Bachelor's project

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
NTNU Business School

Philip Emil Gjelstad-Ditlevsen
Mathias Mydske
Albert Holten Skånlund

Blockchain-based Finance

How Asset Tokenization can transform the Financial Industry

Bachelor's project in Economics and Business Administration
Supervisor: Mike Denis Becker
April 2021

NTNU
Norwegian University of Science and Technology

Philip Emil Gjelstad-Ditlevsen
Mathias Mydske
Albert Holten Skånlund

Blockchain-based Finance

How Asset Tokenization can transform the Financial Industry

Bachelor's project in Economics and Business Administration
Supervisor: Mike Denis Becker
April 2021

Norwegian University of Science and Technology
Faculty of Economics and Management
NTNU Business School

Summary of Bachelor's Project

This thesis explores the application of blockchain technology in finance through the process of asset tokenization. The first part gives an overview of fundamental concepts, like blockchain, asset tokenization, security tokens, and token offerings. The second part examines the implications that these concepts can have for financial markets. In this part we touch upon areas that are improved by blockchain technology. These areas include market liquidity, transparency, and market access. The third and last part is a detailed analysis that looks at the use of tokens in diversifying traditional stock portfolios.

Sammendrag av Bacheloroppgave

Denne oppgaven utforsker anvendelsen av blokkjedeteknologi i finans med utgangspunkt i tokenisering av eiendeler. Den første delen av oppgaven gir en oversikt over fundamentale konsepter, som blokkjede, tokenisering av eiendeler, sikkerhetstokener og tokennoteringer. Del to ser på implikasjonene disse konseptene kan ha for finansmarkeder. I denne delen går vi inn på områder som kan forbedres av blokkjedeteknologi. Disse områdene inkluderer markedslikviditet, transparens og markedstilgang. Den tredje og siste delen er en detaljert analyse som ser på bruken av tokener i diversifisering av tradisjonelle aksjeporteføljer.

Table of Content

Figures and Tables

Abbreviations

By order of appearance

DLT	Distributed Ledger Technology
PoW	Proof-of-Work
P2P	Peer-to-peer
IoT	Internet-of-Things
ICO	Initial Coin Offering
STO	Security Token Offering
IPO	Initial Public Offering
SEC	U.S. Securities and Exchange Commission
ICO Rules	Announcement on Preventing Financial Risks from ICO
IDO	Initial Decentralized Offering
IEO	Initial Exchange Offering
DeFi	Decentralized Finance
DAO	Decentralized Autonomous Organization
NFT	Non-Fungible Token
ERC-20	Ethereum Request for Comment 20
ERC-721	Ethereum Request for Comment 721
ATS	Alternative Trading System
AML	Anti-Money Laundering
KYC	Know Your Customer
SME	Small and Medium-Sized Companies
PE	Private Equity
VC	Venture Capital
VaR	Value at Risk

1 Introduction

The landscape of funding ventures is continuously evolving as new technology emerges, and the demand for financing increases. There are several ways of funding a venture or a product in today's economy. But is the procedure used today the most efficient? Since Bitcoin was first launched by the pseudonym Satoshi Nakamoto in 2009 (Frankenfield, 2021), the technology behind it has found its way into many different parts of the world. The usage of blockchain is not limited to cryptocurrencies, and there are several examples of blockchain being used in other industries. Examples of sectors where blockchain has been implemented are voting mechanisms, advertising insights, tracking of music royalties, and monitoring supply chains and logistics (Daley, 2021). By using the technology one could increase transparency and fairness, while at the same time-saving money and time (Daley, 2021). In addition to the mentioned usage of blockchain, the technology can be implemented in financial instruments and real assets. The implementation of blockchain to financial assets like stocks, bonds, and real estate could change the financial markets as we know it. This thesis will take a closer look at how tokenization of assets has been done in the past, the status of today, and how it could be done in the future, along with how it could change the efficiency in the market.

As the technology behind tokenization has only been around for a decade, and tokenization itself for about half of that time, the literature on the topic is limited. In order to obtain the information needed to get a deeper understanding of the topic, the authors conducted two interviews with the Norwegian crypto and blockchain specialist Lasse Meholm. Meholm worked as Head of Blockchain and DLT Strategy for the Norwegian bank DNB, before joining Ernst & Young as a senior manager of Digital Assets & DLT. Through his years in the industry, Meholm has obtained a deep understanding of how the technology can be used in the financial sector.

