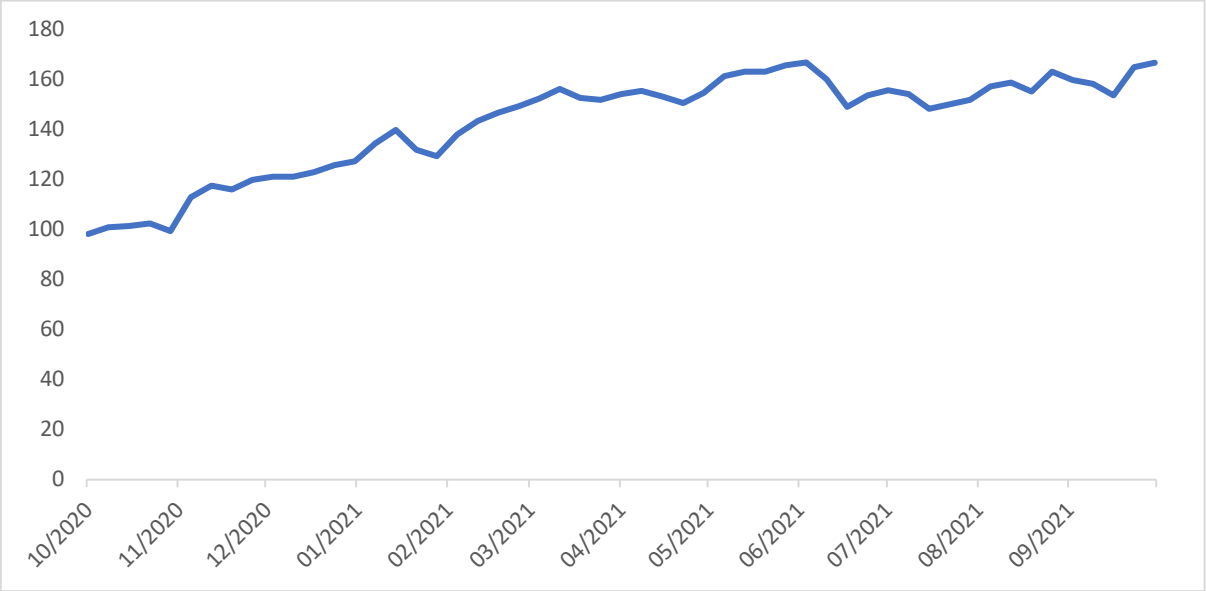


Chart 4. JPM Share Price Evolution in USD from Oct. 2020 to Oct. 2021[14]

1.2. Lending and borrowing services

On the company's website, we can first find the different solutions it offers to companies regarding credit and financing options. These solutions cover assets-based lending, equipment financing, employee stock ownership plans and syndicated finance. At the individual level, the services provided at the loan level are checking accounts, savings accounts, credit cards, mortgages, home equity line of credit, auto.

The most important element in this research is the intermediation role that the bank plays. This is the fact that the bank collects deposits from people "wishing" to lend money and allocates this money to individuals wishing to borrow money. We have therefore selected different services provided by the company in this sense to see the rates that the bank offers and the conditions of access for individuals.

[14] Source: Yahoo Finance, https://finance.yahoo.com/quote/JPM?p=JPM&.tsrc=fin-srch, consulted on December 3, 2021

a) Lending solutions

- Certificate of Deposit (CD)

A certificate of deposit (CD) is a savings account containing a fixed amount of money over a specified period. Interest will be paid by the issuing bank to compensate for the amount locked in. When you cash in or redeem your CD, you get back the amount invested, and the interest earned. This is one of the safest savings options. A CD with a federally insured bank is guaranteed up to $250,000 (investor.gov).

The certificates of deposit offered by JP Morgan Chase range from minimum 6 months to maximum 120 months. The bank only provides CDs with a fixed interest rate that can vary depending on the amount of the deposit. A minimum deposit of $1,000 is required to qualify for a CD with JP Morgan Chase. The annual percentage yields (APY) offered by the bank for the available CDs are shown in Table 5 below. Note that these certificates are only available to customers with a linked Chase personal checking account.

Table 5. APYs per CD[15]

CD term	$0 - $9,999.99	$10k - $24,999.99	$25k - $49,999.99	$50k - $99,999.99	$100k - $249,999.99	$250k +
1-Month	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
2-Month	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
3-Month	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
6-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
9-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
12-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
…						
120-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%

Certificates of deposit are therefore a solution offered to people who have surplus money and are willing to make it available to people in need for a fee. Of course, this is one of the safest solutions offered by banks and that is why the rates offered are relatively low. In fact,

[15] cf. appendix 2 for completed table. Source: chase.com

the interest rate offered is proportional to the risk taken, the greater the risk, the higher the interest rate charged to compensate for the risk involved.

- Saving Account

A second option available to "lenders" is the traditional savings account. Chase offers two types of savings accounts, the "Chase Saving" and the "Chase Premier Saving". The main difference between these two savings accounts is the monthly fee for the service provided, depending on the different conditions, the first costs $5 per month while the second costs $25 per month. In addition, the interest rate charged also varies slightly between the two options. While the basic option offers a single rate regardless of account size of 0.01%, the Chase Premier Saving offers either a 0.01% rate or 0.02% if the savings account in question is linked to a checking account. The interest rates charged are in all cases, compound interest rates and paid monthly on a daily collection basis. In addition, interest rates are variable and determined daily at the discretion of Chase (chase.com).

b) Borrowing solutions

When it comes to borrowing money, the different options available generally depend on how the consumer will use the borrowed money, the term of the loan and the amount required. There may also be variations depending on whether collateral is made available. All of this is estimated by the bank to minimize its risk.

JP Morgan Chase does not offer consumer credit per se. The two major types of loans the company offers to individuals are mortgages and credit cards.

- Mortgage

A mortgage is a common solution available to households. It is a loan whose collateral is a real estate property. The risk incurred by the bank is therefore minimized because if there is a default in payment, the bank can seize the real estate to repay itself by selling the property.

Of course, the interest rate offered by JP Morgan Chase differs according to the amount of the loan, its duration and the applicant's credit score. The credit score is an American peculiarity which allows to estimate the quality of payer of the borrower based on his past loans. The scale ranges from 0 to 800 and a consumer with a score close to 800 will be considered an excellent payer. This will generally be a person who has always paid back his loans on time and who does not accumulate credit cards, etc. The credit score is built up over time and should not be

neglected if the consumer wants to benefit from interest rate reductions. On the JP Morgan Chase website, we can find a table showing certain interest rates based on specific conditions.

For example, the bank is offering a 30-year fixed rate of 2.99% or an APR of 3.058% for a loan amount between $300,000 and $349,999 for a single-family residence with a 30-day mortgage rate lock period and a customer profile with excellent credit. The APR (annual percentage rate) is the annualized interest rate to be paid when borrowing money on a credit card. This rate can be avoided if the balance is paid on time at the end of the month.

- Credit cards

JP Morgan Chase offers several types of credit cards based on the benefits offered. Each card allows you to accumulate points and redeem them for various prizes including hotel nights, discounts on airline tickets, the possibility of being upgraded, etc. or receive cash back based on the amount spent. The bank offers a total of 33 different cards with similar benefits and are divided into 3 main categories:

- **Rewards Cards**: one of the most popular cards in this category is the Freedom Unlimited which is free. Its two main features are that it allows you to get $200 if you have spent $500 with it during the first 3 months and 5% cash back in grocery stores under certain conditions. The APR is 0% for the first 15 months but then varies between 14.99% and 23.74% depending on the credit score of the subscriber.
- **Travel Cards**: One of the most popular cards in this category is the Southwest Rapid Rewards card costing $69 per year. Its main feature is that it offers 40,000 points after the cardholder spends $1000 in the first 3 months. These points can then be converted into purchases for future travel. The APR is between 15.99% and 22.99% depending on the credit score of the subscriber.
- **Business Cards**: One of the most popular cards in this category is the Ink Business Unlimited which is free. It offers $750 cash back after $7,500 spent in the first 3 months and 1.5% cash back on all business purchases. The APR is 0% for the first 12 months and ranges from 13.24% to 19.24% thereafter depending on the subscriber's credit score.

Overall, if we analyze all the APRs available for the 33 credit cards, they range from 13.24% at best to 23.99% at worst.

2. Aave

2.1. Description

Aave is an open source, non-depository DeFi protocol whose main feature is to allow the interests of capital and asset providers and seekers to meet. Aave was created in 2017 by Stani Kulechov under the name ETHLend where the strategy was based on decentralized P2P where lender and borrower met directly. In 2020, the protocol changed to Aave, and it is now a liquidity pool-based strategy. This system is possible and relies on the use of smart contracts. Etymologically Aave is a Finnish term translating to ghost. This name was not chosen at random as it reflects the founders' desire to create a transparent and open infrastructure for highly decentralized finance. On the one hand, lenders make crypto currencies available in a contract pool to provide liquidity. On the other hand, within the same contract, the total pooled funds are available to borrowers after placing a guarantee. This system allows for loans to be made instantly, the characteristics of which are based on the state of the pool.

In Aave's white papers, we can directly read how the interest rate is determined. Whether it is the interest rate charged to the lender or the interest rate to be paid by the borrower, both are determined algorithmically. For lenders, the interest rate charged depends on the cost of money, i.e., the availability of funds in the pool. Once a pool is 100% complete, borrowers will be able to borrow a portion. As the available cash diminishes, the interest rate increases. For the lenders, the interest rate they must pay corresponds to the interest rate. The algorithm saves a cash reserve to guarantee withdrawals at any time.

Aave supports around 30 different crypto assets, with a wide selection of stablecoins. When depositing in the Aave protocol, aTokens are forged. Its market cap is currently $3M.

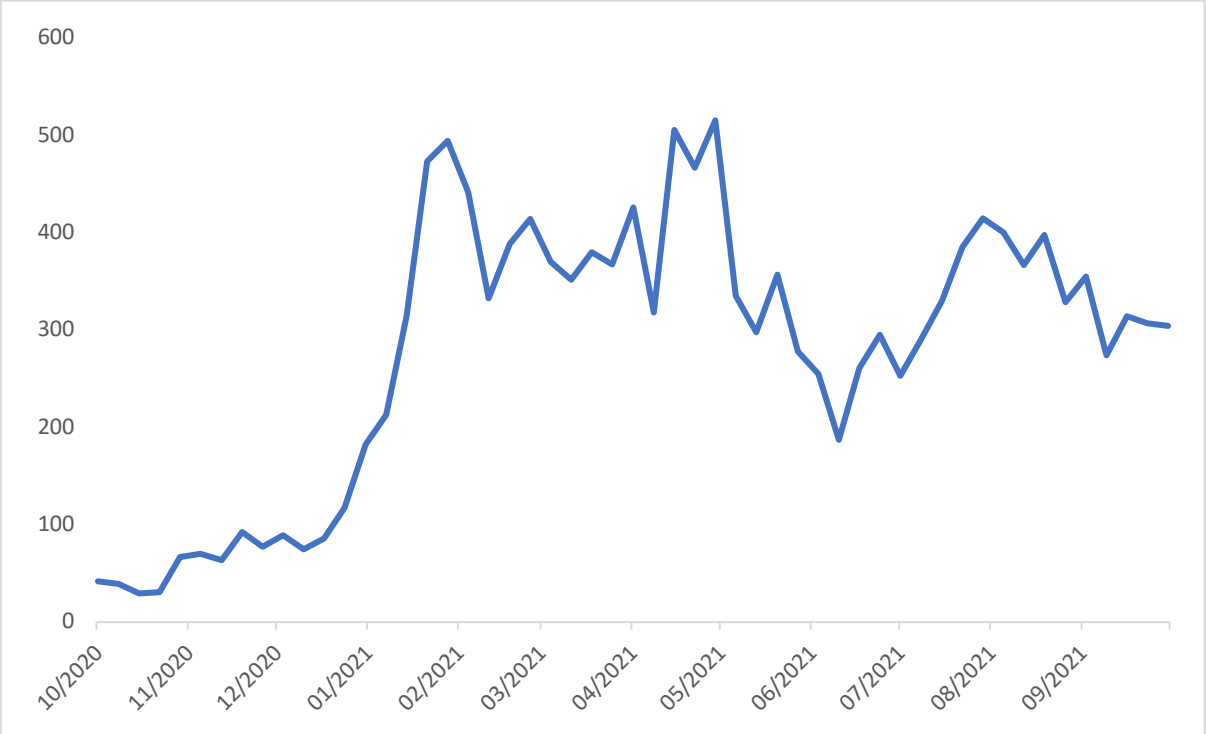


Chart 5. Aave Share Price Evolution in USD from Oct. 2020 to Oct. 2021[16]

Aave has raised funds twice. The first one in 2017 in the form of an ICO (initial coin offering, a concept developed in chapter 4 of this section), allowed it to raise $16.5m. The second took place in 2020 via several investment funds such as DTC Capital, Parafi Capital, Three Arrow Capital and Framework Ventures. This second round of funding allowed the company to raise an additional $7.5m (Wardzala, 2020).

2.2. Lending and borrowing services

Aave allows the interests of lenders and borrowers to meet without the help of an intermediary. It is the smart contracts embedded in the protocol that manage the execution and the transfer of funds when the different conditions are met.

