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ADVANTAGES AND DISADVANTAGES OF DECEN-TRALIZED FINANCIAL (DEFI) SERVICES

ABSTRACT

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New innovations such as blockchain and smart contracts have opened a door for new kinds of fully decentralized and open financial services, that work without the need for intermediaries. This movement has been given the name Decentralized Finance (DeFi). DeFi is an open and decentralized peer-to-peer open-source financial system. This thesis aims to study the advantages and disadvantages of these Decentralized Financial applications, in comparison to traditional financial services. This study was conducted by performing a literature review to act as a basis for an empirical study, which was conducted using qualitative methods and semi-structured interviews with professionals of the topic. As results, the study found that DeFi's advantages are transparency, decentralization, interoperability, openness, efficiency, security, innovations and profits. DeFi's disadvantages however are user experience, technology risks, lack of regulation, scalability, environmental impacts, systemic risk, The Oracle Problem, speculation, lack of decentralization and illicit activity. This thesis' contribution, the frameworks of advantages and disadvantages of DeFi can act as a basis for future research and offer valuable insights for practitioners.

Keywords: blockchain, smart contract, decentralized finance

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Uudet innovaatiot kuten lohkoketju ja älysopimukset ovat avanneet oven uudenlaisille täysin hajautetuille ja avoimille rahoituspalveluille, jotka toimivat ilman välikäsiä. Tämä uusi suuntaus on saanut nimen hajautettu rahoitus (De-Fi). DeFi on avoin ja hajautettu vertaisverkollinen avoimen lähdekoodin rahoitusekosysteemi. Tämän pro gradu -tutkielman tavoitteena on selvittää, mitkä ovat näiden hajautettujen rahoituspalveluiden hyödyt ja ongelmat verrattuna traditionaalisiin palveluihin verrattuna. Tutkielma alkaa kirjallisuuskatsauksella aiheeseen, joka toimii pohjana empiiriselle osuudelle. Tutkielman empiirinen osuus on toteutettu kvalitatiivisin menetelmin, puolistrukturoituja asiantuntijahaastatteluja hyödyntäen. Tutkielman tulokset osoittavat, että DeFi:n edut traditionaalisiin rahoituspalveluihin verrattuna on läpinäkyvyys, hajautus, yleistoimivuus, avoimuus, tehokkuus, turvallisuus, innovaatiot ja tuotot. DeFin heikkouksina on sen sijaan käytettävyys, teknologian riskit, regulaation puute, skaalausongelmat, ympäristöhaitat, systeeminen riski, oraakkeli ongelma, spekulaatio, hajautuksen puute sekä laiton käyttäytyminen. Tämän tutkielman kontribuutio, taulukot DeFi:n hyödyistä ja rajoitteista voivat toimia pohjana tulevaisuuden lisätutkimukselle aiheesta ja voivat antaa arvokkaita oivalluksia alalla työskenteleville.

Avainsanat: lohkoketju, älysopimus, hajautettu rahoitus

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ABBREVIATIONS

AML	Anti-Money-Laundering
AMM	Automated Market Maker
DAO	Decentralized Autonomous Organization
dApp	Decentralized Application
DeFi	Decentralized Finance
DLT	Distributed Ledger Technologies
EVM	Ethereum Virtual Machine
FinTech	Financial Technology
ICO	Initial Coin Offering
KYC	Know-Your-Customer
NFT	Non-Fungible Token
PoW	Proof-of-Work
PoS	Proof-of-Stake
RegTech	Regulatory Technology
TradFi	Traditional Finance

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1   INTRODUCTION

The financial crisis of 2008 was one of the worst economic disasters in the history. Typical problems in the traditional financial markets, such as asymmetric information and conflict of interests lead to the crisis (Mishkin, 2019 s. 327-337), which crumbled the public's trust in the financial markets (Sapienza & Zingales, 2012). A need for a better system arose.

In the same year, an author or a group using the pseudonym Satoshi Nakamoto published an article describing a new peer-to-peer electronic cash system, Bitcoin. Satoshi Nakamoto had solved the double spending problem and introduced a new, trustless way of peer-to-peer transactions. The promise of Bitcoin was to enable direct payments from one party to another without the need for a financial intermediary as a middleman. Before, these financial intermediaries have been needed because of the lack of trust between individual parties, but now the trust was achieved by cryptographic means. (Nakamoto, 2008).

The core technology behind Bitcoin was something called blockchain. Blockchain is a type of Distributed Ledger Technology (DLT), and which cannot be tampered and is open for everyone. Instead of trusting one intermediary to manage the ledger, the ledger is distributed to multiple actors, which validate the transactions and their order in the blockchain (Pierro, 2017.)

People soon started to realize the potential of the technology and started to imagine other use cases for blockchain. Young Russian programmer called Vitalik Buterin noticed a problem with Bitcoin: it did not have a capability outside of simple currency transactions. Buterin wanted to create a general purpose, Turing-complete system, that could inherit the promises of blockchain technology, but at the same time act as a platform for new kind of decentralized applications (Buterin, 2014.) The other main core innovation needed for this was smart contracts, originally proposed by Nick Szabo in 1994. Smart contracts are computer programs that execute pre-determined actions automatically once certain conditions are met (Raskin, 2016). Smart contracts allowed for complex, multi-step processes that Bitcoin could not perform. In 2013, Buterin published the whitepaper for his brainchild, Ethereum.

Ethereum introduced new kinds of possibilities with blockchain. Now innovators could design complex, decentralized applications, dApps, that used the security, openness and trustlessness of blockchain technology and the complex automated processes of smart contracts. These decentralized applications would work without the need for a human intervention (Cai, Wang, Ernst, Hong, Feng & Leung, 2018).

One of the first sectors affected by these innovations was finance, which led to the beginning of new movement, Decentralized Finance or DeFi. DeFi promises to bring the core values and benefits of blockchain into the financial markets and challenge the current status quo of using financial intermediaries.

1.1   Research problem

The development of DeFi protocols, much like other cryptocurrency projects, have reminded more of a goldrush than profound, methodological development. The DeFi market has exploded with different protocols in the past few years. DeFi total market capitalization was 115 billion dollars as of March 2022 and reached its historical highs of 170 billion dollars in November 2021 (CoinGecko, 2022a).

In addition to the explosive growth of the markets, the academic literature regarding the topic drags behind substantially. The topic needs more research, as it has the potential to even disrupt the whole financial sector (Chen & Bellavitis, 2020; Schär, 2021). Chen and Bellavitis (2020) also propose that the emergence of these decentralized business models may require researchers to compile new theories on their advantages and disadvantages. However, the actual advantages and disadvantages are still a bit scattered in the literature. This thesis plans to complement that research gap and bring some academical viewpoint into the topic. The purpose of this thesis is to try to fill the gap on research on DeFi's advantages and disadvantages in comparison to traditional financial services. The current literature has these scattered and no studies were found, were there would be a framework formed to collect these advantages and disadvantages.

Therefore, the main research question for this thesis is:

- How is DeFi advantageous/disadvantageous in comparison to traditional financial services?

Sub-research question supporting the main research question is:

- What is DeFi?

The main purpose of this thesis therefore is to study the advantages and disadvantages the DeFi applications have over traditional financial service counterparts. To answer the main research question, we will also have to an-

swer the sub-research question to explain what is meant by DeFi and how is it defined. Expected results for this thesis are twofold: firstly, I expect to get a clearer definition for DeFi. Secondly, the results should show the advantages and disadvantages DeFi currently has in comparison to traditional finance. By understanding the advantages and disadvantages of DeFi better, this thesis can act as a basis for future research and provide valuable insights for practitioners.

1.2 Structure

This thesis starts by conducting a literature review, which covers the basics of traditional finance, distributed ledger technologies, smart contracts, Ethereum and finally, DeFi. In the end of literature review, a table representing the advantages and disadvantages of DeFi found in the literature review is shown. The literature review will act as a basis for the empirical part of this thesis.

After the literature review, the methodology for the empirical study is explained. Research method -chapter will go through and justify the chosen research method, data collection process, data sample and data analysis. Empirical data for this study was collected by interviewing professionals in the topic, using semi-structured interviews. The data was analysed via qualitative data analysis methods.

The Results-chapter then presents the results from the interviews, the interview partners' definitions of DeFi, and the advantages and disadvantages. This chapter ends with a table representing the advantages and disadvantages of DeFi found in the interviews.

Discussion chapter discusses the results found in the study, and compares the results found in the literature review to the ones found in the interviews. The thesis finishes with a Conclusion chapter, where the study in concluded and the research questions are answered. Conclusion chapter also includes the contribution, limitations of this study, and suggestions for future research.

2 LITERATURE REVIEW

This chapter includes the literature review, which acts as the background for this thesis by introducing the main concepts and the state of the current literature regarding the topic. Literature review was conducted by using mostly Jyk-Dok international e-material database and Google Scholar. Literature was collected mostly from peer-reviewed publications. Also, some of the technical innovations needed a studying of the whitepapers and yellow papers to understand and explain them. Keywords used in the literature collection process were: 'defi', 'decentralized finance', blockchain', 'finance', 'financial markets', financial intermediaries', 'smart contracts', 'ethereum', 'distributed ledger technology' and variations and combinations of these words. Also, any additional keywords that came up during the literature review were used for further research into topics and concepts.

The structure of this chapter starts from introduction to traditional financial markets and institutions in the first subchapter. To understand DeFi better, we should understand first how traditional financial markets work. The second subchapter goes through the main technological concepts regarding the topic such as DLT, blockchain, smart contracts and Ethereum. The third subchapter then presents the current state of the literature regarding DeFi.

2.1 Traditional financial markets and institutions

This chapter introduces the traditional financial markets and institutions in it. This chapter will introduce the basics of financial markets, financial intermediaries and their purpose. In the last subchapter, I will explain how financial crises have affected public's trust. For traditional finance, I will from now on use the abbreviation TradFi.

2.1.1 The purpose of financial markets

The most important function of financial markets is to improve the allocation of capital (Wurgler, 2000). Simply speaking, there are three different kinds of actors in TradFi:

1. Actors wanting to invest money in order to grow their capital
2. Actors seeking funds to invest in tangible investments
3. Intermediaries bringing said actors together and managing the transactions (Drake & Fabozzi, 2010 s.15.)

Financial markets have three basic economic purposes: price discovery, liquidity, and the reduction of transaction costs. Price discovery means that in free and working markets the buyers and sellers determine the cost of an asset. Liquidity means the presence of buyers and sellers ready to trade, and financial markets provide a way for this to happen. Without liquidity, buying or selling assets is hard. The reduction of transaction costs happens in two types: search costs and information costs. There are also two types of search costs, explicit and implicit. Explicit search cost are basically the costs of advertising your willingness to buy or sell financial instruments. Implicit costs mean the loss of time trying to find counterparties for transactions. Information costs are costs regarding the assessment of investments attributes. (Drake & Fabozzi, 2010. s. 17-18.)

2.1.2 Types of financial markets

Financial markets consist of multiple different kind of markets. There are a lot of ways to describe the structure of the financial markets. The rough way to categorise markets are based on the maturity of the traded instruments in to two types: Money markets and Capital markets. Money markets are for short-term debt instruments, which maturity is usually less than one year. These markets are usually very liquid and are usually seen as more secure. Capital markets are for longer-term debt instruments (maturity one year or greater). (Mishkin, 2019 s.77.)

The transactions can either happen in the primary or in the secondary markets. Primary markets are for new issues of securities, and are usually closed to the public (Mishkin, 2019 s.76). Secondary markets, or more commonly known exchanges (for listed securities) and Over-the-Counter markets (for unlisted securities) are the markets where the common public can trade securities (Mishkin, 2019 s. 75-76).

Markets can also be categorized based on what is being traded. Stock markets are for stocks of companies, foreign exchange (forex) for trading currencies, commodities markets are for commodities such as gold, wheat and oil, derivatives markets are for derivatives, which derive their value from the underlying security. Derivatives were originally created as a way to hedge investments, but they are nowadays used also for speculation and adding leverage. (Mishkin, 2019 s. 76; Drake & Fabozzi, 2010 s. 29.)

2.1.3   Financial intermediaries

The role of financial intermediaries and institutions is to provide the means for capital allocation. Different kinds of financial intermediaries are for example banks, investment funds and insurance companies.

There are three main problems, that financial intermediaries are designed to solve. These problems are transactions costs, asymmetric information and risk management. Transaction costs are a big problem in the financial markets. Intermediaries are designed to reduce transaction costs with two solutions: Economies of scale and expertise. Economies of scale is achieved by bundling individual investors into a group, which lowers the transaction costs for an individual. Intermediaries also reduce transaction costs via their expertise; their expertise helps to choose the right investments, markets, people etc. more efficiently. Asymmetric information is the second major problem in financial markets. Asymmetric information means that the other party of the transaction has insufficient information about the other party, which can lead to problems either before the transaction, or after the transaction. When the problem occurs before the transaction, it is called adverse selection. Adverse selection means basically just that the borrowers that are more likely to result in undesirable outcomes, are the ones who most likely seek out a loan. Moral hazard happens after the transaction, and it means that once the borrower acquires the funds, they are more likely to engage in activities that are undesirable. The third function of financial intermediaries is risk management and risk sharing. (Mishkin, 2019 s. 83-88.)