The following thesis is divided into three main parts. Firstly, the main aspects of tokenization will be explained. Systematically presenting theory about the fundamental technology of the tokens, the first issuing of tokens to investors, and how assets and securities are tokenized. Secondly, the implications of tokenization on the financial market will be discussed. Different hypotheses of how tokenization can increase market liquidity, efficiency, and transparency will

be explored. In addition to this, the thesis discusses the use of decentralized finance and regulatory challenges the tokenizers face. Lastly, the thesis will compare different types of portfolios, containing stocks and tokens, in order to examine whether an investor could use tokens in a portfolio to increase diversification, and thereby reduce risk and increase return.

2 Overview

2.1 Blockchain Explained

Simplified, blockchain is a chain of blocks that contains information. The idea of the blockchain was first introduced by cryptographer David Chaum in 1982. Chaum's proposal of "blind signatures" - digital signatures blinding the content of the message before it is signed - paved the way for the idea of a decentralized payment network where transactions would be untraceable for any financial intermediary or third party (Chaum, 1985, p. 1036). The idea was further developed by Stuart Haber and W. Scott Stornetta, two cryptographers that, in 1991, opted for a system in which digital documents were timestamped so that it would be impossible to backdate or tamper with them (Haber & Stornetta, 1991, p. 110). In 1992, mathematician Dave Bayer joined Haber and Stornetta in incorporating a "hash tree" to the timestamp design, improving the system by allowing for several documents to be certified and added into a "block" (Bayer, Haber & Stornetta, 1992, p. 3-4). In 2009, the first blockchain was developed by an unknown developer working under the pseudonym Satoshi Nakamoto (The Economist, 2015). The blockchain was created as a distributed financial ledger, using its native digital cryptocurrency known as "bitcoin". The distributed ledger technology (DLT) Nakamoto created was open to anyone and, using the techniques previously introduced by Bayer, Chaum, Haber, and Stornetta, cryptographically stored and secured transaction information.

On a general basis, a blockchain consists of a collection of datasets known as blocks. Each block contains some form of data, as well as a hash function specified to the block, and a hash function specified to the previous block on the chain. The blockchain is decentralized, meaning that everyone on the network has access to the information lying within each block. Every time a block is updated, i.e., when new information is added to the block, the hash function of the block changes. When the hash function changes, all nodes (users) on the network must approve this new information for it to be included on the blockchain, and for the new hash function to be added to the blocks. The information added on the blockchain becomes immutable, preventing it from being changed. In the case of the blockchain Nakamoto created, the Bitcoin blockchain consists of transaction data, such as information about the sender, the receiver, and the number of coins changing hands. What makes Nakamoto's Bitcoin blockchain so secure is its "proof-of-work"-system (PoW). The system makes sure that a change to a block is completed in 10-minutes intervals, guaranteeing that a hacker, who would have to change all

the blocks to alter one block, quite simply doesn't have enough time to change the whole blockchain until he is caught. This makes the network Nakamoto created extremely secure and hacking-proof. Nakamoto posted his justification and explanation for the system he created in the form of a "white paper" on the internet. He argued that the current trust-based system at the time, where financial transactions exclusively relied on financial institutions serving as trusted third parties to process the payments, was inherently weak (Nakamoto, 2008, p. 1). Contrary to this system, the blockchain Nakamoto created would work as a "trustless" system where every user on the network would have a copy of the whole blockchain ledger, ensuring full transparency. Bitcoin was peer-to-peer (P2P), meaning that transactions were made from person to person, without a third party involved. Nakamoto also tackled and fixed the so-called double-spending problem. He argued that in a traditional monetary system, a payee can't verify if the person he or she is completing a transaction with has not double-spent the money switching hands, unless a central authority is involved to check every transaction for double spending (Nakamoto, 2008, p. 2). According to Nakamoto, "the problem with such a system is that the fate of the entire money system depends on the company" checking each transaction (Nakamoto, 2008, p. 2). Through timestamping and transparency, ultimately making the records immutable and open for anyone, double-spending could never occur because anyone could see the balance and the transactions of every wallet on the network.