[16] Source: Yahoo Finance, https://finance.yahoo.com/quote/AAVE-USD?p=AAVE-USD&.tsrc=fin-srch, consulted on December 3, 2021

a) Lending solution

The solution proposed to holders of assets with excess liquidity is to remunerate the provision of this liquidity via the payment of interest. Lenders must first have a connection to an external wallet supporting Ethereum before they can make their liquidity available. Individuals can provide liquidity to the assets they hold according to the list of crypto currencies that the protocol manages. See Appendix 1 to have the entire current table. The crypto currency offering the highest interest rate is Binance USD with an APY of 19.80%. This is partly because the utilization rate is currently very high for this one, 83.98%, which means that there is only 16% of the liquidity pool available for borrowing. Figure 11 shows the different information about the state of the liquidity pool regarding the crypto currency Binance USD.

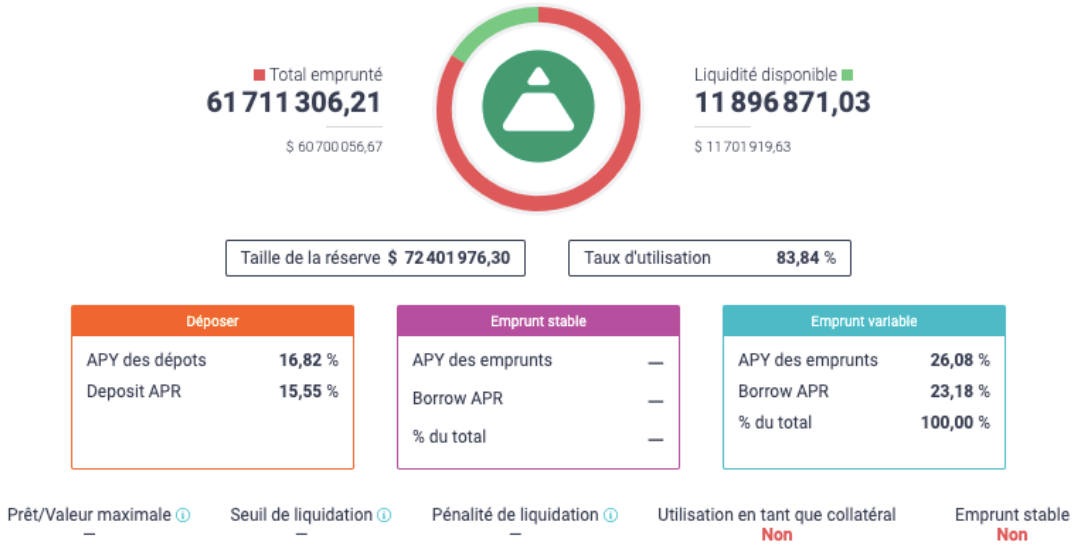


Figure 11. Status and Configuration of the pool for Fei USD at 10 Dec. 2021

The lending solution is very interesting for stablecoin holders. Unlike other crypto currencies which usually fluctuate widely, stablecoins have almost no volatility. Therefore, making stablecoins available via Aave allows holders to earn a higher interest than if they kept them as is. If we take the example of Fei USD, making the crypto currency available for borrowing now allows the lender to earn an annualized interest of 16.8% which is much higher than keeping the stablecoin. In addition, this solution is also safer than investing these

stablecoins in crypto currencies because the borrower must bring in collateral that offers some form of protection to the lender.

b) Borrowing solution

The solution offered to borrowers is the counterpart of the one offered to lenders. The only condition allowing the borrowing of various crypto currencies is the contribution of a guarantee which will be used as collateral.

The size of the loan will depend on the collateral deposited. Borrowing crypto currencies is of major interest to crypto currency investor. Let's imagine for a moment that you invested a significant amount of money in ETH a while back and you have a buying opportunity. Since crypto currencies are so variable, a drop in price of several percent in the same day is not unusual. An individual who is convinced that his investment is the right one and wants to strengthen his position in the face of a lack of liquidity may turn to Aave. He will be able to bring a certain amount of ETH in his possession as collateral without having to sell them to obtain a certain amount of stablecoins to buy back more ETH. He will hope that the gain he will make on his new ETH will be greater than the interest he will have to pay on his loan. Once the collateral is provided and the amount of the loan is determined, the borrower must choose whether to pay a fixed rate or a variable rate (an option not offered to lenders). The fixed rate allows the borrower to plan the interest to be paid. It is a short-term fixed rate that can be rebalanced over the long term, even if this is unlikely. For the fixed rate to be rebalanced, the borrowing rate must be less than 25% for a utilization rate greater than 95%. The variable rate, on the other hand, depends on supply and demand in Aave.

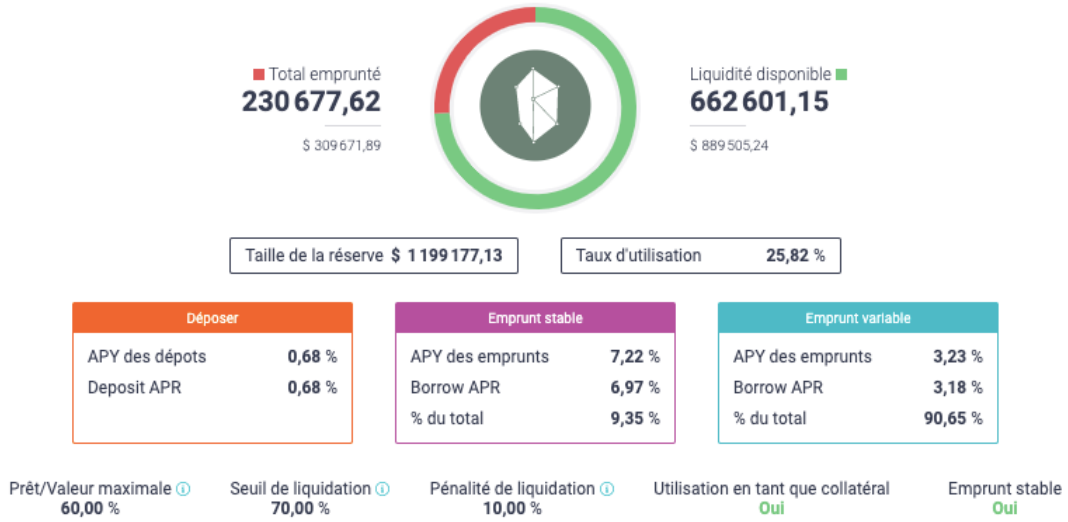


Figure 12. Status and Configuration of the pool for Keber Legacy at 10 Dec. 2021

In Figure 12, we can see that a Keber Legacy borrower will have a choice at this time between a variable rate of 3.23% and a fixed rate of 7.22%. The fixed rate in this case being less beneficial than the variable. Of course, it's a trade-off between paying less now and perhaps paying much more tomorrow and having certainty about future cash flow by choosing a fixed rate. A lender, on the other hand, will receive in any case a fixed interest rate of 0.68%.

3. Comparative analysis between JP Morgan Chase and Aave

First, it is interesting to note that the correlation between JPM's stock and Aave is 65%. There is a relatively strong positive correlation between the two. However, we can see from the two price charts that Aave is much more volatile than JPM stock, which has a stronger upward trend. This difference can be explained by the daily trading volume. While it was generally above $1 billion during the month of December 2021 for JPM, it never exceeded $400m for Aave. This seems logical to us given the global recognition of the former compared to the latter, which only saw the light of day in 2021. Over one year, between October 2020 and October 2021, both entities have experienced some growth, 70% for JPM and 633% for Aave. This difference is mainly because the beginning of the period marks the ICO of Aave and the hype that there was while JPM was a stock already well installed for years.

Then, regarding the solutions offered by the two entities, we note some notable differences. While JPM offers different solutions for both lending and borrowing, Aave offers a single solution. The purpose of the loans is also very different. JPM offers loans to its clients mainly for consumer purposes to buy goods and a particular solution for the purchase of a house as it is an asset that can be used as collateral. Aave offers a unique borrowing solution. To get a loan from JP Morgan, you need to have a specific file that meets different criteria such as credit score, equity requirements, a payroll statement, etc. The file will be evaluated on a case-by-case basis by a bank officer who will accept or reject the loan. Since Aave is automated and operates without intermediaries, the loan will be granted if the conditions necessary for the execution of the smart contract are met. The only binding condition is the deposit of a guarantee. Note that the ETH that we must provide as collateral always belong to us if we do not default. This is the same principle as in a mortgage where the house always belongs to the client if he does not default.

Finally, the last very distinctive element concerns interest rates. JP Morgan does not tell us publicly how the interest rate is calculated, whereas in the Aave white papers we have a mathematical explanation of how their algorithm works. Moreover, the interest rates charged by JPM for the same product vary according to the individuals and their profile. Let's imagine X and Y, two individuals who want to take out a 30-year mortgage for $500,000 at a fixed interest rate. The interest rate that each of them will have to pay will be different because it will depend mainly on their credit score and on what they earn annually. In contrast, Aave does not differentiate between borrowers. If collateral is provided, everyone can borrow at the fixed or variable interest rate indicated on the platform on the day of the loan. The size of the interest rates also varies significantly between the two entities. The maximum interest rate to be paid on Aave is around 26%, which is the same as the maximum interest rate to be paid on JP Morgan. However, the difference is obvious in the interest rates offered to lenders. The rate offered on risk-free options for capital lenders at JP Morgan is a maximum of 0.05%. This maximum rate is nearly 17% on Aave for Fei USD lenders.

4. Conclusion

Could Aave replace the traditional lending and borrowing system? We believe that Aave is not yet a complete solution to replace a player such as JP Morgan Chase. Aave has, in our opinion, some significant advantages over the solutions offered by JP Morgan Chase. The first one is the absence of intermediary, borrowers and lenders do not have to trust their bank to be

convinced that their assets are secured. The second is the equal treatment of all users. Unlike a traditional bank, Aave does not discriminate between users based on their liabilities. The last one is the remuneration for the lenders which can be much more advantageous on Aave. This low-risk remuneration option is very interesting especially in inflationary situations like the one we are currently experiencing.

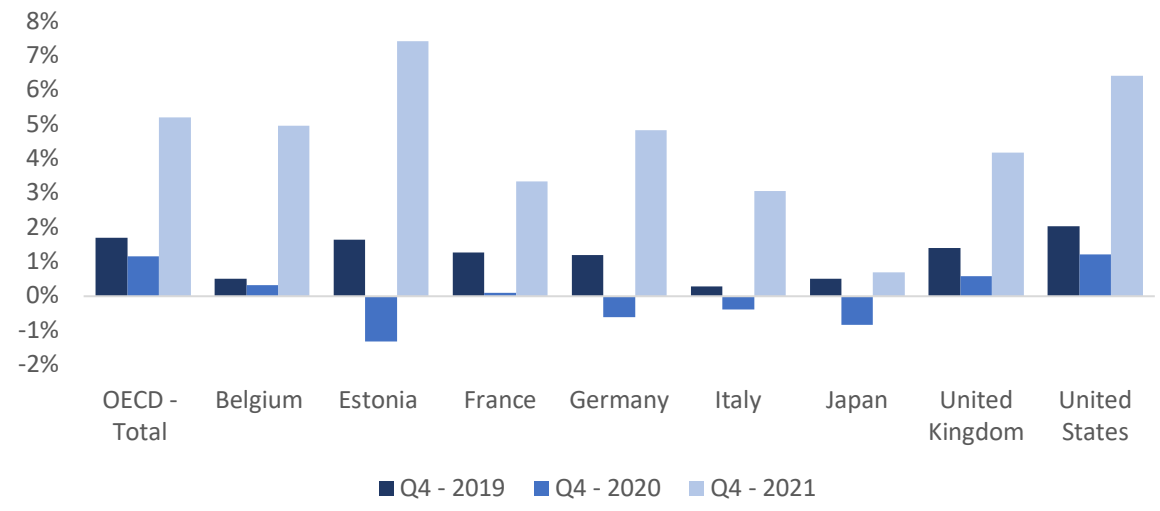


Chart 6. Inflation rate evolution in several OECD countries[17]

With an inflation of 5.21% for all OECD countries in Q4 of 2021, the yield offered on savings accounts is not enough to compensate even a little for this inflation. On the contrary, some rates offered by Aave allow to protect against this inflation.

However, Aave is not yet ready to fully replace all services offered by JPM. It does not, for example, provide a credit card for payment of various goods and services both online and in physical stores. Currently most individuals use this type of payment method daily but as we pointed out earlier some stores and service providers already accept crypto currencies. To do this, all you need is a virtual wallet on which the different crypto currencies you hold are registered.

[17] Source: OECD, https://data.oecd.org/price/inflation-forecast.htm, consulted on December 17, 2021

Chapter 3. Security Market

Section 1. New York Stock Exchange

1. Description

The New York Stock Exchange is a stock exchange located in Manhattan, New York. It is considered, based on the total market capitalization of the securities it lists, as the largest stock exchange in the world. It is a public entity since 2006. Since 2007, the NYSE merged with Euronext to become "NYSE Euronext". Since 2013, the NYSE is the name of the Intercontinental Exchange.

The NYSE is composed of two parts: one for equities trading on a trading floor and the other for options trading. In August 2021, the market capitalization of the NYSE exchange was $26.64 trillion.

2. How does the NYSE work?

The NYSE operates through two trading methods. The first is through brokers and the second is entirely through electronic bias. What these methods have in common is that they work on an auction basis.

