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An Analysis of Decentralized Finance and its Applications

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Abstract

Cryptocurrency and blockchain technology are relatively recent economic and technological trends. Within the cryptocurrency sphere a new form of decentralized peer-to-peer finance network has emerged. This is of course Decentralized Finance (DeFi). DeFi is a relatively quick and permissionless financial movement within the greater world of cryptocurrency and blockchain technology. DeFi is built on ideas of easy access, interoperability, transparency, and limited third-party meddling. As such, DeFi and its principles are in clear contrast to traditional financial institutions that value centralized control.

The aim of the thesis is to further investigate the technological and financial properties of DeFi and disclose how these relate to the broader aspects of the financial world. The thesis answers key research questions of interest by performing a deep dive into the DeFi sphere.

In this thesis the underlying protocols of DeFi is analyzed. This is supplemented by examining and comparing DeFi to traditional financial foundations and values. A comprehensive literature review is explored and summarized to point out the uniqueness of DeFi, in addition to advantages and disadvantages and finally what yet needs to be improved within the sphere. Based on the analysis in this thesis, several findings were made regarding the nature of the decentralized market today. Finally, concluding remarks are provided about DeFi and its greater implication on today's world and what the future holds for alternative financial options. The research and results show DeFi as a growing movement with real life implications and use cases, but still in its infancy with legislative challenges yet to be properly addressed.

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Abbreviations and Concepts

AMM	Automated Market Makers
BTC	Bitcoin
DAO	Decentralized Autonomous Organization
DApps	Decentralized Applications
DeFi	Decentralized Finance
DEX	Decentralized Exchange
DFO	Decentralized Flexible Organization
DID	Decentralized ID
Fiat	Government-issued Currencies
Forking/Fork	Copy of a source that is independent from the original
ICO	Initial Coin Offering
PLF	Protocols for Loanable Funds
PoW	Proof-of-Work
TLV	Total Value Locked
UGC	User-generated Content
USD	United States Dollar
USDC	United States Dollar Coin

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1 Introduction

Decentralized Finances (hereafter: DeFi) refers to financial applications built on decentralized blockchain networks [11]. DeFi refers to a movement that aims to create a permissionless, transparent and open-source ecosystem of financial services – available to everyone around the world, and that can operate without any central authority [44]. This is in clear contrast to centralized financial institutions such as commercial banks and stock exchanges.

In contrast to traditional and regulatory financial sectors, DeFi does not rely on intermediaries and integrated institutions. Instead, it is based on open protocols and decentralized applications (hereafter: DApps). Agreements are enforced with smart contracts; transactions are executed in a secure and deterministic way and legitimate state changes are persevered on a public blockchain. This design can create an immutable and highly interoperable financial system with unparalleled transparency, equal access rights and little to no need for custodians, central clearing houses or escrow services, as most of these roles can be assumed by the implementation of smart contracts [29].

Since the creation of the Ethereum blockchain ecosystem in 2015, the DeFi movement has slowly surged in popularity. This is because the majority of the DeFi protocols, platforms and exchanges are built on top of the Ethereum blockchain. DeFi and blockchain technology has the potential to reduce the role of many middlemen in society across many different sectors and industries. This is done by allowing people to transfer currency, data, or other unique digital assets in a secure, immutable, and quick way [21]. DeFi applications range from automated markets makers, price oracles, to financial derivatives, decentralized exchanges, and many others [12]. One of these applications which is crucial for DeFi is self-enforcing digital contracts, more commonly known as smart contracts, whose execution does not require any human intervention; the result is decentralized marketplaces that aim to operate free from the reach of regulation and central control [21]. As of April 2021, the total value of locked cryptocurrency and other assets in DeFi platforms and applications was estimated to be around 100 billion USD and the total market cap for all the cryptocurrencies tipped 2 trillion dollars [67].

1.1 Thesis Objectives

The objective of this thesis is to take a closer look at DeFi and its underlying protocols that has made it surge in popularity, especially since 2020. To achieve the objective of this thesis, a thorough literature review is conducted, where assessments are presented based on a set of research questions. The aim of the thesis is to answer the following research questions:

- *Research question 1: What is DeFi and why has it emerged as an alternative form of finance?*
- *Research question 2: What is the applicability of DeFi today?*

- *Research question 3: What does the future look like for the DeFi movement?*

The thesis is structured in a simple manner to ensure a full systematic understanding of DeFi and its main components. Firstly, an introduction is provided which is followed by a literature review that gives valuable information and an understanding on previous research about DeFi as an alternative financial movement. Secondly, the main protocols that make up DeFi is examined and explained. Next, the advantages and disadvantages are put forward. Furthermore, the results of the literature review and analyses are presented and interpreted. Finally, the results and the corresponding conclusion of the thesis is laid out.

2 The DeFi Movement

This chapter outlines the DeFi movement as a continuation of the emergence of blockchain technology. With the advent of blockchain technology, cryptocurrencies and smart contracts, alternative financial systems have steadily gained more attraction. In addition, the most important promises of DeFi are laid forward. These promises are decentralization, borderless transactions, increased transparency, and better interoperability.

2.1 The Emergency of DeFi

Decentralized finances, at least as a concept, is not a new phenomenon. An early example of decentralized finance emerged in the foreign currency (forex) market approximately 20 years ago [38]. Instead of individual corporations demanding various banks to get the best rate, an electronic system was introduced to match the buyers and sellers directly at an agreed-upon price with little to no spread. The banks could offer this service to its own customers and collect a modest fee (compared to the spread). Excessive costs and unhappy customers have always brought in many fintech innovations that have revolutionized traditional finances, PayPal being a great example.

In 2009 the landscape of digital currencies changed forever with the publication of Bitcoin's whitepaper by the creator(s) Satoshi Nakamoto and the subsequent launch of Bitcoin. The paper presents a peer-to-peer system that is decentralized and utilizes the concept of blockchains. Blockchains allow for cryptographic scarcity (Bitcoin has a fixed supply cap of 21 million which in concept is deflationary), censorship resistance and user sovereignty (no entity other than the user can determine how to use funds), and portability (send any quantity anywhere at any time for a relatively low fee). These features combined in a single technology make cryptocurrencies a formidable innovation in the financial world.

Compared to traditional currencies such as the United States Dollar (USD), Bitcoins value proposition becomes easier to understand. The USD is no longer backed by gold, it was removed in 1971 [68]. In addition, The Federal Reserve can adjust the supply of USD through monetary policy to achieve certain financial or political goals, and lastly the people do not "own" their own money. Inflation eats away at the value of USD, decreasing its ability to store value over time.

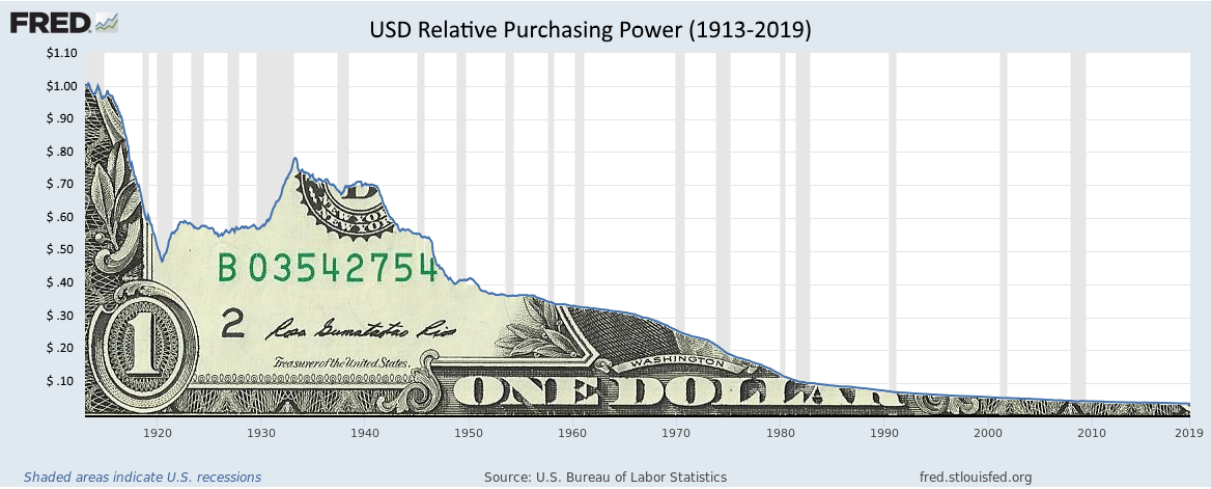

Figure 1: The purchasing power of the United States Dollar over time.

Bitcoins inherent values such as scarcity, limited supply and self-sovereignty makes it a great potential for store of value and a hedge against political and economic unrest at the hands of global governments. As Bitcoin grows, its value proposition only increases with time due to increased trust and liquidity. If Bitcoins current trajectory persists, it will continue to grow as an important store of value and a potential inflation hedge.

Cryptocurrencies as a whole has risen due to a desire to be free from financial systems dominated by governments and central banks. They present new ideas such as being immutable, borderless, open-source and decentralized.

2.2 The Ethereum Blockchain

As of February 2021, Ethereum is the second largest cryptocurrency platform after Bitcoin by market capitalization and the number one platform when we look at daily transaction fees. It is also the number one platform for DeFi applications and exchanges [40]. Its first block came into existence in 2015, which is relatively younger than the Bitcoin blockchain.

Figure 2: The total market cap of Ethereum as of March 2021 was near 300 billon USD.

Ethereum relies on a public blockchain where consensus is maintained by proof-of-work (PoW) like Bitcoin. A PoW system is where miners maintain the blockchain by competing to solve computationally rigorous cryptography, and then validate them [30].

In a sense, Ethereum is the next logical extension of Bitcoin. While Bitcoin is great for storing wealth, it lacks complex functionality. You can send and receive transactions and execute some other critical functions, but smart contracts are not supported. This is where Ethereum comes in.

It provides the following features on top of what is offered by Bitcoin:

- DApps (decentralized applications)
- Complex smart contracts
- Digital token creation

Simply put, the main idea behind the Ethereum blockchain system is that developers can create and launch code which runs across a distributed network instead of existing on a centralized server. And in theory, these applications can't be shut down or censored – they are decentralized and autonomous [69].

As pointed out above, Ethereum allows for the use of smart contracts. A smart contract is *just* code. The code is neither smart, nor is it a contract in the conventional sense. It is called smart

because it executes itself under certain conditions, and it could be regarded as a contract in that it enforces agreements between parties [69].

Smart contracts are codes that live on a blockchain, they can control assets and data, and define interactions between the assets, data, and network participants. The capacity for smart contracts defines Ethereum as a *smart contract platform* [38]. More on smart contracts in Chapter 4.2. Smart contract platforms have given rise to decentralized application or DApps. These DApps are built with interoperable, transparent smart contracts that continue to exist as long as the blockchain they live on exists [38]. DApps allow peers to interact directly and remove any middlemen or for a company/institution to act as a central governing body. DApps that are focused on financial use cases, services and products are known as DeFi DApps.

DeFi may be defined as the movement that promotes the use of decentralized networks and open-source software to create multiple types of financial services and products. The idea is to develop and operate financial DApps on top of a transparent and trustless framework, such as permissionless blockchains and other peer-to-peer protocols [44]. DeFi is in rapid progress and is gradually drawing more market share from the traditional financial ecosystem.

To sum it up, the Ethereum blockchain is the next logical evolution of the simpler Bitcoin blockchain technology. Its allows for the usage of smart contracts, which are codes that are executed within certain conditions. This allows for the development of DApps and DApps that are focused on financial products are called DeFi. The DeFi movement is shifting traditional financial products and services to the open-source and decentralized world. This removes the need for intermediaries, reduces overall costs, and greatly improves interoperability [44].

2.3 The Promises of DeFi

DeFi offers a mix of promises and key properties not readily available today in the context of traditional financial economy. If successful, it may have the potential to create an alternative financial system that is more decentralized, innovative, interoperable, transparent, and borderless. Moreover, this movement highlights the potential of blockchain technology in spawning a new set of business models centered around decentralization [36].

In the following subchapters we will look at key promises of DeFi.

2.3.1 Decentralization

One of the key promises of DeFi is in the name itself – *decentralization*. When centralized financial institutions—such as Citibank (or any major bank for that matter) or online payment services like PayPal, or Square rise to dominance, it accumulates disproportionate market power and large profits. In a centralized financial system, financial institutions are the main intermediaries negotiating and controlling financial transactions.

In contrast, in a decentralized financial system, financial transactions are facilitated not by centralized institutions but by decentralized peer-to-peer networks across the globe - without the need for governmental or institutional interference [36]. By reducing or completely removing the involvement of centralized institutions, DeFi platforms can reduce transaction costs. As decentralized peer-to-peer networks emerge and rise to power, everybody can participate in the system to carry out financial transactions. And yet, no central figure can monopolize or limit the network and exclude others from participating. Decentralization is in the heart of the DeFi movement, in addition to general blockchain technology and several cryptocurrencies.

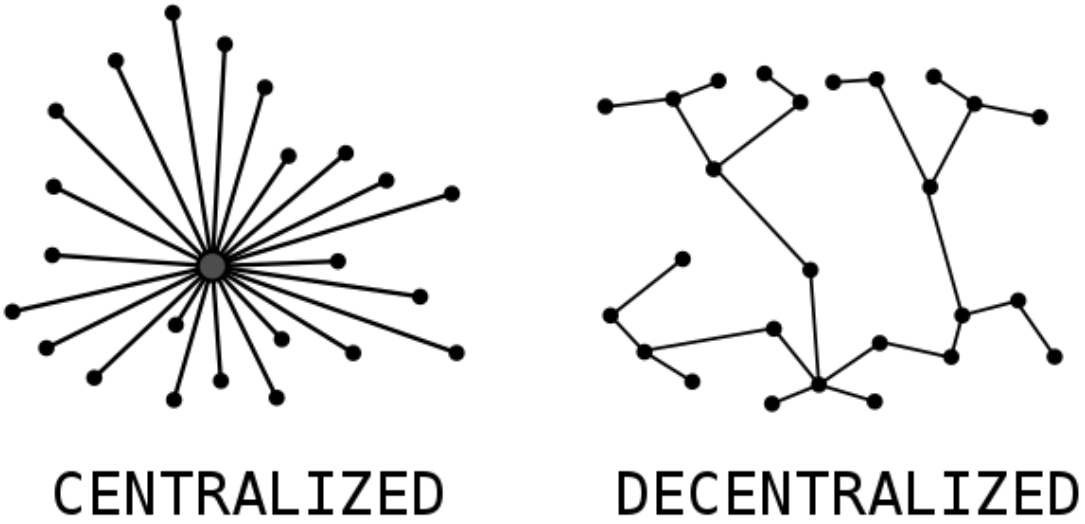

Figure 3: Centralized network vs. decentralized network.