Also, financial regulators are institutions that have effect on the financial markets. Financial markets are heavily regulated, to ensure their safeness. The most important tasks for regulators are reducing asymmetric information by increasing information that is available to investors and making sure the financial intermediaries are safe and sound. The regulators do this for example by having tight rules on who is allowed to create a financial intermediary, having strict reporting principles for intermediaries, and having restrictions for assets and activities these intermediaries are allowed to do and hold. These regulations can differ between countries, but usually they are fairly similar. (Mishkin, 2019 s.93-94.)

2.1.4   Financial crisis of 2008 and loss of trust

Financial crisis of 2008 showcases well some of the problems within the TradFi markets. Asymmetric information, creed and conflicts of interest made for a disastrous combination which resulted for one of the biggest stock market crashes, institutions that were thought to be too big to fail, failing and a lot of people losing their jobs (Mishkin, 2019 s 327-337). Lack of transparency in the system allowed banks to accumulate massive risks without intervention (Gudgeon, Perez, Harz, Livshits, & Gervais, 2020). Scandals, which reveal corruption and colluding are not rare in financial markets. For example, Libor scandal in

2012, where traders at major banks had been colluding to create an illusion of healthier financial condition (Mishkin, 2019 s. 340).

Trust in financial intermediaries and financial markets was significantly harmed during the 2008 financial crisis. (Sapienza & Zingales, 2012). Since trust is integral part of a working financial system, either trust in TradFi markets needs to be restored or some kinds of innovations in the area are needed. Financial innovation and financial technology, or Fintech and its applications such as PayPal has changed finance by replacing institutions, but it has not removed intermediaries. It has only changed them from financial institution to a technology company (Chen & Bellavitis, 2020). The financial revolution that DeFi promises is to replace intermediaries altogether and give the control to the individuals. In the next chapter, I will introduce the technologies that could make this a possibility.

2.2 Distributed ledger technologies and smart contracts

This chapter focuses on the core technologies behind DeFi. First, I will introduce Distributed Ledger Technologies (DLT) and most importantly, blockchain. Then I will introduce smart contracts and finally combine these two by explaining Ethereum, which started the movement and is still the leading platform for DeFi applications.

2.2.1 Distributed Ledger Technology

Distributed Ledger Technologies (DLT) are one of the core innovations behind DeFi. There are still no universal and accepted definition in the literature to what DLT even is. A study by Krause, Natarajan and Gradstein (2017) from the World Bank describes DLT as following:

> "a novel and fast-evolving approach to recording and sharing data across multiple data stores (ledgers), which each have the exact same data records and are collectively maintained and controlled by a distributed network of computer servers, which are called nodes. One way to think about DLT is that it is simply a distributed database with certain specific properties."

DLTs are a solution to the problem of trust among actors who don't know each other. Often people confuse DLT and the technology behind bitcoin, blockchain, and think of them as the same thing. However, that's not entirely accurate. Blockchain is just one form of DLT. A DLT doesn't necessarily require a chain to work. (Rauchs et. al., 2018.). One example of a distributed ledger that doesn't use blockchain is IOTA network. IOTA instead uses something called directed acyclic graph, which tries to achieve higher scalability compared to blockchains (Popov, 2018). However, in this study I will be focusing mostly on blockchain-based DLT's, because at the moment basically every major DeFi application runs on them.

2.2.2 Blockchain

The most currently used form of DLT, and the technology behind Bitcoin and most of the cryptocurrencies and DeFi applications is called blockchain. The name "blockchain" comes from its property of adding "blocks" or data sets, which are comprised of transactions in the ledger, and then connecting these blocks in to a "chain" by each block storing information from the previous block, so that the chain is retraceable all the way back to the first block, the "Genesis block" (Nofer, Gomber, Hinz & Schiereck, 2017). Figure 1 shows an example of a basic blockchain structure, however each blockchain can have its own differences.
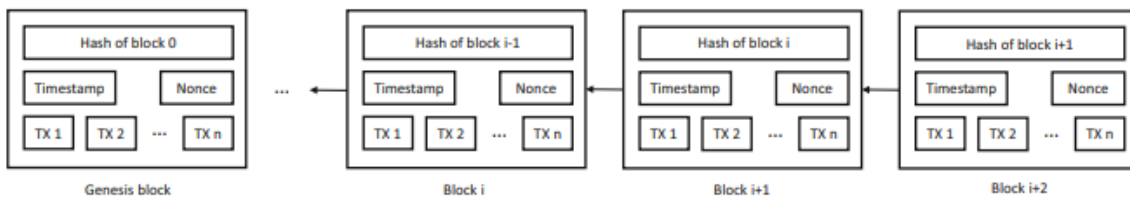

FIGURE 1 Example of a blockchain structure. (Zheng et. al., 2018)

According to Monrat et. al. (2019) there are three types of blockchains: public, private and consortium. However, some studies like Pilkingtons (2016) have added also fourth type, hybrid. These blockchains can also be categorized in to permissioned and permissionless blockchains (Zheng et al., 2018). Public blockchains are seen as permissionless blockchains, meaning everyone can participate freely on the consensus process of the network. Consortium and private blockchains are usually permissioned blockchains. They can be for example owned and operated by one organisation (private) or multiple (consortium).

Public blockchains are the most known blockchains, like Bitcoin and Ethereum. Their advantages are high immutability, open to everyone to participate and read, and decentralization (Zheng et al., 2018). Private and consortium blockchains are usually more efficient, since they have fewer nodes on the network. However, since they are operated by one or multiple organisations, they are highly or fully centralized. That also means that they could be tampered, if the majority in the network decided to cooperate (Zheng et al., 2018). Hybrid blockchains are trying to combine the best of permissioned and permissionless blockchains (Cai, Wang, Ernst, Hong, Feng & Leung, 2018).

The transactions in the network are validated via digital signatures. Each user has two keys, public and private. Users sign the transaction using the private key and these signed transactions are then spread throughout the network for verification. The signing works by user X generating the hash value of the transaction, encrypting it with the private key and the sending it on with the original data. User Y then verifies the transaction. Verification happens by decrypting the hash using the user X's public key and comparing it to the hash

value of the data received from user X. (Zheng et al., 2018.) This method of using two keys is also called the Asymmetric-Key Cryptography (Yaga et al., 2019).

Mentioned before, hashes, and specifically the cryptographic hash functions are fundamental component to blockchain technology. Hashing works by applying the hash function to the data and deriving a unique output, called digest. What makes hashing secure, is that the process is almost impossible to reverse, meaning it is not feasible to try to guess the original data from the digest. Also, different inputs will not (in theory) produce the same output. However, the data can easily be verified by other nodes by deriving the same hash function, as even a small change in the input data completely changes the output digest. One of the most used hash functions is called SHA-256. The name comes from Secure Hash Algorithm and 256 is the size of the output size (256 bits). Hashing in blockchain context is used for example securing the block data, address derivation, securing the block header and creating unique identifiers. The hash is also used in the Proof of Work (PoW) consensus model, which will be discussed next. (Yaga, Mell, Roby, Scarfone, 2019.)

Consensus mechanism means the process of the majority of network validators reaching consensus about the state of the blockchain (Nofer et al., 2017). Two of the most popular consensus mechanisms at the moment, and which I will explain deeper are Proof of Work (PoW) and Proof of Stake (PoS).

Proof of Work works by making the miners compete at solving a puzzle. Solving the puzzle requires lots of computing work but checking that the solution is valid is easy. This way other nodes on the network can easily validate the proposals for the next block (Yaga et al., 2019). One example of a PoW puzzle, is the one Bitcoin uses, requiring the SHA-256 algorithm and the hash function. The aim of the puzzle is to find the digest value smaller than the target value by changing the nonce. The value usually starts by a line of zeroes, and the difficulty of the puzzle can be adjusted by adding or removing the required amount of zeroes. The difficulty of the puzzle can be adjusted to keep the rate of block publication at wanted rate. For example, Bitcoin adjusts the difficulty every 2016 blocks to keep the rate around 10 minutes per block. (Yaga et al., 2019.)

Proof of Stake (PoS) is the second most commonly used consensus method. Instead of need for intensive computations and miners, PoS uses each nodes stake in the ecosystem as the determining factor for new block creation. In simple terms, the more you have in stake, the more likely you get to publish the new block. (Yaga et. al., 2019.) Stake here means usually the amount of cryptocurrency locked into the system by user. This method removes the need for miners and intensive computational work made by them. Because of that it is also seen as more environmentally friendly and new blockchains are preferring it instead of PoW. (Yaga et. al., 2019.)

The network of a PoW -blockchain is visualised in the figure below (Figure 2). PoS -blockhain works similarly, but instead of miners to verify the transaction, the stakers perform the validation.
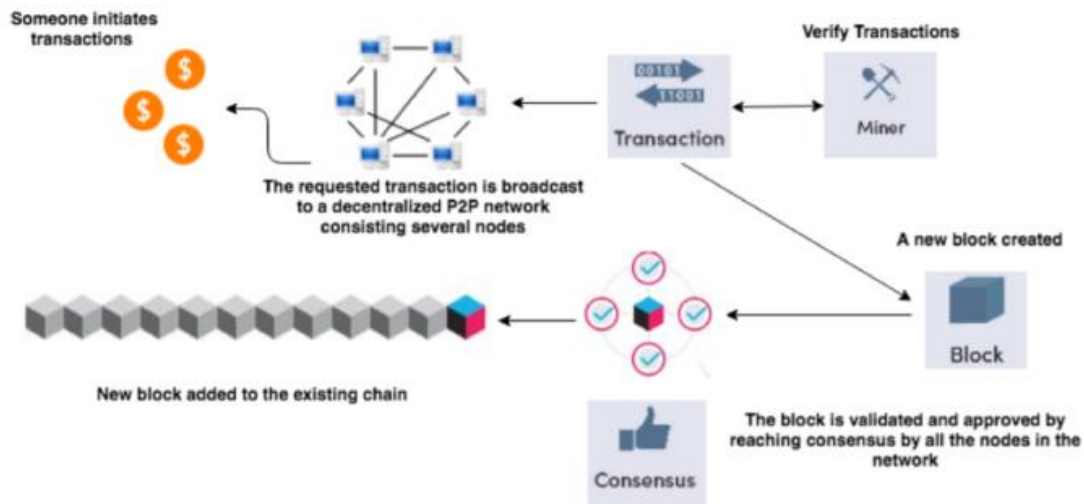
FIGURE 2 PoW -blockchain network. (Monrat et.al., 2019)

The most common use case for blockchain is currently cryptocurrencies such as Bitcoin and Ethereum. However, it has many other use cases, in the likes of healthcare, supply chain management, crowd funding, online voting and identity management (Monrat et.al., 2019.)

2.2.3 Smart Contracts

Computer programs and pieces of code have been long used to automate tasks. Smart contracts were originally proposed by Nick Szabo in 1994, defining them as "a computerized transaction protocol that executes the terms of a contract" (Szabo, 1994). Smart contracts are not legal contracts. To also give an everyday example, Szabo (1997) compares them to vending machines; you decide the product you want, insert some money into it and the machine automatically releases the product. Smart contracts work in a same way; the contract executes itself automatically if the needed conditions are met (Raskin, 2016). Smart contracts essentially remove the need for a middleman to enforce contracts between actors and that was Szabo's idea all along.

Smart contracts however go way beyond the humble vending machine. Instead of simple asset transactions between one party to another, smart contracts allow more complex multi-step processes to take place. Also, smart contracts operate autonomously, which behaviour is predictable, and its code can be inspected by everyone on the network. (Christidis & Devetsikiotis, 2016; Raskin, 2016.)

Smart contracts are deterministic, meaning they will always produce the same output for the same input. This is important in blockchain's context, as nodes in the network need to reach consensus, and if a smart contract in the blockchain would be non-deterministic, different nodes would get different outputs and could not form a consensus. (Chistidis & Devetsikiotis, 2016.)

Smart contracts are addresses in the blockchain network. Smart contracts are activated by sending a transaction into its address. It then automatically performs the predetermined actions, depending on the instructions sent via the transaction. (Buterin, 2014.)

Smart contracts combined with the values of blockchain opened a lot of new possibilities. One of the first one to realize this was Vitalik Buterin in 2013, when he published the whitepaper to a new kind of a blockchain, Ethereum.

2.2.4 Ethereum

Ethereum whitepaper was published in 2013 by Vitalik Buterin, at the time a 20-year-old Russian-Canadian programmer. Buterin wrote the paper because he believed Bitcoin network needed a scripting language to develop applications. Buterin wanted to create a Turing-complete programming language, that would act as a basis for decentralized applications, dApps (Buterin, 2014).

Like Bitcoin, with Ethereum one can transact the native currency, called ether (ETH) from one party to another (Wood, 2014). However, whereas Bitcoin is often called blockchain 1.0, Ethereum gets referred as blockchain 2.0. The difference between these blockchain evolutions is that where Bitcoin is simply used as a payment service, Ethereum (and other 2.0 blockchains) can be used as a basis for basically any system which logic can be expressed with lines of code (Buterin, 2014; Chen, Pendleton, Njilla & Xu, 2020). This allows systems to be built on top of the Ethereum blockchain, using smart contracts to operate.

Ethereum universe, as Ethereum community calls it, has a computer called Ethereum Virtual Machine (EVM), which is a canonical entity to which's state other nodes on the network agree on. This means that every node on the network keep a copy of EVM's state on their computer. Every node on the network can then request for computation (transaction request) from the EVM. After this, the state of EVM has changed and this is broadcasted and verified across the network. (Wood, 2014; Vujičić, Jagodić & Ranđić, 2018.)