Brokers exchange securities between buyers and sellers directly on the trading floor. They connect the various market participants, whether institutional or retail, through their stockbrokers. The market participants then place their buy and sell orders and set their prices, and the NYSE brokers take care of organizing the meeting between the traders.

The brokers set a bid price, the price at which buying players are willing to pay for a security. On the other hand, the selling brokers submit a selling price, a price called the "Ask" price. The sell price is higher than the buy price and this is what constitutes a market where trading at a negotiated price takes place. The role of the NYSE broker is therefore that of an intermediary, bringing together two players: the buyer and the seller.

Most of these exchanges are obviously done through electronic exchanges, requiring the intervention of computers. The computer itself is the broker that puts the market players in contact with each other to establish the exchanges (Amadeo, 2021).

Section 2. Uniswap

1. Description

Uniswap is the leading decentralized exchange in the world, and it has been created in 2018. Its operation is based on the Ethereum blockchain and uses a cutting-edge system to make trades. This revolutionary system is called "Automated Market" and consists in doing without order books. This system consists of pooling the Ethereum-based assets of investors into smart contracts. These investors are called "Liquidity Providers" (or "LPs") and are compensated for the transaction costs they incur in exchange for the funds they place with Uniswap. They receive what Uniswap calls "Liquidity Tokens", corresponding to a proportion of the transaction fees (currently 0.30% of each trade). The more trades are placed on Uniswap, the higher the transaction fees.

Uniswap is a decentralized liquidity protocol enabling various services to be provided to peers via smart contracts. The primary features of Uniswap are as follows:

- Exchanging Ethereum's ERC-20 tokens, including the ability to exchange "wrapped" versions of non-Ethereum blockchain based assets.
- Create liquidity pools for various ERC-20 based assets, allowing for profits to be made through fees paid by these same pools.

Uniswap has 3 main features:

1) **Non-custodial**: Uniswap, unlike traditional institutions, allows its users to choose whether to retain control of their assets to carry out transactions. Users of the platform have the choice to have their own funds in hard wallets or to leave the funds directly on the platform. By having funds in their private wallets, they avoid the risk of platform hacking, although this is becoming less frequent over time.
2) **Completely permissionless**: Through Uniswap and in contrast to traditional markets, anyone can trade in liquidity pools. This means that any individual with an Internet connection and an Ethereum wallet can invest, transfer or trade cash without being approved by any agency. Individuals living in risky areas or under authoritarian regimes can therefore benefit from these services in complete safety.
3) **Trading peer support**: Uniswap allows its users to trade a multitude of assets, provided they are based on Ethereum or are subject to a wrapped conversion of it. Not

all these pairs are always available on depository exchanges such as Coinbase Pro or Binance for example. They have the advantage of offering excellent liquidity as well as fee advantages.

Section 3. Comparative analysis between NYSE and Uniswap

The first major difference between the two exchanges is the centralization of governance. On the one hand, the NYSE is a completely centralized entity, with a traditional governance, directed by a board of designated persons. On the other hand, Uniswap is completely decentralized and offers the possibility, via its governance token, to give any holder the right to contribute to the governance of the decentralized company actively or passively.

In terms of securities exchange, Uniswap works exclusively on the principles of smart contracts. This is a big difference with the NYSE, which requires the intervention of a broker and market makers to operate. Therefore, there is no middleman to place trades on Uniswap and the user of the platform directly exchanges his securities through his own Ethereum portfolio.

There is no order book on Uniswap. The exchange price established between the buy and sell securities is done through an "automated market making (AMM)" system. This is directly managed by the smart contracts of the Ethereum blockchain. AMM allows Uniswap exchanges to set a price using algorithms and therefore does not require buyers or sellers to enter the quotes for their securities themselves. To make the AMM work, Uniswap has integrated a concept of "liquidity pools" to replace the traditional order book of the traditional institutional brokers of traditional finance.

Section 4. Conclusion

Could Uniswap replace the NYSE? If the world continues to evolve into an increasingly digital world, Uniswap and other DEXs could replace traditional exchanges. There are already tokens that replicate the evolution of certain stocks, so investors could invest in traditional companies via a decentralized exchange. However, it seems unlikely that the shift will happen quickly and that all traditional companies will see a counterpart of their stock replicated on the DeFi. Again, it is more likely that the two will coexist, but that Uniswap will become more popular and take a larger place in the future society. More and more players in the traditional world are looking at the implementation of regulations as well as the introduction of digital

money by some central banks. These elements show that the trend is towards a hybrid system where digital solutions are seriously considered.

Moreover, decentralized exchanges make it possible to respond to two major issues, albeit very different today. The first one concerns privacy protection. By using a decentralized exchange, it is not necessary to provide personal information to a trusted third party as is required when registering with a broker. This does not mean that exchanges cannot be traced but rather that individuals can keep control of their personal information without necessarily needing to share it with a third party.

The second issue is financial inclusion. Almost all you need is an internet connection and a smartphone to use a decentralized exchange. Therefore, all individuals who are currently unable to invest for financial inclusion reasons because they do not have easy access to a bank, broker, etc. could invest their assets through DEXs. Once again, these explanations confirm the tendency for the two solutions, traditional and decentralized, to coexist rather than replace the former with the latter.

Chapter 4. Mutual Funds

Section 1. BlackRock

1. Description

BlackRock is the world's largest asset manager. With a current market capitalization of nearly $139 billion the company had over $9 trillion in assets under management as of October 2021 (Vanjani, 2021). Among the solutions offered to its investors, BlackRock offers various mutual funds.

The New York-based company was founded in 1988 as a fixed income institutional asset manager. Today, the company has 16,000 employees in 38 countries and is available to investors in more than 100 countries.

On their site, we can read that BlackRock serves 6 different types of clients:

- **Individuals and families**: providing choice for those investing for retirement, a new home or a child's education.
- **Financial advisors**: helping people of all income levels invest for their future.
- **Educational and nonprofit organizations**: working to educate more students and solve social problems.
- **Pension plans**: manage the retirement savings of teachers, doctors, workers, and small business owners.
- **Insurance companies**: supporting people through life's toughest times.
- **Governments**: funding new hospitals, schools, roads, and other projects that contribute to economic growth

2. Mutual Funds Offering

BlackRock offers several hundred funds that differ in terms of the investors who can access them. Some funds are accessible by several types of investors but sometimes under different conditions. Note, for example, that retail investors must invest a minimum amount, usually $1,000, to start investing in a fund. Fees differ from fund to fund. However, they are generally less than 1% and in some cases are very low, such as for WFSPX where the fee is 0.03%.

- **Institutional**: shares that are available only to large institutional investors. These funds are complete portfolios for their clients, offering various market objectives. These are investment solutions used by governments, pension funds, insurers, etc.
- **Class A**: shares that are available to all investors as distributing and non-distributing shares and are issued in the form of registered shares and global certificates.
- **Class C**: shares that are available as distributing and non-distributing shares to clients of certain distributors (who provide nominee facilities to investors) and to other investors at the discretion of the management company
- **Class D**: shares that are only available to certain distributors who have separate commission agreements with their clients and other investors at the discretion of the management company.
- **Class E**: shares that are available in certain countries, subject to the relevant regulatory approval, through specific distributors selected by the management company and the principal distributor
- **Class G**: shares that are only available to investors on eligible platforms. Eligible platforms are those where clients invest in the Fund through a single omnibus account in the name of a financial intermediary that meets a minimum initial investment of $2.5 billion.
- **Class K**: shares that are only available to certain investors. They include certain employee benefit plans, such as health savings accounts, and certain employer-sponsored retirement plans. But also, group trust funds, investment companies and other pooled investment vehicles. And finally, different types of institutional investors such as endowments, pension funds, family offices, foundations, etc.
- **Class R**: shares that are available only to certain employer-sponsored retirement plans.
- **Investor A**: shares that are generally available to investors who purchase shares through financial intermediaries.
- **Investor C**: shares that are generally available to investors who purchase shares through financial intermediaries. The share must be held through a financial intermediary.
- **Investor P**: shares that are only available to investors who purchase shares through registered representatives of an insurance company broker who has entered into an agreement with the Fund's distributor to offer such shares (the "Financial Intermediary").

The funds are also separated according to the asset class that composes it, its horizon, and its focus, both sectorial and geographical. In addition, there are index funds that track specific and major indices. The table 6 showing the 10 largest funds in terms of net assets (in m USD) offered by BlackRock.

Mutual funds are attractive to investors seeking diversity to minimize their risk. Morningstar can help you evaluate a fund's risk/return profile to see if it fits your strategy. Take the example of the Strategic Income Opportunities Fund, BSIIX. According to Morningstar, the fund has an average risk for its category while its performance is considered above average (Appendix 3).

Chart 7 shows the evolution over the last year for the most widely available, well-capitalized mutual fund, Global Allocation Fund (MDLOX). The fund is composed of 70% stocks, 22% bonds, 4% cash and the rest is made up of preferred stocks and ETFs. The top 5 components are SPDR S&P 500 ETF Trust as well as Microsoft, Apple, Google, and Amazon stocks. Its net return for the calculated period was negative -3.28%.

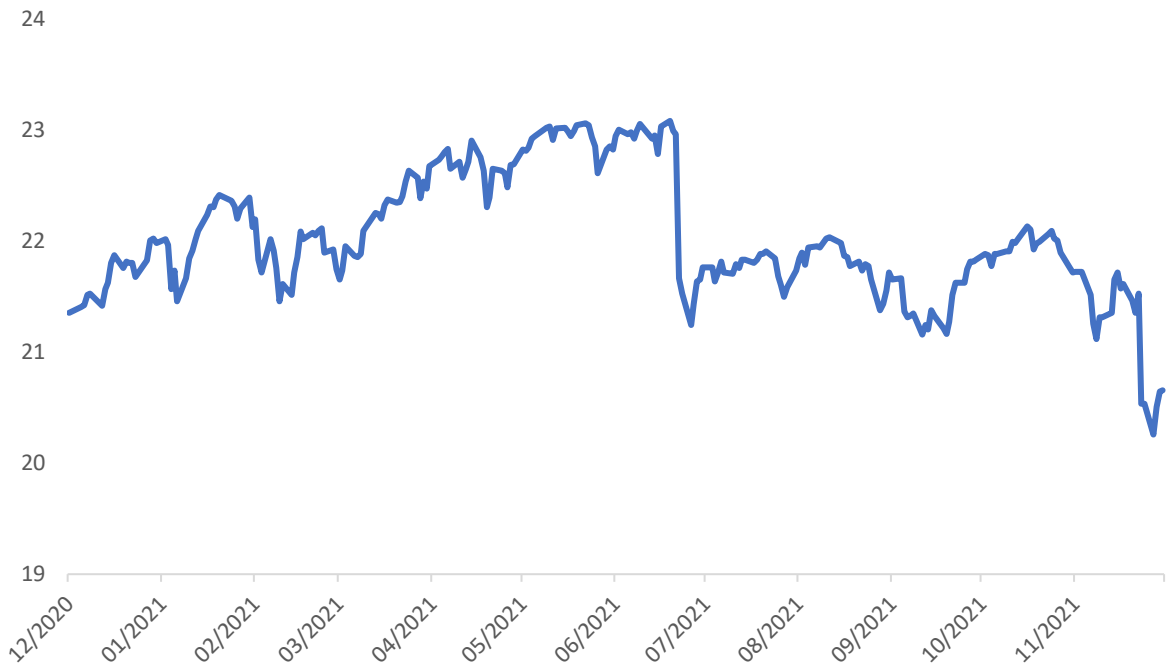


Chart 7. MDLOX Share Price in USD Evolution from Dec. 2020 to Dec. 2021[18]

[18] Source: Yahoo Finance, https://finance.yahoo.com/quote/MDLOX?p=MDLOX, consulted on December 24, 2021

Table 6. Top 10 BlackRock Mutual Funds[19]

Ticker	Fund Name *Share Class*	Asset Class	YTD (%)	3Y (%)	5Y (%)	10Y (%)	Inception date	Net Assets (in m USD)
BSIIX	Strategic Income Opportunities Fund *Institutional*	Fixed Income	0.62	5.16	4.08	4.01	Feb 05, 2008	33,512
BHYIX	High Yield Bond Fund *Institutional*	Fixed Income	3.74	7.29	6.28	7.00	Nov 19, 1998	13,325
WFSPX	iShares S&P500 Index Fund *Class K*	Equity	23.13	20.37	17.88	16.10	Jul 31, 1993	12,808
MDLOX	Global Allocation Fund *Investor A*	MultiAsset	4.13	12.23	9.28	7.18	Oct 21, 1994	12,266
MADVX	Equity Dividend Fund *Institutional*	Equity	13.97	11.35	10.87	11.46	Nov 29, 1988	11,856
MAHQX	Total Return Fund *Institutional*	Fixed Income	-0.73	6.44	4.26	4.35	Sep 24, 2007	11,286
CMGIX	Mid-Cap Growth Equity Fund *Institutional*	Equity	12.85	27.15	25.52	19.37	Dec 27, 1996	10,877
MALOX	Global Allocation Fund *Institutional*	MultiAsset	4.37	12.53	9.57	7.48	Feb 03, 1989	10, 460
BSPGX	iShares S&P500 Index Fund Class G	Equity	23.15	20.38	17.89	16.10	Jul 01, 2019	10,378
BIICX	Multi-Asset Income Fund *Institutional*	MultiAsset	4.92	7.47	6.29	6.50	Apr 07, 2008	10,187

[19] Source: BlackRock, https://www.blackrock.com/us/individual/products/investment-funds#!type=mutualFunds&style=All&view=perfNav, consulted on December 22, 2021

Section 2. Set

1. Description

Set is the largest asset manager in the DeFi world. Set Protocol was announced in 2017 but its web application TokenSets was only launched in 2019. As of March 2021, there were over $180m in assets under management.