2.3.2 Borderless

DeFi and decentralized applications are inherently borderless. In contrast, centralized finances cannot truly be borderless, as it is often tied to specific governmental rules and geographical locations with specific fiat currencies.

With the use of cryptocurrencies, a participant in a DeFi system can move capital (or other digital assets) freely across borders, geographical locations, and bypass authoritarian governmental rules. Transferring value across the globe in a decentralized financial system can then be compared to sending an email – with minimum transaction costs [17, 37].

2.3.3 Transparency

Centralized financial institutions cannot have full transparency, as they must secure their centralized assets. DeFi, in contrast, secures their public ledgers through distributed consensus and fundamental transparency. It uses public records that can be easily viewed and verified, and it records transactions on public blockchains to limit opportunistic behavior. Transacting parties can then interact and trust each other without pre-existing relationships or an intermediary. This can expand the scale and scope of potential transactions across the world as distributed ledgers generate distributed trust.

DeFi platforms are also often built with open-source code. This means external parties can check business logics to expose hidden biases, risks, and threats. In addition, transparent public ledgers and open-source code help keep records of historical transactions [36].

2.3.4 Interoperability

Institutions within traditional finances tend to work in single, isolated islands – driving up transaction barriers. Different financial institutions must maintain their own records, so one financial service may not be interoperable with another. Moving capital and value across these institutions become cumbersome, time consuming and costly. In contrast, DeFi is built on public blockchains with open principles, increasing the interoperability across different decentralized services. With high interoperability, financial capital and value can flow effortlessly across various services and borders.

Although projects developed on the same public blockchain enjoy high-level interoperability, decentralized finance has not reached full interoperability yet, due to the lack of interoperability across blockchains. Currently, many projects—such as Cosmos and Polkadot—are working on intersecting different blockchains to achieve full interoperability in the decentralized financial space.

As of early 2021, Ethereum is the dominant platform for DeFi institutions, and all Ethereum-based projects enjoy high interoperability. In total, 87% of all publicly funded projects within DeFi is built on the Ethereum blockchain [17].

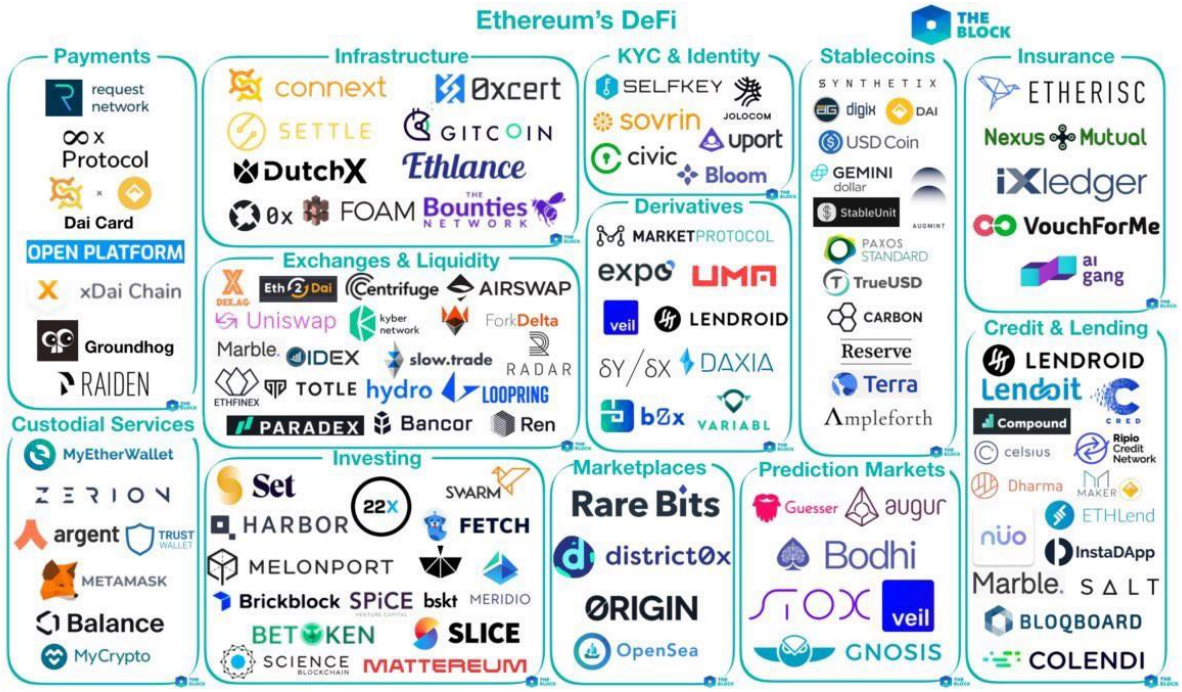

Figure 4: Ethereum's DeFi ecosystem.

3 Literary Review

This chapter outlines the most recent research on DeFi and whether an alternative financial system is possible or not. Chapter 3.1 gives a quick explanation on the breakdown of the studies and Chapter 3.2 summarizes the latest research. By going through this chapter, the reader should be familiar with the most recent research on DeFi and its main benefits and challenges.

The cryptocurrency market, blockchain technology and DeFi as a movement are relatively new trends in comparison to traditional financial institutions and services. Banking, lending, and traditional money has existed for thousands of years. In comparison, Ethereum's first genesis block was mined in 2015, which is the backbone for the majority of the DeFi projects. DeFi has surged steady in popularity since then, total value locked soared into DeFi projects from the beginning of 2020 and onwards, largely due to the COVID-19 pandemic. The lockdowns and over inflations of fiat money has made many people open their eyes to the limitations of traditional finances and governmental monetary control.

With this as a backdrop, most of the scientific papers and published literature related to DeFi are from recent years. The majority between 2015 and 2020. In this chapter, an in-depth literary assessment is done to get a quick overview of the latest findings related to the DeFi space.

3.1 Breakdown of the Studies

This thesis is an addition and expansion of the already emerging literature on DeFi. Many of the published literature has focus on two main categories [13]:

1) Blockchain mechanics for generating and maintaining decentralized consensus.
2) Real-world use cases and implications of blockchain functionality.

The first category can then be further divided into several studies and analysis of different blockchain mechanics and DeFi systems emphasizing decentralization and its advantages and disadvantages.

The second category links analysis and experiments to DeFi and its impact on the real-world and institutional financial services. This paper adds relevant information to both categories. More broadly, this thesis relates to literature that examines blockchain and cryptocurrency finances in terms of the DeFi space and its rapid growth.

3.2 The Latest Research – An Overview

Scholten et al. (2019) paper surveyed popular crypto games, which use the Ethereum network [2]. Crypto games mainly focus on ownership of virtual goods, which in return can be exchanged over a decentralized network. This supports the DeFi movement where people can exchange digital assets, notably NFTs (Non-Fungible Tokens). In a study of DApps on the Ethereum blockchain, Wu et al. (2019) did a comprehensive empirical study [4]. Based on an extensive dataset of 995 Ethereum DApps and 29 846 075 transaction logs, they show that even though DeFi apps account for just 15% of the 995 DApps they looked at, they had over 55% of all the users and 86% of all transaction volume. In another DApp study, Cai et al. (2018) traces the development of blockchain systems to reveal the importance of DApps and the future value of blockchain [20]. They discuss how DApps have certain desirable characteristics not found anywhere else. These include new and fast payment channels, novel consensus models and network computing. They believe we are on the edge of an era of decentralized

ecosystem. And from their standout and where we stand today, it's not difficult to see how DeFi is in the middle of this change.

Henriquez et al. (2020) looked at whether a DeFi-based business model could be used in trade finance [3]. They present a sketch of a DeFi trade finance business model, indicating how it could address the reasons behind the trade finance gap (supply-related and demand-related costs and difficulties). Ramos et al. (2020) reviewed the most important aspects of the DeFi market [6]. They discuss the relationship between DeFi and the overall cryptocurrency market. Here, any stable trend between the cryptocurrency market and DeFi leads to further growth. Another study by the same authors did a review on smart contract functionalities to offer services that imitate or even surpass those offered by regular banking institutions [7]. They show how DeFi keeps growing by offering different kind of financial services.

Liu et al. (2020) presented a comprehensive measurement study of DeFi price oracles deployed in practice [5]. They looked at oracles for four prominent open DeFi platforms – MakerDAO, Compound, AmpleForth and Synthetix. They present recommendations to make oracles more transparent, accountable, and robust to further the trust in DeFi. The same year Ramos and Zanko (2020) looked at institutional adoption of DeFi and explain how this idea was unthought of just a couple of years back [23]. If both the potential institutional adopters and the largest DeFi platforms on the market make the necessary efforts and compromises to improve on both ends, a gradual transition could be created in a way that the implementation of the systems is not disruptive enough to generate concern in regulatory agencies, but fast enough to keep up with the expected demands of both traditional institutions and their clients. Jensen and Ross (2020) did a taxonomical overview of agents, incentives, and risks in DeFi applications where they looked at potential key risks for stakeholders [32]. They conclude with DeFi being a movement with far-reaching implications for the future of financial services. In the previous year Chen and Bellavitis (2019) assessed the benefits of decentralized finance, identify existing business models, and evaluate potential challenges and limits [36]. Furthermore, Gudgeon et al. (2020) explored how design weaknesses and price fluctuations in DeFi protocols could lead to a DeFi crisis [41]. DeFi needs to develop to become a better asset manager for the general populous. Mitigating, removing and understand risks, uncertainties and potential vulnerabilities is a key part of this.

Monrat et al. (2019) presented a comparative study regarding the usage of blockchain technology [8]. They provide a comparison among difference consensus mechanisms and discuss challenges such as scalability, privacy, interoperability, energy consumption and regulatory issues. The researchers believe blockchain has immense potential in both academia and various industries such as healthcare, trade, asset tracking, voting and lastly finances. Here, the advantages of a decentralized exchange are put forward. The paper explains how eliminating intermediaries and speeding up transaction settlements, blockchain technology can help reduce fees. Furthermore, the technology can provide practical use in transaction clearing and settlement while easing the tedious paperwork of the trade and legal ownership transfer. In addition, by using smart contracts, blockchain is mitigating the need of a third-party regulators by acting as an oracle for all transactions. In another studie, Varma (2019) looked at how blockchain can be used in finances and compares the shortcoming of centralized institutions and global central banks [14]. Here he argues traditional businesses should seek to understand blockchain technology because their underlying ideas are powerful and likely to be influential – particularly in the financial space. However, Andolfatto (2018) had a more conservative and pessimistic view on blockchain technology, where the consensus was that it is not needed – at least not at the time of writing [18]. In the same year Wu and Tran (2018) looked at how blockchain can be used in sustainable energy sectors [39].

Bahga and Madisetti (2020) presented a Value Token Transfer Protocol (VTTP) to allow intra-chain and inter-chain transfers of cryptocurrencies or tokens in DeFi [9]. Their research could help bridge the gap between different blockchain networks even closer and make it easier to trade between decentralized exchanges across different blockchain systems. In terms of better adaption and synergy, Saleh (2019) examined an alternative blockchain protocol that induces low volatility and enhanced welfare [34]. For DeFi to get more popular it's important to understand and improve volatility to increase mass adaption in the general populous. Similarity, Arruñada and Garicano (2018) proposed how a "soft" decentralized governance can allow blockchain networks to avoid bad equilibria and further the adoption of blockchain technology so it can outcompete centralized firms [16].

El Fagir et al. (2020) reviewed the main software platforms that offer DAO (Decentralized Autonomous Organizations) creation as a service, which simplifies the use of DAOs to non-blockchain experts [10]. This could introduce the world of DeFi and DAO to less experienced

people and further the growth of blockchain technology. Chanson et al. (2020) investigated the role of user-generated content (UGC) for ICO success [42]. ICO platforms have emerged through the use of DAOs and could jumpstart several blockchain-focused companies.

Mohan (2020) presented a paper where he looks at AMM (Automated Market Makers) for creating DEXs (Decentralized Exchanges) [11]. DEXs and their usage are the backbone of the DeFi movement. Later in the paper, we will take a closer look at some of the most popular DEXs that have turned DeFi into a multi-billion-dollar movement. Similar to Mohan, Wang (2020) examined AMM for DeFi [12]. He proposes market makers that are more robust against front-runner bots (slippage) attacks which in turn could further the robustness of DEXs and their usage in DeFi.

Cong et al. (2018) examined smart contracts and how they are used in blockchain networks [13]. As noted, smart contracts are used frequently in the DeFi space, especially in DEXs. Later Schär (2020) examined how DeFi is emerging on top of the public Ethereum smart contract platform, compared it to the centralized architecture of traditional financial markets and highlighted opportunities and potential risks of this ecosystem [29]. The conclusion is even though DeFi is a niche market relative to traditional finances, it could potentially contribute to a more robust and transparent financial infrastructure. Lo and Medda (2020) presented a paper on Uniswap and the rise of DEXs [43]. These exchanges overturn centuries of practice in financial markets and establishes a building block for a new decentralized financial system.

Pass and Shelat (2016) put forth a micropayment scheme for any ledger-based transaction system that can be used without any change to the current infrastructure [33]. Micropayments are challenging due to their relatively high transaction costs. Transferring $ 5.0 from Norway to a country across the world would eat up most of the value in transaction costs. DeFi can help to reduce the costs and make micropayments more available for people in less developed countries. A different study related to economics by Guerrero (2020) examined the economics of blockchain technologies as it pertains to transaction costs in startup financing [15]. They propose a model to demonstrate how and why blockchain-based applications are effective. Here, they show how blockchain technology can be used to overcome many problems inherent in startup financing. Before all this, Kubat (2015) showed the economic aspects of blockchain, specifically Bitcoin – especially regarding the store of

value proposition [1]. Bitcoin in recent years has been compared to gold and is often referred to as “digital gold”.

Chen and Bellavitis (2020) assessed the benefits of decentralized finance, identifying existing business models, and evaluated potential challenges and limitations [17]. If successful, decentralized business models have the potential to reshape existing industries and create a new landscape for entrepreneurship and innovation. Subramanian (2018) in an article explains how facilitating key marketplace functions, decentralization will supplement and rival traditional conventional e-marketplaces [22]. In similar manner Guo and Liang (2018) looked at how the banking industry can be transformed by blockchain technology [30]. They propose the industry to develop standards and rules to further the adoption of blockchain technology in financial systems.