2.2 Cryptocurrency Explained

As previously mentioned, the blockchain can include any form of data. When Nakamoto created the bitcoin-blockchain, he also created the cryptocurrency bitcoin to record the financial transactions on the network. In general, a cryptocurrency functions as a digital decentralized representation of value. As is the case with fiat money, cryptocurrencies have no intrinsic value. But their value is determined by market supply and demand, as well as their user's inherent trust in that the technology behind the coin works well, and that the coin will work as a sufficient medium of exchange. However, as their extremely fluctuating demand and finite supply suggest, cryptocurrencies have a fundamental problem in serving as an efficient store of value and unit of account. This limitation can also be traced to the fact that the value of a cryptocurrency is usually set in terms of the value of a fiat currency (Ofir & Sadeh, 2019, p. 11).

Cryptocurrencies can also be different from traditional fiat currency in terms of scarcity. Cryptocurrencies usually have a limited supply, i.e., bitcoin will continue to grow until its

supply reaches 21 million bitcoins. A typical fiat currency like the dollar, on the other hand, has an unlimited supply that is controlled by the Federal Reserve of the United States. Cryptocurrencies, therefore, differ from fiat currencies in that they run on decentralized networks that operate on a supply limit but are not controlled by a central authority. Furthermore, the records of names holding cryptocurrency are largely anonymous and encrypted as opposed to holders of fiat currency, whose private information is held by the financial intermediary processing the transactions.

As previously mentioned, the value of a cryptocurrency is also determined by the technology in which the company or legal entity behind the currency is providing. Some of the original value of bitcoin lies in its cryptographical ability to anonymously and securely make monetary transactions. As the first realized cryptocurrency, bitcoin soon saw the rise of alternative cryptocurrencies or "altcoins" claiming to have produced a better technology than the Bitcoin blockchain was promising. An example of this is "bitcoin cash". In August 2017, the Bitcoin source code was split in two, creating bitcoin cash as a "fork" of Bitcoin, a divide and independent continuation of the original source code (Meholm, 2018, p. 77). What bitcoin cash promised was a larger amount of transactions held by each block, and the resulting ability to handle 50 transactions per second versus the original Bitcoin's 7 transactions per second. Similarly, cryptocurrencies like ether and its belonging Ethereum-blockchain promise a technology focusing on integrating smart contract functionality and internet-of-things (IoT) capability.

2.3 Smart Contracts Explained

In essence, smart contracts are computer programs that can be stored inside a blockchain. The idea was proposed by computer scientist Nick Szabo in the 1990s. Szabo described smart contracts as "a set of promises, specified in digital form, including protocols within which the parties perform on these promises." (Szabo, 1996). The most common analogy used to describe a smart contract is that of a vending machine. As Szabo explained, "When the money is paid, an irrevocable set of actions is put in motion. The money is retained and a drink is supplied. The transaction cannot be stopped in mid-flow. The money cannot be returned when the drink is supplied. The transaction's terms are in a sense embedded in the hardware and in the software that runs the machine." (Schulpen, 2018, p. 8-9). This describes one of the most important features of smart contracts, immutability. When a smart contract is executed on the blockchain,

it cannot be undone. Another important feature is that smart contracts are distributed between all nodes on the blockchain. In practice, this entails that it is close to impossible to hack a smart contract and execute it prematurely. Since all users on the blockchain have access to the code, the output of the smart contract is validated by everyone on the network, meaning that no single person can force the contract to release the funds (Simply Explained, 2017, 02:45).

The idea of smart contracts quickly gained traction in the blockchain community. Following the creation of the Bitcoin blockchain, support for smart contracts was implemented in the code. However, this implementation was fairly limited and didn't fully utilize the concept (Buterin, 2013). To fix this issue, Vitalik Buterin, a 19-year old Russian-Canadian computer programmer proposed the idea of the Ethereum blockchain. Ethereum would, in practice, function as an alternative protocol to the Bitcoin blockchain, differentiating itself in "allowing anyone to write smart contracts and decentralized applications where they can create their own arbitrary rules for ownership, transaction formats, and state transition functions." (Buterin, 2013). This would allow for greater functionality as one could write as many programs as possible on the Ethereum blockchain, creating automated systems to represent value. According to etherscan, the analytic platform for Ethereum, as many as 300,000 smart contracts are associated with one single token (Brickken, n.d.). The scope of functionality for smart contracts is only limited to one's creativity, at least in finance. The programs made on the blockchain can do anything from automatically paying out dividends to deducting taxes. More recently, the Swiss bank UBS created a fully automated self-paying "smart-bond" which was programmed to automatically pay out risk-free payment streams (International Financing Review, 2015). There exist different standards for tokens that support smart contracts, like ERC-20 for fungible tokens and ERC-721 for non-fungible tokens. The difference between these standards will be discussed in chapter 2.8.3.