Set Protocol is a tool from DeFi that allows users to create, manage, and rebalance wallets consisting of Ethereum-based token. It is a native DeFi primitive of Ethereum that is owned by the community due to its decentralized nature. The possession of ERC-20 tokens allows users to implement passive asset management. It is the underlying smart contracts that enable the management of the entire Set protocol. They support external integrations with exchanges, lending platforms, automated market makers and asset protocols. In addition, Set also allows for more advanced strategies using DEX transactions, but also yield farming and margin trading. For example, an ERC-20 token that represents a particular Set can be used on a lending platform such as Aave as collateral or be staked for yield farming. Note that the Set Protocol itself does not have a native utility token, only the Sets proposed by the protocol are represented by an ERC-20 token.

One of the reasons for the existence of Set Protocol is the new complexity of the crypto-currency world. There are more and more possible strategies offering new possibilities of return. With the exponential growth of return opportunities, retail users do not have the time, inclination, or technical knowledge to monitor, design and implement the strategies.

We are currently in the second version of the Set Protocol (Set "V2"). We can read in the Litepaper that this version of the protocol allows for the following:

- Multi-Asset: Set V2 enables the creation and implementation of strategies employing single asset, pairs, and 3+ assets.
- Margin Trading: Set V2 allows traders to safely implement margin trading through Set's native lending pool. This enables traders to take leveraged long and short positions and enables Set owners to mint/redeem positions.
- 3rd Party Protocol Support for Tokenized Positions: Set V2 enables Set traders to take advantage of yield opportunities from 3rd party lending protocols (e.g., Aave) and automated market makers (e.g., Uniswap).

- Trader Subscription and Performance Fees: Traders can implement time-based (subscription) and performance-based (profit) fees
- SetToken Compatibility: Set V2's SetTokens are implemented using the ERC-20 standard, are fully collateralized by the underlying, can be issued/redeemed like ETFs, are trustless, have specified components, units/natural unit, and are trustless as specified by the Set Protocol whitepaper.
- Protocol Fees: To allow for protocol sustainability, the Protocol will charge fees for protocol-native transactions such as trading via Dutch auctions, borrowing using the protocol's lending pool, and subscription/profit fee sharing.
- Protocol Token Distribution Support: In anticipation of a Protocol Token that requires on-chain distribution mechanisms, protocol design will anticipate the needs of token distribution logic.
- Manager Admin: Set V2 gives managers greater control over how and when Sets can be minted and by whom.

There are 3 types of users: investors, managers, and developers. Investors allocate their capital and receive Set tokens representing their share in the portfolio. Managers are the creators of products that they structure as Sets and maintain for the benefit of investors. They can use streaming fees to monetize their products. These fees are paid overtime and are calculated based on the total capitalization of the set. They are determined by the manager when creating his set. It is therefore an incentive for managers to increase the value of the Set for investors. Developers, on the other hand, oversee building the next generation of financial applications using the Set Protocol as a basis.

2. Mutual Funds Offering

There are several hundred funds that have been created through the Set Protocol and are accessible by investors. Each fund is accessible by any investor. Sets can be purchased on TokenSets directly or via an exchange such as Uniswap. Any investor wishing to purchase a Set must first have a wallet supporting and holding ETH as this is the crypto currency that serves as a medium of exchange.

Table 7. Top 10 Sets[20]

Ticker	Fund Name	1M (%)	3M (%)	1Y (%)	Inception date	Number of investors	Market Cap. (in m USD)
ETH2X-FLI	ETH 2x Flexible Leverage Index	-4.51	69.40	76.76	Mar 14, 2021	3,033	166
DPI	DeFi Pulse Index	-10.40	-25.00	134.35	Sep 9, 2020	14,008	155
MVI	Metaverse Index	-20.27	152.10	156.36	Apr 2, 2021	2,054	51
BCT2X-FLI	BTC 2x Flexible Leverage Index	-20.80	17.90	-52.74	May 5, 2021	464	12
sushiHOUSE	Sushi DAO House	-2.30	21.00	23.08	May 27, 2021	4	9
BED	Bankless BED Index	-6.15	16.67	58.17	Jul 16, 2021	527	5
n.a.	The Quant	-3.34	-2.51	13.07	Dec 29, 2020	1,103	4
DATA	DATA Economy Index	-18.48	12.50	-5.90	Sept 17, 2021	n.a.	2
SCIFI	SCIFI Index	2.74	17.62	102.70	Dec 19, 2020	322	2
FAANG	FAANG Index	0.28	3.20	19.65	Feb 21, 2021	17	0.2

[20] Source: TokenSets https://www.tokensets.com/explore?show=featured, consulted on December 24, 2021

Table 8 lists the 10 most important sets available based on their market cap. The most popular fund in terms of number of investors is DeFi Pulse Index (DPI). It is a capitalization-weighted index that tracks the performance of decentralized financial assets. The streaming fees are 0.95%. The fund manager is DeFi Pulse which is the leading website for the latest analytics and rankings of DeFi protocol. It is composed of a total of 17 digital assets whose projects are specialized in decentralized finance. The 5 most important components are Uniswap, Aave, Loopring, Maker and Sushi. The profitability over the last year was 178%.

Chart 8. DPI Share Price Evolution in USD from Dec. 2020 to Dec. 2021[21]

Section 3. Comparison between BlackRock and Set

Both BlackRock and Set offer asset management services to their clients through mutual funds. Each offers a wide variety, with several hundred funds available, based on the risk/return profile as well as the sector/thematic focus that investors are looking for. Although Set is much newer than BlackRock, its offering is already very broad. There are, however, some differences

[21] Source: Coinmarketcap, https://coinmarketcap.com/currencies/defi-pulse-index/historical-data/, consulted on December 24, 2021

in the size of the two entities and the solutions. While BlackRock has several trillion dollars in assets under management, Set has only $180 million. In addition, the size of the funds is also much smaller for Set, whose largest fund has a market cap. of $166m while its counterpart at BlackRock has net assets of $33bn. Of course, one of the reasons for this is that Set launched its first fund in 2019, while BlackRock's first fund was conceived in 1988.

Furthermore, the way the two entities and their funds operate also varies. Each fund offered by BlackRock has been created by a portfolio manager and his team. They are directly employed by the asset manager who pays them a fixed salary and a bonus based on overall performance. The funds offered by Set are, on the other hand, created by managers who are not employed by the protocol. They are only paid by the streaming fees announced in the fund data sheet. Any individual wishing to create his fund can do so and make it available to investors on Sets. The funds available on Sets are generally composed of less than 20 elements. On the contrary, BlackRock funds are very strongly diversified, and the positions held are rarely higher than 6-7% of the total size of the fund.

Finally, fund performance varies greatly from one entity to another. While the best performance over one year is 23% for BlackRock, it is almost 160% for Set. Obviously, this is inherent to the underlying elements of the fund. As we can see by comparing chart 7 and 8, the volatility of the fund representing decentralized finance is much higher than that of the fund representing traditional finance.

Section 4. Conclusion

Can Set replace BlackRock? We do not believe that a strict replacement of BlackRock by Set is possible. According to us, it is rather a question of companies that will coexist and that will be, in the long run, competitors like BlackRock and Vanguard for example.

There are two important points to keep in mind to understand the interest of investors in the solutions offered by mutual funds. The first is the fees that investors must pay. We have found that fees are generally lower for funds managed by BlackRock, although there is a minimum investment of sometimes $1,000 or more. The fees charged by Set fund managers are generally higher with rates that can go up to over 2%. Conversely, there is no minimum investment required to get a share of the fund.

The second important point is that Set already offers funds that include positions that are not directly related to DeFi or the wider crypto-currency and Blockchain world. For example, the FAANG fund tracks the movement of the big 5 US tech stocks, namely Google, Facebook, Apple, Netflix, and Amazon. Therefore, an investor interested in the decentralized side of Set but wanting exposure to existing stocks could buy such a fund.

Finally, we believe that the main advantage of Set over BlackRock is its decentralized nature. This allows for greater transparency and any investor wishing to find information on the protocol, the managers, or any other element that could influence his choice can find it on the Set website. On the other hand, its negative point is the volatility. Most of the funds still have a very high volatility which can slow down the adoption of these funds by conservative passive investors.

Chapter 5. Insurance

Section 1. UnitedHealth Group

1. Description

UnitedHealth Group is an American insurance and health care company located in Minnesota. It was founded in 1977 and ranks among the 500 largest U.S. companies by total revenue. Its market capitalization is $466 billion, making it the largest insurer in the world in terms of market capitalization.

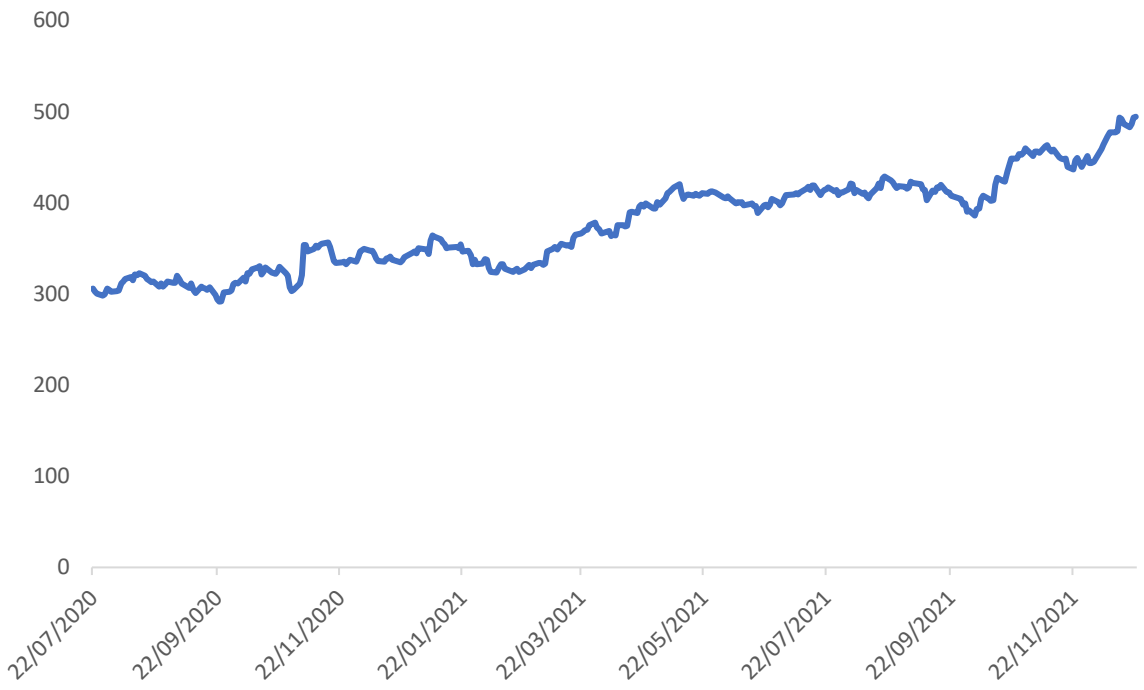


Chart 9. UNH Share Price Evolution in USD from Jul. 2020 to Dec. 2021[22]

[22] Source: Yahoo finance, https://finance.yahoo.com/quote/UNH/ , consulted on December 24, 2021

2. Services offered by UnitedHealth Group

UnitedHealth Group focuses on health insurance, drug plan management and administrative management, ranging from reimbursement to patient complaints and claims. The company also offers IT services. These focus on consulting, development and integration of transaction management solutions, health plan management and data processing.

The different coverage plans are divided into 3 distinct categories: Medicare and Medicaid plans, health and supplement plans and employer plans.

The first category includes the following solutions:

- Medicare: for people 65+ or those who qualify due to a disability or special situation
- Medicaid: for people with lower incomes
- Dual Special Needs Plans: for people who qualify for both Medicaid and Medicare

The second category includes the following solutions: health insurance plans, supplemental insurance plans, dental plans, vision plans, short term health insurance, Affordable Care Act (ACA) plans, health plans through work.

The last category concerns:

- Small business plans: group health insurance for companies with 2 to 50 employees.
- Midsize business plans: variety of group health insurance for companies with more than 51 employees including vision, dental, pharmacy options.
- National accounts: health care benefits programs for companies with more than 5,000 employees. The range of products includes medical and pharmacy plans to ancillary and specialty benefits such as dental, vision and life insurance
- Group health insurance basics

Each plan is adapted and individualized according to many parameters such as the state of residence, the age of the applicant, whether he or she is a smoker or not. Some programs are complementary and can be added together to provide greater coverage.