Ahangama and Choon Poo (2016) assessed the credibility of cryptocurrency networks [19]. They argue how if more traditional institutions utilized blockchain technology and cryptocurrency, it would increase its credibility. We have slowly seen the adoption of cryptocurrency in different countries and markets. As of today, several international exchanges such as RobinHood, Binance and Coinbase provide people all over the world with the ability to use, exchange and even get Visa cards that use cryptocurrency. Regarding DeFi, all these institutions increase the credibility of blockchain technology within the finance space. In addition, they all have simple methods to move and trade cryptocurrencies to DEXs.

Wright and De Filippi (2015) explored the benefits and drawbacks of emerging decentralized blockchain technology [21]. They bring about how as blockchain technology becomes widely adopted, centralized authorities, such as governmental agencies and large multinational corporations, could lose the ability to control and shape the activities of unequal people through existing means. They propose a *Lex Cryptographia* where ideals of individual freedom and emancipation might come true. They conclude how regardless of nationality, people could be granted equal access to basic digital institutions and infrastructure such as decentralized laws, markets, judiciaries, and payment systems, which can be customized to each country’s, group’s, and individual’s needs. All these ideals are key factors in the DeFi movement. Later Nabilou (2019) proposed a more nuanced policy recommendation for regulatory intervention in the cryptocurrency ecosystem [25]. The proposal relies on a decentralized regulatory architecture that is built upon the existing regulatory infrastructure. When it comes to

regulating cryptocurrencies and DeFi, governmental and traditional institutions are facing a significant challenge. The nature of decentralized blockchain technology goes against being governed by a central figure, though a more “lax” and decentralized governance system voted by and implemented by the people might be more welcome in the DeFi space. Zetzsche et al. (2020) placed DeFi in the context of the traditional financial economy, connects DeFi to Open Banking and ends with various policy considerations for future adaption of DeFi [37].

Nadler and Schär (2020) analyzed various DeFi protocols in terms of their token distributions [24]. The paper offers new insights on DeFi interoperability as well as token ownership distribution. They conclude with DeFi being an exciting and rapidly growing new financial infrastructure, though its limitations need to be further researched for better understanding. In terms of policy and regulation, Padilla (2020) concludes with that DeFi could offer regulators the impetus to discover new ways to fulfill their mandate and realize that they can likewise harness blockchain and smart contracts to enhance their regulatory functions, without necessarily relying on intermediaries as chokepoints for enforcement [28]. Dynamic policies could enable blockchains to flourish, like the internet, and encourage DeFi to evolve as a free-market solution that will optimize financial inclusion in the long term. It is imperative from these remarks that lawmakers do no try to limit blockchain technology and DeFi as it could lead to a wild west mentality among the users. Rather, lawmakers should try to incorporate DeFi into today’s society.

Perez et al. (2020) presented the first in-depth empirical analysis of liquidations on protocols for loanable funds (PLFs) [26]. These investigations further the DeFi movement and makes it more understandable for people who are only used to traditional finances. In similar matter Gudgeon et al. (2020) reviewed the methodologies used to set interest rates on three prominent DeFi PLFs, namely Compound, Aave and dYdX [27]. Bartoletti et al. (2020) looked at the exciting world of lending pools in DeFi [31]. Lending pools are decentralized applications which allow anonymous users to lend and borrow crypto assets.

Leonhard (2019) looked at how DeFi on the Ethereum Blockchain can help people in crisis, such as those in Venezuela [35]. He proposes an alternative form of financial planning that circumvents dysfunctional governments and insolvent banks. To conclude, DeFi can be an option for refugees escaping political and societal collapse. And as DeFi grows, people will be introduced to other available options for stabilizing financial holdings, trading, borrowing,

speculating, and hedging. In a similar study, Harvey et al. (2020) looked at how unbanked people, small business owners, less economically fortunate people are impaired by high transaction costs and high credit card costs [38]. In addition, many are facing exclusion from certain traditional financial services due to lack of government issued identification. Here the argument is that DeFi poses a challenge to the current system and offers several potential solutions to the problems inherent in the traditional financial infrastructure.

4 The DeFi Infrastructure

The following subchapters will give a clear overview of how the DeFi market works and the main underlying protocols will be put forward. The DeFi movement is built upon blockchain technology with the implementation of smart contracts. The subchapters will breakdown the underlying technology of the movement to show how DeFi functions.

4.1 Blockchain Technology

The aim of blockchain is to allow digital information to be logged and distributed, but not edited. Blockchain technology was first outlined in 1991 by Stuart Haber and W. Scott Stornetta, two researchers who wanted to implement a system where documented timestamps could not be interfered with. But it wasn't until almost two decades later, with the launch of Bitcoin in January 2009, that blockchain had its first real-world application [45]. Blockchain facilitates peer-to-peer transfer of digital assets without the need for any intermediaries. The blockchain itself is similar to a chain of blocks that store all committed transactions using a public ledger. The chain grows continuously when new blocks are added to it. Each block (except the first) contains the hash of the previous block. The blockchain ensures integrity by linking blocks of transactions together in such a way that modifying any block breaks the link with the next block. It is not possible to change one block without changing the next block, which in turn forces a change in the next one and so on until the very last block. This ensures that while new blocks can be added at the end, older blocks remain immutable: the ledger is append-only [14].

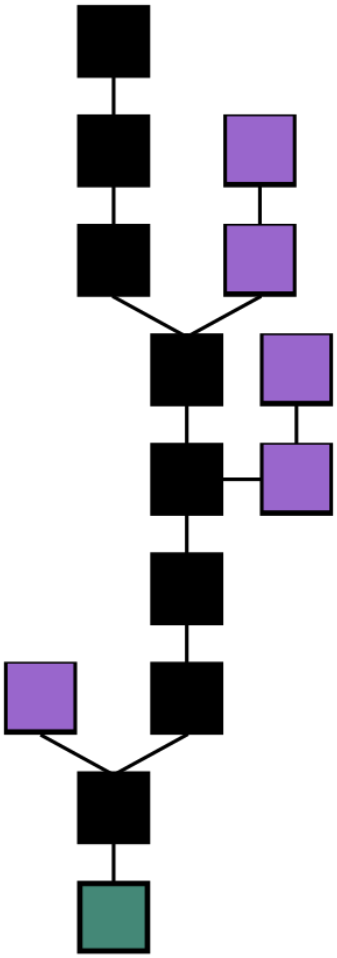

Figure 5: A simple blockchain formation. The main chain (black) is the longest series of block coming out of the genesis block (green). Forked blocks (purple) exist outside the main chain and has no effect on it.

From an DeFi-application point of view, the blockchain provides the following features:

1) Decentralization and replication imply that a full audit-trail is available to all the participants. Furthermore, the inbuilt cryptographic integrity-checks ensure that this audit-trail is verifiable. The result is a considerably lesser need for intermediaries and central hubs.

2) The blockchain is partition resistant: If some nodes fail or are disconnected from the network, the rest of the nodes can continue to function because they all have a copy of all the previous transactions. However, in traditional finances if the central institution is temporarily down for any reason, the whole system grinds to a halt. Remember the last time your online bank was unavailable due to an error?

3) Blockchain technology is an excellent platform that allows for the use of smart contracts. By automating contract negotiation and implementation, smart contracts reduce transaction costs and make minor value transactions economically feasible [14].

Currently, there is a considerable assortment of blockchain-based projects looking to implement blockchain in different ways to help society – One of these approaches is in financing and banking, through DeFi. With numerous practical applications for the technology already being implemented and explored, blockchain technology stands to make business and government operations more accurate, efficient, secure, and cheaper with fewer middlemen. The general consensus among blockchain technology enthusiasts is that it's no longer a question of *if* traditional companies will catch on to the technology—it's a question of *when*.

4.2 Smart Contracts

The term "smart contracts" was first coined by Nick Szabo over 3 decades ago, when the internet was first in its infancy. In principle, a smart contract refers to the idea that a legal contract can be notarized and executed automatically, without the need for any intermediaries. As consensus is essential to many economic and social functions, the advantages and empowerment for everyone sharing and trusting the same ledger are clear-cut. Usually, courts, government agencies, notary agencies, etc., provide such consensus, but in a way that is sometimes thought to be labor-intensive, time-consuming, and prone to tampering and monopoly control. This is where smart contracts come in: Contracting on contingencies reached based on a decentralized consensus, with relatively low cost and more automated implementation [13].

Decentralized consensus ensures that the need for third parties is eliminated. This removes traditional resolutions by third parties such as courts or mediators, who are human after all and are less algorithmic and more subjective in their judgement.

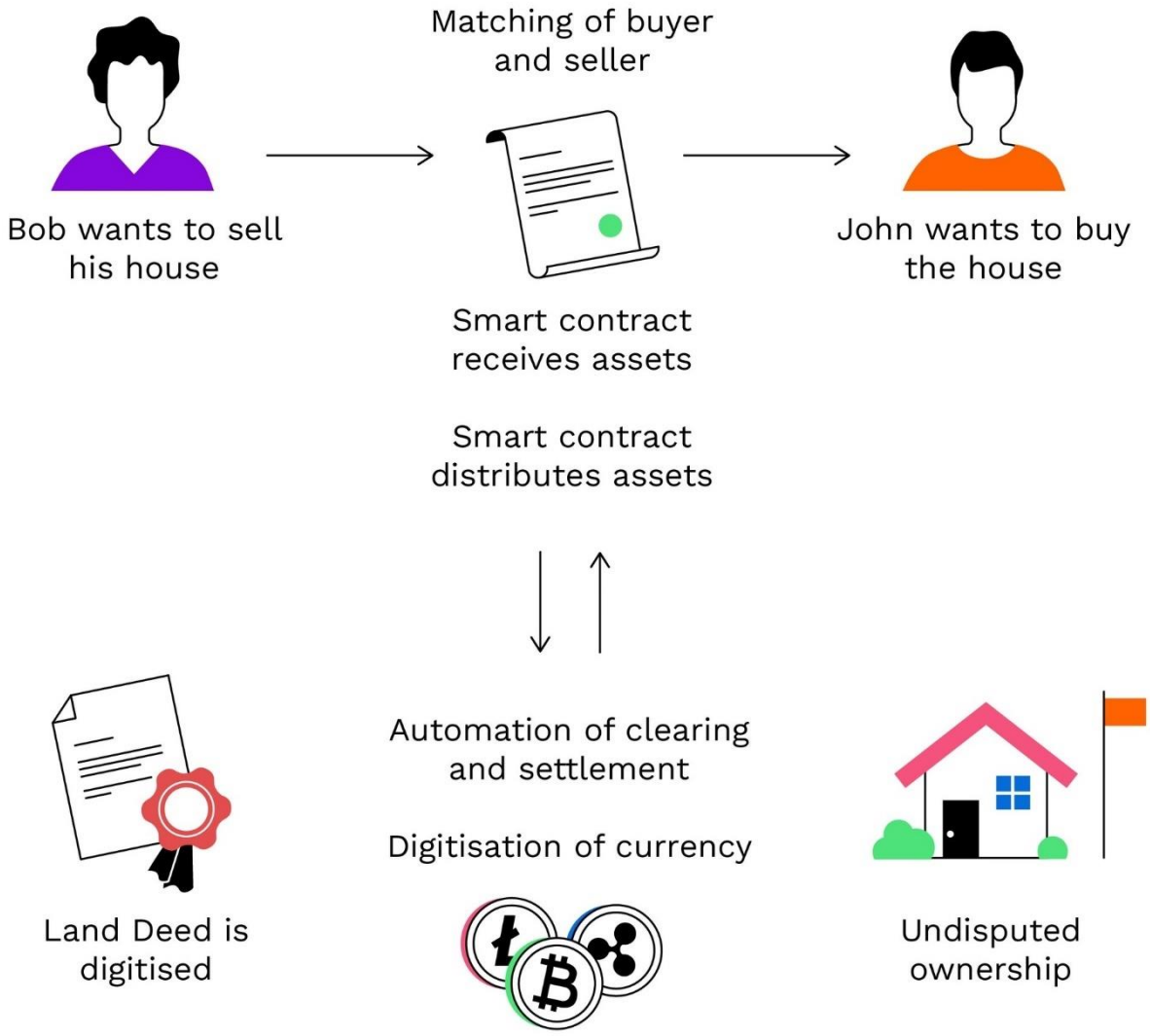

Figure 6: An example of a smart contract implementation.

Smart contracts can increase and facilitate exchanging money, shares, assets, services, or anything of value in a clear-cut automated method, based on algorithms which ensure a conflict-free transfer [13]. A smart contract is when a *meeting of minds* materializes. In short, A smart contract is a computer protocol intended to digitally facilitate, verify, or enforce the negotiation or performance of a contract. Smart contracts allow the performance of credible transactions without third parties [46]. In DeFi, the need for intermediaries is removed through the application of smart contracts on blockchain technology that power DEXs.

4.3 Price Oracles

In DeFi, a continuing goal is to provide low volatility of crypto assets available for trading on DEXs. This can be done by having the price pegged to real-world assets. However, unlike traditional finances, protocols communicating exchange prices is not that straightforward,

since these protocols are implemented through smart contracts deployed on the blockchain – without having access to any external resources such as current asset prices. Therefore, price oracles are a fundamental component to bridge cryptocurrencies with external data [15].

Price oracles feed smart contracts with external (off-chain) information that can prompt predefined actions. The primary challenge with price oracles is the need to trust outside sources for valid information. Oracles are often third-party services that are not part of the blockchain consensus structure, they are not subject to the underlying security mechanisms that is the public infrastructure of the blockchain [47]. In short, price oracles are the middlemen that bridge the gap between real-world (off-chain) services and blockchain (on-chain) protocols. Oracles take off-chain data and position this data to the blockchain for smart contract implementation and execution. They also relay messages and directives from a smart contract to off-chain external systems [48].

4.4 DAOs

Blockchain enabled Decentralized Autonomous Organizations (DAOs) have emerged as a new form of collective governance, in which communities can organize themselves relying on decentralized infrastructure [10]. One can define a DAO as an internet-native entity with no central management or control, regulated by a set of automatically enforceable rules on a public blockchain. The DAO will take a life of its own and incentive people to achieve a shared goal – in the instance of DeFi, to trade on DEXs. A DAO supports to keep a network safe and optimized without the need for manual input by its members. Participants are not obligated by a legal contract, but rather incentivized by rewards in the form of native asset tokens that help them work towards a unified goal [49]. In short, a DAO is a scalable, self-organizing coordination on the blockchain, controlled by smart contracts. The rise of DeFi protocols has led to a rise in the popularity of DAOs. Many yield farming and DEX platforms like Compound (COMP), yearn.finance (YFI) and Uniswap (UNI) are dependent on them for effective governance [49].