2.4 The Rise and Fall of ICOs

2.4.1 ICO Explained

There are disagreements about finding a single and universal definition for an Initial Coin Offering (ICO). Christian Fisch defines ICO as a mechanism used by new ventures to raise capital by selling tokens to a crowd of investors (Fisch, 2019, p. 3). These ventures are usually somewhat related to the cryptocurrency industry. The tokens referred to in the definition, are using blockchain technology and smart contracts, these topics are more thoroughly in

respectively chapters 2.1 and 2.3. By using the presented definition, we understand ICO as a type of crowdfunding for emerging ventures and companies, normally companies within tech, application, or the crypto industry. An ICO can be used to get a stake in a company, in a specific project, or the tokens can be used within the ventures' emerging ecosystem. When a company decides to issue a coin offering, the investors usually purchase these tokens using other cryptocurrencies, such as bitcoin or ether. In some cases, traditional fiat money is used, but because the majority of the purchases are made with cryptocurrencies, the volume of ICO funding is influenced by the value of the most common cryptocurrencies (Fisch, 2019, p. 3).

The process of an ICO usually starts with an announcement on online forums for cryptocurrencies, such as Bitcoin Talk, Cryptointalk, etc. This announcement is made prior to the launch, and its main function is to generate interest in the upcoming ICO. In addition to this, the company creates a so-called white paper. A white paper is a summary of the company's financial state, and other key aspects of the company and its project, that a potential investor would need prior to making an investment decision. These white papers are not audited by any authority, making the preliminary work critical for achieving the credibility needed in order to get investors to trust the company and its project. Then, a selected group of main investors is presented with an offer. When the offer is signed the official launch of the ICO is announced, and a PR campaign is implemented. In this stage, and through the mentioned PR campaign, the smaller investors are included in the offering (Dell'Erba, 2018, p. 4-7).

As mentioned earlier, the tokens bought in the offering come in different forms. The most common type of tokens issued in an ICO is known as utility tokens. This refers to a form of cryptocurrency that can only be used within the ventures' own ecosystem. di Angelo et. al defines a token as "a digital asset on top of a cryptocurrency or blockchain, often as a programmable asset managed by a smart contract*"* (di Angelo et. al, 2020, p. 1). In addition to the mentioned utility token, there is a phenomenon called security tokens. This token is issued through a so-called security token offering (STO). In the next chapter, the paper explores that ICOs are connected to several cases of fraud. As a result of this, the form of token offering is changing with time, in order to lose some of the stigma related to the ICO-name, as will be discussed in chapter 2.6.

ICOs and STOs are the crypto world's answer to the financial world's Initial Public Offering (IPO), where a crypto-related company funds a future project or venture by selling digital

tokens to a crowd of investors. By using blockchain technology the venture is able to finance its project before it is launched by promising investors services or stakes in the project, through a decentralized cryptocurrency. This way, the investors get a discounted price on the project's services, in exchange for an investment pre-launch. However, given the lack of regulation in ICOs, these forms of offerings have often been subject to fraud.

2.4.2 ICO Frauds

A large number of investors buy into an ICO hoping to get a quick and powerful return on their investment. The most successful ICOs over the past several years have resulted in people becoming millionaires overnight, and many were quick to jump on the bandwagon. However, this enthusiasm among investors led people astray (Frankenfield, 2020). An estimated 10% of ICO funds have been lost to fraud (Tiwari, Gepp & Kumar, 2019, p. 1). With ICOs being unregulated, there is always a danger of fraudsters looking to scam naive and poorly informed investors. Furthermore, with the lack of regulations from financial authorities, like the U.S. Securities and Exchange Commission (SEC), investments lost due to fraud or incompetence may never be traced or returned.

Many early ICO scams are similar to the dot-com bubble, where bad actors emerge in an up-and-coming new market, trying to make millions overnight by exploiting the gullibility of investors. The most typical scams involve fortifying the value of the token through social media, celebrity endorsement, and the overall hype train (Matthews, 2019, 0:46). As soon as the token reaches a satisfying price, the owners will immediately sell their shares and disappear. This way of raising the price before dumping the holding is called pump-and-dump. This dump of the significant amount of stake will result in a fall in the price, thereby “cornering the market”, causing enormous losses for token holders. When it comes to typical publicly available commodities, cornering the market usually requires a significant amount of resources. I.e., The Hunt brothers tried to corner the market with silver as a commodity during the 1980s by investing billions, but were cut short by the government, sending them into bankruptcy (Matthews, 2019, 1:24). The price of a crypto asset launched by an actor with bad intentions can be more easily manipulated, since the government cannot regulate the actions (Matthews, 2019, 1:38).