Section 2. Nexus Mutual

1. Description

Nexus Mutual (NXM) is a decentralized insurance solution aimed at serving as an alternative to traditional forms of insurance. This company relies on blockchain technology and uses it to create risk sharing pools. This system is developed in the form of a mutual insurance company to which users can subscribe. Nexus Mutual is built on the Ethereum blockchain and therefore allows anyone to subscribe to it. Its principle is based on a DAO and therefore allows its members to take part. By actively participating in the development, notably through votes, users receive economic incentives. NXM's market capitalization is $888 million (December 26, 2021). As of September 2021, the total coverage provided amounted to about $700m, while the staking pool was about $1 billion in size (Allison, 2021).

Chart 10. NXM Share Price Evolution in USD from Jul. 2020 to Dec. 2021[23]

[23] Source: Coinmarketcap, https://coinmarketcap.com/currencies/nxm/, consulted on December 24, 2021

2. Features and services covered by NXM

Nexus Mutual provides protocol and custody coverage for users of smart contract technology platforms.

The protocol risks covered are the following:

- Code is used unintentionally: when malicious code is embedded in a smart contract and executed by an unfortunate user.
- Economic design flaw
- Governance attack: a governance attack can occur when a user proposes a solution to a problem and the users give their approval or not through a vote. A malicious person can then attach a personal address to the proposed solution and extort funds from users who did not bother to understand the proposed smart contract solution.
- Protection for assets using layer 2 solutions: consists in protecting users using services and assets operating under layer 2.
- Protection for smart contracts not operating on the Ethereum blockchain
- Protection for a protocol available on several chains

The custody risks covered are as follows:

- The custodial platform has a suffered a computer attack and has been hacked. The user lost more than 10% of the funds he had placed on it.
- Withdrawals from the custodian platforms have been interrupted or blocked for a period of more than 90 days.

Nexus Mutual is also responsible for intervening in cases of lost tokens. The platform does not guarantee protection against devaluation of tokens but when they are lost during a transaction or on a depository platform.

Nexus Mutual also offers comprehensive protection for assets exposed to multiple underlying protocols. This hedging offer is called "Yield Token Cover" and covers the risks associated with smart contracts arising from these underlying protocols.

Section 3. Comparison between UnitedHealth Group and Nexus Mutual

In terms of capitalization, UnitedHealth is 480 times larger than Nexus Mutual. This is due to two reasons. The first is that UnitedHealth is a much longer established entity, it was founded in 1977 while Nexus Mutual was only listed in 2020. The second reason is that health insurance is a necessity in the US. Therefore, almost every citizen has at least one, allowing UnitedHealth to have a strong customer base. In contrast, Nexus Mutual's insurance offerings have yet to gain a reputation. However, its significant growth since its listing and the fact that it is the first insurer in decentralized finance indicates a growing interest in the solutions offered. Over the period July 2020 to December 2021, Nexus Mutual grew by a total of 1688% while UnitedHealth's growth was 62% for the same period. Although Nexus Mutual's growth is much higher, UnitedHealth's growth is still very good and shows a growing interest in insurance. This is especially true given the current climate due to covid-19.

In terms of services offered, the two entities are drastically different. While one offers insurance mainly concerning health, the second offers insurance to cover the risks related to the use of a blockchain and the underlying smart contracts. The first one is therefore an insurance covering health risks while the second one covers IT risks.

Insurance management is also very different. On the one hand, UnitedHealth is a traditional insurer that determines the premium amount internally and decides on governance. On the other hand, Nexus Mutual is completely decentralized and its management depends on its users. It is the sharing of risk among users that allows them to be covered.

Section 4. Conclusion

Could Nexus Mutual replace UnitedHealth? Currently this is clearly not possible. A person wishing to cover their health risk and obtain health insurance would not be able to do so through Nexus Mutual. However, a DAO would democratize the cost of health insurance and could compete with traditional insurers.

Chapter 6. Payment Service Provider

Section 1. Paypal

1. Description

Paypal is a company created in 1998 in Silicon Valley and is the product of a merger between two companies: Confinity (Peter Thiel) and X.com (Elon Musk). Its dazzling success pushed Ebay to buy the company in 2002, which was then looking for more secure payment services for its products (Capital, 2015).

The company is the leader in online electronic payments and allows all types of users, whether they are buyers or sellers, to trade online. The service is deployed in more than 200 countries and currently has more than 250 million users. Its market capitalization is $220 billion (December 14, 2021).

2. How Paypal works

Paypal is a digital service that allows individuals and businesses to pay for goods or services online directly. Users of the platform must create an account by filling in their personal information. They associate a bank, debit or credit card and are charged the amount paid on the Internet when they make a payment.

The company also allows its users to send or receive money from third parties. The money received or sent can be used to pay for goods or services but can also be stored in the Paypal account.

The service also allows money to be transferred to credit cards associated with the account. If you sell an item on Amazon or an online store, this money can be transferred directly to your bank account through Paypal (Henderson, 2020).

3. Features of Paypal

Paypal offers a unique payment solution to its customers allowing them to access all the services and features offered by the company.

It is a digital service that allows individuals and businesses to pay for goods or services online directly. Users of the platform must create an account by filling in their personal

information. They associate a bank, debit or credit card and are charged the amount paid on the Internet when they make a payment.

Paypal also allows its users to send or receive money from third parties. The money received or sent can be used to pay for goods or services but can also be stored in the Paypal account.

The service also allows money to be transferred to credit cards associated with the account. If you sell an item on Amazon or an online store, this money can be transferred directly to your bank account through Paypal.

The company has a key reputation, due to its seniority, but also offers affordable services for smaller retailers. Paypal also guarantees increased protection for its users and in particular buyers.

If an item does not conform to its description or does not correspond to what the customer was looking for, the company will refund the amount paid to the customer. Paypal has also set up a system of possible litigation in case of fraud or suspicion of fraud. The sellers also benefit from a protection on behalf of the company because this one requires guarantees on behalf of the salesman to prove his good faith vis-a-vis a malicious purchaser.

PayPal also offers a secure solution for its payments concerning the protection of the data and identities of its users. Indeed, thanks to its system of accounts linked to an email address and phone number, sellers do not have the private details of buyers.

Finally, the service allows users of tablets or smartphones to benefit from an application to make transactions.

Section 2. MetaMask

1. Description

MetaMask is a wallet based on the Ethereum blockchain and operating through a plugin directly installed on the Internet browser. This digital wallet allows users to store ETH and other ERC-20 or ERC-721 tokens. With this, users can make transactions to any other address on the Ethereum network (Hussey and Phillips, 2020). The project was born in 2016 and was designed by two developers: Aaron Davis and Dan Finley. These entrepreneurs were supported by the Ethereum ConSensys incubator. The goal of the project was then to make it possible for

its users to interact with their favorite dApps through a revolutionary and easy-to-use tool: the MetaMask wallet.

MetaMask allows users to have access to many decentralized applications and to interact with the Ethereum Blockchain without directly owning a copy of it and thus becoming a node. This remains exclusive to the developers and validators of the network.

2. How MetaMask works

MetaMask is powered by a computer coding library called web3.js. It is part of the Ethereum project and has been made available to developers to allow interoperability between the Ethereum blockchain and web applications.

MetaMask has a dual purpose as it is both a tool to interoperate with dApps and a digital wallet for Ethereum. To link the two uses, MetaMask establishes a communication channel between the web extension and the dApp in question. When the dApp is active, users can perform actions or tasks authorized by it. Examples are numerous: exchange of tokens (ERC-20, ERC-721), purchase or resale of NFT or access to services offered by third party sites.

When MetaMask users use their wallet to make transactions, they must pay a transaction fee. These fees are paid in Ethereum and are directly withdrawn from the users' wallets. MetaMask takes care of controlling and charging the transaction fees to the users via smart contracts.

3. Features of MetaMask

MetaMask allows to buy, sell, store or swap tokens. All these operations are obviously secured by a powerful cryptographic system. The web extension as well as the application of the service allows its users to benefit from an ultra-secure digital safe.

Section 3. Comparison between Paypal and MetaMask

Paypal and MetaMask both offer the possibility for their users to store money in their digital wallet. Paypal offers a centralized service, where users' money flows through their servers and they have the option to leave their cash online or transfer it to their bank accounts whenever they want. MetaMask, on the other hand, offers its users the possibility to store

Ethereum directly on the digital wallet. They must have tokens based on ERC-20 or ERC-721. It is not possible for MetaMask to let its users have real currencies or stablecoins.

The services offered by Paypal and MetaMask differ in various ways because their practical use is currently not comparable. Indeed, the services offered by Paypal extend to many webs uses while MetaMask only operates on the possible applications based on the blockchain. Paypal offers its users the possibility to use its services to make transactions with sites such as Ebay or Amazon. The company also allows its users to have a cryptocurrency wallet where they can buy, sell, or store cryptocurrencies through a digital wallet integrated with Paypal servers. However, users do not have private keys, indicating that the cryptocurrencies are not held directly by the users but by Paypal itself. MetaMask serves as an intermediary for services directly related to the blockchain such as Maker, Uniswap, Aave, Compound, Axies, Rarible, Gitcoin or OpenSea. MetaMask is also used by many sites offering the purchase or sale of NFTs since the digital wallet is secure, reliable and guarantees its users to be in total control of the actions they wish to perform on the blockchain. Thanks to the technology developed by MetaMask, users do not have to download the entire Ethereum blockchain since the channel system developed by MetaMask allows its users to use the

In terms of security, Paypal offers a recognized, secure, reliable, and centralized service. The data is contained on their servers, but the users keep the guarantee that the third parties they interact with do not have it at their disposal. MetaMask generates passwords and private keys on its users' devices that only they can retrieve. Users are the only ones who have access to these passwords and keys and are therefore the sole guarantors of their private data. MetaMask does not store any data and its users are then the only ones able to choose what can be shared with third parties and what must remain private. Wallet keys are stored on the users' local browser and no data is stored on MetaMask's servers.

Section 4. Conclusion

Could MetaMask replace Paypal? Since MetaMask is a payment solution only valid for services based on or in partnership with the Ethereum Blockchain, it does not seem possible to consider it as a replacement for Paypal which is usable for most online purchases. However, if we go back a few years Paypal was far from being accepted by all online businesses. Therefore, a popularization of the use of MetaMask is possible if merchants see an interest in it.

As we have seen, the adoption of crypto currencies is more important in some countries. As a result, payment solutions allowing payment with them would develop more rapidly in these countries. The increase in the number of acceptances of MetaMask by the various platforms depends largely on the acceptance among citizens and consumers of crypto currencies as a new means of payment. Paypal itself believes that the world is following this trend since the recent ability to purchase crypto currencies through its interface directly. However, the crypto currencies purchased through Paypal are not directly held by the buyer who cannot put them on a wallet.

Chapter 7. Supervisory and Regulatory Body

Section 1. European System of Financial Supervision

The European system of financial supervision is composed of 4 complementary entities.

1. ESRB

The European Systemic Risk Board (ESRB) is a European body responsible for the supervision of the activities carried out by the financial system of the European Union. The organization also works to prevent and reduce systemic risks that may emerge from this sector of activity. The ESRB covers banks, insurers, alternative banks, asset managers and other related institutions operating in the markets. It is therefore used to assess risks, issue alerts and warnings but also to give recommendations.

2. EBA

The European Banking Authority (EBA) is an independent body of the European Union. Its role is to apply regulation and close supervision of the European banking sector. It ensures that the integrity and stability of the European Union is maintained.

It contributes to the creation of a single European regulation for the banking sector. It ensures the efficiency and the functioning of the sector. The EBA was established in 2011 and is responsible for the existing tasks of the Committee of European Banking Supervisors.

3. ESMA

The European Securities and Markets Authority (ESMA) is a completely independent body of the EU. Its role is to protect investors by ensuring the stability of the financial system.

It also collaborates with other European supervisory bodies such as the European Supervisory Authorities (EBA) and the European Insurance and Occupational Pensions.

ESMA is accountable to the major European bodies and in particular to the European Parliament. It reports regularly on its work through meetings and an annual report published on its website.

4. EIOPA

The European Insurance and Occupational Pensions Authority (EIOPA) is an independent body of the European Commission as well as of the EU Parliament and Council. Its work is not only legal but also technical and scientific. It provides independent advice and fair and neutral recommendations. Its contribution helps in the drafting of new laws at national and European level. Together with EBA and the European Securities and Markets Authority (ESMA), EIOPA constitutes a European supervisory authority.

Section 2. Supervisory and Regulatory body in DeFi

Currently, there is no regulation of the DeFi within the large. There is neither a legal framework nor an institution specifically in charge of supervising and regulating the DeFi sphere. However, given the growing interest of the public and the multiplication of offers and solutions offered in the world of crypto-assets, DeFi, etc., some institutions have decided to investigate the matter. For example, the European Capital Markets Institute (ECMI) published in October 2021 a special dedicated regime for crypto-asset providers. The objective of this proposal is the creation of a Markets in Crypto Assets (MiCA) regulation. This would first allow a clear definition of what is included in the notion of crypto assets as well as the simplification of the European supervision architecture.

This is not the first publication of this kind. Indeed, in 2019, the European Commission had published a "proposal for a regulation of the European Parliament and of the Council on Markets in Crypto-assets". The objective of this proposal was to highlight several measures to support the potential of digital finance in terms of innovation and competition while minimizing the risks.