4.5 Stablecoins

Stablecoins are a category of cryptocurrencies whose value is tied to an outside asset, such as the USD or gold. As of date, since cryptocurrency and blockchain technology is still in its infancy - a key drawback is that cryptocurrencies' prices are unpredictable and more volatile.

Values of currencies like the dollar do change gradually over time, but the day-to-day changes are unnoticeable. With cryptocurrency the effects are often more drastic, where the value can go up and down in extreme levels throughout the day. Stablecoins try to tackle price fluctuations by tying the value of cryptocurrencies to other more stable assets – such as government-issued currencies like the USD or Euro. The entity behind the stablecoin will set up a "reserve" where it securely stores the asset backing the stablecoin. The money in the reserve serves as "collateral" for the stablecoin. A participant can theoretically redeem one unit of a stablecoin for one unit of the asset that backs it [50]. An example of a stablecoin is USDC (United States Dollar Coin). USDC is a stablecoin managed jointly by the cryptocurrency firms Circle and Coinbase through the Centre Consortium. USDC is pegged to the USD. It is the second largest stablecoin by market capitalization behind Tether, another stablecoin pegged to the USD [50].

4.6 DeFi Apps

As DeFi has boomed from 2020 and onwards, a whole ecosystem of DApps have been developed to be used in the space. Below is a list of the top 5 DApps (in terms of use case, innovation, and popularity) in specific categories as of February 2021 [51]:

Lending:

1. Aave – an open source and non-custodial protocol to earn interest on deposits and borrow assets.
2. Akropolis – a lending protocol aiming at DeFi yield optimization and interest-rate sharing.
3. Atomic Loans – a lending platform that offers non-custodial Bitcoin-backed loans.
4. bZx – a decentralized and open finance protocol that facilitates lending and borrowing for margin trading.
5. Centrifuge – an on-chain risk assessment tool and pooling infrastructure for borrowing against illiquid holdings such as invoices, real estate, and commodities.

Trading:

1. Augur – a decentralized oracle and peer-to-peer protocol for prediction markets on the Ethereum blockchain that lets anyone create a market around the outcome of any real-world event.

2. ACO – a decentralized and non-custodial options trading protocol.
3. AirSwap – a peer-to-peer trading network powered by the Ethereum blockchain.
4. Balancer – a non-custodial portfolio manager, liquidity provider, and price sensor.
5. Bancor – a protocol on the Ethereum blockchain for non-custodial token exchange using shared liquidity.

Infrastructure:

1. 0x – a protocol for peer-to-peer exchange of tokenized assets.
2. Betoken – a crowd-managed crypto asset fund ruled by protocol and meritocracy.
3. Cover Protocol – a peer-to-peer coverage market beyond smart contracts and crypto.
4. DFOhub – an Ethereum-based research and development project that provides a framework for DFO's (Decentralized Flexible Organizations), on-chain companies and voting tokens as programmable equities.
5. EPNS – a service that allow DApps, smart contracts and services to send push notifications to their users in a decentralized manner.

Assets:

1. Ampleforth – an Ethereum-based crypto with an adjustable circulating supply.
2. Augmint – a smart contract platform that issues stable tokens pegged 1:1 to the Euro backed by guaranteed collateral.
3. Basis Cash – a decentralized algorithmic stablecoin pegged to the US Dollar.
4. Benchmark Protocol – an elastic stablecoin-alternative bridging capital to the DeFi market.
5. DAI – a decentralized stablecoin soft-pegged to the US Dollar.

For this thesis we will take a closer look at DEXs and lending platforms.

4.6.1 Decentralized Exchanges (DEXs)

In the simplest term, a decentralized exchange (DEX) is a type of cryptocurrency exchange which allows for direct peer-to-peer transactions securely, without the need for any intermediaries. No one takes custody of your funds, and you don’t need to trust the exchange to do so. After the swap, you are still the owner of your assets and can move them freely as you please [52]. Traditionally, centralized exchanges have dominated the field of crypto

exchanges. However, with the rapidly evolving blockchain technology, a growing number of tools for decentralized trades have emerged.

How a decentralized exchange works:

DEXs are similar to centralized exchanges in certain ways and significantly different in others. The common key theme among DEXs is that orders are executed on-chain (with smart contracts) and that users do not sacrifice custody of their funds at any point. This is arguably the most transparent approach, as you're not trusting a third-party to relay the orders for you, and there's no way to obfuscate them.

Decentralized exchange	**Centralized exchange**
The user controls the funds	The exchange controls the funds
Anonymous	Not Anonymous
Open 24/7	Not open 24/7

Table 1: Decentralized exchange vs. centralized exchange.

Automated Market Makers (AMM):

In general, a regular market maker is a unit that offers to buy or sell an asset, making a profit from the bid-ask spread, as in the disparity between the ask or offer rate (the rate at which the market maker sells an asset) and the bid rate (the rate at which the market maker buys an asset) [11]. In contrast, an Automated Market Maker (AMM) automates this by allowing traders to place orders which then algorithmically provides a price. With a traditional market maker, a person trades directly with the market maker by selecting a quantity of an asset to trade at a price listed by the market maker. With an AMM, the market maker acts as the counterparty to all the trades, liquidity is provided even when markets are thin. Owners of various assets act as liquidity providers for the AMM by placing their assets within a liquidity pool; the quantities of assets in a liquidity pool are its reserves. In return for placing their assets with the AMM, liquidity providers are typically entitled to a share of the transaction fees paid by traders for exchanging assets on the AMM [11].

4.7 DeFi Concepts

The pace of innovation in the DeFi space can be difficult to keep up with, leaving newcomers unsure on how to get into the main concepts of DeFi. In this chapter the two main concepts f DeFi is put forward. The concepts are related to the day-to-day usage of DeFi and how

everyone can participate in the space and increase their portfolio or the value of their assets by participating in the DeFi ecosystem.

4.7.1 Liquidity Mining

Liquidity mining is related to how market makers are implemented in DeFi. In DeFi, as stated before, AMMs are used to provide relevant prices for trading. A token issuer or a DEX can reward a pool of miners to provide liquidity for a specified token or asset. Since the primary goal of an exchange is to be liquid, DEXs seek out ways to reward users willing to bring capital (liquidity) to their platform.

Figure 7: Deception of Uniswap (one of the most popular DEXs) AMM flowchart.

While the token swapper pays a small fee to trade on a decentralized exchange, the liquidity provider earns money for providing the liquidity that the first user will need. For example, people who provide liquidity for Ether (the token used in the Ethereum blockchain) get a small interest every time someone trades Ether on a DEX such as Uniswap. To conclude, liquidity mining is a fairly simple concept. New DEXs can only survive with appropriate liquidity that can facilitate trades. DEXs motivate cryptocurrency holders to provide this liquidity, by rewarding them with a fraction of the platform's trading fees [53].

4.7.2 Yield Farming

Yield farming is a method to generate rewards with cryptocurrency holdings. As discussed from the chapter above, users can provide liquidity in a liquidity pool and earn rewards in the form of fees paid by token swappers. Some liquidity pools pay their rewards in multiple tokens. The rewards can then be deposited to other liquidity pools to earn more rewards, and so on. With large amounts of capital, an investment can thus be folded many times over in order to maximize the amount of interests earned [54]. With yield farming, the aim is to

maximize a rate of return on investments by leveraging different DeFi protocols. An investor will possibly use a DeFi platform like Compound, accumulate crypto assets, and lend them to potential borrowers. The borrowers will then pay back interest on the loan to the investor. Interest can be either flat or flexible with the rates decided by the individual platform. Compound rewards users with its native token “Comp”, along with the interest payment. As such, yield farming can attract more people to DeFi protocols and increase user adoption [55].

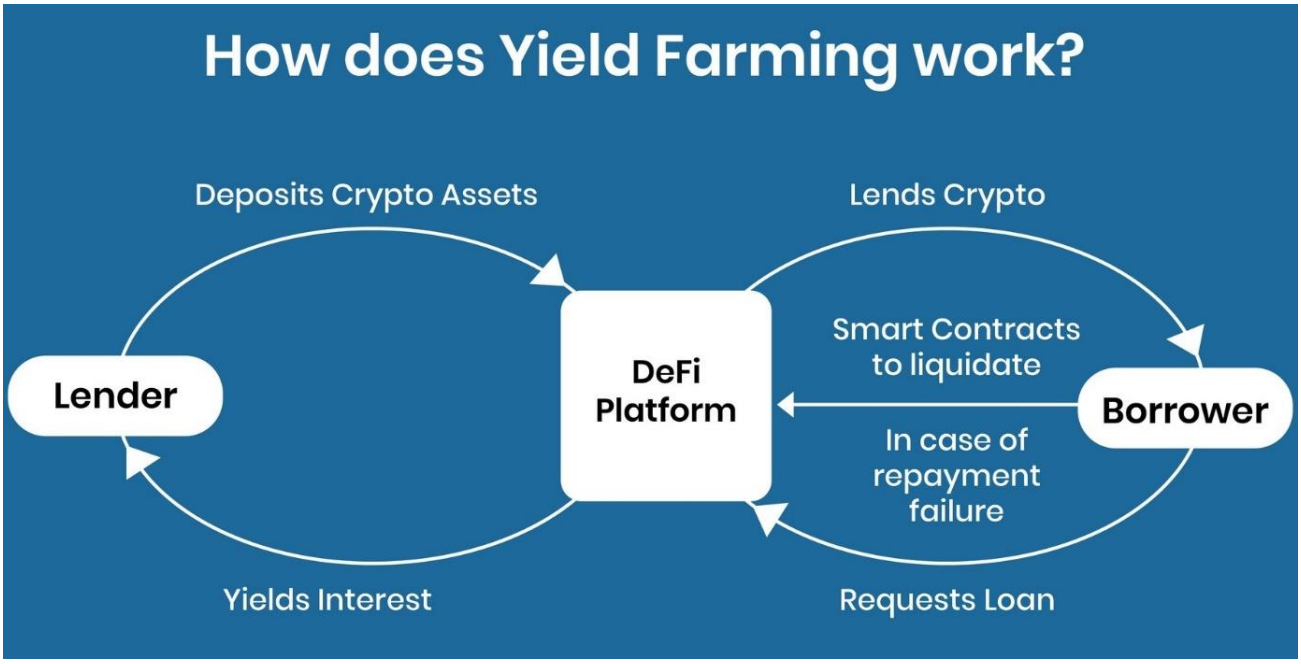

Figure 8: Yield farming explained.

5 The DeFi Market

As of 2020, the DeFi market continuous to boom in popularity, usage and TLV (Total Value Locked). The DeFi movement is based on the idea that the financial structure should not be controlled by monopolistic third-party providers but that it should instead be decentralized. In this chapter, the current state and the future of the DeFi market is laid to ground. An overview is given to the state of the DeFi market as of early 2021 and what the future holds for this movement.

5.1 The Current State of the Market

DeFi in its current state is still in its infancy, yet rapidly progressing with new innovations and use cases.

Staking:

A staking reward is a positive staked incentive by which an individual receives a bonus in his token balance based on the stake he has in the system. Staking is similar to earning interest from a bank account — the longer you hold, the more you earn.

Flash loans:

Flash loans allow an individual to borrow instantly from a publicly funded smart contract pool without providing any collateral [56]. These loans must be repaid before the end of a transaction time (usually only valid within one block transaction). The transaction will be reverted if the borrower does not repay their debt by this time. This process ensures that liquidity is always returned to the pool. Flash loans are commonly used for arbitrage, collateral swapping, self-liquidation, and quick trades.

The table below gives a brief explanation of the main DeFi use cases as of early 2021 [57].

Application	**Description**	**Use case**	**Examples**
Layer 3 applications	Applications combining core DeFi infrastructure. This provides an abstraction of complexity.	Combining several DeFi platforms allow customers easier interactions, monitoring and general better usability.	InstaDapp Zerion DeFi Saver DeFi Pulse
Borrowing/Lending	Lend crypto assets and receive interests. Borrow crypto assets and pay interests.	Lender: Provide capital and earn interests Borrower: Create leverage or short an asset Both: Arbitrage	Compound Maker dYdX Exchange bZx
DEXs	Decentralized alternative to centralized	Trading of cryptocurrencies.	Uniswap Kyber Swap dYdX Exchange 1inch Exchange

	exchanges to trade crypto currencies.		
Stablecoins	Crypto coins pegged to a fiat currency.	For the trader, the cryptocurrency has minimal volatility. For the ecosystem, it allows easy comparison of value for various cryptocurrencies.	Tether USDC Dai Binance USD
Derivatives	Decentralized alternative to traditional financial derivatives.	Risk management, leveraged trading and betting.	Synthetix Nexus Mutual DerivaDEX Augur
Prediction/Betting	Decentralized alternative to prediction and betting markets.	Betting and prediction.	Augur Stox Gnosis Polymarket
Insurance	Insurance against price risk, technological risk, network risk, hacking risk etc.	Insurance against a variety of risks affecting DeFi and online trading.	Nexus Mutual Etherisc Cover Protocol Opium Insurance

Table 2: Main DeFi use cases [57].

The core benefits of the DeFi market as of early 2021:

- True decentralization that allows worldwide participation regardless of social status. This dispenses the need for third parties and is censorship resistant.
- Relatively low-cost and swift transactions and settlements, even across national lines.
- Non-custodial ecosystem. The user is in full control of the money without a trusted third-party.

- Increased ecosystem transparency and thus price and market efficiency. Personal interests are governed by a transparent protocol.
- DeFi favors network effects, and the network keeps growing.

As of early 2021, one can easily lock-up several million of USD for staking or allow the money to be loaned out and earn interests - without the need for any bank account, custodial protocol and third-party involvement. In addition, the customer is always in possession of the underlying cryptocurrency and can anytime take out their investment. Compared to the traditional financial industry, actions like this comes at the cost of heavy centralization and the need for bank accounts, government papers and custodial protocols.

5.2 The Road Forwards for the DeFi Market

A closer look into the future of DeFi gives us certain challenges. First of all, in the grand scheme of total financial services, DeFi is still in a niche spot – mainly used by blockchain enthusiasts. Accessibility and more liquidity are needed to gain mainstream attraction. However, consider the state of the financial system for a moment. As of early 2021, 1.7 billion people are unbanked across the world. Small businesses, even those with a banking relationship, often must rely on high-cost financing. High costs also impact retailers who lose 3% on every credit card sales transaction. These total costs for small businesses are massive by any metric. The result is less investment and decreased economic growth [38, 58]. With DeFi, you deal with peers algorithmically in a secure environment enabled by blockchain technology. Cutting out the centralized institutions significantly reduces costs, making loans more affordable and increasing deposit rates.