In reality, Ethereum is not fully Turing-complete, but something called quasi Turing-complete, meaning that there is one limitation regarding the computation, gas (Wood, 2014). Gas is fundamental to Ethereum, as it limits the computational resources used. This limitation is used to combat attackers in the system and to avoid infinite loops and exponential blowup (Buterin, 2014; Vujičić, Jagodić & Ranđić, 2018). Gas fees are charged for computations used in the system (Wood, 2014); the more complex the transaction, the more gas fees charged.

Ethereum allowed for a new kind of way to build applications and services. These decentralized applications, or dApps, work, in the best-case scenario, without the need for a human intervention (Cai et. al., 2018; Wu, Ma, Huang & Liu, 2021). The smart contracts in the Ethereum blockchain allow to program business logics into these applications and users interact directly with these smart contracs, so that the whole process is automated (Wu et. al., 2021). Dapps have certain common characteristics, which are 1. It is built on open-source code, so that it follows the trusted and auditable nature of blockchain, 2. it has

internal cryptocurrency, which powers the ecosystem, 3. it has decentralized consensus, again to honour the value of decentralization in blockchains and 4. it has no single point of failure, because it is fully ran in the blockchain and with smart contracts (Cai et. al., 2018). In addition to decentralized applications, Ethereum also allows the creation of DAOs, or Decentralized Autonomous Organisations. These work by the same principles as dApps, but are in theory whole organisations, that have decentralized governance and organise themselves via premeditated, self-executing rules in the blockchain (Hassan & De Filippi, 2021; Buterin, 2014.)

Innovators started to experience with Ethereum, and started building different decentralized applications. One of the first sectors to be affected, was finance. This marked the beginning of a new movement, Decentralized Finance.

2.3 Decentralized Finance

Decentralized Finance, or DeFi, is an emerging technological movement, which has got a lot of people talking. Some think it is just a bubble and other's think it will revolutionize the whole financial system. In this chapter, I will present the current state of the subject. I will introduce the technological architecture of DeFi, its applications, advantages and disadvantages according to current literature.

Intermediaries play a big part in today's world and especially in financial markets. They help different parties finding each other, settle transactions and establish trust between the agents. However, with the rise of distributed ledger technologies, innovators have realized a possible paradigm shift in the financial world. With DLT, different parties can now trust each other without the need for intermediaries. Whereas the trust in traditional finance comes from the trust to institutions and intermediaries, in DeFi the trust comes from the underlying technologies. Some of the core beliefs in the DeFi space is the "don't be bad" to "can't be bad", meaning, that instead of trusting intermediaries to act in the best interests of the users, we should use technology and code instead, because it "can't be bad". Technology has no conflicts of interests or principal-agent problems.

DeFi, utilizes distributed ledger technologies and smart contracts, to form a peer-to-peer financial system (Gudgeon et. al., 2020). DeFi, or Decentralized Finance, is trying to bring the values of DLT into the financial services. DeFi also has the ability to reduce transaction costs and give the power to the individuals to control their capital via permissionless and transparent systems (Chen & Bellavitis, 2020. Since the first DeFi protocols have launched, the total market capitalization of DeFi has reached hundreds of billions of dollars. DeFi has grown explosively and has reached the attention of major TradFi participants.

2.3.1 DeFi definition

DeFi does not currently have a universally agreed definition. DeFi, is neither a legal nor a technical term (Zetzsche, Arner & Buckley, 2020). A few ways the Ethereum website (2021) describes DeFi are following: "DeFi is a collective term for financial products and services that are accessible to anyone" and "an open and global financial system built for the internet age". Schär (2021) simply defines it as "blockchain-based financial infrastructure", whereas Jensen, von Wachter and Ross (2021) describe it as "a new type of open financial applications deployed on publicly accessible, permissionless blockchains". Gudgeon et. al. (2020) define DeFi as "a peer-to-peer financial system, which leverages distributed ledger-based smart contracts to ensure its integrity and security."

Although DeFi does not have an official definition, the consensus in prior literature seems to be that DeFi is financial services which utilize smart contracts, built on top of open, permissionless and transparent blockchains.

2.3.2 DeFi architecture and ecosystem

DeFi's multi-layered architecture can be separated in to five different layers (Schär, 2021). The layers are hierarchical, meaning that each layer is only as secure as the layers below it (Schär, 2021). Schär (2021) compiled a framework for these layers in the context of Ethereum (Figure 3) and I will open up these layers a bit next.

1. The Settlement Layer. This Layer consists of the actual DLT, in this case blockchain. Blockchain can be seen as a foundation which is the basis of all the other layers and provides the trust and the security into the system. The Settlement Layer stores the transactions securely and provide a way to reach consensus in the network. Examples of the Settlement Layer are Bitcoin and Ethereum.
2. The Asset Layer. This layer consists of native assets in the Settlement Layer (the actual cryptocurrency) such as ETH (Ethereum) or Bitcoin, and they can also be additional assets issued (called tokens), such as ERC20 or ERC721 on Ethereum.
3. The Protocol Layer. This layer is about the protocols for different use cases for DeFi, for example lending, exchange and derivatives, and I will talk about them more deeply later in the next subchapter.
4. The Application Layer. This layer can be thought as the UI-layer, that creates applications for users to connect to individual protocols.
5. The Aggregation Layer. Aggregation layer is an extension to the Application layer, which job is to connect multiple different applications together, making it possible to execute multiple types of transactions.
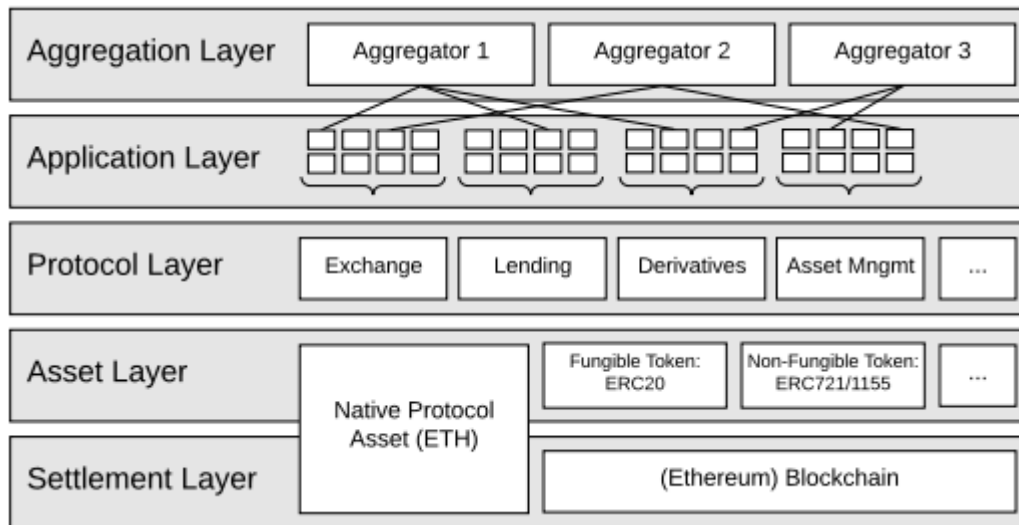
FIGURE 3 Layers of DeFi. (Schär, 2021)

Some studies like Frajtova, Michalikova and Poliakova's (2021) only mention four layers, as they fuse Asset Layer into the Settlement Layer, but overall, they are exactly similar.

Asset tokenization is one important aspect of DeFi ecosystem. In addition to the native cryptocurrencies, need for additional assets rose as the blockchain became more popular. Adding new assets in to the blockchain is called asset tokenization. Issuing assets into the blockchain makes them more accessible and the transactions more efficient. (Schär, 2021.) The issuance of new tokens can also be used to raise capital. Initial Coin Offerings (ICO) have emerged as a new financing method especially for crypto companies or open-source projects. (Schueffel, 2021; Li & Mann, 2018).

One example of tokenization are stable coins. Stable coins are an integral part of DeFi. The extreme volatility of the cryptocurrency markets raised the need for more stable investment vehicles in the crypto markets, hence the introduction of stable coins. Stable coins are defined as cryptocurrencies that are pegged to assets that are in normal situations stable, such as US dollar or gold. This means that the stablecoin tracks the value of the asset it is pegged to as closely as possible. (Hoang & Baur, 2021.) According to Salami (2021) there are three types of stable coins: fiat-, or commodity-backed, crypto-backed and algorithmic stablecoins. The first two are quite straight forward; the stablecoins are either backed to fiat currencies like USD, commodities like gold or other cryptocurrencies to maintain stability, and the peg can be maintained by methods like overcollaterization. The third one, algorithmic stable coins are trying to maintain their stability by using an algorithm to increase or decrease the circulating supply in response to market behaviour. (Salami, 2021.)

Stablecoins are not however only use of tokenization. Non-fungible tokens (NFT) are a way to represent unique assets in the blockchain. In comparison to fungible tokens, non-fungibility means that each asset can be uniquely identified and tracked. Current use cases for NFT's are for example digital art, music

and other different collectibles, and new use cases are being invented. Other tokens in DeFi are for example governance tokens, which are used in DAO's, and synthetic tokens used for tracking real-world asset prices. (Schär, 2021.)

One other thing important in the DeFi ecosystem are addresses and wallets. Address in DeFi means the digital address, where the assets and smart contracts can be transferred to and stored. Wallets are software used to generate and manage addresses. The self-custodial aspect of DeFi means that the individual is in control and responsible for their own digital assets, which are stored and managed using these wallets. (Schueffel, 2021.) These wallets are then used to interact with different DeFi protocols. Below is represented the DeFi ecosystem and how the components are connected (Figure 4).
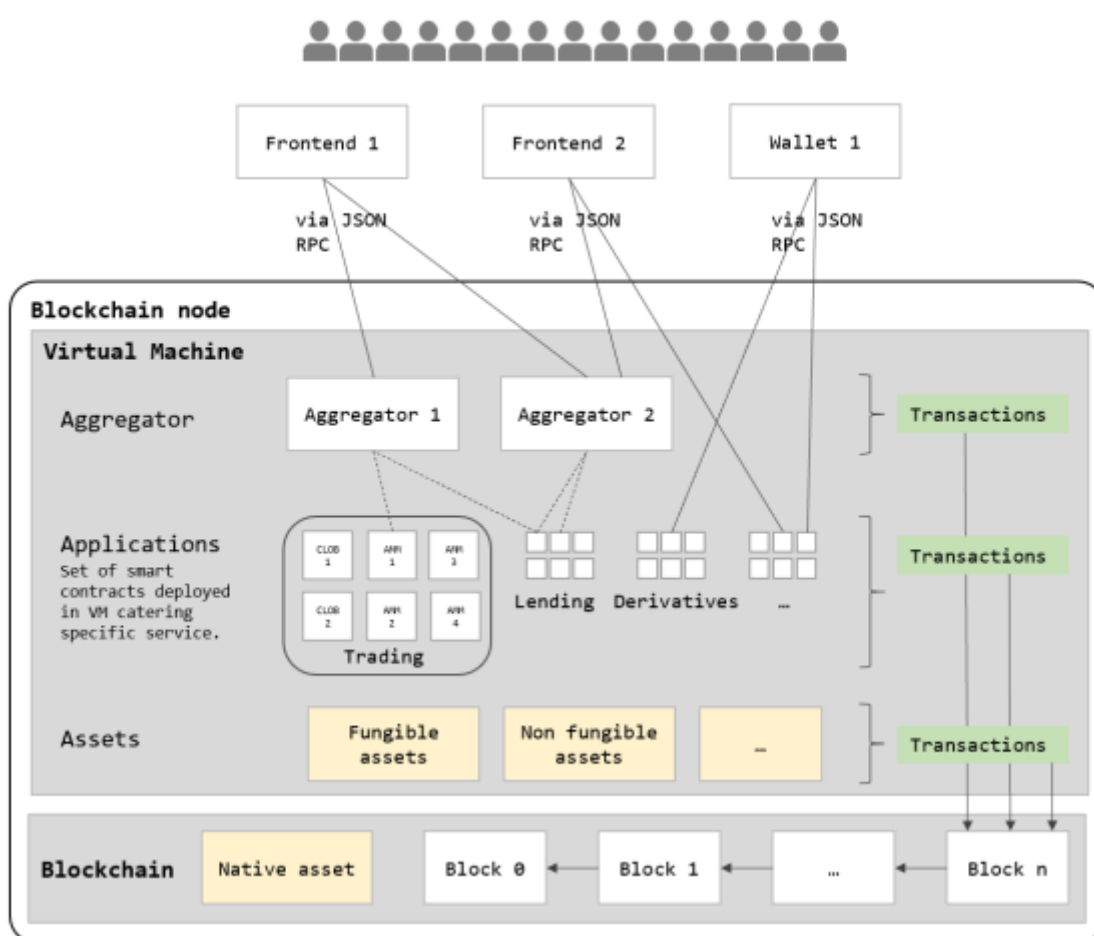
FIGURE 4 DeFi ecosystem. (Jensen, von Wachter & Ross, 2021).

2.3.3 DeFi applications

This subchapter is presenting some of the dApps that run in the protocol layer of the DeFi architecture. While there are too many application types to mention all, and new ones are surfacing all the time, the applications presented here are the most common and the most used types currently. The most common applications currently are similar to traditional financial services in theory, but can

be quite actually quite different. The most common dApps currently are for decentralized exchanges, lending and borrowing, derivatives and asset management.