These two examples are currently only at the proposal stage and there are no clear and fixed rules for all DeFi players yet. These proposals specifically concern crypto assets. However, we have seen that some DeFi protocols do not have their own tokens making it impossible to apply this type of measures. Moreover, the regulators have also noted that since the DeFi is a global market, there is a need for global regulation for it to be functional. Thus, it is necessary that the different regulators in the world agree on a common policy to adopt.

Section 3. Conclusion

Given the global and borderless nature of DeFi solutions, the various regulatory bodies have noted the need for global regulation. We live in an increasingly globalized world where globalization has almost reached its paroxysm and the solutions related to Blockchains are the best example. Let's note that the regulation of the sector is not seen with a bad eye by the users. The regulation adapted to the vision and the needs of the developers and users would allow to eliminate the bad projects as well as those which have bad intentions towards the investors. Although there is no regulation now, there is a system of external auditing to verify the validity, security and credibility of the different projects. This is not an obligation, but it allows informed users to see the legitimacy of the various projects and protocols.

Conclusion

The financial sector and the financial system are concepts that have been implemented in our lives for centuries. They have evolved from a simple barter between individuals to a perfectly organized system of many actors that maintains the global economy. However, in the last few years a new concept has come to disrupt the existing system, making us think that an alternative financial system is possible. This one removing the need for trusted intermediaries that had to be implemented with globalization and the increase of exchanges. Trusted intermediaries such as banks, insurance companies or asset managers are only the result of the increase and complexity of exchanges between individuals. The same is true for the creation of money, which is the commonly accepted translation of the concept of value that enables these exchanges.

After the advent of Bitcoin, more and more supporters saw Blockchain as an opportunity to disrupt an existing system. Decentralized finance is one example. In the last few years, a whole new ecosystem has been created to provide all the necessary systems for a decentralized parallel financial system to exist. The latter does not need a trusted third party and allows any individual to directly contribute to the governance and development of the system and the proposed services.

The first part of this thesis allowed us to understand the current financial system, its components as well as what the Blockchain is and what it includes. The Bitcoin as a new currency has allowed us to highlight the first step of a new mode of payment and the smart contracts have allowed us to understand how the absence of a trusted third party is not an illusion but a real possibility. After having taken the state of the field, we were able to conduct our various comparative qualitative analyses to understand the differences between the components of traditional finance and those of decentralized finance. These comparisons allowed us to better understand the state of decentralized finance and how it can compete with the traditional financial system.

However, it is important to mention that given the recent nature of this new technology that is the Blockchain, and the solutions offered by DeFi, there are still many areas of darkness and possible improvement. DeFi is still in its infancy and the different existing protocols are constantly being improved to increase the services offered as well as their quality.

1. Could Decentralized Finance replace Traditional Finance?

To try to answer this question we have taken different examples that we have compared to highlight the similarities and differences of each component of a financial system. This comparative analysis allowed us to identify 3 observations that allow us to answer our question.

First, we found that each component of decentralized finance grew much more than its namesake in traditional finance over the same period. This exponential growth may reflect massive adoption by individuals. The growing interest of users is an important indicator because if they turn to these kinds of new solutions, it is because they feel a lack in traditional solutions. Of course, the number of users of traditional solutions is much larger in absolute terms. This is partly because decentralized finance solutions do not (yet) meet all the needs of citizens. The best example is probably health insurance. Although insurance exists in DeFi, it does not yet cover all the risks known in society. This does not mean that DeFi cannot meet these needs, but that it does not yet meet them. We can therefore see that on the one hand the offer is more complete in traditional finance, while on the other hand there is a growing interest in decentralized finance.

A second finding we made concerns the way products are offered to individuals. The constraints that must be respected to benefit from a particular service (loan, investment in a mutual fund, etc.) are less important for decentralized finance. Moreover, the services are also less individualized. For example, in the case of a loan, everyone wishing to borrow a certain crypto currency at a given time will have to pay the same interest rate. On the contrary, in addition to these constraints, others are added in the case of a loan via the traditional system and the profile of the borrower will also define the amount of interest he will have to pay. It is partly for this reason that DeFi and the use of crypto currencies have seen a significant boom in developing countries in South America and Africa. People excluded from the financial system for one reason, or another are becoming integrated and able to borrow through DeFi, which is less restrictive and discriminating than traditional finance. It is important to keep in mind that the objective of the developers and creators of DeFi protocols is not to find the exact DeFi solution like a traditional finance solution but rather to meet a need that allows the whole ecosystem to function and be inter-correlated. This is also why the two systems do not work in the same way and do not offer the same products.

The third observation concerns regulation. Where a comprehensive and well-functioning system allows for the evaluation, supervision, and regulation of the traditional financial system, DeFi is currently almost completely devoid of it. This lack of global regulation is one of the elements that makes it difficult to answer our question. It is difficult to predict how regulators will position themselves in relation to DeFi. Although there are some publications and proposals, there is nothing concrete yet, especially at the international level. Regulators may therefore decide to completely ban the use of this type of system, blocking the evolution that DeFi is experiencing today. Even if this seems unlikely given the existing proposals, it is not impossible. On the other hand, if the regulator decides to put a clear legal framework in favor of the DeFi, it could reassure many individuals thinking that it is a scam or a simple speculation tool. It is therefore too early to determine what the future of DeFi will be.

To conclude, we believe that as things stand, DeFi will not replace the traditional financial system. Certain advantages such as security, transparency and efficiency will allow DeFi to take its place in the daily life of the world's citizens. Moreover, we rather envision a future where the traditional system and the decentralized system will coexist. This can also be justified by the fact that more and more players of the traditional system have started to develop research centers in Blockchain, and some are therefore ready to adapt to the observed trend.

2. Limits of our thesis

We must remain critical of our conclusions because like any study, our thesis has certain limitations.

Regarding our comparative analysis, it is based on one example of each of the two systems. These do not necessarily represent all the actors involved. To have a more complete, representative, and exhaustive analysis, it would be necessary to enlarge our sample.

Furthermore, the current state of regulation regarding crypto-currencies and DeFi makes the potential future of these uncertain and makes part of our analysis hypothetical.

Finally, as we have seen the different projects of DeFi have grown exponentially and every day new projects are developed. All this makes the field of study more complex and the analyses quickly obsolete. For example, when writing our study, we selected, when we could, the most capitalized DeFi projects. However, given the volatility of the projects, these have since been dethroned.

3. Further paths of analysis

We have confined ourselves to studying the DeFi by taking only the constituent elements of a financial system as defined by the MFI. However, DeFi encompasses even more actors fulfilling other roles. It would therefore be relevant to study the DeFi as its own innovative system or ecosystem. We can ask ourselves how DeFi as an independent and self-sufficient ecosystem can fulfill all the needs of individuals and citizens? Why is transparency an attractive feature for DeFi users and why do they turn away from traditional finance? Given the systemic nature of banks and the components of the broader financial system, does DeFi maintain such stability? All these questions deserve to be studied in order to better understand the stakes of DeFi and its implication in the future world.

Bibliography

Scientific Articles

Arrow, K.J. (1972). Gift and Exchanges. *Philosophy & Public Affairs*, 1 (4), 343-362. https://www.jstor.org/stable/2265097.

Bach, L.M., Mihaljevic, B., & Zagar, M. (2018). Comparative Analysis of Blockchain Consensus Algorithms. *IEEE*, 1545-1550. DOI: 10.23919/MIPRO.2018.8400278.

Bamakan, S.M.H., Motavali, A., & Bondarti, A.B. (2020). A survey of blockchain consensus algorithms performance evaluation. *Expert Systems With Applications*, 154 (2020). https://doi.org/10.1016/j.eswa.2020.113385.

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, 2663-2683.

Bencic, F.M., Zarka, I.P. (2018). Distributed Ledger Technology: Blockchain Compared to Direct Acyclic Graph. *IEEE*, 38,1569-1570. DOI 10.1109/ICDCS.2018.00171.

Bentov, I., Gabizon, A., & Mizrhi, A. (2014). Cryptocurrencies without Proof of Work.

Buterin, V., Reijsbergen, D., Leonardos, S., & Piliouras, G. (2019). Incentives in Ethereum's hybrid Casper protocol. *International Journal Network Management*, DOI: 10.1002/nem.2098.

Cao, B., Zhang, Z., Feng, D., Zhang S., Penge, M., & Li, Y. (2020). Performance analysis and comparison of PoW, PoS, and DEG based blockchains. *Digital Communications and Network*, 6 (2020), 480-485. https://doi.org/10.1016/j.dcan.2019.12.001.

Chowdhury, M.J.M., Colman, A., Kabir, M.A., Han, J., & Sarda, P. (2018). Blockchain versus Database: A Critical Analysis. *IEEE*, 17, 1348-1353. DOI 10.1109/TrustCom/BigDataSE.2018.00186.

Chowdhury, M.J.M., Ferdous, S., Biswas, K., Chowdhury, N., Kayes, A.S.M., Alazab, M., & Watters, P. (2019). A Comparative Analysis of Distributed Ledger Technology Platforms, IEEE, 7, 167930-167943. DOI 10.1109/ACCESS.2019.2953729.

Detzel, A., Liu, H., Strauss, J., Zhou, G., & Zhu, Y. (2020). Learning and predictability via technical analysis: Evidence from bitcoin and stocks with hard-to-value fundamentals. *Financial Management*, 50 (1), 107-137. https://doi-org.proxy.bib.ucl.ac.be:2443/10.1111/fima.12310.

Dib, O., Durand, A., & Brousmiche, K.-L. (2018). Consortium Blockchains: Overview, Applications and Challenges. *International Journal on Advances in Telecommunications*, 11(1&2), 51-64. hal-02271063.

Duhamel, J., Fasterling, B. & Refait-Alexandre, C. (2009). La transparence : outil de conciliation de la finance et du management. *Revue française de gestion*, 198-199, 59-75. https://doi.org/.

Flouzat, D. (2012). Stabilisation du système financier et croissance. *Vie & sciences de l'entreprise*, 191-192, 206-219. https://doi.org/10.3917/vse.191.0206.

Freni, P., Ferro, E., & Moncada, R. (2020). Tokenization and Blockchain Tokens Classification: a morphological framework. *IEEE*. DOI: 10.1109/ISCC50000.2020.9219709.

Frizzo-Barker, J., Chow-White, P.A., Adams, P.R., Mentanko, J. Ha, D., & Green, S. (2020). *International Journal of Information Management*, 51 (2020). https://doi.org/10.1016/j.ijinfomgt.2019.10.014.

Garg, P., Gupta, B., Chauhan, A.K., Sivarajah, U, Gupta, S, & Modgil, S. (2020). Measuring the perceived benefits of implementing blockchain technology in the banking sector. *Technological Forecasting & Social Change*. https://doi.org/10.1016/j.techfore.2020.120407.

Guimaraes, T., Silva, H., Peixoto, H., & Santos, M. (2020). Modular Blockchain Implementation in Intensive Medicine. *Procedia Computer Science*, 170(2020), 1059-1064. DOI:10.1016/j.procs.2020.03.

Guo, Q., He, Q.-C., Chen, Y.-J., & Huang, W. (2020). Poverty mitigation via solar panel adoption: Smart contracts and targeted subsidy design. *Omega*. https://doi.org/10.1016/j.omega.2020.102367.

Han, D., Zhang, C., Ping, J., & Yan, Z. (2020). Smart contract architecture for decentralized energy trading and management based on blockchains. *Energy*, 199 (2020). https://doi.org/10.1016/j.energy.2020.117417.

Hazari, S.S., & Mahmoud, Q.J. (2019). Comparative evaluation of consensus mechanisms in cryptocurrencies. *Internet Technology Letters*, 2 (3). https://doi.org/10.1002/itl2.100.

Hewa, T., Ylianttila, M., & Liyanage, M. (2020). Survey on blockchain based smart contracts: Applications, opportunities, and challenges. Journal of Network and Computer Application. https://doi.org/10.1016/j.jnca.2020.102857.

Hochard, P. (2020). L'apparition de la monnaie frappée : invention ou innovation ? Bilan historiographique et enjeux historiques. Dialogues d'histoire ancienne, 20, 15-34. https://doi-org.proxy.bib.ucl.ac.be:2443/10.3917/dha.hs20.0015.

Jaward, K., & Jihad, J. (2020). Deposit Insurance System and Its Role in Enhancing Public Confidence in the Banking Sector in Order to Achieve Economic Development: An Iraq Case Study. *International Journal of Innovation, Creativity and Change*, 13 (5), 1124-1134.

Katsiampa, P. (2019). An empirical investigation of volatility dynamics in the cryptocurrency market. *Research In International Business and Finance*, 50 (2019), 322-335.

Kayal, P., & Balasubramanian, G. (2021). Excess Volatility in Bitcoin: Extreme Value Volatility Estimation. IIM Kozhikode Society & Management Review, 10 (2), 222-231. https://doi-org.proxy.bib.ucl.ac.be:2443/10.1177/2277975220987686.

Khan, F.A., Asif, M., Ahmad, A., Alharbi, M, & Aljuaid, H. (2020). Blockchain technology, improvement suggestions, security challenges on smart grid and its application in healthcare for sustainable development. *Sustainable Cities and Society*, 55 (2020). https://doi.org/10.1016/j.scs.2020.102018.

Leshno, J, & Strack, P. (2019). Bitcoin: an impossibility theorem for proof-of-work based protocols. Cowles foundation discussion paper, 2204.