Going back to accessibility; mainstream users want a one-stop solution where they can trade tokens, create a digital wallet, and use their favorite DApps with a single login. While this is not an easy hurdle to clear, in the near future DApps will be as user-friendly as the centralized applications they are trying to replace [59]. Today, the DeFi ecosystem is similar to a walled garden, which is counterintuitive, seeing as all anyone needs to get started with DeFi is an internet connection and a smartphone or a computer. While a big share of the DeFi ecosystem is centered around lending and borrowing, this is just the tip of the iceberg. DeFi will continue to challenge the entire traditional financial system and start providing services that mimic and improve upon traditional financial apps. Each time the DeFi ecosystem creates a viable decentralized alternative to existing traditional applications, it enters a new market as a

challenger. In the end one can argue DeFi is unstoppable, a movement created by the people for the people around the world. Everyone deserves access to financial services with secure, low-cost transactions that are governed by fair operating principles.

6 DeFi as Alternative Finance

For years, we have lived in a world of centralized finance. Central banks and governments control the money supply. Financial trading is largely done via intermediaries. Borrowing and lending is conducted through traditional banking establishments. However, in the last few years, Bitcoin, blockchain technology and recently DeFi has entered the market to challenge our traditional ways of doing finance. As a new era of financial technology is upon us, DeFi may reshape the structure of modern finance and create a new landscape for entrepreneurship and innovation, highlighting the potential of decentralization as a basis for new business models.

6.1 Limitations of Traditional Financial Institutions

For centuries, financial institutions have played important roles in negotiating and structuring economic transactions that would otherwise be difficult to execute due to transaction costs. This require the involvement of centralized institutions, who are relied upon to build trust among transacting parties and to operate digital platforms [36].

The centralized financial system has five key limitations [36, 38]. These are:

1. Centralized control
2. Limited access
3. Inefficiency
4. Lack of interoperability
5. Non-transparency

The following chapters will go deeper and give a brief clarification into the main limitations of traditional financial institutions.

6.1.1 Costs

One of the biggest disadvantages of using traditional financial systems is the relatively high costs. This is more apparent in less developed nations, and especially when sending micropayments across national borders. Take for example the transfer of a micropayment of 15 USD from USA to Venezuela, the transfer fee can range from 0.5% up to 5%. In addition,

many banks charge their customers between $15 and $30 to receive international transfers [60]. This highlights the key disadvantage when it comes to micropayments and high fee rates.

6.1.2 Geographical Limitations

Due to banks requiring governmental identification, traditional financial services are limited by geographical locations. You are dependent on using the service in your geographic location due to monetary and identification limitations. Transferring funds from one national bank to another may take days, if not weeks.

6.1.3 Transaction and Service Speed

Many of the financial services provided by banks still require human-to-human interaction. The need for intermediaries and human-to-human interaction makes traditional banking much slower than DeFi. Moving big capital also typically requires a more rigorous process, where one often has an obligation to meet up physically in the bank offices.

6.1.4 Low Interest Rates

One of the biggest disadvantages traditional banking has is the low interest rates for cash savings. This has been exacerbated by the financial crises we have faced in recent years as central banks reduced their interest rates to rock bottom rates [61, 62]. In some cases, keeping your money in the bank would in real terms lose its value as inflation rates are often higher than interest rates. While in comparison, investing in relativity “blue-chip” DeFi projects like Aave or YFI will give you an 8-12% annual percentage yield [61, 62].

6.1.5 Inefficiency

A centralized financial institution has several inefficiencies. The first example that comes to mind is the credit card interchange rate that causes consumers and small business to pay up to 3% transaction fee for every swipe [36]. Another example is the time it takes to settle stock and bond transaction between different accounts. In the age of internet and blockchain technology, this hardly seems like a proper system. Other examples of inefficiency include incompetent microtransactions, direct and indirect brokerage fees, costly and slow transfer of large funds and stoppage of transactions during weekends/holidays.

6.1.6 Lack of Interoperability

The financial system of today is like a collection of islands with no effective bridge of connection between them. Moving money from one institution to another can be excessively lengthy and complicated. A wire transfer can take up to three days to complete. Since we deal

with several financial systems such as stock markets, insurance providers, banks, retirement funds and accounts, we need a superior system to incorporate better interoperability [36].

6.1.7 Lack of Transparency

As of right now, the current traditional financial system is not transparent. As a customer, you have limited knowledge about the financial health of your bank. You must place your faith in the company and government protection (insurance). Another area that lacks transparency is when seeking loans. Different banks provide different payment plans and interest rates, and you as a customer is limited to differentiate between the best plans.

6.1.8 Centralized Control

Most consumers and businesses deal with a single bank, and the bank controls the interest rates and fees. Switching is time consuming and may even be costly. And often, the largest banks frequently undercut the smaller banks to crush any competition. And in certain countries like the United Kingdom or Canada, the largest banks have an oligopolistic business practice [36].

6.1.9 Limited Accessibility

As stated before, over 1.7 billion people are unbanked [36]. This makes it particularly challenging to operate in a world that depends on banks, especially when it comes to international commerce, obtaining loans and opening businesses. But being banked does not solve the limited accessibility problem. Banks set the amount of loans a person or business can apply for, and you as a customer have limited options.

6.1.10 Political Limitations

Political turmoil and governmental policies affect the banks of nations. Being unwanted by a certain governmental agency can make it incredibly tricky to obtain financial services and access to money. The centralized banks of nations are often in close contact with the government due to regulatory policies to ensure a safe financial service. However, tyrannical governments can use this connectivity to limit the access of money to the people to keep their power and have the population under their control.

6.2 Micropayments

Electronic transactions, especially transactions that are international have relatively high costs. As a result, micropayments that are for example in pennies or fractions of pennies are essentially impracticable. Traditional financial transactions usually incur fees of between 21

to 25 cents (in the US) in addition to a percentage of the total transaction, and thus transactions that are less than $1 are rare because of this wastefulness; and credit-card based transactions can be even more expensive [33, 63]. Though popular cryptocurrencies like Bitcoin and Ethereum have solved the transparency and centralization problem, they are still not cheap enough to enable micropayments. This is where other cryptocurrencies come into the picture, like NANO that have no fees and are instant. In the world of DeFi and cryptocurrencies, small to no fees and instant transactions will be possible in the near future and available for everyone. By providing people all over the world the ability to transfer pennies or even fraction of pennies, micropayments without any downside are big step forward to a better financial system. This can have tremendous effect on people that live in developed nations with limited money. With the use of DeFi and its decentralized services, improving the lives of possibly billions of people can become a reality.

6.3 Customized Asset Management

With the help of the DeFi ecosystem, the potential is there to bring in millions of new investors into the financial world, many whom have never had the opportunity or the knowledge to invest before. In traditional finance, transparency is rather complicated to ascertain. Because of lengthy (often 2-3 day) settlement times, and typical quarterly or even yearly reporting, many fund managers only have to publicly display their holdings once a month or once a quarter [64]. This implies that when someone invest in a fund, they might not know the holdings at that specific moment. They might only know the performance of the fund, and the managers as of the previous quarters/years. In a DeFi fund, people have up-to-the-block outlook into the holdings of a fund or token, as well as the performance of the fund and manager since everything is visible for everyone on the public ledger. For example, *Set Protocol* offers simple asset management of crypto holdings through their *Token Sets*. They have *Robo-Advisor* that rebalances the tokens based on technical trading strategies. Their *Social Trading Robot* will follow your favorite trader and copy their token allocations [64].

Another challenge in traditional asset management is to create a portfolio that includes growth, income, hedge, and liquidity. This level of management comes with higher fees that must be paid to the manager of these funds. There are now several DeFi asset manager tools that have the ability to move into multiple positions, layering exposure, yield, liquidity and risk management in one transaction. Zapper.fi is an example that offers this service. An individual

can insert their wallet address and get a clear overview of the assets and liabilities in one simple interface. DeFi asset management allows one to obtain an overall higher return on low-risk lending investment by moving funds among different lending protocols. In traditional finance, the equivalent would be moving money to whichever bank is paying the highest interest rate on savings accounts or funds, without the fees and friction associated with moving banks. By using DeFi which operates on public ledgers, there is no need for KYC (Know Your Customer) information. There is no need to speak to any fund manager or any intermediaries. Simply connect your wallet to the chosen DeFi asset manager provider and you can easily move your funds.

With the growth of protocols like Synthetix and UMA, creating tokens that mimic off-chain assets is easily done. This allows the management of all assets on-chain. This is seen in assets like foreign currencies, oil, and gold that are currently available in synthetic forms on the Synthetix platform as of today. Synthetic representations will allow investors and fund managers to create exposure, hedges, and diversification across traditional and crypto assets. In addition to this, assets from other blockchain platforms can be included in an asset portfolio. With DeFi, hyper-customization of portfolios is a possibility. A DeFi asset portfolio can include tokens, cryptocurrencies, derivatives, hedges, stablecoins, off-chain mimics, and cross-chain tokens.

6.4 Real-World Example of DeFi Use Cases

6.4.1 The Political Crises in Venezuela

As of February 2021, Venezuela is still in a major political and economic crisis. Geopolitical actions have already begun with U.S.-led sanction worsening the already damaged Venezuelan economy. The banks are under governmental control, and even if the population could withdraw their savings, the Bolivar is experiencing hyperinflation making it practically worthless [35]. Many people in Venezuela have successfully managed to convert their lifesavings into cryptocurrency to avoid hyperinflation and possibly get out of the country. They are able to spend money to buy much needed food and other necessary services in a turmoil country with the help of cryptocurrencies.

An example of this is an individual by the name of Carlos who was able to save about $ 10 000 and left Venezuela [35]. He knew his cash would be confiscated by the government if he tried to cross the border. He had access to the internet through his smartphone. He got a

cryptocurrency wallet (MyEtherWallet) for his phone. Furthermore, he was able to convert his cash to Ether by using chat sites to find locals who were willing to trade cash for crypto. By doing this Carlos was successful in not only converting his cash to crypto but was able to get out of the country without his hard-earned money being confiscated by the government.

Daniela is another example; she lives and works in Venezuela. She was in the USA before and had a checking account with $ 15 000 on it. Fearing that she might lose control over those funds now that the USA is sanctioning Venezuela and knowing that she can't transfer the money to a Venezuelan bank due to the government control, she came up with a plan to use cryptocurrency to safely move those funds back to Venezuela. She opened a Coinbase account and spent her money buying Ethereum, from there, she transferred the funds into her own private wallet. By doing it this way she has total control of her savings without the need for any intermediaries in the USA or Venezuela. She then converted the Ethereum to stablecoins that are pegged to the USD through a DEX thanks to the DeFi ecosystem. She then was able to lend some of her funds on the Compound platform to earn interest over time.

DeFi can be an option of last resort for refugees escaping political and societal collapse. DeFi can be used to circumvent the authority of dysfunctional governments and insolvent banks.

6.4.2 Illegal Activities

Money laundering is the unlawful process of obscuring the origins of money obtained illegally by passing it through several sequence of banking transfers or business-related transactions. The overall scheme of this process returns the money as "clean" to the launderer in an indirect manner. With the decentralized nature of DeFi, and the lack of intermediates or international regulation, money laundering can transpire (and has probably occurred) in the DeFi space. The same can be said about the purchase of illegal substances through the use of cryptocurrencies. In the early days of Bitcoin, it was mainly used to buy and sell illegal substances over the internet. With DeFi, a more robust and international trade has been set forward. With it comes the challenge of regulation and monitoring for illegal and unlawful use of cryptocurrencies.

6.5 DeFi Opportunities

DeFi offers several opportunities that were not available in the world of traditional finances or even on regular, simpler blockchains like Bitcoin. In this chapter we will address the concrete solutions that DeFi presents to the flaws of traditional finance: these flaws include,

as discussed before; inefficiency, limited access, lack of transparency, centralized control, and lack of interoperability.

6.5.1 Increased Efficiency

One of the biggest flaws of traditional finances that DeFi fixes is inefficiency. With DeFi the accomplishment of financial transactions with high volumes of assets and low friction can be executed, this would generally be a large organizational burden for traditional finance. DApps designed to execute a specific financial operation is possible with reusable smart contracts. These DApps are available to anyone who seeks to interact with DeFi projects and platforms. A user can easily interact with the DeFi ecosystem, regardless of geographical location as long as internet service is available. With DeFi, moving funds is simple with no organizational overhead, increasing the efficiency of financial transactions.

To provide the best service for DeFi protocols, a DApps' benefits and services are optimally priced, rewards are often structured as an auction. Pure, accessible competition provides value to DeFi platforms by guaranteeing users pay the market price for the services they require. One big notion that incentives efficiency is the concept of *forking*. A fork can be explained as a copy and reuse of the code with upgrades or enhancements layered on top. A common fork of blockchain protocols is to reference them in two similar currencies and chains. Doing so creates competition at the protocol level and creates the best possible smart contract platform [38]. Each DeFi DApp built on top of the Ethereum blockchain has a public code that is forkable. Should inefficient or inadequate DeFi applications exist, the code can be easily copied, improved, and redeployed through forking. Forking and its benefits arise from the open nature of DeFi and blockchains [38].

6.5.2 Unconstrained Access

DeFi gives large groups of people such as the global population of the unbanked as well as small businesses that employ substantial portions of the workforce direct access to financial services that can better service their interests. As DeFi platforms continue to improve and scale, user friction falls, enabling a wide range of users, and thus mitigates another flaw of traditional finance: limited access.

The subsequent impact on the entire global economy should be obviously positive. Even regular consumers who have access to traditional financial services such as bank accounts, mortgages, and credit cards, do not have access to the financial products with the most

competitive pricing and most beneficial terms; these products and structures are limited to larger institutions. DeFi allows any user access to the entirety of its financial infrastructure, regardless of their wealth or geographic location [38]. An example of more accessibility to more financial services provided through DeFi is through yield farming as mentioned in Chapter 4.7.2. To recapitulate, yield farming provides inflationary rewards to users for staking investment or utilizing a protocol. These rewards are payable in the same primary asset the user holds or in a distinct asset such as a governance token. A user can stake any amount of any size, regardless how small, and receive a proportional reward. And any user can participate in yield farming. This is a rare occurrence in traditional finance. While in DeFi, this process is a common and a respected way to give ownership of the platform to the people who use and benefit from it.