Another way scammers can exploit the market is through pyramid schemes, which pays off profits to earlier investors by using the funds obtained from more recent transactions. Some ICOs also provide incentives for investors to refer other users. This type of scam often happens together with misleading or false information about the asset and the team behind it. These schemes also tend to promise guaranteed returns, as a trick to lure people into investing. Sooner or later, investors will expect an actual product or service, the scheme is therefore difficult to sustain for a longer amount of time. As a result, these kinds of schemes are often short-lived and require a lot of work. (Jenkinson, 2019)

Fraudsters can also exploit the lack of information that is needed for an ICO. It is typical for an ICO to be launched alongside a white paper providing an overview of the project, normally 20 to 40 pages. These white papers don't have to provide as much detail, and pale in comparison to Form S-1 (the SEC filing required for an IPO) which provides hundreds of pages, containing extensive information about the company's business model and prospect. Because so little information is required, scammers can produce a website that is easy on the eye, along with a vague white paper regarding a product that does not even exist. The fraudsters then typically tend to aggressively promote and hype the ICO on social media, potentially using fake spam accounts. Furthermore, because cryptocurrency tends to rely on complicated and even esoteric technology, fraudsters can hide a project’s illusionary nature behind seemingly complicated, but in reality meaningless, jargon (Underhill, 2019).

One of the biggest ICO scams to date is the Pincoin and iFan scam. Taking place in Vietnam in the spring of 2018, two ICOs launched by the same company are believed to have swindled around 32 000 investors for a combined $660 million. This was a typical Ponzi scheme, with Pincoin promising 48% monthly return to its early investors (Roy, 2018). Its purpose was allegedly 'building an online collaborative consumption platform for the global community. iFan was advertised as a social media platform, in which celebrities were supposed to promote content to their fans (Jenkinson, 2018). The people behind the scam, representing the fictitious company Modern Tech, allegedly fled the country with the investors’ money in March 2018. Investors eventually found out that the tokens were not traded on any crypto exchange, making them useless. The company then refused to process cash withdrawals. This led to a protest outside the company's offices, which turned out to be deserted. The police investigated the scam, but with crypto being decentralized the government couldn’t confiscate the gains.

This risk involving ICOs caused The Chinese Central Bank to completely ban ICOs. The ban, “Announcement on Preventing Financial Risks from Initial Coin Offerings” (ICO Rules), was implemented in September 2017, and its purposes were investor protection and financial risk prevention. Under the ICO Rules, raising cryptocurrencies through the circulation and irregular sale of tokens is classified as engaging in public financing without official authorization, which is an illegal activity. The ICO Rules also warn about the financial crimes which can take place in ICOs, such as illegal issuance of tokens or securities, illegal fundraising, and financial fraud. The tokens generated in an ICO are not issued by the country's monetary authority and are therefore not classified as mandatorily accepted legal tender. They do not have equal legal status as a fiat currency and "cannot and should not be circulated and used in the market as currencies" (Zhang, 2018). In the limelight of the risks involved with investing in ICOs, in early 2018, companies such as Facebook, Twitter, and Google all banned ICO advertisements (Frankenfield, 2020). With so many investors having lost their money in prior ICOs, the reputation of the coin offering is somewhat tarnished. Therefore, the demand for more regulation in token offerings increased.