Lohmer, J., & Lash, R. (2020). Blockchain in operations management and manufacturing: Potential and barriers. Computers & Industrial Engineering, 149 (2020). https://doi.org/10.1016/j.cie.2020.106789.

Liu, X., Muhammad, K, Lloret, J., Chen, Y.-W., & Yuan, S.-M. (2019). Elastic and cost-effective data carrier architecture for smart contract in blockchain. *Future Generation Computer Systems*, 100 (2019), 590-599. https://doi.org/10.1016/j.future.2019.05.042.

Lo, S., & Wang, J.C. (2014). Bitcoin as Money? *Current Policy Perspectives*, 14 (4).

Marinici, D., Cartofeanu, C., & Gao, S. (2018). Smart contract applications within blockchain technology: A systematic mapping study. *Telematics and Informatics*, 35 (2018), 2337-2354. https://doi.org/10.1016/j.tele.2018.10.004.

Mien, E. & Staes, A. (2019). Les trois fonctions de la monnaie. *Regards croisés sur l'économie*, 24, 82-88. https://doi-org.proxy.bib.ucl.ac.be:2443/10.3917/rce.024.0082

Mingxiao, D., Xiaofeng, M., Zhe, Z., Xiangwei, W, & Qijun, C. (2017). A Review on Consensus Algorithm of Blockchain. *IEEE*, 2567-2572.

Noyer, C. (2010). Régulation et confiance. *Revue d'économie financière*, 100, 111-122. DOI : https://doi.org/10.3406/ecofi.2010.5826

Orain, A. (2007). Le rôle des préférences individuelles dans la controverse Condillac-Le Trosne sur la valeur et les prix. *Cahiers d'économie Politique*, 52, 7-30. https://doi.org/10.3917/cep.052.0007

Pan, X., Pan, X., Song, M., Ai, B., & Ming, Y. (2020). Blockchain technology and enter^rise operational capabilities: an empirical test. *International Journal of Information Management*, 52 (2020). https://doi.org/10.1016/j.ijinfomgt.2019.05.002.

Panwar, A., & Bhatnagar, V. (2020). Distributed Ledger Technology (DLT): The Beginning of a Technological Revolution for Blockchain. *IEEE*, 1-5, doi: 10.1109/IDEA49133.2020.9170699.

Parizi, R.M., Dehghantanha, A., & Singh, A. (2018). Smart Contract Programming Languages on Blockchains: An Empirical Evaluation of Usability and Security. *Springer International Publishing*, 1-17. DOI: 10.1007/978-3-319-94478-4_6.

Patriat, L. (2016). Le rôle du secteur de l'assurance dans le développement. Techniques Financières et Développement, 122, 7-14. https://doi.org/10.3917/tfd.122.0007

Pelletier, G.-R. (1977). Three Bicentenaries: Hume, Condillac, Smith: Adam Smith between Marginalism and Marxism. *L'Actualité économique*, 53 (1), 44-64. https://doi.org/10.7202/800711ar.

Perrin, A. (2019). Le bitcoin et le droit : problématiques de qualification, enjeux de régulation. Gestion & Finances Publiques, 1, 84-93. https://doi-org.proxy.bib.ucl.ac.be:2443/10.3166/gfp.2019.00014.

Poon, J., & Dryja, T. (2016). The Bitcoin Lightning Network: Scalable Off-Chain Instant Payments. Retrieved from https://lightning.network/lightning-network-paper.pdf.

Ren, W., Hu, J., Zhu, T, Ren Y, & Choo K.-K. R. (2020). A flexible method to defend against computationally resourceful miners in blockchain proof of work. *Information Sciences*, 507 (2020), 161-171. https://doi.org/10.1016/j.ins.2019.08.031.

Sankar, L.S., Sindhu, M., & Serthumadhavan, M. (2017). Survey of Consensus Protocols on Blockchain Applications. *IEEE*, 4, 1-5, DOI 10.1109/ICACCS.2017.8014672.

Singh, A., Parizi, R.M., Zhang, Q., Choo, K.-K., & Dehghantanha, A. (2020). Blockchain smart contracts formalization: Approaches and challenges to address vulnerabilities. Computers & Security, 88 (2020). https://doi.org/10.1016/j.cose.2019.101654.

Suciu, G., Vulpe, A., Nadrag, C., Ditu, M.-C., Istrate, C., & Subea, O. (2018). Comparative Analysis of Distributed Ledger Technologies. *IEEE*, 6, 370-373.

Szabo, N. (1996). Smart Contracts: Building Blocks for Digital Free Markets. Extropy Journal of Transhuman Thought, 16.

Tas, R., & Tanriover, O.O. (2019). Building A Decentralized Application on the Ethereum Blockchain. *IEEE*. DOI: 10.1109/ISMSIT.2019.8932806

Viglianisi, E., Ceccato, M., & Tonella, P. (2020). A federated society of bots for smart contract testing. *Journal of Systems and Software*, 168. https://doi.org/10.1016/j.jss.2020.110647.

Wamba, S.F., Queriroz, M.M., & Trinchera, L. (2020). Dynamics between blockchain adoption determinants and supply chain performance: An empirical investigation. *International Journal of Production Economics*, 229 (2020). https://doi.org/10.1016/j.ijpe.2020.107791.

Wang, Y., Singgih, M., Wang, J., & Rit, M. (2019). Making sense of blockchain technology: (How) sill it transforms supply chains? *International Journal of Production Economics*, 211, 221-236. https://doi.org/10.1016/j.ijpe.2019.02.002.

Wu, K., Ma, Y., Huang, G., & Liu, X. (2019). A first look at blockchain-based decentralized applications. *Software Practice and Experience*, 51(4), 1-18. DOI: 10.1002/spe.2751.

Xu, X. (2020). Towards Automated Migration for Blockchain-based Decentralized Application. *IEEE*.

Zheng, Z., Xi, S., Dai, H., Chen, X., & Wang, H. (2017). An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends. *IEEE*, 6, 557-564. DOI 10.1109/BigDataCongress.2017.85.

Articles

Acheson, N., Nguyen, H., Biggs, J., & Tan, E. (2018, February 23). What is Bitcoin's Lightning Network? *CoinDesk*. Retrieved from https://www.coindesk.com/learn/what-is-bitcoins-lightning-network/.

Amadeo, K. (2021, January 27). What is the New York Stock Exchange, and how does it woark? *The balance*. Retrieved from https://www.thebalance.com/what-is-the-new-york-stock-exchange-3306243.

Bernie, I. (2018). Amsterdam, l'entrepôt du monde au XVIIe siècle. *Futura Sciences*. Retrieved from https://www.futura-sciences.com/sciences/questions-reponses/epoque-moderne-amsterdam-entrepot-monde-xviie-siecle-10047/.

Bitcoinik. (2020, August 27). Risks Involved in Decentralized Finance (DeFi). *Bitcoinik*. Retrieved from https://bitcoinik.com/risks-involved-in-decentralized-finance-defi/

Blockchain France (2016, May 12). Qu'est-ce qu'une DAO. *Blockchain France*. Retrieved from https://blockchainfrance.net/2016/05/12/qu-est-ce-qu-une-dao/.

Clément, G. (2019). Qu'est-ce qu'une banque d'affaires? *Le Revenu*. Retrieved from https://www.lerevenu.com/finances-privees/banque/quest-ce-quune-banque-daffaires.

Comité de Bâle sur le contrôle bancaire. *Finma*. Retrieved from https://www.finma.ch/fr/finma/cooperation-internationale/policies-et-reglementation/cbcb/.

Concepta. (2019, February 27). What is the difference between front-end and back-end development? *Concepta*. Retrieved from https://www.conceptatech.com/blog/difference-front-end-back-end-development.

Consensys. (2021). 11 ways Ethereum can benefit enterprise. *Consensys*. Retrieved from https://consensys.net/enterprise-ethereum/best-blockchain-for-business/11-ways-ethereum-can-benefit-enterprise/.

Cimpanu, C. (2018). Hacker Makes Over $18 Million in Double-Spend Attack on Bitcoin Gold Network. *Bleeping Computer*. Retrieved from https://www.bleepingcomputer.com/news/security/hacker-makes-over-18-million-in-double-spend-attack-on-Bitcoin-gold-network/.

Daily, A., Hanson, M., Kirkpatrick, K., & Spiegler, T. (2021, September 1). Decentralized Finance – Risks, Regulation, and the Road Ahead. *JD Supra*. Retrieved from https://www.jdsupra.com/legalnews/decentralized-finance-risks-regulation-9351911/.

Dansa, A. (2021, June 12). Une revue du protocole DeFi Aragon: le pouvoir des organisations autonomes décentralisées (DAO). *Be in crypto*. Retrieved from https://fr.beincrypto.com/technologie/27732/revue-protocole-defi-aragon-organisations-autonomes-decentralisees-dao/.

de Best, R. (2021). Maximum and current supply of various cryptocurrencies worldwide as of November 22, 2021. *Statista*. Retrieved from https://www.statista.com/statistics/802775/worldwide-cryptocurrency-maximum-supply/.

Dhir, R. (2021). Investment Banks vs. Merchant Banks: What's the difference. *Investopedia*. Retrieved from https://www.investopedia.com/ask/answers/05/investmentbank_vs_merchantbank.asp.

Doyle, M. (2021). Building A Decentralized Future With dApps. *The world we create*. Retrieved from https://theworldwecreate.net/insights/building-a-decentralized-future-with-dapps.

European Central Bank. (2017, June 20). Qu'est-ce que la monnaie? Retrieved from https://www.ecb.europa.eu/ecb/educational/explainers/tell-me-more/html/what_is_money.fr.html.

Frankenfield, J. (2021, May 26). Smart Contracts. *Investopedia*. Retrieved from https://www.investopedia.com/terms/s/smart-contracts.asp.

Frankenfield, J. (2021, December 22). Ethereum. *Investopedia*. Retrieved from https://www.investopedia.com/terms/e/ethereum.asp

Godoy Hilario, P. (2021, January 8). Bitcoin: utilisateurs de portefeuilles Blockchain dans le monde T1 2015-2020. *Statista*. Retrieved from https://fr.statista.com/statistiques/665756/nombre-detenteurs-portefeuille-bitcoin-sur-blockchain-monde/.

Goldmann, M. (2019, September 16). App vs. dApp. *Cryptopolitan*. Retrieved from https://www.cryptopolitan.com/app-vs-dapp/.

Hamza, N. (2020, May 2). Qu'est-ce que le secteur bancaire et financier ? *Parlons finance.* Retrieved from https://www.parlonsfinance.be/index.php/2020/05/02/quest-ce-que-le-secteur-bancaire-et-financier/.

Haar, R. (2021, August 12). Ethereum: what you should know before you invest. *NextAdvisor*. Retrieved from https://time.com/nextadvisor/investing/cryptocurrency/what-is-ethereum/.

Hayes, A. (2021). Stablecoin. *Investopedia*. Retrieved from https://www.investopedia.com/terms/s/stablecoin.asp.

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.

Ifegwu, O. (2021). Mainnet. *Binance Academy*. Retrieved from https://academy.binance.com/en/glossary/mainnet.

Kenton, W. (2021, October 11) New York Stock Exchange (NYSE). *Investopedia*. Retrieved from https://www.investopedia.com/terms/n/nyse.asp.

Lisa, A. (2021, August 25). 10 Major Companies That Accept Bitcoin. *Go Banking Rates*. Retrieved from https://www.gobankingrates.com/money/business/10-major-companies-that-accept-bitcoin/.

Meredith, S. (2018, April 10). Facebook-Cambridge Analytica: A timeline of the data hijacking scandal. *CNBC*. Retrieved from https://www.cnbc.com/2018/04/10/facebook-cambridge-analytica-a-timeline-of-the-data-hijacking-scandal.html.

Pratap, M. (2018, August 28). What are Decentralized Applications, DApps? *Hackernoon*. Retrieved from https://hackernoon.com/what-are-decentralized-applications-dapps-3b63b4d587fe.

Rajca, P. (2017). Histoire de l'or comme monnaie d'échange. *Education Finance*. Retrieved from https://educationfinance.ca/economie/historique-de-lor-comme-monnaie-dechange/.

Rapoza, K. (2021, September 12). Is Ethereum's DeFi boom setting itself up for DeFi bust? *Forbes*. Retrieved from https://www.forbes.com/sites/kenrapoza/2021/09/12/is-ethereums-defi-boom-setting-itself-up-for-defi-bust/?sh=24506a36a57f.

Raval, S. (2021). Decentralized Applications. *O'Reilly*. Retrieved from https://www.oreilly.com/library/view/decentralized-applications/9781491924532/ch01.html.

Reiff, N. (2021, November 30). Bitcoin vs Ethereum: what's the difference? *Investopedia*. Retrieved from https://www.investopedia.com/articles/investing/031416/bitcoin-vs-ethereum-driven-different-purposes.asp.

Riksbank. Historical timeline. Retrieved from https://www.riksbank.se/en-gb/about-the-riksbank/history/historical-timeline/.

Rodriguez, S. (2019). Meet Morgan Beller, the 26-year-old woman behind Facebook's plan to make its own currency. *CNBC*. Retrieved from https://www.cnbc.com/2019/07/20/facebook-libra-partly-created-by-female-engineer-morgan-beller.html.