Presenting the most common DeFi applications can of course depend on the fact what constitutes as DeFi, as it is not quite clear. For example, according to Coingecko (2022a), different Play to Earn protocols are massively popular currently, and have a bigger market cap than for example lending/borrowing services. The area what constitutes as DeFi is grey and changing constantly. Some other types of decentralized financial services that will not be explained here more deeply are for example insurance and prediction markets.

Decentralized Exchanges

Decentralized exchanges, or DEXs, are the biggest applications by market cap at the moment in the DeFi space (CoinGecko, 2022a). Some examples of the most known DEXs are PancakeSwap and UniSwap (Coingecko, 2022b). DEXs should not be mixed with centralized cryptocurrency exchanges like Binance and Coinbase, which operate in the crypto space but are centralized companies offering brokering services. Decentralized exchanges are distributed ledger applications and protocols, built on blockchain, that enable peer-to-peer cryptocurrency transactions without the need to trust the intermediary or a centralized entity to execute and validate the transactions (Lin, Budish, Cong, He, Bergquist, Panesir & Zhang, 2019).

Orders are usually handled off-chain (Daian, Goldfeder, Kell, Li, Zhao, Bentov & Juels, 2019) but can be also on-chain (Lin et al., 2019). Instead of working like a traditional market of buyers and sellers, some decentralized exchanges like UniSwap use something called Automated Market Maker (AMM) protocols. These protocols don't use order books at all. Instead, they use something called liquidity pools. Liquidity pools are comprised of a reserve of a cryptocurrency pair(s), for example BTC-ETH, and it lets users trade between these assets freely, using its reserves, or the liquidity pool as the counterparty. This allows for trading without counterparty discovery and matching. (Daian et.al., 2019.)

Lending and borrowing

Another popular DeFi applications are platforms for lending and borrowing. DeFi money markets have two parties: lenders or "liquidity providers", and borrowers. Liquidity providers can lend their excess crypto assets and receive continuous interest. Borrowers can borrow crypto assets in exchange for paying interest rate. However, since DeFi is pseudonymous and the loan cannot be based purely on credit, to borrow assets one needs to overcollateralize their loan, meaning that they provide some other crypto asset to back up their loan, and this collateral need to be higher in dollar value than the loan. (Jensen, van Wachter & Ross, 2021.) The money market protocol here takes care of the loans algorithmically, meaning for example the smart contract will liquidate the loan if the value of the collateral drops too much, it will set the interest rates for the

loan based on the supply and demand of the specific crypto asset and so on. Current popular lending and borrowing DeFi protocols are for example Aave and Maker (CoinGecko, 2022c).

Blockchain technology and smart contracts bring a new interesting although controversial application to loans, something called flash loans. These flash loans happen atomically and entirely on-chain, meaning the loan and repayment happen inside the same transaction. The borrower receives the funds, uses them and repays the loan with interest almost instantly. This might sound strange at first, what of use would the loan have if one must pay it back right away. Flash loans have its use cases, for example arbitrage trading or swapping collaterals. What makes these flash loans controversial, is that they have been used in attacks. (Qin, Zhou, Livshits & Gervais, 2021.)

Derivatives

One of the fastest growing market segments in DeFi is derivatives (Jensen, von Wachter & Ross, 2021). The same financial contracts such as options, futures etc. are being brought to blockchain. Derivatives derive their value from the underlying asset such as stock, commodity, or cryptocurrency. The price feed of the asset is being fed through external oracle (Schär. 2021). This use of external oracles can cause problems, which are explained later in the DeFi disadvantages - chapter. Currently popular decentralized derivatives platforms are for example Synthetix and dYdX (Coingecko 2022d).

Asset management

Traditionally, asset management means that individuals or institutions pool their asset for centralized fund to manage and invest. In DeFi, this centralized party is replaced by smart contract protocols, which operate algorithmically, without human intervention (Jensen, von Wachter & Ross, 2021). There can also be human fund managers, but in that case the smart contract ensures that the fund manager follows the predetermined strategies (Schär, 2021). When investor invest in decentralized asset management protocols, their funds are locked in the smart contract and the investor receives fund tokens, which represent an ownership in the fund and allows for liquidation of their share of the assets whenever (Schär, 2021). Currently one of the biggest DeFi asset management protocols are Tenset and Enzyme (Coingecko, 2022e).

2.3.4 Advantages of DeFi

The core promises with DeFi are inherently the same as with DLT; decentralization, transparency, openness and interoperability (Chen & Bellavitis, 2020). These core advantages bring a lot of other advantages too, which I will also introduce in this chapter.

Transparency

Transparency is also one of the core premises of DeFi. All the transactions in the public ledgers are freely viewable for everyone. Public ledgers enhance trust between actors and no pre-existing relationship or intermediaries are needed to perform transactions with trust. Public ledgers also help in possible post-mortems, as the transaction history can easily be viewed and analysed. The core idea of DeFi is also building the protocols with open-source code, which means the business logic and the software can be verified and scanned for possible risks and bugs. (Chen & Bellavitis, 2020.) Because of public transfer logs, possible research and post-mortems are also much easier to perform (Schär, 2021).

Interoperability and composability

According to Popescu (2020), composability is the most important advantage of DeFi. In comparison to TradFi's siloed model, DeFi can enhance interoperability between protocols. Especially protocols using the same blockchain have a very good interoperability. Interoperability between different blockchains however is still in development, although some solutions have been innovated. DeFi applications can be thought as pieces of Lego which can be stacked and combined to create new services (Schär, 2021; (Frajtova Michalikova & Poliakova, 2021). With interoperability, capital and value can move around between services effortlessly, in the best-case scenario creating a something called internet of value (Chen & Bellavitis, 2020).

Openness, borderlessness and permissionlessness

Unlike centralized TradFi, DeFi is truly borderless and is not tied to geographic location. Transferring value across country borders can be inefficient and DeFi fixes this. It is also not tied to any currencies or central banks. That means anyone, from anywhere, can participate in it (Chen & Bellavitis, 2020). The risk of discrimination is also basically non-existent due to the pseudonymity of DeFi (Schär, 2021). DeFi removes the friction of moving capital across the globe (Frajtova Michalikova & Poliakova, 2021).

Innovation

The permissionless nature of DeFi is a great breeding ground for innovation. As the protocols have no centralized controlling party, developers can freely participate in building and experimenting with new applications (Chen & Bellavitis, 2020). Open-source nature of the protocols also means that developers can built on top of and combine applications like Lego building blocks. Chen and Bellavitis (2020) call this "combinatorial innovation", which comes from permissionless innovation and open sourcing. Compared to traditional financial services which usually will not share their intellectual properties, everything is freely accessible and usable in DeFi. Open sourcing can also accelerate innovation via increased competition, which leads to better and cheaper products and services

(Chen & Bellavitis, 2020). Every problem needs to be only solved once, as the protocols are open source.

Decentralization

Decentralization of financial services has many benefits. It can allow the same benefits as TradFi, like reducing transaction costs, but without creating monopolies (Catalini & Gans, 2019). As the transactions are facilitated by decentralized peer-to-peer networks, no one entity can gain a monopoly power and it allows for anyone to participate in the services (Chen & Bellavitis, 2020; Frajtova Michalikova & Poliakova, 2021).

Efficiency

Trust in traditional finance is created by centralized institutions. DeFi can replace this need for trust with smart contracts, at least partially. Since the transactions are settled atomically, it basically removes the counterparty risk. Removing the counterparty risk also makes transactions much more efficient. (Schär, 2021). Another advantage of cryptocurrencies and tokens is that transferring them is much faster than transfers in traditional financial system. (Schär, 2021).

2.3.5 Disadvantages of DeFi

The aspects of DeFi that can be seen as its strengths, might also be some of its biggest potential limits and risks. The technologies are still novel and new innovations trying to solve the problems regarding DeFi are being developed. In this subsection I will introduce the disadvantages that DeFi has that was found in the prior literature.

Scalability, network congestion and transaction costs

One fundamental problem with blockchain development, which inherently also affects DeFi, is something called "the scalability trilemma". The term, originally proposed by Vitalik Buterin, state, that three of the key properties of blockchain, decentralization, security and scalability cannot perfectly co-exist (Zhou, Huang, Zheng & Bian, 2020). Therefore, developers need to constantly evaluate their priorities regarding these three properties. To give an example, if developers want to enhance the scalability of the blockchain, they have to often sacrifice the security of the chain (Zhou, Huang, Zheng & Bian, 2020). Some chains sacrifice the decentralization part of the trilemma and have a central organization to enhance security and scalability of transactions. Scalability has been probably the main problem regarding mainstream adoption of blockchain technologies such as DeFi, as they are not yet at the level of transactions-per-second with the likes of Visa (Zhou, Huang, Zheng & Bian, 2020). There are currently many different propositions as the solution for the scalability issue, which of some would im-

prove the scalability of the underlying blockchain (layer 1 solutions), whereas others would increase the scalability with using protocols built on top of the underlying blockchain, while still inheriting the security of its base blockchain (layer 2 solutions) (Zhou, Huang, Zheng & Bian, 2020). Most of the current solutions however sacrifice some of the decentralization or security parts of its blockchain, so the scalability trilemma will hinder the adoption of blockchain as long as it is solved (Zhou, Huang, Zheng & Bian, 2020).

Scalability problem directly causes two other problems: congestion of networks and high transaction costs. Transaction costs (or "gas fees" in Ethereum) are a way to battle the abuse of computational resources in the system. That means, that there is a secondary market for transactions, as users outbid each other to get their transaction to be included in the next block by the miners. During times of high network congestion, transaction fees can rise very fast and make transactions unfeasible to make. Scalability problem causes the networks to congest and therefore transaction fees to go higher. (Jensen, von Wachter & Ross, 2021.)

Lack of regulation

The decentralization aspect of DeFi also means that it suffers from lack of accountability and enforcement issues (Zetzsche, Arner & Buckley, 2020; Chen & Bellavitis, 2020). Because these DeFi protocols work autonomously, there are no actor to be held accountable in case of malfunctions or fraud (Zetzsche, Arner & Buckley, 2020; Chen & Bellavitis, 2020). Institutions and intermediaries that are essential to the traditional finance and the trust within it, can be regulated. The laws and regulations regarding these intermediaries are what creates the trust in centralized system The great question is, how do you regulate something permissionless and decentralized globally. Schär (2021) mentions that it might not even be possible. Regulation in different countries and jurisdictions can differ immensely and since DeFi projects can be global, the regulatory framework regarding it can become mixed (Zetzsche, Arner & Buckley, 2020).

Another problem with DeFi regulation is that there are no Know-Your-Customer (KYC) and Anti-Money Laundering (AML) components. These two are the backbone of traditional finance's regulation toolbox. AML is the processes of how institutions can fight money laundering. KYC is one part of AML processes, and it means that institutions can verify the users' identity. No intermediaries means that it is hard to implement any AML or KYC practices, and transfer of funds is easy for any illicit activities. (Salami, 2021.)

The places where regulation is currently possible regarding DeFi, is the fiat on- and off-ramps (Schär, 2021). Before people can get their money to the blockchain, they must go through a centralized traditional financial service, which are regulated and can carry out background checks (Schär, 2021).

Technology risks

DeFi inherits the same risks which come from its underlying technologies, DLT and smart contracts. Jensen, von Wachter and Ross (2021) mention software integrity and security as one of the main risks in DeFi. One of blockchain's benefits, immutability of transactions can also be one of its risks. Once a transaction is signed in a block, it can't be reversed. That means that any mistakes or coding errors can result in irreversible damage (Schär, 2021). This can also make the protocols rigidity and inflexible (Chen & Bellavitis, 2020). The novelty of the technologies means that new risks are being discovered at the same rate that the technologies are being developed.

Systemic risks and The Oracle Problem

Interoperability, which is one of the core promises of DeFi applications, can also create systemic risks (Schär, 2021; Jensen, von Wachter & Ross, 2021). As DeFi protocols can be stacked like Legos, one bad piece could have large effects in the system. Collapse of one protocol could have cascading effects on the whole system (Gudgeon et. al., 2020). A common habit of complex methods using leverage and collaterals in the protocols can also increase the systemic risks, as a rapid depreciation in one asset can trigger market wide liquidations (Jensen, von Wachter & Ross, 2021).

One the systemic risks that might compromise the ecosystem is regarding the data that is fed into the system. Smart contracts, while providing decentralized and trustless solution to contracts, however, inherit one fundamental limitation; they can't access data off-chain from the external world. Many contracts need a way to access some information for example price of an asset, result of a competition or the weather to execute the contract. To answer this problem, oracles. Oracles are a kind of smart contracts, which provide data to other smart contracts (Al-Breiki, Rehman, Salah & Svetinovic, 2020). There has been a lot of talk around oracles, because they are fundamentally in conflict with the trustless and decentralized nature of blockchain (Caldarelli & Ellul, 2021). This problem of external data and its centralization is called "The Oracle Problem" (Al-Breiki et al., 2020).

Illicit activity

New technology, novice investors and sometimes hard to use protocols are an enticing combination for bad actors. While DeFi is growing explosively, illicit activity in the ecosystem is growing proportionally (Wronka, 2021). Scams, exploits and attacks are being make even easier via the lack of regulation in the space, as there are sometimes no ways to identify the malicious parties (Wronka, 2021). While one of the advantages of DeFi is transparency, its pseudonymity increases actors' privacy, and this privacy can be used for illicit activities (Schär, 2021).