2.6 Changes in Crypto Offerings

The field of cryptocurrencies and their offerings is a topic that is still evolving, according to Meholm (Meholm, L., personal communication, March 10, 2021). Following the wave of ICO frauds, as discussed in the previous passage, the amount of money raised through ICOs has fallen drastically. As shown in figure 2.1 below, the amount raised falls after Q1 2018 (Statista, 2019). During this time there were several ICO scams, like the aforementioned iFan and Pincoin frauds, and may be considered the bubble burst of the ICOs. As the graph presents, the amount of funding raised through ICOs is almost down to the same amount as the very beginning of ICOs. From this, we can understand that ICO might not be a phenomenon that survives in the coming years. But the general concept of tokenization is here to stay, according to Meholm (L. Meholm, personal communication, March 10, 2021). The offering itself, and the term used to describe it, might change through the coming years. As the reader will learn through this paper, the term used to describe the offering is not essential for its function in the financial markets. ICO is a term that carries a lot of stigmas, because of the frauds and scams mentioned in chapter 2.4.2. As the demand for regulation increased, the STOs emerged as a more secure form of offering. There are other variations of token offerings, such as Initial Decentralized Offering (IDO) and Initial Exchange Offering (IEO). The IEO is quite similar to an ICO, but to overcome both the fraudulent problems from unregulated offerings and strict

regulation from the government, the offering is protected and regulated by a single exchange, making it more difficult to get away with scam and fraud (icodata, 2021).

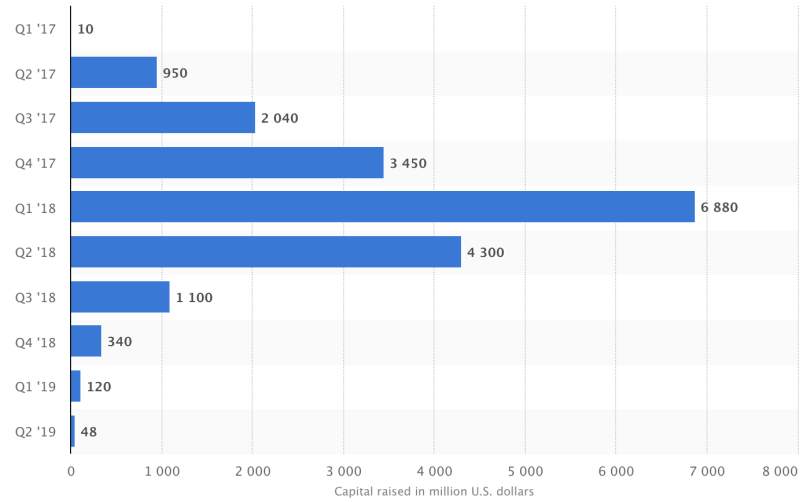

Fig. 2.1: Reprinted from "Total funding raised by blockchain initial coin offerings (ICO) worldwide in 2017 and 2019, by quarter (in million USD)" by Statista, 2019 (https://www.statista.com/statistics/804748/worldwide-amount-crytocurrency-ico-projects/). Copyright 2021 by Statista.

Because of the increased demand for regulation in the tokenized markets, STOs and their security tokens became a preferred alternative to the unregulated ICOs. The security tokens are regulated because it is acknowledged as an investment, and therefore falls under the jurisdiction of the SEC. The SEC uses a so-called Howey test to determine what kind of assets fall under their regulatory powers (SEC, 2017), we will discuss this more exhaustively in chapter 2.8.2. One of the main issues with crypto offerings today is the uncertain future of the offerings. In December 2017, the chairman of the SEC released a public statement where he declared certain parts of the token market regulated by the SEC (Clayton, 2017). Before this, the field of ICOs and other crypto offerings was not a regulated matter in the same way as it is today. There are examples of the SEC intervening before this. One example is from July 2017, when the SEC recognized a token issued by Slock.it as a security, making it a part of SEC's jurisdiction (SEC, 2017). Since 2017, the market for security tokens has grown exponentially. According to Forbes, the market capitalization for STOs grew by almost 517% in 2020 to $366 million (Amoils, 2021). Even though it is small compared to the market capitalization of ICOs, the number of security tokens issued through STOs is growing. Thereby, the leading technology behind, known as asset tokenization, is becoming a more established practice.

2.7 Asset Tokenization Explained

With the advent of cryptocurrencies in the early 2010s, people realized that using the same blockchain technology powering currencies like bitcoin and ether, one could use blockchain to digitally represent and hold an asset, similar to the way one would hold a US dollar or a stock certificate (World Economic Forum, 2020, 01:28). This innovation has helped kickstart what is known as decentralized finance (DeFi). DeFi is, according to Investopedia, defined as "a concept where financial products are available on a public, decentralized blockchain network, making them open to anyone to use rather than going through a middleman like banks or brokerages" (Sharma, 2021). Through digitization and ultimately tokenization, one could make an asset digital on a programmable blockchain-platform, and build applications on top of the asset, similar to how Ethereum allows for smart contracts to be implemented onto ether. These smart contracts have all the instructions needed to manage any aspect of the token. These instructions facilitate corporate actions such as coupon or dividend payments and voting rights, as well as escrow arrangements such as the release of funds to investors, and collateral management such as the exchange of ownership interest (OECD, 2020, p. 16).