6.5.3 More Transparency

Transparency is clearer in DeFi due to the implementation of smart contracts. All parties are aware of the capitalization of their counterparts and can see how funds are being deployed. At any time, the parties can read the contracts and determine for themselves if the terms are agreeable or not. This removes ambiguity as to what will happen when they interact under the contract terms. In reality, the average consumer does not understand the contract code, but can depend on the open-source nature of the platform and the wisdom of the crowd to feel secure. DeFi mitigates counterparty risk and thus creates a host of advantages that is not present under traditional finance.

If you participate in DeFi contracts you are held accountable. One mechanism that ensures accountability is through staking. Staking is escrowing a crypto asset into a contract, so that the contract releases the crypto asset to the proper counterparty only after the contract terms are met; otherwise, the asset reverts to the original holder. Staking enforces agreements by enforcing a tangible penalty for the misbehaving side and a tangible reward for the counterparty. These transparent incentive arrangements provide much safer and more obvious guarantees than traditional financial agreements. Another kind of smart contract in DeFi that improves transparency is a token contract. Tokenization allows for transparent proprietorship and economics within a system. Users can know exactly how many tokens are in the system as well as the inflation and deflation parameters [38].

6.5.4 Decentralized Control

In the traditional finance system, there is a strong control exerted by government agencies and large corporations that hold a near monopoly over elements such as the money supply, rate of inflation, and access to the best investment opportunities. DeFi defies this centralized system by relinquishing control to open protocols, where transparency and immutable properties is part of the ecosystem. If a DeFi app contains special privileges for an overseer, all users are aware of the privileges, and any user can quickly create a less-centralized counterpart. The open-source ethos of DeFi and blockchain technology in addition to the public nature of smart contracts assures flaws and inefficiencies in a DeFi project can at any time be identified and forked by users who want to improve a more flawed project. As a result, the DeFi system is constantly being improved, and is not being held down due to monopolies and concentrated power on top who have their own interests at hand.

The path to a decentralized financial system will encounter challenges because of the disputes for every eventuality and economic nuance. However, the transparency and security achieved through a decentralized approach will lead to strong protocols that can become trusted financial infrastructure for a global userbase with time. One of the biggest problems with centralized power is that corporations are resistant to share their innovations with each other, due to the fear of losing control over the market. This results in traditional finance products and services being difficult to integrate with each other. The innovation possibilities in DeFi are significant, and improvements are growing at a rapid nonlinear rate. The growth is fueled by the ease of composability in DeFi products. New protocols can easily be layered on top of base infrastructures [38].

6.5.5 Better Interoperability

DeFi platforms integrate and interact with each other through the method of tokenization. In traditional finances, to use assets that are locked up can be relatively difficult. Take for example someone having a percentage ownership stake in a private commercial real estate venture. To use this asset for a loan or as margin to open a levered derivative position would be quite challenging.

In DeFi this procedure is more simplified, due to the shared interfaces and applications that can directly plug into each other's assets and subdivide positions as needed. With DeFi, a whole new world opens up due to the method of tokenization of traditionally illiquid assets.

This makes them ready to be traded with a few clicks. A simple use case would be creating fractional shares from a unitary asset such as a stock. We can extend this concept to give fractional ownership to scarce resources such as rare art. The tokens can be used as collateral for any other DeFi service, such as leverage or derivatives [38]. Tokens or bundles of groups of real-world digital assets can then be traded like an ETF. A real estate development trust (REIT) can then be traded as a token but with the added capability of allowing the owner to subdivide the REIT to select a preferred geographic distribution and allocation within the REIT, thanks to tokenization. Ownership of the token provides direct ownership of the distribution of the properties. The owner can trade the token on a decentralized exchange to liquidate the position at any time. A tokenized version of a position in a DeFi platform is a pluggable derivative asset that is serviceable in another platform. Tokenization allows the benefits and features of positions to be portable. In DeFi, the concept of interoperability extends to network liquidity. Traditional exchanges do not easily allow liquidity to be shared without special access to a broker, which are generally limited to hedge funds. This is different in DeFi, this capability allows for networked liquidity and leads to extremely competitive rates for users within the same application [38].

7 DeFi Limitations

DeFi allows people to enter a whole new world of financial products and services, expanding the possibilities of financial technology and opportunities. However, just with traditional financial services, there are risks involved with DeFi. This chapter puts forward a list of the main risks associated with using DeFi services.

7.1 smart Contract Execution

Since smart contracts are algorithmic and programmable, coding errors may create vulnerabilities that can allow attackers to drain funds or cause a protocol to be unusable. As a user, one must be aware that a protocol is as secure as the underlying smart contract. This is a challenge, since the average user is not able or in most cases, willing to read through a contract code, let alone evaluate if it is compromised or not. Insurance services, code audits and verifications exist, but to some degree, some uncertainty still remains.

7.2 Security of Operation

With DeFi, protocols and applications need admin keys used typically by the core development team to perform upgrades and if necessary, emergency shutdowns. While the need for these

keys is understandable, the existence of these keys can be a potential problem. If the keyholders do not create and/or store their keys in a secure manner, malicious third parties could gain access to the keys and exploit the smart contract. Most projects try to mitigate this risk with multisig (M of N keys needed to execute any of the smart contracts admin functions) and timelocks (time delays that can be used to respond accordingly).

7.3 Dependencies

Since the DeFi ecosystem allows for more interoperability and openness, it can also introduce more dependencies. If there is an issue with one smart contract, this may potentially have wide-reaching consequences for multiple applications across the entire DeFi ecosystem. Many smart contracts can also be reliant on external data. Whenever a smart contract depends on data that is not natively available on-chain, this data must be provided by external data sources [29]. Price oracles introduce dependencies and could, in some cases, lead to heavily centralized contract execution. To mitigate this risk, many projects rely on large oracle networks with M-of-N data provision schemes [29].

7.4 Governance Risk

DeFi applications rely on more than just autonomous computer codes. For example, MakerDAO, the decentralized credit facility, is reliant on a human-controlled governance process that actively adjusts protocol parameters to keep the system solvent [38]. Many other DeFi protocols use comparable systems and rely on humans to actively manage protocol risk. To participate in the governance process, users and investors must acquire a token that has been explicitly assigned protocol governance rights on a liquid marketplace. Holders use these tokens to vote on protocol changes and guide future direction [38]. Any financially equipped adversary can simply acquire a majority of liquid governance tokens to gain control of the protocol and steal funds. However, this has yet to happen and is more of a theoretical risk.

7.5 Oracle Risk

Oracles are required by most DeFi protocols in order to function properly. Oracles try to answer a simple question related to blockchain technology; How can off-chain data be accurately reported on-chain? Without oracles, blockchains are completely self-encapsulated and have no knowledge of the outside world other than the transactions added to the native blockchain [38]. Many DeFi protocols need oracles to access secure, reliant asset prices to ensure routine actions such as prediction markets and liquidation resolutions function

appropriately. Protocol dependence on these data feeds establishes an oracle risk. Until oracles are blockchain native and proven to be resilient, they represent a large systemic risk to DeFi today.

7.6 Scaling Difficulties

Blockchains have a fixed block size (similar to how a hard drive has fixed amount of disk space). With the decentralized nature of DeFi, there are no centralized nodes that can handle thousands of transactions in seconds like Visa or Mastercard. For a block to become part of the chain, every Ethereum miner must execute and validate all the included transactions. To expect each miner to process all of the financial transactions for a global financial market is not realistic. If DeFi cannot properly scale, it will be unable to meet the necessary worldwide demand. As of date, several scaling solutions for the Ethereum blockchain are at work, including a *proof of stake* migration from the more cumbersome *proof of work*. Many approaches today aim to decrease the scalability risks facing the DeFi ecosystem. One thing is certain, as long as the growth of DeFi is limited by blockchain scaling, applications will be limited in their potential impact on the world.

7.7 DEX Risks

The main method to interact and swap tokens in DeFi is through the use DEXs. These decentralized exchanges vary greatly in design and architecture, but all are attempts to solve the same challenge —To create the best decentralized exchange for trading assets. The majority of DEXs use AMM (automated market makers). AMMs allow users to exchange holdings privately and securely, while removing traditional counterparty risk. Uniswap is perhaps the best-known example of an AMM-DeFi exchange. Uniswap relies on the product of two assets to determine an exchange price. The amount of liquidity in the exchange pool decides the slippage when assets are swapped during a transaction. This allows the pool to attract liquidity but exposes it to smart contract risk and impermanent loss [38]. Impermanent loss happens when two assets in a pool have uncorrelated means and high-level volatilities. The risks around the DEX landscape today are evolving, they should shrink over time as technology advances and market players increase in sophistication and architecture.

7.8 Regulatory Risks

As the growing influence and size of DeFi increases, it will face several regulatory scrutinies. Governance tokens that are released by certain DeFi projects are also facing increasing inquiry

as the SEC continues to evaluate if these new assets will be regulated as securities or not [38]. As DeFi continues to flourish and the total number of distributed holdings continues to expand, it is expected to see increasingly specific and nuanced regulation aimed at DeFi protocols and their users. For example, cryptocurrency taxes are yet to be fully developed from a regulatory standpoint, and as of today, individuals have to manually do their taxes – with little to no guidelines by central governments. The outlook is still hazy, though it is not unrealistic to foresee that in the future, governments will develop easier methods to file in taxes and on-chain assets.

8 DeFi as a Technology-Pushing Movement

DeFi offers exciting opportunities and has the capability to create a truly open, transparent, and immutable financial infrastructure. The future of DeFi depends on several factors. DeFi allows for revolutionary interoperability beyond what could ever be achieved in the traditional finance world. The public nature of DeFi cultivates trust and security across national borders. In term of regulations, it is generally ideal for laws to be technology-agnostic. The true potential of DeFi is transformational. In the future, the firms that refuse to adapt will be lost and forgotten. And with time, traditional financial firms should begin to integrate and develop their services with crypto and DeFi in mind. To see how DeFi will look in the future, this paper promises four key areas that will experience leaps of innovation in the coming years.

8.1 Key Area of Improvement 1: Evolution of Digital Identities

Digital identities in today's world are nothing new. You can hardly find a person without a Facebook account, an online bank service account or any gaming account for that matter. Chances are if you use the internet, you have a digital identity – whether you know of it or not. Though strides have been made to protect individual privacy rights on the internet, the measures are far too lenient on big corporations collecting personal data. Blockchain technology offers a new vision for personal identities in the digital age through decentralized identity (DID). By removing central harvest algorithms that collect data, they give power back to the users. Decentralized identity platforms such as *CanDID* would allow seamless integration with legacy systems, simplifying the on-boarding process and broadening the potential user base [65]. In addition to minimizing the risk of counterfeit and fraud, DID allows for the monetization of one's own data through DeFi. Individuals could license their anonymized health data to be analyzed in broad population studies or release their browsing

history to advertisers in return for compensation. The Covid-19 pandemic has created large interests for more secure digital identity solutions. As an example, IBM is working on digital health passports, built on its blockchain technology. Decentralized technology and the use of DeFi will break up data-hoarding monopolies and return control back to the users of the internet.

8.2 Key Area of Improvement 2: Tokenization

Tokenization is the process of taking an asset that is not native to a specific blockchain and represent it on-chain through tokens. These assets can be completely off-chain, such as real estate, or from another blockchain platform, such as BTC represented on Ethereum blockchain through wBTC (wrapped BTC). Ownership of a token serves as a claim to the underlying asset. In the future, instead of owning several papers and contracts to your house or car, you would simply own the tokens that represent that asset. This token would be available on the blockchain, and anyone could confirm that it is in fact you who own the asset. Trading would also become less cumbersome - all you would need is the other party to buy the underlying asset and the ownership of the asset would transfer from your wallet to the buyers wallet – without the need for any intermediaries. Property of any asset can be transferred at any time with a couple of clicks from anywhere in the world [65].

The possibilities are endless since anything can in theory be tokenized. Perhaps the greatest potential growth lies in the field of non-fungible tokens (NFTs). An NFT is distinctive and one of a kind, it represents a scarce asset. Tokenized art has attracted huge interests lately. The benefit of tokenized assets is the ability to stay within the crypto and DeFi ecosystem. The support for trading stock indices such as the FTSE 100 and the Nikkei, as well as commodities including gold, silver, and oil is increasing, this means that investors do not have to remove their capital from crypto and into brokerage accounts to gain exposure to said assets [65]. It's not too farfetched to believe that in the future, buying and selling houses, cars and other assets would be similar to trading crypto assets through the DeFi ecosystem.

8.3 Key Area of Improvement 3: Governance

With DAOs, there is no centralized control or hierarchical structure. The DAOs are controlled by members where they can vote on proposals that must reach a certain, predetermined level of consensus. Membership and the privileges that come with it is achieved through holding governance tokens. The rules are encoded onto the blockchain through smart contracts.

Therefore, the organization's financial history is visible on the blockchain, so anyone can see where the holdings are being stored and spent. Through DAOs and the usage of governance tokens in the DeFi ecosystem, organizations will have more of a flat structure - Ensuring members equal representation and more transparency. In essence, DAOs allow the public to exchange its funds with anyone in the world. This can be done in the form of an investment, a charitable donation, capital raising, borrowing and so on, all without a mediator. DAOs try to fix everything that's wrong with how modern-day organizations are operated and run. A well-structured DAO gives every investor an opportunity to influence the organization. There's no hierarchical structure, which means every groundbreaking idea can be put forward by anyone and be taken into consideration by the entire organization. With a set of pre-written guidelines that every investor is aware of before joining the organization as well as the voting system, there is little room for bickering between participants in the DAO [66].

8.4 Key Area of Improvement 4: Digital Security

New field of technology always present unique opportunities and risks. The shift from a centralized to a decentralized financial ecosystem must consider security as an important factor. DeFi systems gain an important security feature, and that is that they do not rely on any single point of failure. To access identities in a decentralized system the hackers would have to circumvent the cryptography that secures each individual user's wallet. This would be incredibly time-consuming and require computer power that is unimaginable to achieve as of date [65]. To fully realize the potential of DeFi, more security measures are needed, encoded in the smart contacts and the underlying platforms. There have been exploits, due to faulty coding or unforeseen exploitation on exchanges. With new technology, new challenges arise. DeFi is pushing technology-based security protocols to not only ensure a safer user experience for participants in the DeFi space, but for the overall online world.