There are many types of illicit activities in the DeFi space. One of the biggest problems regarding this is the previously mentioned external oracles. With oracles, one needs to trust the source of information and its integrity. According

to Caldarelli and Ellul (2021), almost two thirds of DeFi hacks were possible because of oracle exploitation.

Decentralized governance and the distribution of governance tokens can sometime lead to problems in protocols. Largest token holders, usually founders can sometimes collude (Jensen, von Wachter & Ross, 2021), and the largest owners can "rug pull" investors by dumping their holdings through DEX's (Schär, 2021).

There are also some DeFi application specific risks. One of the biggest risks especially in decentralized exchanges (DEX) is transaction frontrunning. Like high-frequency traders in TradFi, frontrunners can take advantage of the inefficiencies in the protocol to anticipate and exploit ordinary users' transactions (Daian et. al., 2019). Like mentioned before, flash loans can also be used for illicit activities. Since the amount of capital anyone can borrow, without collateral, from flash loan pools is only limited by the pool size, this can enhance the attack and damage the ecosystem even more. These flash loan pools are offering billions in USD, so the effect can be massive. (Qin et.al., 2021.)

2.4   Summary of the literature review

In traditional finance, intermediaries bring value via reducing asymmetric information, transaction costs and risk. Conflict of interests, creed, lack of transparency and centralization can however cause devastating crises in the financial sector. Trust in financial intermediaries and financial markets has been reducing since the financial crisis of 2008. This model has been the status quo for a long time, but new innovations in technology might be starting to change it.

Distributed Ledger Technologies, and mainly blockchain, has emerged as a new method of peer-to-peer transactions, removing the intermediaries. The underlying blockchain brings trust, transparency, openness, decentralisation, and immutability to the system. Smart contracts were another important innovation, which allowed for complex, multistep processes to take place automatically, without for a human to execute them. Ethereum blockchain was the first to combine these two technological innovations to create a platform for new kinds of decentralized applications, dApps. One of the first sectors to utilize these dApps was finance, which marked the start of a new movement, Decentralized Finance (DeFi).

DeFi is a movement dedicated to creating open and decentralized financial markets. DeFi's core purpose is to replace the middlemen and create the trust between actors with technology. DeFi protocols market capitalization has grown explosively and is starting to gain the attention of TradFi world.

The biggest DeFi applications at the moment are decentralized exchanges (DEX's), money market protocols for lending and borrowing, derivatives and asset management. Many other types of applications are constantly being developed for example for insurance and prediction markets.

DeFi has a lot of advantages, which are usually inherited straight from the underlying technologies, blockchain and smart contracts. DeFi advantages are transparency, openness, permissionlessness, borderlessness, interoperability, decentralization, innovation and efficiency.

There are however still a lot of risks and drawbacks to DeFi applications that need to be addressed. These risks and drawbacks are often the same properties that can be thought as the strengths of these protocols. DeFi's disadvantages are different tehnological risks, scalability, network congestion and transaction fees, systemic risks and The Oracle Problem, illicit activity and lack of regulation. The advantages and disadvantages of DeFi are collected to the Table 1.

TABLE 1 Advantages and disadvantages of DeFi from the literature review

Advantages	Disadvantages
Transparency (Chen & Bellavitis, 2020; Schär, 2021)	Technological risks (Jensen, von Wachter & Ross, 2021; Schär, 2021; Chen & Bellavitis, 2020)
Decentralization (Catalani & Gans, 2019; (Chen & Bellavitis, 2020 ; (Frajtova Michalikova & Poliakova, 2021)	Scalability, network congestion and transaction fees (Zhou, Huang, Zheng & Bian, 2020; Jensen, von Wachter & Ross, 2021)
Interoperability & Composability (Popescu, 2020; Schär, 2021; Frajtova, Michalikova & Poliakova, 2021)	Systemic risks and The Oracle Problem (Schär, 2021; Jensen, von Wachter & Ross, 2021; Al-Breiki et. al., 2020; Caldarelli & Ellul, 2021)
Borderlessness, Permissionlessness, Openness (Chen & Bellavitis, 2020; Schär, 2021; Frajtova, Michalikova & Poliakova, 2021)	Illicit activity (Wronka, 2021; Schär, 2021; Caldarelli & Ellul, 2021; Jensen, von Wachter & Ross, 2021; Daian et. al., 2019; Qin et.al., 2021)
Efficiency (Schär, 2021)	Lack of regulation (Zetzsche, Arner & Buckley, 2020; Chen & Bellavitis, 2020; Schär, 2021; Salami, 2021)
Innovation (Chen & Bellavitis, 2020)	

3   RESEARCH METHOD

In this chapter, I will introduce the research methodology of this thesis. I will justify the chosen method and explain how the empirical data is collected, what is the data sample and how is the data analysed. For this study, qualitative research method was used. For the interviews, semi-structured professional interviews were utilized. Interviews were analysed using qualitative data analysis methods.

Due to the novelty of the research topic, qualitative research method was chosen to be best suitable. Qualitative research methods can help understanding subject on a deeper level. Qualitative research methods are also suitable, when there are no existing theories explaining the phenomenon (Merriam, 2002).

Qualitative interviews are one of the most common data gathering tools in qualitative research methods (Myers & Newman, 2007). Qualitative interviews were also chosen for this study, more specifically semi-structured, or theme interviews. Semi-structured interviews allow for specifying questions from the researcher (Bhattacherjee, 2012), which was important regarding the research method. Other advantages of semi-structured interviews are their flexibility, which allows both the researcher and the interviewee to focus on specific topics and freely express their opinions and views (Horton, Macve & Struyven, 2004). Semi-structured interviews also allow for issues that had not been previously defined to come up, and to be further followed up and used in other interviews (Horton, Macve & Struyven, 2004).

3.1   Data collection

The empirical data for the thesis was collected from professionals of the topic, using semi-structured interviews. The invitation to the interviews was sent to 9 people with experience in the DeFi space. One person declined, and three people did not answer the invitation, meaning five people attended the interview,

or 56% of the prospects. The data collection process included three steps: preparing the interview structure, contacting potential interview partners, and conducting the actual interview.

The data collection process was conducted in December 2021. The interviews were held online using Microsoft Zoom video communications platform, due to the scattered geographical nature of the professionals and the covid-19 situation. The average length of the interviews was around one hour.

Semi-structured interviews mean that the interview has pre-defined themes, but the actual interview can be flexible. For this study, the pre-defined themes were background information, traditional finance and DeFi. Interviews started with a few background questions, to ease the tension at the start of the interview and to give interview partners a chance to assess their background regarding the topic and to evaluate their proficiency regarding the topic. Background questions went through the interview partners' education, job history and current position and company they were working in, and their introduction to the world of DeFi.

The second area of interview questions covered questions about the traditional finance, in order to assess the interview partners' knowledge on that topic. Asking these questions were relevant for two reasons: First, DeFi is currently mimicking a lot of services from traditional finance, so in order to be able to discuss the advantages and disadvantages of DeFi in comparison to traditional finance, the interview partners had to have some knowledge on traditional financial services as well. Secondly, the idea in asking questions about the traditional finance was to help the interview partners to start mirroring DeFi's advantages and disadvantages more naturally to traditional finance, and that way also cover more themes.

The third section in the interview questions was questions regarding DeFi. The main questions in this section were questions about the advantages and disadvantages of DeFi, but it also had some supporting questions to firstly nurture interview partners' imagination. For example, questions like "How do you see the future of DeFi in 5/10 years?" and "Do you think DeFi can replace traditional banks in the future?" were asked to push interview partners to think deeper into the future of DeFi and maybe gain some new perspectives on the advantages and disadvantages of DeFi. This section also included the question to answer the second research question: "What is DeFi?", which allowed the interview partners to define it in their own words.

The interview ended with an open-word section, to give interview partners chance to give their final thoughts about the topic. Although the interview had this predefined structure, the conversation flowed freely around the themes. That means the order of the questions varied in every interview, and a lot of specifying questions were asked regarding different answers. The pre-defined structure for the interviews can be found in the Appendix.

3.2 Data sample

Data sample for the study consist of five professionals currently working/having worked in the DeFi space. The novelty of the topic meant that the professionals were hard to find, and they were scouted through many different channels, like Twitter, Discord and LinkedIn. Pseudonymity in DeFi also made it harder to find potential candidates. The scarcity of professionals in DeFi also means that not a lot of information can be revealed about the participants, in order not to reveal their identity. The prospects were contacted by email, Twitter and Discord. The data sample was anonymised for this study.

Due to the novelty of the topic, the experience of the interview partners was naturally only around 1-4 years in the DeFi space. However, some of the interview partners could be described as pioneers in the space, having been part of building on of the first DeFi protocols. Most of the interview partners also had experience in the cryptocurrency space even before DeFi was a thing, which can also be seen as valuable experience even in the DeFi space.

Even though the sample is not large, it is quite extensive with interview partners from different backgrounds. The target was to get as much different backgrounds and specialties from technical side and business/finance side of DeFi, so that the answers would cover the space as much as possible. Almost all of the interview partners had experience from both finance and technology, so it broadens their perspective on the topic. Four of the five professionals currently worked in some DeFi company/project, and the one had experience from working in one. I believe the quality of the data set was very good given the novelty of the subject. Interview partners' backgrounds are presented below in Table 2.

TABLE 2 Interview partners

	Employer	Role	Work experience in DeFi/crypto
Interview partner 1	Self-employed (currently non-DeFi)	CEO	~ 3 years
Interview partner 2	DeFi Protocol	Head of Product	~ 3 years
Interview partner 3	Decentralized web infrastucture company	Product & Business Development	~ a year
Interview partner 4	Self-employed/ Venture capital	CEO	~ 9 years
Interview partner 5	Digital Asset Lending Company	DeFi Portfolio Manager	~ 1,5 years

3.3 Data analysis

The collected data was analysed using thematic analysis. The data analysis needs to also be qualitative because of the qualitative research method. (Bhattacherjee, 2012). Qualitative analysis is about understanding the topic, rather than predicting or explaining (Bhattacherjee, 2012). The data analysis process followed the process identified by Braun and Clarke (2006) which splits the process in to four phases:

1. Familiarising yourself with your data
2. Generating initial codes
3. Searching for themes
4. Reviewing themes

The first step in the analysis phase was to familiarize oneself with the data. This was done by two ways: transcribing the interviews into their own text files and reading the transcription for a couple of times. The transcription process was done carefully to ensure the texts' equivalence to the recordings. The second step of this phase of the data analysis was reading all the interviews a couple of times, in order to get an overview of the data and familiarize the material to understand it better. Simultaneously with reading the data, initial thoughts about it were noted down.

The second phase was to generation of initial codes in the data. The codes were derived by highlighting words or sentences from the text that were thought to be key concepts or thoughts regarding the interview questions. Some examples of generated codes were "regulation", "one of the biggest problems currently", "advantage" and "user experience".

Third and fourth phases were about searching for themes and reviewing them. After coding the key concepts, they were thematized to potential themes by collecting them to their own text files by category. The themes were identified by searching for repeating patterns. The four themes that were formed were the following: Interview partners' background information, Definition of DeFi, Advantages of DeFi, and Disadvantages of DeFi. The second theme was formed to answer the thesis' supporting research question and the last two were formed to answer the thesis' main research question. The last two themes were also again thematized, to form the final themes that can be found in the Results -chapter. These themes were also compared to the themes found in prior literature, and the research questions for the study.

4 RESULTS

This chapter will introduce the results of the interviews and construct a framework for the advantages and disadvantages of DeFi based on the empirical data. This chapter will first present the results for DeFi definitions from the interviews, and after that the advantages and disadvantages of DeFi, respectively, divided into themes that arose from the interviews. This chapter will conclude with a framework of advantages and disadvantages of DeFi found from the interviews.

4.1 DeFi defined

To answer the sub-research question of this thesis, here is collected the ways the interview partners described DeFi. Decentralization and openness, automation and autonomy, smart contract -based systems and trustlessness were the key attributes mentioned:

"Maybe DeFi is in its simplest form finance happening on top of open and decentralized systems" -Interview partner 3

"I would say DeFi is open technology build on top of blockchains, which is used mainly performing different finance tasks" -Interview partner 2

"Automatized smart contract -based financial system" -Interview partner 1

"Smart contract is a bad term, because people start to think about traditional paper contracts, more appropriate would be smart transactions or autonomic systems. -Interview partner 4

"How I see DeFi, is that it is different pieces of financial markets operating without intermediaries, or at least with a "lighter" intermediary, and what that means in practice is that you can participate in different financial ser-

vices so that you are fully in control of your money the whole time." -Interview partner 5

"It is maybe an idealistic definition that you don't have to trust anyone, but if we take it in to practical level, I see it that way that you have to trust less. There is less trust needed and much more transparency in comparison to traditional financial word, at least in those protocols that operate the most transparent way." -Interview partner 5

Although DeFi has "finance" in its name, one interview partner would not limit the definition to include only financial services:

"I would not necessarily start specifying that it (DeFi) needs to be only financial products. There are components that can be brought in to DeFi, with standards like ERC-721 and ERC-1155, these fungible things, for example in the future some real estate could be brought there, and people could bet with it or divide it into IOU's, so you could do basically anything with it, so I would not necessarily limit DeFi like it is usually seen as only financial services." -Interview partner 2

The interviewed professionals agreed that DeFi is products or services built on some kind of a distributed ledger, usually blockchain, and utilizes smart contracts to allow for open and autonomous systems. There are still no clear boundaries on what DeFi actually includes, as currently its services are mostly mimicking traditional financial services, but the technology and innovation might allow for completely new kinds of services and products to be built. The most idealistic world view for the future which came up in the interviews, is that every real-world asset will also be transferred in to the blockchain some way, and that way DeFi could transform to be something completely more transformative than what it currently is.