Asset tokenization is the process in which "any physical object, an intellectual work, a financial asset or any type of transaction" is given a digital value representation through a token created on a Blockchain network (Agudelo, 2019). The token issued is called a security token or an asset-backed token because of the asset it digitally represents. The token represents a percentage ownership position in the underlying asset, and the value of the position fluctuates in accordance with the value of the asset. The process of tokenization is in many ways similar to the process of securitization, where contractual debt is pooled together and sold off as securities to investors. Both processes focus on taking otherwise illiquid assets and enhancing their liquidity by selling off pieces to investors. The difference between the two is that, in the case of tokenization, a single asset can be broken down into smaller parts, or digital tokens. Securitization on the other hand relies much more on pooling together a large number of financial assets in order to produce an investable security. Furthermore, the tokenization of assets is a more transparent process than securitization, given that asset tokenization is done through blockchain technology. When an asset is tokenized through a blockchain, all trades on that asset are made available on the ledger produced through the blockchain DLT. In this way, investors can easily get insights into how much a tokenized asset is traded on a day-to-day

basis. Juxtaposed to securitization, where a financial intermediary is needed in order for the asset to be securitized, the tokenization of an asset leads to greater market transparency.

Examples of tokenized assets vary. If one were to visualize a specter measuring the complexity of the asset which is tokenized, you would have safe financial assets like US dollars or gold on one end of the specter. In the case of tokenized gold, a "gold token" would represent a percentage ownership position in a given amount of gold. The value of this position would fluctuate in accordance with the value of gold. In the case of a US dollar, the situation would be similar, with the value of the token following its percentage value of a US dollar. In the middle of the specter, one would find traditional property assets like real estate or other forms of physical property. Through tokenization, an investor can purchase a percentage stake in a given property, like a corporate building. On the other end of the specter, one would find more complex assets like art or NBA-player contracts (Nelson, 2020). A more recent example is that of air carbon tokens, or tokenized carbon credits tradable in emerging secondary markets through Australia (World Economic Forum, 2020, 03:30).

The process of tokenization is intricate. In the early stages, the asset must go through a valuation process to determine the value to which the tokens will be pegged to. Assets that exist in an established market, like gold or US dollars, already have established prices. But for more scarce assets like fine art or vintage items, where there is no established value, the asset must go through a thorough valuation analysis to determine a price (Brickken, n.d.). The valuation is done as part of a total due diligence process, in which the asset is thoroughly investigated to guarantee factual accuracy and consumer protection. Once this process is completed and a value is determined, the issuer must decide what kind of business model the valuation will follow. In this case, one must choose if the objective of the tokenization is to ensure a loan from investors or to "divide the asset in a co-ownership model" (Brickken, n.d.). Through this process, the issuer will have to define the rights of the investor through the terms and conditions of the token purchase. This document, similar to a prospectus document created before an IPO, must include the total amount of tokens issued, their corresponding price, the value of the asset in which the tokens are pegged against, as well as a legal framework providing the rights of both the investor and the issuer of the tokenized asset. When all this is done, a firm specialized in tokenization, or a "tokenizer", will issue the tokens through an STO.

2.8. Security Tokens Explained

2.8.1 Utility Tokens vs. Security Tokens

As previously mentioned, utility tokens are issued through an ICO. Utility tokens are tokens that promise the future use of a product or service. They are not meant to be an investment, as they have a utility. Exactly what this utility is can vary, i.e., it can be early or exclusive access, discounts, or other advantages within the network. This could for example mean that you buy a token for a project that does not yet exist, for a discount, so that you can use this token if and when the project launches. Because a utility token isn't meant to serve as an investment, it is not a regulated asset. A simple analogy for ICOs and utility tokens would be selling $1 casino chips for 80 cents a chip to build a new casino. If the casino project comes through, the investors made a good decision when investing (Martin, 2019, 1:15). Because utility tokens are not backed by real assets and only depend on the future money supply of a technology, they are hard to value. Its price is therefore usually very volatile and speculative.