Ruvic, D. (2021). Tesla likely to start accepting bitcoin as payment again, says Elon Musk. *The Guardian*. Retrieved from https://www.theguardian.com/technology/2021/jul/22/tesla-likely-to-start-accepting-bitcoin-as-payment-again-says-elon-musk.

Sander, P. (2021, February 22). Decentralized finance will change you understanding of financial systems. *Forbes*. Retrieved from https://www.forbes.com/sites/philippsandner/2021/02/22/decentralized-finance-will-change-your-understanding-of-financial-systems/?sh=4bc7e5b65b52

Semeney, A. (2021). The Future of DApps: What's in Store for 2021. *DevTeam.space*. Retrieved from https://www.devteam.space/blog/the-future-of-dapps/.

Sharma, R. (2018, October 8). Why blockchain-based dApps are the future of decentralization. Net Solutions. Retrieved from https://www.netsolutions.com/insights/why-blockchain-based-dapps-are-the-future-of-decentralization/.

Sharma, R. (2021, December 30). Decentralized Finance (DeFi) definition. *Investopedia*. Retrieved from https://www.investopedia.com/decentralized-finance-defi-5113835.

State of the dapps. (2021). Les statistiques DApp. Retrieved from https://www.stateofthedapps.com/fr/stats.

Statista Research Department. (2021, November 1). Facebook: number of daily active users worldwide 2011-2021. *Statista*. Retrieved from https://www.statista.com/statistics/346167/facebook-global-dau/

Vergara, I. (2020, December 9). Tezos, la blockchain aux racines françaises qui veut concurrencer Ethereum. *Tech & web*. Retrieved from https://www.lefigaro.fr/secteur/high-tech/tezos-la-blockchain-aux-racines-francaises-qui-veut-concurrencer-ethereum-20201209.

Vessière, G. (2013, August 16). Le billet de banque, des débuts chaotiques. *Canal Ordinaire*. Retrieved from https://canalordinaire.wordpress.com/2013/08/16/naissance-du-billet-de-banque/.

Yakovenko, A. (2018, April 19). Proof of History: a clock for Blockchain. *Medium*. Retrieved from https://medium.com/solana-labs/proof-of-history-a-clock-for-blockchain-cf47a61a9274.

Encyclopedia

Albouy, M. (2021). Entreprise. Financement. In *Encyclopaedia Universalis*.

Baubeau, P. (2021). Banque – Histoire de l'institution bancaire. In *Encyclopaedia Universalis*.

Baud-Babic, M.-F., & Marty, O. (2021). Banque des règlements Internationaux. In *Encyclopaedia Universalis*.

Berta, N. (2021). Valeur, économie. In *Encyclopaedia Universalis*.

Blumberg, G. (2021). Banque d'Angleterre. In *Encyclopaedia Universalis*.

El Mekkaoui De Feitas, N. Fonds de pension. In *Encyclopaedia Universalis*.

Goyeau, D. (2021). Bourse. Marchés de valeurs mobilières. In *Encyclopaedia Universalis*.

Pollin, J.-P. (2021). Macroéconomie. Systèmes financiers. In *Encyclopaedia Universalis*.

Books

Andreau, J. (1977). *M. I. Finley, La Banque Antique et l'Économie Moderne*. Annali Della Scuola Normale Superiore Di Pisa. Classe Di Lettere e Filosofia, 7(3), 1129–1152. http://www.jstor.org/stable/24303431.

Bénoit, F. (1978). *2 - Le libéralisme économique*. Dans : , F. Bénoit, La Démocratie libérale (pp. 161-167). Paris cedex 14: Presses Universitaires de France.

Beitone, A., Abeille-Becker, C., Buisson-Fenet, E., Fleutôt, D., Joubert, M., Letessier, J .. & Rodrigues, C. (2018). Chapitre 1. Les fondements de l'économie. Dans : Alain Beitone éd., Économie, sociologie et histoire du monde contemporain: ECE 1 et 2 (pp. 6-68). Paris: Armand Colin. https://doi-org.proxy.bib.ucl.ac.be:2443/10.3917/arco.beito.2018.01.0006.

Cornut St-Pierre, P. (2019). Chapitre 6 - Le risque systémique. Dans : , P. Cornut St-Pierre, La fabrique juridique des swaps: Quand le droit organise la financiarisation du monde (pp. 223-257). Paris: Presses de Sciences Po.

Deleplace, G. (2018). *Histoire de la pensée économique*. Paris.

Delaplace, M. (2017). *Monnaie et financement de l'économie*. Paris.

Grigo, J., & Hansen, P. (2020). Decentralized Finance (DeFi) – A new Fintech Revolution? Bitkom.

Guillaumin, C. (2020). Chapitre 4. La monnaie et le système bancaire. Dans : , C. Guillaumin, Macroéconomie (pp. 140-161). Paris: Dunod.

Jessua, C. (1991). 9. Léon Walras et la théorie de l'équilibre économique général. Dans : , C. Jessua, Histoire de la théorie économique (pp. 319-371). Paris cedex 14: Presses Universitaires de France.

Marie Henry, G. (2009). *Chapitre 9 - William Stanley Jevons et l'économie mathématique*. Dans : , G. Marie Henry, Histoire de la pensée économique (pp. 139-147). Paris: Armand Colin. https://doi-org.proxy.bib.ucl.ac.be:2443/10.3917/arco.henr.2009.01.0139.

Markovits, F. (1986). *IV - Les modèles cartésiens de la valeur : Quesnay*. Dans : , F. Markovits, L'ordre des échanges: Philosophie de l'économie et économie du discours au XVIIIe siècle en France (pp. 161-192). Paris cedex 14: Presses Universitaires de France.

Mougayar, W. (2017). Tokenomics – A Business Guide to Token Usage Utility and Value, Startup Management.

Narassiguin, P. (2004). Chapitre 1. Le troc, la monnaie et les banques. Dans : , P. Narassiguin, Monnaie: Banques et banques centrales dans la zone euro (pp. 11-25). Louvain-la-Neuve: De Boeck Supérieur.

Orléan, A. (2011). *L'empire de la valeur. Refonder l'économie*. Seuil.

Pastré, O. (1997). *La Banque*. Milan.

Touchard, J. (1958). *Histoire des idées politiques, du XVEEEe siècle à nos jours*. PUF.

Verboven, K. (2004). *Mentalité et commerce: Le cas des negotiatores et de ceux qui negotia habent : une enquête préliminaire*. In Andreau, J., France, J., & Pittia, S. (Eds.), Mentalités et choix économiques des Romains. Ausonius Éditions. doi:10.4000/books.ausonius.10005.

Yermarck, D. (2015). Handbook of Digital Currency. Bitcoin, Innovation, Financial Instruments, and Big Data. *Academic Press*. https://doi.org/10.1016/B978-0-12-802117-0.00002-3.

Reports

Auer, R., & Bohme, R. (2021). BIS Working Papers No 948 Central bank digital currency: the quest for minimally invasive technology. Retrieved from https://www.bis.org/publ/work948.pdf.

BIS. (2021). Annual economic report. CBDCs: an opportunity for the monetary system. Retrieved from https://www.bis.org/publ/arpdf/ar2021e3.pdf

ECB. (2020). Study on the payment attitudes of consumers in the euro area (SPACE). Retrieved from https://www.ecb.europa.eu/pub/pdf/other/ecb.spacereport202012~bb2038bbb6.en.pdf.

Nbb. (2017). Infrastructures de marches financiers. *Réglementation et contrôle prudentiels*. Retrieved from https://www.nbb.be/doc/ts/publications/nbbreport/2017/fr/t1/rapport2017_tiii_h6.pdf.

OECD. Des efforts supplémentaires pour renforcer la confiance dans les entreprises et la finance. Retrieved from https://www.oecd.org/fr/presse/des-efforts-supplementaires-pour-renforcer-la-confiance-dans-les-entreprises-et-la-finance.htm.

Rapport Macroprudentiel. (2020). Banque National de Belgique. Retrieved from https://www.nbb.be/doc/ts/publications/fsr/fsr2020_rapport.pdf.

Ward, O., & Rochemont, S. (2019). Understanding Central Bank Digital Currencies (CBDC). Institute and Faculty of Actuaries. Retrieved from https://www.actuaries.org.uk/system/files/field/document/Understanding%20CBDCs%20Final%20-%20disc.pdf

Appendix

Appendix 1.

Actifs	Taille du marché	Total emprunté	APY des dépots	Variable APY des emprunts	Stable APY des emprunts
DAI	1,75B	1,37B	2,82 % 0,51 % APR	3,99 % 1,32 % APR	12,70 %
Gemini Dollar	15,31M	12,1M	2,85 %	4,03 %	–
sUSD	65,67M	34,83M	1,13 % 0,40 % APR	2,69 % 1,51 % APR	–
TrueUSD	105,73M	66,24M	1,88 % 0,35 % APR	3,18 % 1,16 % APR	12,26 %
USD Coin	3,62B	3,08B	3,07 % 0,56 % APR	3,85 % 1,34 % APR	11,51 %
USDP	12,55M	7,9M	1,60 % 0,59 % APR	2,84 % 1,87 % APR	–
USDT Coin	1,01B	852,34M	2,97 % 0,58 % APR	3,81 % 1,40 % APR	12,60 %
Balancer	476,64K	98,16K	0,53 % 1,15 % APR	3,26 %	–
Ethereum	1,28M	29,39K	0,01 % 0,30 % APR	0,28 %	3,41 %
ChainLink	17,16M	205,85K	0,00 % 0,98 % APR	0,19 %	3,32 %
Maker	57,43K	162,16	0,00 % 0,67 % APR	0,04 %	3,11 %
Rai Reflex Index	12,89M	7,48M	1,35 % 0,48 % APR	2,94 % 1,67 % APR	–
Uniswap	2,72M	215,6K	0,08 %	1,24 %	–
WBTC Coin	27,42K	648,75	0,01 % 0,30 % APR	0,29 %	3,42 %
xSUSHI	10,53M	–	– 0,81 % APR	–	–
yearn.finance	1,87K	99,48	0,04 % 0,59 % APR	0,83 %	–
Binance USD	13,77M	8,38M	1,68 % 0,28 % APR	3,09 % 0,92 % APR	–
Fei USD	73,62M	61,72M	16,83 %	26,10 % TRIBE	–
Frax	19,26M	7,88M	0,67 % 0,22 % APR	2,07 % 1,10 % APR	–
Aave	1,53M	–	–	–	–
Ampleforth	7,49M	577,58K	0,08 %	1,20 %	–
Basic Attention Token	4,63M	406,82K	0,11 %	1,38 %	5,08 %
Curve DAO Token	13,09M	6,05M	5,12 % 0,42 % APR	14,46 %	–
DeFi Pulse Index	180,17K	–	– 0,79 % APR	–	–

EnjinCoin	9,43M	247,63K	0,01 %	0,41 %	0,59 %
Kyber Legacy	893,29K	230,69K	0,68 %	3,23 %	7,22 %
Decentraland	14,18M	444,29K	0,01 %	0,49 %	3,77 %
REN	46,58M	1,33M	0,02 %	0,44 %	0,63 %
renFIL	64,35K	21,25K	0,62 %	2,93 %	–
SNX	1,34M	161,12K	0,38 %	4,92 %	–
0x Coin	17,72M	351,94K	0,04 %	0,31 %	3,50 %

Appendix 2.

CD TERM	$0 - $9,999.99	$10K - $24,999.99	$25K - $49,999.99	$50K - $99,999.99	$100K - $249,999.99	$250K+
1-Month	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
2-Month	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
3-Month	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
6-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
9-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
12-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
15-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
18-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
21-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
24-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
30-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
36-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
42-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
48-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
60-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
84-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%
120-Month	0.02%	0.05%	0.05%	0.05%	0.05%	0.05%

Appendix 3.

BlackRock Strategic Income Opps Instl BSIIX★★★★ Morningstar Analyst Rating

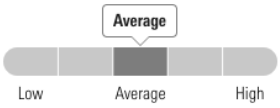
Analyst rating as of Feb 17, 2021

Quote | Fund Analysis | Performance | Sustainability | Risk | Price | Portfolio | People | Parent

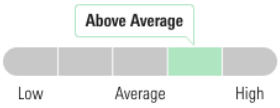
Risk 3-Yr | 5-Yr | 10-Yr

Morningstar Risk & Return

Risk vs. Category



Return vs. Category



Category: Nontraditional Bond as of Nov 30, 2021 | Rankings are out of 296 investments.

Risk & Volatility Measures

Trailing	Investment	Category	Index
Alpha	2.12	1.03	0.07
Beta	0.47	0.35	0.98
R^2	10.13	8.41	99.29
Sharpe Ratio	0.85	0.49	1.36
Standard Deviation	4.99	6.32	3.41

USD | Investment as of Nov 30, 2021 | Category: Nontraditional Bond as of Nov 30, 2021 | Index: Morningstar US Core Bd TR Hdg USD as of Nov 30, 2021 | Calculation Benchmark: Bloomberg US Agg Bond TR USD

Source: https://www.morningstar.com/funds/xnas/bsiix/quote

UNIVERSITÉ CATHOLIQUE DE LOUVAIN
Louvain School of Management

Place des Doyens, 1 bte L2.01.01, 1348 Louvain-la-Neuve
Boulevard Emile Devreux 6, 6000 Charleroi, Belgique
Chaussée de Binche 151, 7000 Mons, Belgique

www.uclouvain.be/lsm