4.2 Advantages of DeFi

This subchapter presents the advantages of DeFi that came up in the interviews.

4.2.1 Efficiency

One advantage in DeFi compared to TradFi, that all interview partners mentioned, was efficiency. Efficiency was seen here from two perspectives, and the transaction speed and cost efficiency are the first perspective:

"For example in Ethereum, the settlement time is around 10-15 seconds, when going through traditional systems it could take a couple of days." -Interview partner 2

"In institutional level and global level, its (DeFi) advantages start to become clearer. For example, if you transfer dollars to China, it will cost you

probably around 100 dollars fee and in DeFi, optimally on top of some layer 2 solution it could be around 50 cents. Also, the settlement issue, meaning that in Ethereum it is around 10-15 seconds, in Solana around 600 milliseconds for one settlement, when traditionally it would probably be around 15 days between different jurisdictions and still would not be certain to happen." -Interview partner 2

The settlement time for transactions in DeFi is therefore only limited by the underlying blockchain. This is a massive improvement in transactions between different countries and jurisdictions.

The other way to look at the efficiency is from the efficiency of running these protocols, from the human capital perspective:

"The thought that we can build most of the services from traditional finance using smart contracts, is making these services enormously more efficient, because the intermediary has been removed and a load of bureaucracy and needless administrative work which is a massive overhead cost for the banks." -Interview partner 1

"Aave is even compared to Finnish banks a top tier company, only difference is that there is not 5000 people working but 30-40 people, which are coding and could stop the coding today and the service would continue working all the same." -Interview partner 1

"One simple thing that comes with IT is cost efficiency, meaning that if you can produce the same service with zero people versus producing it with a hundred people's manual work where paperwork is flown around it is obviously more expensive." -Interview partner 4

"Because there is no counterparty risk, and a lot of the human capital in banks goes to compliance and risk management." -Interview partner 4

"And if you start a financial service in the blockchain, when it is running it is kind of permanent, meaning that it requires little to no maintenance." -Interview partner 4

"When you can automate different simple things, meaning that you can perform things with automatic contracts, it could lighten our financial sector." -Interview partner 5

"There comes an ideological possibility, that if everything changed to this automatic way of operating, we could release 20% of world's human capital and re-allocate it to where it could bring at least the same amount of value and we could therefore drive us as humanity forward" -Interview partner 5

Smart contracts allow for the protocols to work, in theory, completely autonomously. Therefore, these DeFi protocols save a lot of resources in human capital, as there is no need for compliance, risk management, and in theory any mainte-

nance. This means that some of the blue-chip protocols today are as big as some of the traditional banks but operate with a fraction of their personnel.

4.2.2 Openness

Another significant advantage mentioned by all interview partners was openness. Firstly, openness in DeFi means that everyone in the world with an internet connection can participate and use these protocols.

> "Different people around the world can be offered the same opportunities, which is quite limited in our current financial system. It could be that you need to send money from Great Britain to Africa and it costs you a lot. Also, in these developing countries they are considerably behind in being able to offer different banking services and this way I believe DeFi could bring these services there as a global thing." -Interview partner 5

> "We have billions of people in the world who does not have access to banking services" -Interview partner 3

> "Maybe it does not show to a person living in a western society, but when you start speaking with people from Turkey or China where the institutions are probably more corrupt, then the advantages start showing more, meaning that they (the people) can invest and control their own money and they don't have to trust the institutions." -Interview partner 4

DeFi protocols could therefore bring financial services to everyone with an internet connection. In addition to being open for use, openness also means that everyone can participate in building DeFi protocols, as they are open source.

> "It is somewhat regulatory arbitrage, that anyone can participate in it and anyone can build on top of it (blockchain). Will regulation change this in the future, we'll see but currently it is one of the advantages that anyone can think to themselves that hey, here's a financial product I would like to build, no chance to build it in TradFi so let's go to DeFi." – Interview partner 2

Future regulation might change the fact that currently anyone has a change to build a financial service in DeFi, when in traditional financial world it is very hard to get a permission for that.

4.2.3 Transparency

Another advantage of open source and blockchains is transparency. Transparency was one of the main advantages seen in DeFi by the interview partners. Public, decentralized ledgers allow anyone to view the transactions happening in it.

> "If this all (finance sector) was built on automatic smart contracts, then it would be perfectly transparent, meaning everyone will see where the money comes and where it goes, although it is anonymized environment,

> this kind of transparency would undoubtedly bring a lot of benefits in the current financial system." -Interview partner 1

> "Everything is open source, and transparent per se, which I believe to be an advantage." -Interview partner 3

> "If we have a public blockchain like Ethereum, the information is available to everyone, meaning anyone can confirm that the settlement has happened, rather than it being somewhere in banks' private books hidden from everyone else. Therefore, I see the transparency is an advantage on some use cases, for example it would be preferable for all the charity organisations to do everything on-chain, because then people could really see where the money has gone, because if the money moves between bank accounts it can be hard or even impossible to track even with audits." -Interview partner 2

> "One advantage is overall transparency, meaning that in DeFi there won't happen, or can happen but is much harder to execute these fully "under the wraps" kind of things. For example, following where the money goes and stuff like that is much easier for the public to follow." -Interview partner 5

Transparency increases trust in the system, as it allows anyone to view the code and transactions in the protocol. This of course means that one must understand the code in order to verify it, so it doesn't completely eradicate the need for trust, as you need to at least trust the code verifiers.

> "Of course, the idea of trustlessness requires that you can actually verify the code yourself that you are using" -Interview partner 5

4.2.4 Security

Another advantage of open source, and DeFi, is security.

> "It (security) is a bit of a two-way street; on one hand, if the smart contract is secure and there are no bugs, then it is much safer than regular financial system. The risk of hacks and other goes down. If the smart contract works like it is supposed to, it basically minimizes all the risk, you don't have a counter-party risk because people can participate in this permissionless peer-to-peer network." -Interview partner 1

> "It is important to remember something called base-layer compatibility, meaning that if these smart contracts work in the Ethereum ecosystem, then if some piece of code has worked before then people can use it again and you don't have to start building stuff from the ground up" -Interview partner 2

In simple terms, if it works, it really does work, meaning that because these protocols and smart contracts are open source and verifiable by anyone, it increases security. The longer the base-layer blockchain keeps running, the chance for

bugs found decreases. If the smart contract works as intended, the security of these protocols can be seen as much better than traditional financial services, as there is no counter-party risk.

4.2.5 Decentralization

As one could guess from the DeFi name, decentralization was one of the advantages mentioned.

> "There is that advantage in this geopolitical point of view that if one (node) would go bust it does not matter, or if like an asteroid would hit the earth and half of the world would go bust, we still would have this one database that would keep going. That might the biggest advantage of decentralization." -Interview partner 2

Although decentralization, a bit surprisingly, was not directly mentioned a lot, its advantage was brought up in indirect way, especially while speaking about the regulation of DeFi, and how it could challenge the authority of governments and central banks:

> "I think governments might disagree about the ideology that people should have control of their own money, as it is a very powerful way to affect people if they can control their money." -Interview partner 2

> "We have Turkey, China, Russia, countries that try to prevent people from getting in to the blockchain because it makes controlling their authoritarian society harder." -Interview partner 4

> "So, if this all goes to this kind of a dirty version where this all is controlled by central banks and governments, then this system is actually even better regulation tool than the traditional system." -Interview partner 5

4.2.6 Profits

Other advantage seen currently in DeFi was its superior expected yield in the markets.

> "You can get 15-20% yield on your stablecoin in the blockchain world. I don't have any volatility risk because I am using a stablecoin, be it USDT or USDC or USDG and I get 15-20% annual percentage yield for it. Basically, the only risk is the smart contract risk, you don't even have the counterparty risk." -Interview partner 1

4.2.7 Innovations

Finally, another advantage that was mentioned in the interviews was all the new innovations that DeFi has brought to life and can't really work in the traditional financial world, like self-repaying loans, flash loans etc.

"For example, Alchemix; self-repaying loans. Meaning that I can put 100 Ether as a collateral and take a 100 000-dollar loan for myself and a nice new summer car. That 100 Ether I put as a collateral, Alchemix will invest it in different DeFi protocols where it will gain interest and that yield will be reinvested so that over time that yield will repay my original loan. So basically, you have a loan and the yield for your collateral will pay the principal and the interest back." -Interview partner 1

"Maybe these kind of crowd fundings etc. are something that you can't really do in the real world efficiently, or you can do but they are not as efficient and you can do things like if you have some kind of an ideology, and anyone in the world can participate in it with small amount of money, maybe the most popular example is this Constitution DAO, where people tried to buy the United States constitution. It would not have worked without the DAO in the background." -Interview partner 4

"One I personally like is this apparatus called Klimadao, which idea is to buy carbon off the markets and save the world when they have bought all the carbon credits. And it is purely a ponzi scheme, because they are buying the carbon credits so that their price goes up -- So, it is kind of a positive ponzi scheme, because it is of course better for the world if the price of the carbon credits goes up." -Interview partner 4

"If you can use capital more efficiently or allocate it more efficiently it will bring more value for you, and likely for the whole society -- for example like flash loans, a concept that I find brilliant and brings a lot of value to a lot of places." -Interview partner 5

"The innovation in flash loans is that you don't need your own capital to trade, like it is in the traditional financial world where these big financial institutes can perform this arbitrage in big exchanges, basically it requires that you are well connected and are friends with the CEO of the exchange, which gives you the ability to do market making. In crypto world it is different, because of its openness and these flash loans remove the capital requirements, which makes it purely based on merit." -Interview partner 4

Lastly, one of the innovations that blockchain and smart contracts bring, is tokenization of assets:

"For example NFT's, which are currently mostly pictures or music or stuff like that, but we could create digital representations of real life assets in to the digital world. We could transfer our real estate ownership records, our Nasdaq listed stocks in to the blockchain. We could bring for example the rights of some park or forest or carbon credits in to the blockchain." -Interview partner 3

The open-source aspect also means that every problem has to be only solved once. The lack of regulation can also be an innovation increasing factor. This combination increases and speeds up the innovation happening in DeFi and has allowed the explosive growth of crypto and DeFi:

"Generally speaking, when a protocol is built with open-source principals, it means in my view that it increases innovation in the system just because you don't have to always invent the wheel again, rather, you can take the "wheel-library" and use it to build a car" -Interview partner 5

4.3 Disadvantages of DeFi

This subchapter presents the disadvantages of DeFi that came up in the interviews.

4.3.1 User experience

According to the interviews, maybe the biggest challenge with DeFi at the moment, mentioned by all of the interview partners is the user experience and usability of DeFi protocols.

"The usability of these services is miles behind in DeFi compared to traditional financial services. Their services are simple and easy to use." – Interview partner 1

"The usability of is still a problem, it is very hard, and the services are not kind of mature and simple enough, so they are currently for the more professional users. Or let's say also for the more skilled individual users. -Interview partner 3

"The usability is the main thing, it is still very bad, especially Ethereum mainnet, expensive and difficult to use, and that is the biggest problem currently, so when we are able to get sensible transaction fees in the future and can get the services more localized. -Interview partner 4

In addition to the inconvenience coming from bad usability, it also acts as a big security risk for the inexperienced user.

" Currently, when the usability is so bad that using these user interfaces require knowledge about keys, it leads to human error, when a bad actor sends you a message to click on this link and you as an inexperienced user click it and the attacker gains access to your computer and spies on your Metamask password or something like that." – Interview partner 1

"Most of the errors are user errors, for example you accidentally publish your seed phrase somewhere etc. If we can improve education around the topic, the risk decreases." -Interview partner 2

The interview partners saw that education and new innovations are key in minimizing the risk coming from bad usability.

" The risk that you lose your keys is very real. Coming back to the issue with UX, what are the ways in the future to recover your lost keys. I find it

difficult to believe that billions of people find the way to store their possessions in some ledger, so I believe we are going to see some new innovations regarding it." -Interview partner 3

"People learned pretty quickly what you should and what you should not do in the internet -- I believe that DeFi is no different (from internet), everyone will make mistakes in the beginning -- especially when the younger generation, which is more digitally native, starts adopting these services, they won't have to be taught that much, so I believe it is also a kind of generational change type of thing." -Interview partner 4

User experience sounds like a problem that is only solved by time, and trial and error. Given the novelty of DeFi, it can be expected that there are problems regarding it at the moment, like any new technology. Its severity cannot however be underestimated at the moment, as the interview partners emphasize.

4.3.2 Technology risks

Although DeFi was seen to decrease risk by removing the counterparty risk, it still has risk in its technology.