8.5 Lending and Borrowing

The most popular services with the largest fractions of the total DeFi market cap are lending and borrowing operations. Platforms that offer lending, borrowing and flash loans in a decentralized system has huge potential to grow even larger in the coming years. These platforms will most likely continue to grow and offer users across the world simple access to funds previously not available to them. As of early 2021, MakerDAO is among the most popular decentralized lending protocol where each of its native token DAI is pegged to USD

and is backed by collateral in the form of crypto assets. Other popular borrowing and lending platforms are Compound and AmpleForth [15].

8.6 Derivatives

Derivatives are one of the key aspects of a strong financial system. Derivatives "derive" the value from something. In traditional finances, the most frequently used derivatives are forwards, futures, options, and swaps [70]. In the DeFi space, derivatives allow crypto companies and private crypto investors to hedge their exposure to different cryptocurrencies. Every growing market naturally develops its own derivatives market that can end up being several orders of magnitude bigger than its underlying market. The derivatives market in traditional finance is massive and it will be exciting to see how big it will become in the DeFi space [70]. There are several derivatives platforms in the Defi ecosystem, the most popular being Synthetix. Synthetix allows the creation of synthetic assets that track the price of their underlying assets.

9 Results and Discussion

The literature review and consequential information in this paper gives several key insights into the DeFi ecosystem today and where it is headed. Crucial findings are listed down below as an overall summary of the most vital findings in this thesis:

- DeFi continues to grow in popularity as of 2021 [38]. Since 2020, and especially early 2021, the DeFi movement has exploded in popularity with several DApps, DEXs, lending/borrowing platforms in play and billions of USD in locked value.
- DeFi is still in its infancy with more room to expand [38, 43]. DeFi as an alternative finance is still in its early years. If the DeFi movement lasts, it will take years if not decades to realize its full potential.
- DeFi has several opportunities over traditional finances [29, 36, 38]. The opportunities DeFi offers over traditional finances are better interest rates, unconstrained access, more transparency, better interoperability, and total control over invested funds. However, there is a discussion to be had here if the average person wants more control over their finances in this way. There are several stories out there of individuals losing their private keys to their wallets, forgetting passwords, or getting tricked by scammers to give up personal information. With DeFi, there is no customer support line. Each individual is fully responsible for their own funds.

- DeFi provides countless opportunities for previously bankless people [33, 35]. People who today have no way to partake in the traditional financial system can partake in DeFi with internet access and a laptop or smartphone. The opportunities DeFi can offer these people is immeasurable. Merely allowing a simple farmer in India to invest their money and earn interests without the need for any credit card, government issued ID or social security number cannot be understated.
- DeFi faces regulatory challenges from government agencies [25, 28, 37]. The main concern with DeFi is in its decentralized spirit. Without any central authority, tracking where funds come from – or where they go is no easy task. Governments need to balance regulations so that they do not infringe on individuals right (at least in democratic countries). However, hardheaded Defi fanatics might argue that any regulation goes against the spirit of DeFi - and if governments demand documentation, then DeFi is no longer decentralized.
- DeFi has certain inherit risks that need to be addressed before mass adoption [29, 32, 41]. To fully adopt DeFi as alternative finance, smart contract faults and oracle price errors need to be better optimized. Scaling is also another issue in DeFi. Usually, the better a blockchain is at scaling and mass adoption the less decentralized it is and vice versa. The latest research certainly puts these concerns at the forefront, and the solutions to these hazards are still being researched as of date.
- DeFi can transform how we use money and assets in our day-to-day life through tokenization [38]. By turning virtually any asset into a token, trading becomes much simpler for the common individual. For example, selling ownership of a house through tokenization could remove cumbersome paperwork.
- NFTs that are part of the larger DeFi ecosystem can modernize how we trade scarce assets and art [38]. NFTs turn digital art into easy tradable assets. As long as an induvial has ownership of the NFT, then they are the sole proprietary owner. Though critics argue they are more akin to a fad than groundbreaking technology. NFTs in the DeFi space have also surged in popularity since early 2021. It remains to be seen if they are here to last or will be forgotten as a novel, but impractical concept.
- DeFi can encourage traditional financial institutions to improve and adapt new and better technology or risk becoming obsolete [30, 37]. Traditional finances can

drastically improve their transaction speed and costs, especially for international transfers.

- DeFi can help marginalized people get out of difficult situations [35]. People who live in authoritarian places, without any or limited access to traditional finance can use DeFi to keep their earnings safe and possibly escape.
- DeFi challenges governments by needing newer and better laws and regulations that don't prohibit blockchain technology but regulates it in a safe manner [25, 28, 37]. Blockchain technology can revolutionize the health sector, the financial sector, the trade sector and virtually any sector that needs better interoperability, more transparency and improved efficiency. The challenge here is to regulate the technology in a way that promotes synergy between governments, people and blockchain as a tool for enhancing society.
- DeFi encourages a flatter structure where everyone has the same access to important data about their economics [36, 65]. By removing any central authority from the financial system, the space becomes more transparent and equal. People will have access to the same data, regardless of where they live, their economic background and how much they have invested. The latest research does not discuss how this will impact individuals from a day-to-day basis, or whether this is something the majority of people wish for. There is an argument to be had here that the reason traditional finances have strong, central control is to ensure people are not exploited by opportunistic companies or entities.
- With the growth of DeFi, the role of middlemen and other centralized gatekeepers may become unnecessary and obsolete [36, 37]. The role of judges, middlemen, contract negotiators, finance lawyers, agents, and brokers can be threatened by the DeFi movement and its implementation of smart contracts. Smart contracts and their algorithmic execution can remove a lot of unmercenary middlemen and paperwork. However, one can argue that a new class of middlemen might arrive, for example smart contract advisors. Smart contracts are codes, written by people, and they still need to be verified by people to ensure they are bug-free and can be implemented in a reliable way.

The results show DeFi (as well as blockchain technology) growing with real-world use cases and implications and risks that need to be addressed and solved.

10 Conclusion

In this paper, the possibilities, and benefits of the DeFi ecosystem is presented, along with the risks. The latest research is summarized and an in-depth look at the mechanisms of DeFi is revealed. In addition, the difference and pitfalls of traditional financial instruments is laid forward. As such, this thesis answers the following questions:

Question 1: What is DeFi and why has it emerged as an alternative form of finance?

The emergence of DeFi can be compared to any radial new technology in the past decade or century. The internet has disrupted nearly every industry since its inception in the early 1990s. Each innovation builds on the previous one, and digital products, services, and assets become more sophisticated – including financial services. DeFi leverages blockchain technology to create an alternative financial system that can be more decentralized, groundbreaking, interoperable, transparent, and borderless. To recapitulate, DeFi stands for *Decentralized Finance*, an umbrella term within the blockchain technology movement that has exploded in popularity in the last year. In short, DeFi refers to using financial services by utilizing smart contracts, which are automated, enforceable agreements that don't need any intermediaries. DeFi offers individuals access to various currencies, global markets, automated and trustless transactions systems, trustless smart contracts, smart property and crypto assets, and innovative models of governance based on transparency and equality. Regardless of nationality, individuals can be granted equal access to basic digital institutions and infrastructure such as decentralized markets, judiciaries, and payment systems - which can be adapted to each country's, group's, or individual's specific needs [21].

The emergence of DeFi can be explained through the lens of traditional finances. Generally, central authorities such as governments have issued the currencies that bolster the financial system. Central banks and institutions were expected to carefully oversee and regulate the supply of currency in circulation. As the size and complexity of our economy continues to increase, these central authorities have gained more power. This in turn results in a system where we often have little say in how banks handle our investments, or even how our governments manage the greater economy. The emergence of DeFi comes from a place

of building a system that is better than the current one. The DeFi movement aims to create a financial system that is accessible to everyone and minimizes the need to trust and rely on central agencies. Technologies like the internet, cryptography, and blockchain gives individuals the means to cooperatively create and control a financial system without the need for centralized figures or unnecessary intermediaries. DeFi provides compelling advantages over traditional finance such as decentralization, increased access to data, efficiency, interoperability, and transparency. Decentralization allows financial assets to be owned collectively by the community without centralized control. Access to these new services for all individuals could dramatically decrease the wealth gap between social groups [38]. As such, DeFi offers exciting opportunities and has the potential to create a truly accessible, transparent, and immutable financial infrastructure. DeFi may lead to a paradigm shift in the financial industry and potentially contribute towards a more robust and transparent economic infrastructure.

Question 2: What is the applicability of DeFi today?

DeFi and blockchain technology is still in the beginning stages of a technological evolution. The most popular and fastest growing use case for DeFi is borrowing and lending. Similar to regular banks, individuals (or companies) can deposit money and earn interest from clients borrowing their assets. The assets are on the blockchain, and smart contracts connect the lenders to borrowers, enforce the terms of the loans, and distribute the interest – without the need for any intermediaries. With minimal transaction fees and no middlemen cost, individuals can earn higher return on their investment by participating in the DeFi ecosystem.

Another valid use case in the DeFi ecosystem is the usage of stablecoins. Cryptocurrencies experience high volatility. Individuals who want to experience the transparency, accessibility, and privacy of DeFi without big changes to their portfolio can convert their crypto assets to stablecoins in times of high volatility. Stablecoins are tokens designed to hold a specific value and are typically pegged to real world currency like the US dollar. To access the world of DeFi, DEXs are used. When trading on a DEX, there is no exchange operator, no sign-ups, no identity verification, and little to no exchange fees. DEXs can be used by anyone with a smartphone and internet connection. In addition, DeFi can be a last resort option for refugees escaping political and societal collapse. By using the DeFi ecosystem which include DEXs and stablecoins, individuals can circumvent the authority of dysfunctional governments and

insolvent banks. There have been several scenarios where individuals from Venezuela have successfully managed to secure their funds through the use of DeFi protocols.

As a whole, decentralized marketplaces provide many advantages to the market participants. This includes increased trust, better privacy, lower transaction costs, and robust transaction integrity. DeFi can even directly distribute value to users to incentivize its growth, as demonstrated by Compound (via the COMP token) and Uniswap (via the UNI token). Yield farming is the practice of seeking rewards by depositing into platforms that incentivize liquidity provisioning. Token distributions and yield farming have attracted large amounts of capital to DeFi over incredibly short time windows. Platforms can engineer their token economics to both reward their innovation and foster a long-term sustainable protocol and community that continues to provide value [38]. To summarize, individuals can borrow and lend cryptocurrencies and earn high interest rates using platforms such as Compound or Aave. Use prediction markets such as Augur for betting. Create and swap derivatives of off-chain assets such as different real-world currencies or precious metals such as silver and gold on the Synthetix platform. Buy cryptocurrencies known as stablecoins, which are pegged to the value of a particular currency or commodity to keep the value of their investments stable over long periods of time. Trade hundreds of different crypto assets and NFTs. Partake in voting and building a community through DAOs, and lastly use DEXs without the need for any KYC-practice.

Question 3: What does the future look like for the DeFi movement?

Leveraging blockchain technology, DeFi builds on distributed trust and open platforms to create an alternative financial system that can be more innovative, decentralized, interoperable, transparent, and borderless. DeFi has the potential to reshape the structure of modern finance and create a new landscape for entrepreneurship and innovation. Decentralization will likely see more diverse and competitive financial service ecosystems and reduce the importance of larger centralized financial hubs. As DeFi grows, markets and marketplaces created or maintained by decentralized autonomous organizations will not easily allow for government intervention. Regulations that try to avoid market manipulation, price cutting, or other anticompetitive practices, as well as regulations banning marketplaces from selling a good or a product, will become much harder to enforce in the DeFi space. Thus, if the need to preserve the opportunities provided by emerging blockchain technologies is

important—in terms of individual freedoms and emancipation, more democratic institutions, and creative individual expression—while avoiding or reducing the possible drawbacks that they might introduce in society, then law agencies need to think about a new paradigm of regulations. A paradigm that could balance the power of blockchain technology, DeFi and evolving autonomous systems in ways that encourage economic growth, free speech, democratic institutions, and the safety of individual liberties.

There are still many open concerns that need to be further researched and analyzed to create more workable and effective apps that can fully benefit DeFi and achieve the intended goals. Future work is required to address issues and close the gaps for more efficient and universal blockchain applications to further the DeFi movement. With the advent of DeFi, the decentralization and self-governance of the movement dilutes the concept of regulation and has a critical impact on the existing financial regulatory system. However, any groundbreaking technology is accompanied by risks. Therefore, DeFi regulation will probably be necessary, and should be formulated sooner rather than later to face upcoming challenges. In the future, decentralized institutions and governance models could be designed and constructed iteratively, through use and experimentation of emergent DeFi applications, rather than being imposed by centralized legal decrees. In some cases, new rules and policies need to be established to address the unique risks formed by DeFi. The emergence of DeFi and decentralized control through decentralized autonomous organizations (DAO) could reduce the relevance — if not bypass, traditional regulated intermediaries [28]. The emergence and continues popularity of DeFi is a rare example of a financial market operating without the classic features of bids and asks, traditional market makers or auctioneers. It is an obvious call to regulators, governments, and financial market participants that the innovation and decentralization promised by DeFi is starting to gain traction – with significant implications for traditional financial trading, stability, and regulation. An argument made by Lo and Medda (2020) is that blockchain technology does not only build superior systems, but also alternative systems that are attractive along less common dimensions, e.g., decentralization and censorship resistance. The question for the future is how regulators and governments respond to a marketplace that does not need a registered address and geographically fixed physical infrastructure.

DeFi also raises accountability and enforcement concerns around issues of both public and private ordering. Most notably, difficulties of establishing and determining the applicable law and authority of regulators, supervisory authorities and courts, and the difficulties of establishing how many clients or counterparties are in a given jurisdiction. But then again, to some extent, this is one of the major objectives of DeFi [37] – To bypass or improve laws and regulations that damper individual rights. To finalize the answer to the third question; blockchain technology, cryptocurrencies and lastly DeFi are still an evolving and innovative technology; it is hard to predict how successful DeFi can be because of its infancy. History shows us that radical new technology may take decades or more to realize their full potential. Thus, it is perfectly possible that DeFi could prove to be as revolutionary as it promises to be in the years to come.

This paper thus answerers the research questions from above. To punctuate further, DeFi could revolutionize the underlying technology of the payment and credit information systems in banks, thus upgrading and transforming them. Blockchain applications also promote the formation of multi-center, non-intermediary settings, which could enhance the efficiency of the financial industry. In the advent of smart contracts, blockchain technology, DeFi and other distributed ledgers, new legal paradigms and regulatory strategies ought to be explored to discourage illicit and improper use of the technology, while reaping the benefits of the technology as a promoter of economic growth, decentralization, and competition [38]. If done correctly, dynamic policies could enable the DeFi space to flourish, like the internet, and encourage DeFi to evolve as a free-market solution that will optimize financial inclusion for everyone in the long term.