"The risk goes the other way also, that if the smart contract has a bug, then it can lead to that one loses his assets, and that is of course a significant risk." -Interview partner 1

"One problem with smart contracts is also that the logic in them could just be wrong, so that there does not necessarily even need to be a bug in the code, and someone just has not thought it (the logic) through and someone else finds a way to exploit it this wrong logic in the smart contract, so that is also a significant risk." -Interview partner 1

As mentioned before, the open-source nature improves the security of the smart contracts. There is of course a possibility, that the underlying blockchain also has bugs:

"Level 1 side has the native risk, meaning that for example Ethereum blockchain has some kind of a bug, which is pretty unlikely, but if found would compromise the whole system." -Interview partner 2

4.3.3 Lack of regulation and illicit activity

While the technology behind DeFi keeps on going, the regulation is crawling behind. While the lack of regulation was acknowledged to be a disadvantage, it was mentioned mostly through the illicit activity happening in the space, and some of the illicit activities were also already mentioned in the while talking about the user experience.

"People are kind of clever in coming up ways to cheat money of other people, so it also makes it a bit scary seeing what kind of innovations there could come but I believe that over time it will bring a lot of value to the

world, provided that many people lose their money before that." - Interview partner 5

"There is still a lot of frauds and stuff like that happening, so if you can't regulate it (DeFi) properly, you might not be able to get away from those" -Interview partner 5

"Assigning regulation in to DeFi is hard, just because of the values that blockchain brings." -Interview partner 5

4.3.4   Scalability & environmental impacts

One of the main issues with blockchain, the scalability trilemma was also mentioned by interview partners.

"Scalability is a problem, but we will improve on it massively. I don't see it as any kind of problem in the near future, in five years." -Interview partner 4

"The problem is that if we want to retain decentralization, currently we need to sacrifice speed." -Interview partner 5

"Currently we need to compromise in either speed or credible neutrality. There are different solutions to this, for example Solana blockchain has a faster settlement time, but it is also much more centralized than Ethereum, and then Bitcoin is even less centralized with its 10-minute block time. The fact that it is decentralized like in PoW, means that there are these costs for example energy and depending on your views it can cause negative environmental effects, or it can be a wasted resource." -Interview partner 2

The scalability of the underlying blockchains and the environmental impact of them go hand in hand. Although the interview partners acknowledged that it is currently a real issue, consensus was that future innovation will eliminate it.

"I agree that it is a problem, and for example there are talks in Europe about banning PoW mining, because it damages the environment and wastes electricity. However, I believe that it is not a problem that needs too much attention, as I believe that the technological innovation has already surpassed Bitcoin and Ethereum 1.0 and PoW, meaning PoS chains are much more efficient and cheaper to run." -Interview partner 4

"We can discuss about how much Bitcoin wastes electricity, I know that it is something that is talked about in the news a lot, but I believe that it is kind of a growing pains type of an issue, and there are continuously coming new solutions." – Interview partner 5

4.3.5   Systematic risk and The Oracle Problem

In addition to the systematic risk known in traditional finance, DeFi has its own kind of systemic risk regarding the technology and the composability of protocols.

> "For example, two things that come to my mind, is Tether, which is not strictly DeFi, but rather a stable coin, which might be fully pegged or not, no one really knows and I am not sure if they themselves either fully know how much assets they have, that might be a systemic risk. Another thing more regarding DeFi, is Chainlink, and what I mean by that is that we have hundreds of protocols all relying on price feeds of Chainlink." Interview partner 3

> "Can this composability lead to big problems, I think so, there are always mistakes in the code and no one can write perfect code. So, the question is how to make sure that not all of the eggs are in the same basket, so it comes back to decentralization, but maybe here it is more about diversification of assets and technology risk what should be done." -Interview partner 3

Although The Oracle Problem was not directly mentioned, the Chainlink reference from Interview partner 3 describes the problem precisely.

4.3.6   Speculation

Although speculation in the markets is not exclusive to DeFi, it was seen as a current problem in the space:

> "Maybe one unfortunate thing is that I think a lot of people have dollar signs in their eyes, meaning that people have notices that at the current market and the world, where money is cheap and profits can be massive if you can find the right growing protocols, then a lot of people have come in the space to speculate." -Interview partner 5

4.3.7   Lack of decentralization

Decentralization is one of the main advantages of DeFi, but the fact that a few projects are actually decentralized was seen as a problem in the DeFi space:

> "If you think about for example Bitcoin mining, one could say that the miners are decentralized, but a big part of them are located in China, so there is a big political risk that it might not be so decentralized after all." -Interview partner 3

> "Or if all of Solana's servers run in AWS, can you actually say that Solana is decentralized?" -Interview partner 3

4.4   Summary of the results

This subchapter summarizes the results of the empirical study. Below is a table summarizing the advantages and disadvantages of DeFi from the interviews, and by how many interview partners each was mentioned by (Table 3).

The consensus about the definition of DeFi was that it is financial services, built on top of open, decentralized and transparent blockchains, which work autonomously without the need for intermediaries. What actually constitutes as DeFi was debatable among the interview partners. Some defined in to be financial services, while some did not limit DeFi for only, at least in traditional sense, financial services.

TABLE 3 Advantages and disadvantages of DeFi from the interviews

Advantages	Disadvantages
Efficiency (5)	User experience (5)
Openness (4)	Technology risks (5)
Transparency (4)	Lack of regulation (3)
Security (2)	Illicit activity (3)
Innovations (4)	Scalability (5)
Decentralization (3)	Environmental impacts (4)
Profits (2)	Systemic risk (And The Oracle Problem) (3)
	Speculation (1)
	Lack of decentralization (1)

5   DISCUSSION

In this chapter the results of the empirical study and the literature review are discussed and compared. The first chapter discusses the results to the sub-research question, and the second chapter discusses the results to the main research question.

5.1   What is DeFi?

Even though DeFi has no official definition, the definitions from prior literature and from the interviews were quite similar. Both defined DeFi as financial services and products, built on top of decentralized and open blockchains, working autonomously without intermediaries by utilizing smart contracts. The technical aspects of DeFi were quite unanimous, but where different definitions rose up was regarding what actually constitutes as DeFi. Prior literature mostly saw DeFi mimicking traditional financial services. However, the "Finance" part of DeFi was up to debate especially in the interviews, as it can itself be quite a wide topic. Some of the interview partners argued that DeFi services don't have to be limited to what we traditionally view as financial services. New innovations such as tokenization can also change our definition of finance.

5.2   How is DeFi advantageous/disadvantageous in comparison to traditional financial services?

The advantages and disadvantages of DeFi found in the empirical study were quite similar to the ones found in the literature review. Some differences were also found, and sometimes the other emphasized different advantages and disadvantages from other. The tables combining the advantages (Table 4) and dis-

advantages (Table 5) found in the literature review and the interviews can be found below.

TABLE 4 Advantages of DeFi

Advantages	Literature	Interviews
Openness/Permissionlessness/borderlessness	x	x
Transparency	x	x
Efficiency	x	x
Security		x
Innovations	x	x
Decentralization	x	x
Profits		x
Interoperability	x	

TABLE 5 Disadvantages of DeFi

Disadvantage	Literature	Interviews
User experience		x
Technology risks	x	x
Lack of regulation	x	x
Scalability	x	x
Environmental impacts		x
Systemic risks	x	x
Speculation		x
Lack of decentralization		x
Illicit activity	x	x
The Oracle Problem	x	x

DeFi's openness, borderlessness and permissionlessness in both using the protocols and participate building them was seen as a major advantage. DeFi can offer financial services for people who have no access to traditional financial services, all around the world without geographical barriers. The openness to participate I building the protocols is also currently regulatory arbitrage, as getting a permission to build financial services in traditional finance is very hard.

The second main advantage that both the literature review and the interviews agreed on was transparency. Open, public and transparent blockchains allow for anyone to view the transactions happening in the ledger, which is radical difference to the private books of traditional financial intermediaries. Open-source nature of DeFi also increases transparency, as all the code in the proto-

cols is viewable and auditable by anyone. Transparency increases trust in the system, as it is harder to commit illicit activities in a transparent system, and the logic by which the protocols and smart contracts works is viewable by anyone. Transparency also makes research and post-mortems easier.

Efficiency was also seen as a clear advantage of DeFi. Efficiency means two things in this case: the efficiency of transactions and the efficiency of running the protocols from human capital perspective. Firstly, transactions with cryptocurrencies/tokens are far faster to traditional transactions. The difference in western countries like in Finland is not noteworthy, but the advantage comes in transactions between different countries and jurisdictions. As mentioned in the interviews, transactions between continent can take days to settle, where in DeFi it is in theory only limited by the block time of the underlying blockchain. Second part of efficiency, which was emphasized especially in the interviews, is that it decreases a lot of the human capital needed, as DeFi's smart contracts protocols run automatically. They also eliminate the counterparty risk and therefore decrease the labour that would go to risk management, compliance, and administrative tasks.

Interoperability did not come up in the interviews per se, but it was mentioned indirectly while talking about the systemic risks and profits of DeFi. Interoperability and composability were however emphasized in prior literature as one of the main advantages of Defi. It was often compared to pieces of Legos, meaning that one can combine protocols and services on top of each other. Interoperability also allows for capital to move frictionlessly between protocols.

Another advantage that was emphasized in prior literature, but a bit surprisingly was not mentioned a lot in the interviews was decentralization as an advantage. The advantage of decentralization is that it distributes control and makes it harder to create monopolies. When the database is distributed, it increases the security of the ecosystem, as there are no single point of failures. The advantage of decentralization also came up indirectly in the interviews, and its advantage was that it cannot be controlled by a single authority, for example authoritarian government.

The other advantages of DeFi are its innovations, superior profits and security. Superior profits only came up in the interviews, kind of understandably. Even the safer options in DeFi can yield multiple times bigger profits than TradFi bank interest. Some traders and investors have gained returns of tens of thousands of percentages, but this can be attributed to the newness and speculative aspects of DeFi. Innovations were mentioned both in the interviews and and prior literature, although in prior literature it was mentioned regarding the open-source aspect of DeFi. DeFi's core advantages like openness, open-source and interoperability can act as a booster for innovation, increase competition and lead to better and cheaper services and products. DeFi space also has some unique innovations. New innovations in the space are constantly being developed, but already things like stable coins, flash loans, crowd fundings, self-repaying loans and tokenization are changing financial services. DeFi's security was also brought up in the interviews as one of the advantages. Open-source

code of DeFi means that the code is constantly being verified, and the longer the protocols have been working, the chance of bugs being found decreases.

The disadvantages found were also fairly similar in both the literature review and the interviews. Scalability problems, lack of regulation, technology risks, illicit activity and systemic risks were seen as the main risks in both. Interestingly, the biggest problem according to the interview partners, and which was not mentioned widely in the prior literature was the bad user experience. This is quite logical, as user experience is a subjective topic. Also, as the interview partners are working with DeFi daily, the problem with bad UX is more noticeable for them. Bad user experience doesn't only hinder adoption of DeFi, it causes mistakes, like losing the keys to your crypto wallets, and allows for illicit activity to happen more frequently.

Another major disadvantage, agreed by prior literature and the interviews, is the lack of regulation. Regulation has not managed to stay in pace of the rapid technological innovation, which means that the DeFi space is a bit of a wild west currently. Decentralization of DeFi means that implementing regulation to it is difficult, if not impossible. The usual regulative tools such as AML and KYC don't work in DeFi, which is also why illicit activity is still a big problem in DeFi. Decentralization and the autonomy also mean that there are no one to be held accountable in case of malfunctions or hacks.

One disadvantage hindering the adoption of DeFi, that both prior literature and the interviews mentioned was the scalability problem of blockchains. In order to become mainstream, transactions per second needs to be scaled up a lot to match the likes of Visa etc. However, the interview partners were unanimous that this disadvantage is most likely only temporal, and solutions to this will be seen even rather quickly. One problem regarding scalability is also the environmental impact, which is a strong narrative against DeFi and especially PoW mining was mentioned by the interview partners, but they saw it being only a temporal problem, resolved with the same solutions as scalability.

Systemic risks regarding the interoperability and external data of DeFi was seen as a disadvantage by both prior literature and the interviews. Especially The Oracle Problem was seen as a major future hurdle that needs to be solved. Errors in code can lead to cascading effects, as protocols are more intertwined with each other, and sudden decreases in one asset value can lead to liquidation dominoes, as the use of leverage and complex trading strategies are common. The more different protocols rely on central data feeds such as Chainlink, the bigger the risk for a systemic collapse.

Security was seen as one advantage of DeFi, but also technology risks were seen as a disadvantage. The security aspect of DeFi was seen to be kind of a two-sided sword, meaning that if everything works as intended, blockchain and smart contracts being developed by open-source principles are more secure than TradFi services. However, if something goes wrong, the immutability of blockchain means that it is very hard, or impossible to revert transactions, which is why even small malfunctions and hacks have more serious consequences than in TradFi.

Another disadvantage, that is also related to the lack of regulation and bad user experience, is illicit activity in DeFi. Frauds, hacks and attacks are happening frequently. Although it is a serious problem in DeFi currently, the interview partners saw it as "growing pains" -type of a problem, similar to the early days of the internet. Clearer regulation and more educated users are needed to tackle illicit activity in DeFi.

Two other disadvantages of DeFi were seen to be lack of decentralization and speculation. Decentralization is one of the advantages of DeFi, but also lack of actual decentralization or fake decentralization was seen as a problem in DeFi. Some of the DeFi protocols are not actually really decentralized, or are pretending to be in order to abuse the regulation arbitrage. Speculation is not limited to DeFi markets, but is perhaps more apparent there because of the high profits and new innovations.

One thing to consider also is that although DeFi clearly has some advantages to traditional finance on paper, what is unclear is how important are these advantages seen in the real life. Many of DeFi's advantages can be seen as quite ideological. It is unclear how high does "normal" people value for example transparency versus security, or decentralization versus a great UX. These things are not of course necessarily mutually exclusive, but at least at the moment one can make an argument that traditional financial services, especially in the western world are still quite handy for everyday practices.

> "However, I see that one of the main problems currently in DeFi is that people don't really value their need to trust the banks, or what I mean is that ordinary people still trust their banks quite a lot and don't see any reason to leave them." -Interview partner 5

Many of the DeFi's disadvantages were related to the technology and its novelty. Once DeFi evolves and protocols are starting to reach the same level of practicality as traditional financial services, then we are going to start seeing how much the people value DeFi's advantages.

Decentralization has a central purpose in DeFi. If the whole DeFi ecosystem would be controlled by authorities, its advantages could actually backfire, for example transparency of the transactions could just be the greatest tool for authorities to monitor people and where they spend their money. So, this is where the advantage of decentralization comes to light, as the idea is to take the control away from centralized parties and give the power to the individuals. However, one problem with decentralization is something called "tragedy of the commons", which Zhettze et.al. (2020) describe nicely in their study:

> "Yet, DeFi, in its purest form, cannot meaningfully exist within a properly regulated setting, given that decentralization is no panacea—quite the opposite. The problem of pure DeFi is 'the tragedy of the commons'. As Aristotle said about children, and Milton Friedman adapted for the overall economy, 'when everybody owns something, nobody owns it, and nobody has a direct interest in maintaining or improving its condition'. Wherever technical and economic decentralization is taking place, incentives to invest in the sustainable development of a technology or business model po-

tentially vanish: this is one of the core focuses of the economics discipline which is increasingly developing around theories of design of such systems." (Zhettze et al., 2020)

The similarity of findings from the literature review and the empirical study might suggest a couple of things. Firstly, it might just mean that DeFi is a new topic, and the understanding of its advantages and disadvantages is in a basic level. What I mean by that is that the space has not had the chance to even tackle the more complex problems, which might reveal even more advantages or disadvantages. Secondly, the novelty of the topic also means that most of its prior literature is fairly new, and therefore the data is very similar to the interviews. Once the research side of DeFi has the chance to catch up, new advantages and disadvantages will most likely be found, that this thesis did not find.

Some of the disadvantages are a bit difficult to classify if they are actually just problems of people using and building DeFi, or are they fundamentally disadvantages of DeFi. For example, speculation in the DeFi and cryptocurrency space is not limited to DeFi markets and is probably just growing pains. Same goes for the lack of decentralization in some protocols, as they can be argued to be against the values of DeFi and not "real DeFi". Schär (2021) mentions that some protocols could just want to be classified as DeFi, in order to utilize the regulatory arbitrage and get around the current regulation, while being in reality controlled by a centralized party. This also means that lack of decentralization could just be put under the "lack of regulation" theme in the disadvantages. Literature and the interviews also used different terms to describe similar things, and many of the advantages and disadvantages are in connection to each other and are sometimes hard to differentiate from each other. For example, even though openness, permissionlessness and borderlessness were separated in the literature review part, one term "openness" was used to combine these in the interview part, as they were used sometimes to mean the same things in the interviews. So, although the identified themes are presented in this thesis as is, they are not the only way these advantages and disadvantages could be classified. Some of the advantages and disadvantages were also kind of mentioned indirectly in the interviews, like The Oracle Problem while talking about the systemic risks. but were not directly mentioned.

DeFi's ideological values are surely ambitious and only time will tell how the space will grow and evolve. A lot of questions need to be answered. Is real DeFi possible? Should there be some kind of hybrid between TradFi and DeFi? More innovation and regulation are in any case needed. Overall DeFi's advantages and disadvantages are a bit two-sided sword. Although DeFi was seen to have a lot of advantages to traditional finance, most of its advantages could also be seen as its biggest disadvantages. These disadvantages can however be decreased or erased completely via future innovations in the space. DeFi is a novel topic, and it is in its "trial and error" phase. If the current challenges can be mitigated or erased completely, DeFi could seriously challenge the traditional way of conducting financial services, as its advantages are unquestionable.

The most ideological "cryptoheads" are talking about a revolution but there are still miles to travel in order to replace the TradFi services. A lot of development and innovation is needed for this ideological goal, but with the speed the space has been growing, the future of finance might be here sooner than expected and regulators may have difficult decisions in front of them.

6   CONCLUSION

This chapter concludes the study. The purpose of this thesis was to investigate the advantages and disadvantages Decentralized Finance (DeFi) has in comparison to traditional finance. First, the research questions are answered. The second subchapter presents the contribution of this thesis, and the last two subchapters present the limitations of the study and suggestions to the future research, respectively.

6.1   Research questions answered

Answers to the research questions were searched by conducting a literature review, which then acted as a basis for an empirical study. The empirical study was done via semi-structured professional interviews.

The purpose of this thesis was to answer to the two research questions. The supporting research question for this thesis was:

- What is DeFi?

To answer this question, prior research was combined to how the interview partners described DeFi. DeFi has no universally accepted definition yet, but the definitions found in the prior literature were very similar to the ones interview partners gave. When comparing the empirical results to prior literature, a definition for DeFi could be the following:

DeFi can be defined as open, transparent and decentralized peer-to-peer financial system, built on top of distributed ledgers (usually blockchain), utilizing smart contracts to operate autonomously without the need for intermediaries.

DeFi's main characteristics are openness, transparency, autonomy and decentralization. The main technical innovations behind DeFi are a permissionless blockchain, and smart contracts. DeFi was seen to be currently mostly imitating

traditional financial services, but some new innovations could only work in DeFi.

The second, and the main research question of this thesis was:

- How is DeFi advantageous/disadvantageous in comparison to traditional financial services?

To answer this question, results from the literature review and the empirical study was combined. The advantages that DeFi has in comparison to traditional financial services are efficiency, openness, transparency, security, innovations, decentralization, profits and interoperability. The main disadvantages of DeFi are user experience, technology risks, lack of regulation, scalability and environmental impacts, systemic risk and The Oracle Problem, speculation, lack of decentralization and illicit activity.

6.2 Contribution

The contribution of this thesis is for future research and practitioners in the DeFi space. This thesis has collected the current literature around the topic into a concise packet. Also, for future research, the advantages and disadvantages of DeFi this thesis collected can act as a basis for further research into each theme. New research is desperately needed in every aspect of the topic, so the themes introduced in this thesis can offer directions to focus on for researchers. These frameworks of the advantages and disadvantages of DeFi are also the main contribution to research from this thesis. For practitioners, this thesis can offer valuable insights especially about the pain points of DeFi. This thesis presents and categorises the advantages and disadvantages that DeFi services currently have, and these can offer insight for people building, working with or using these protocols. This thesis can also raise awareness about the topic, as it is currently still quite novel, yet possibly status-quo changing.

6.3 Limitations

This chapter presents the limitations that were identified for this study. According to Merriam (2002), it is important to identify and monitor the shortcomings and biases that the researcher could have and how they affect the study. The limitations for this study were related to the sample size and quality, researcher's inexperience and bias, scarcity of prior literature and possible financial incentives.

The first limitation identified was regarding the sample size and quality. The novelty of the research topic means that there are not many people in the world that can call themselves professionals in the topic. DeFi itself is only a

few years old phenomenon, which means that at best the professionals have only a few years of experience in space. As mentioned in the methodology chapter, some of the interview partners had some background from cryptocurrency space, which can be seen as valuable experience in the DeFi space also. Some of the interview partners also had an extensive knowledge of the TradFi sector through university studies or work, which is also an asset regarding this study, as it can help identifying the advantages and disadvantages that DeFi has over TradFi services. The scarcity of professionals was identified as a possible limitation in the research plan for this thesis. The number of interview partners that participated was only five, but it is not necessarily a problem regarding the qualitative nature of the study. According to Hirsjärvi and Hurme (2008), small data sample can affect the generalizability of the study, but the data content can be extensive even with a few participants (Hirsjärvi & Hurme, 2008).

The scarcity of prior literature on the topic can also be seen as a limitation. This can again be attributed to the novelty of the topic, as there has not been enough time for quality literature to catch up the rapid technological innovation. Publishing quality research articles take time. Some compromises in the quality of sources had to be done, in order to get a wider view of the topic and prior literature.

One limitation for this study could be financial incentives for both the interview partners and the researcher. Persons working in the space usually have some "skin-in-the-game", meaning they have invested in cryptocurrencies or tokens or DeFi protocols, have built their own protocols and/or are using them to gain superior returns over traditional financial services. This means that these people might me more incentivised to focus more on the advantages of DeFi and shying away from speaking about the disadvantages. They might overly emphasize the good things and downplay the negatives and the financial stake could affect their judgement. This can also include the researcher. Although the reach of this study is probably not large enough to affect the consensus around the topic in the world, emphasizing the positive sides of DeFi could also mean just reassuring one's investment to themselves.

Lastly, the inexperience, competence and personal bias of the researcher can also a limitation for the study. This thesis was the first empirical study for the researcher, which means that errors in the research process can be more probable. Researcher's inexperience can reduce the reliability and credibility of this study. To reduce the significance of this, methodology literature was read, and supervisor was consulted to limit the effect of inexperience. The researcher can have other biases than the mentioned financial incentives also, that might affect the reliability of the study.

6.4   Future research

This chapter presents the suggestions for future research. The suggestions arose both from the literature review and the interviews. All research around this novel, yet possibly revolutionary topic is needed and valuable. This thesis introduced the advantages and disadvantages of DeFi in comparison to traditional finance, so each of those presented themes can also act as a basis for future research. In addition to that, three suggestions for interesting directions future research could focus are presented here.

The first suggestion for future research revolves around regulation. Like previously mentioned, regulation in the DeFi space is still in its infancy and a lot of research on the topic needs to be done. One interesting take on regulation came up in one of the interviews

> "What regulators could do is to participate themselves in the governance of the protocols via web 3.0 tools, for example by allocating capital and voting, and just actively going in in the space." Interview partner 3

This can also be tied up to The Oracle Problem because the role of the regulators could be in the future on not controlling the protocols, but rather regulating the data that goes in to the blockchains. All in all, the regulation side of DeFi is an interesting and important topic to research. Decentralization and autonomy of the protocols bring up questions about responsibility in case of hacks or malfunctions etc. The directions that regulators take regarding DeFi can have "make it or break it" type of effects for DeFi. Schär (2021) mentions, that while regulation is needed in the space, it should try not to get in the way of innovation. Is it possible to embed regulatory requirements straight in to DeFi systems, using regulatory technology (RegTech) as Zetzsche, Arner and Buckley (2020) ponder.

Second suggestion came up from one of the interviews, when risks of DeFi were discussed.

> "DeFi has technology risks of course as it is a new technology, but the interesting thing is can the risks in DeFi be compared to the ones in traditional finance, are they bigger or smaller and how can they be compared. I don't know if anyone has done any real studies on how that risk could be compared." -Interview partner 4

DeFi's risks certainly need more research. Since DeFi mitigates the counterparty risk and if the used smart contracts are valid, arguably even the technology risk is decreased, then the interesting viewpoint in researching the risk in DeFi is about the systemic risk that comes from the interoperability aspect of DeFi. As the prior literature and the interviews mentioned, systemic risk in DeFi is one of the main risks in the space. One of the biggest current proponents of the systemic risk are the oracles. The Oracle Problem needs to be solved before DeFi can become the mainstream method of financial services.

Third suggestion for future research is to research more about the new innovations that have surfaced with DeFi. For example, stable coins, AMM's, flash loans, NFT's, and tokenization to mention a few. These innovations are on the experimentation phase, and a lot of research regarding them are needed, as they could have massive potential to disrupt not only finance, but any other sector of our lives also.

> "I believe that, this goes a little beyond DeFi but is a part of it, that every asset that has some kind of permanent value or is in some way productive, will move in to the blockchain, and after that there is this kind of a programmable interface, a shared world state, what the world looks like and we can start creating different incentive logics, guide people and societies and communities." - Interview partner 3

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APPENDIX 1 FRAME FOR THE INTERVIEWS

BACKGROUND INFORMATION

1. Please introduce yourself, your education background and job history.
2. Please introduce the current job and the organisation you are working for, what is its industry, mission etc.
3. How long have you worked with blockchain/cryptocurrencies/DeFi?
4. How did you personally got to know about DeFi?

TRADITIONAL FINANCE

1. How would you assess your knowledge concerning traditional finance?
2. What do you think are the advantages that traditional finance and its intermediaries bring?
3. What do you think are the problems in traditional finance, if any?

DECENTRALIZED FINANCE

1. How would you assess your knowledge concerning DLT/blockchain/smart contracts?
2. What is your knowledge of DeFi? How would you define it?
3. What is the state of DeFi at the moment in your opinion?
4. What do you think are the advantages of DeFi in comparison to traditional finance?
5. What do you think are the disadvantages of DeFi in comparison to traditional finance?
6. Do you believe DeFi could replace financial intermediaries completely one day?
7. How do you see the future of DeFi in the near and long term?

ADDITIONAL COMMENTS

1. Do you have any additional comments you would like to say?