11 Bibliography

[1] Max Kubát. Virtual currency bitcoin in the scope of money definition and store of value. *Procedia Economics and Finance,* 30:409-416, 2015.

[2] Oliver James Scholten, Nathan Gerard Jay Hughes, Sebastian Deterding, Anders Drachen, James Alfred Walker and David Zendle. Ethereum Crypto-Games: Mechanics, Prevalence and Gambling Similarities. *CHI PLAY 2019 - Proceedings of the Annual Symposium on Computer-Human Interaction in Play,* 379-389, 2019.

[3] Ricardo Henriquez, F. Xavier Martínez, Jesús Martínez and Cristina Tomás. A Defi-Based Model for Maritime Trade Finance. *Universitat Politècnica de Catalunya. Departament de Ciència i Enginyeria Nàutiques,* 278-300, 2020. ISBN 978-84-9880-827-8. URL: http://hdl.handle.net/2117/329931.

[4] Kaidong Wu, Yun Ma, Gang Huang and Xuanzhe Liu. A First Look at Blockchain-based Decentralized Applications. *Software: Practice and Experience*. arXiv:1909.00939v1, 2019.

[5] Bowen Liu, Pawel Szalachowski, and Jianying Zhou. A First Look into DeFi Oracles. *In Proceedings of ACM Conference (Conference' 17),* 2020.

[6] Daniel Ramos and Gabriel Zanko. A Review of Decentralized Finance as an Application of Increasing Importance of Blockchain Technology. *Mobileyourlife – Bogotá, D.C., Colombia,* 2020.

[7] Daniel Ramos and Gabriel Zanko. A Review of the Current State of Decentralized Finance as a Subsector of the Cryptocurrency Market. *Mobileyourlife – Bogotá, D.C., Colombia,* 2020.

[8] Ahmed Afif Monrat, Olov Schelèn and Karl Andersson. A Survey of Blockchain From the Perspectives of Applications, Challenges, and Opportunities. *IEEE Access. PP. 1-1,* 2019.

[9] Arshdeep Bahga and Vijay K. Madisetti. A Value Token Transfer Protocol (VTTP) for Decentralized Finance. *Journal of Software Engineering and Applications*, 13:303-311, 2020. URL: https://doi.org/10.4236/jsea.2020.1311020.

[10] Youssef El Faqir, Javier Arroyo and Samer Hassan. An overview of decentralized autonomous organizations on the blockchain. *16th International Symposium on Open Collaboration,* 2020. URL: https://doi.org/10.1145/3412569.3412579.

[11] Vijay Mohan. Automated Market Makers and Decentralized Exchanges: A DeFi Primer. *SSRN Electronic Journal*, 2020. URL: https://ssrn.com/abstract=3722714.

[12] Yongge Wang. Automated Market Makers for Decentralized Finance (DeFi). arXiv:2009.01676v2, 2020.

[13] Lin William Cong and Zhiguo He. Blockchain disruption and Smart Contracts. *The Review of Financial Studies*, Volume 32, Issue 5, 1754–1797, 2019. URL: https://doi.org/10.1093/rfs/hhz007.

[14] Jayanth Rama Varma. Blockchain in Finance. *The Journal for Decision Makers*, 44(1):1–11, 2019. URL: https://doi.org/10.1177%2F0256090919839897.

[15] Saurabh Ahluwalia, Raj Mahto and Maribel Guerrero. Blockchain Technology and Startup Financing: A Transaction Cost Economics Perspective. *Technological Forecasting and Social Change,* Volume 151*,* 2020*.* URL: https://doi.org/10.1016/j.techfore.2019.119854.

[16] Benito Arruñada and Luis Garicano. Blockchain: the birth of decentralized governance. *Economics Working Paper Series*, Working Paper No. 1608, 2018.

[17] Yan Chen and Cristiano Bellavitis. Blockchain Disruption and Decentralized Finance: The Rise of Decentralized Business Models. *Journal of Business Venturing Insights,* Volume 13, 2020. URL: https://doi.org/10.1016/j.jbvi.2019.e00151.

[18] David Andolfatto. Blockchain: What It Is, What It Does, and Why You Probably Don't Need One. *Federal Reserve Bank of St. Louis*, vol. 100(2), 2018.

[19] Sapumal Ahangama and Danny Chiang Choon Poo. Credibility of Algorithm Based Decentralized Computer Networks Governing Personal Finances: The Case of Cryptocurrency. *HCI in Business, Government, and Organizations: eCommerce and Innovation, 165-176,* 2016. URL: https://doi.org/10.1007/978-3-319-39396-4_15.

[20] Wei Cai, Zehua Wang, Jason B. Ernst, Zhen Hong, Chen Feng, and Victor C.M. Leung. Decentralized Applications: The Blockchain-Empowered Software System. *IEEE Access*, Volume 6, 53019-53033, 2018.

[21] Aaron Wright and Primavera De Filippi. Decentralized Blockchain Technology and the Rise of Lex Cryptographia. *SSRN*, 2015. URL: https://dx.doi.org/10.2139/ssrn.2580664.

[22] Hemang Subramanian. Decentralized Blockchain-Based Electronic Marketplaces. *Communications of the ACM,* Volume 61 No. 1, p 78-84, 2018. URL: https://doi.org/10.1145/3158333.

[23] Daniel Ramos and Gabriel Zanko. Decentralized Finance on Institutional Level - A Review of Potential, Advantages and Challenges of High-Level Adoption. *MobileyourLife – Bogotá, D.C., Colombia*, 2020.

[24] Matthias Nadler and Fabian Schär. Decentralized Finance, Centralized Ownership? An Iterative Mapping Process to Measure Protocol Token Distribution. arXiv:2012.09306v1, 2020.

[25] Hossein Nabilou. How to Regulate Bitcoin? Decentralized Regulation for a Decentralized Cryptocurrency. *International Journal of Law and Information Technology*, 27(3):266-291, 2019. URL: https://dx.doi.org/10.2139/ssrn.3360319.

[26] Daniel Perez, Sam M. Werner, Jiahua Xu, and Benjamin Livshits. Liquidations: DeFi on a Knife-edge. arXiv:2009.13235v2, 2020.

[27] Lewis Gudgeon, Sam Werner, Daniel Perez, and William J. Knottenbelt. DeFi Protocols for Loanable Funds: Interest Rates, Liquidity and Market Efficiency. *AFT '20: Proceedings of the 2nd ACM Conference on Advances in Financial Technologies*, p 92-112, 2020. URL: https://doi.org/10.1145/3419614.3423254.

[28] Rafael Padilla. DeFi, Law and Regulation, 2020. URL: https://bitpinas.com/feature/defi-law-and-regulation-by-atty-rafael-padilla/.

[29] Fabian Schär. Decentralized Finance: On Blockchain- and Smart Contract-based Financial Markets. *SSRN*, 2020. URL: https://dx.doi.org/10.2139/ssrn.3571335.

[30] Ye Guo and Chen Liang. Blockchain Application and Outlook in the Banking Industry. *Financial Innovation*, volume 2, Article number: 24, 2016. URL: https://doi.org/10.1186/s40854-016-0034-9.

[31] Massimo Bartoletti, James Hsin-yu Chiang and Alberto Lluch-Lafuente. SoK: Lending Pools in Decentralized Finance. arXiv:2012.13230, 2020.

[32] Johannes Rude Jensen and Omri Ross. Managing Risk in DeFi. *CEUR Workshop Proceedings*, 2020. URL: https://dx.doi.org/10.2139/ssrn.3745568.

[33] Rafael Pass and Abhi Shelat. Micropayments for Decentralized Currencies. *CCS '15: Proceedings of the 22nd ACM SIGSAC Conference on Computer and Communications Security*, p 207-218, 2016. URL: https://doi.org/10.1145/2810103.2813713.

[34] Fahad Saleh. Volatility and Welfare in a Crypto Economy. *SSRN*, 2019. URL: https://dx.doi.org/10.2139/ssrn.3235467.

[35] Robert Donald Leonhard. Decentralized Finance on the Ethereum Blockchain. *SSRN*, 2019. URL: https://dx.doi.org/10.2139/ssrn.3359732.

[36] Yan Chen and Cristiano Bellavitis. Decentralized Finance: Blockchain Technology and the Quest for an Open Financial System. *Stevens Institute of Technology School of Business Research Paper*, 2019. URL: http://dx.doi.org/10.2139/ssrn.3418557.

[37] Dirk A. Zetzsche, Douglas W. Arner and Ross P. Buckley. Decentralized Finance (DeFi). *European Banking Institute Working Paper Series 59/2020, University of Hong Kong Faculty of Law Research Paper No. 2020/010, University of Luxembourg Faculty of Law, Economics & Finance WPS, Journal of Financial Regulation*, 2020. URL: http://dx.doi.org/10.2139/ssrn.3539194.

[38] Campbell R. Harvey, Ashwin Ramachandran and Joey Santoro. DeFi and the Future of Finance. *SSRN*, 2020. URL: https://dx.doi.org/10.2139/ssrn.3711777.

[39] Jiani Wu and Nguyen Khoi Tran. Application of Blockchain Technology in Sustainable Energy Systems: An Overview. *Sustainability*, 10(9):3067, 2018. URL: https://doi.org/10.3390/su10093067.

[40] Coinmarketcap.com. Ethereum, 2021. URL: https://coinmarketcap.com/currencies/ethereum/.

[41] Lewis Gudgeon, Daniel Perez, Dominik Harz, Benjamin Livshits and Arthur Gervais. The Decentralized Financial Crisis. *Crypto Valley Conference on Blockchain Technology (CVCBT)*, p 1-15, 2020.

[42] Mathieu Chanson, Nils Martens and Felix Wortmann. The Role of User-Generated Content in Blockchain-Based Decentralized Finance. *ECIS 2020 Research-in-Progress Papers*. 91, 2020.

[43] Yuen Lo and Francesca Medda. Uniswap and the rise of the decentralized exchange. *SSRN*, 2020. URL: https://dx.doi.org/10.2139/ssrn.3715398.

[44] Binance Academy. The Complete Beginner's Guide to Decentralized Finance (DeFi), 2021. URL: https://academy.binance.com/en/articles/the-complete-beginners-guide-to-decentralized-finance-defi.

[45] Luke Conway. Blockchain Explained, 2020. URL: https://www.investopedia.com/terms/b/blockchain.asp.

[46] Ameer Rosic. Smart Contracts: The Blockchain Technology That Will Replace Lawyers, 2020. URL: https://blockgeeks.com/guides/smart-contracts/.

[47] Shermin Voshmgir. Blockchain Oracles, 2019. URL: https://blockchainhub.net/blockchain-oracles/.

[48] Tesa Ho. An Overview of DeFi Price Oracles, 2021. URL: https://messari.io/article/an-overview-of-defi-price-oracles.

[49] Werner Vermaak. What Is a DAO?, 2020. URL: https://coinmarketcap.com/alexandria/article/what-is-a-dao.

[50] Alyssa Hertig. What Are Stablecoins?, 2020. URL: https://www.coindesk.com/what-are-stablecoins.

[51] DeFi Pulse. The DeFi List, 2021. URL: https://defipulse.com/defi-list/.

[52] Binance Academy. What Is a Decentralized Exchange (DEX)?, 2021. URL: https://academy.binance.com/en/articles/what-is-a-decentralized-exchange-dex.

[53] The Shrimpy Team. What Is Liquidity Mining?, 2021. URL: https://academy.shrimpy.io/post/what-is-liquidity-mining.

[54] Binance Academy. What Is Yield Farming in Decentralized Finance (DeFi)?, 2021. URL: https://academy.binance.com/en/articles/what-is-yield-farming-in-decentralized-finance-defi.

[55] DELTEC Bank & Trust. What is DeFi and Yield Farming?, 2021. URL: https://www.deltecbank.com/2021/02/12/what-is-defi-and-yield-farming/.

[56] Rebecca Mqamelo. Top 10 DeFi concepts everyone needs to know, 2020. URL: https://blog.zerion.io/top-10-defi-concepts-everyone-needs-to-know-e1e4e7bf0a69.

[57] Philipp Sandner. Decentralized Finance (DeFi): What Do You Need To Know?, 2019. URL: https://philippsandner.medium.com/decentralized-finance-defi-what-do-you-need-to-know-9cd5e8c2a48.

[58] Campbell R. Harvey, Ashwin Ramachandran, and Joey Santoro. DeFi and the Future of Finance, 2021. URL: https://corpgov.law.harvard.edu/2021/01/14/defi-and-the-future-of-finance/.

[59] Changpeng Zhao. The Future is Decentralized: 5 Reasons Why DeFi's Cool-down Will Be Short Lived, 2020. URL: https://www.cityam.com/the-future-is-decentralized-5-reasons-why-defis-cool-down-will-be-short-lived/.

[60] OFX FAQ. How much does it cost to send money internationally?, 2021. URL: https://www.ofx.com/en-au/faqs/how-much-does-it-cost-to-send-money-internationally/.

[61] Mercury Cash. 5 disadvantages of traditional banking compared to cryptocurrencies, 2019. URL: https://blog.mercury.cash/2019/10/26/5-disadvantages-of-traditional-banking-compared-to-cryptocurrencies/.

[62] Neil Kokemuller. Security Between Traditional Banking and Online Banking, 2019. URL: https://pocketsense.com/security-between-traditional-banking-online-banking-22517.html.

[63] Board of Governors of the Federal Reserve System. Federal reserve

board press release, 2011. URL: http://www.federalreserve.gov/newsevents/press/bcreg/20110629a.htm.

[64] The Defiant. DeFi asset management and the rise of the financial architect, 2020. URL: https://decrypt.co/33157/defi-asset-management-and-the-rise-of-the-financial-architect.

[65] Daryl Hok. The Future of DeFi, 2021. URL: https://www.cityam.com/the-future-of-defi/.

[66] Cointelegraph. What is DAO, 2020. URL: https://cointelegraph.com/ethereum-for-beginners/what-is-dao.

[67] DeBank. Gross Value Locked (USD), 2021. URL: https://debank.com/ranking/locked_value.

[68] Federal Reserve History. Nixon Ends Convertibility of US Dollars to Gold and Announces Wage/Price Controls, 1971. URL: https://www.federalreservehistory.org/essays/gold-convertibility-ends.

[69] Binance Academy. What is Ethereum?, 2021. URL: https://academy.binance.com/en/articles/what-is-ethereum.

[70] Finematics. Derivatives in DeFi Explained, 2021. URL: https://finematics.com/derivatives-in-defi-explained/