Investopedia defines security tokens as "digital, liquid contracts for fractions of any asset that already has value, like real estate, a car, or corporate stock" (Liebkind, 2020). In contrast to utility tokens, security tokens are meant as a form of investment, paying dividends, sharing profits or paying interest in a way that promises future profits. After the ownership of the security token is verified within the blockchain, the token holders can use them for different purposes. They can for instance trade away their tokens for other assets, use them as a collateral for a loan, and store them in different wallets. With that being said, one of the most important features of security tokens is how they can completely redefine the meaning of the word "ownership". They can break down and democratize assets, and distribute them among people all over the world. To exemplify, instead of owning a gold coin, which most people can't afford, it is with security tokens possible for 1000 people to own fractions of that single coin (Mitra, n.d.).

Many issuers will claim their tokens to be utility tokens, which often is not the case because of how they are traded. Even though the definition of a utility token is broad, actual utility tokens are quite rare, because the majority of the tokens are traded as investment objects. Many tokens that claim to be utility, are in fact security tokens. Issuing a utility token allows an issuer to escape government regulation and taxation, which is why many developers have tried to classify their tokens as utility tokens rather than security (Blockgeeks, 2019, 1:11). To prevent

this from happening, the SEC is using the Howey test to differentiate security tokens from utility tokens.

2.8.2 The Howey Test

The Howey test is a test used by the SEC to determine whether an investment is a security or not. This test has been applied in the crypto space to decide whether a token is a utility token or a security token. It states that "A transaction is considered a security sale if a person invests money in a common enterprise and is led to expect profits solely from the efforts of the promoter or a third party" (Martin, 2019, 4:16). This definition entails four criteria for a token to be classified as a security:

1. Is there an investment of money?
2. Is this an investment into a common enterprise?
3. Is there an expectation of profit for the investors?
4. Is this expectation of profit based on the work of others?

If the answer to all these questions is yes, then the token is classified as a security token. For most alleged utility tokens, the answer to question 1 and 2 is most definitely yes. Firstly, there needs to be an investment of money, for there to be an offering. Secondly, with regards to question 2, the funds received are controlled by the common enterprise behind the token. However, the answers to question 3 and 4 are not necessarily that obvious. Some projects claim to sell utility tokens that promise access to a future product or service, but no direct profit. However, if you look at the activity in the so-called utility token market, you can see that tokens are bought in the morning and sold in the afternoon, meaning tokens are bought and sold in order to make a profit (Martin, 2019, 5:05). Therefore, a problem faced by regulators is that of correctly determining whether there is an expectation of profit or not. Issuers that fall under the grid may be able to sell securities disguised as utility tokens, avoiding market regulation. Given an expectation of profit, the employees and developers behind the project are relied upon to provide a working ecosystem around the token that will increase its value, and thereby making the answer to question 4 “yes”.

The first major application of the Howey Test in the crypto space took place in 2017. A year prior, in 2016, some members of the Ethereum community developed the Decentralized Autonomous Organization (DAO). For a short period of time, anyone could buy the DAO tokens with Etherum. During the initial sale period, the DAO team collected 12,7 million Ether,

before they got hacked in June 2016. A hacker found a loophole in the code of the DAO blockchain, which allowed for the hacker to siphon off 3,6 million Ether in just a couple of hours (Prstek, 2021, 3:09). The following year, the SEC ruled that DAO had been offering unlawful securities to its investors, and were therefore subject to federal securities law. The SEC decided not to take enforcement action, and rather warned that the security laws also applied for token sales (Frankenfield, 2021).

2.8.3 Fungible vs. Non-Fungible Tokens

Security tokens can have different purposes and ways of behaving. One way to split security tokens is through the distinction between fungible and non-fungible tokens. In economics, fungibility is the characteristics of goods or commodities, where every unit is interchangeable and indistinguishable from one another (Finematics, 2020, 0:51). Fungible tokens are divisible, and non-unique. A dollar bill is an example of something fungible, it is worth the same in New York as it is in Texas. Every dollar bill is also worth 100 pennies, or four quarters. The same goes for bitcoin, one bitcoin is worth one bitcoin anywhere in the world. (Digital Asset News, 2019, 0:23)

Non-fungible tokens (NFT), on the other hand, are unique and indivisible. One NFT may be worth way more than another NFT of a similar kind. To illustrate with an everyday example of a non-fungible item, a concert ticket in the front row will be worth a lot more than a ticket in the back row. Another example could be property. A square meter of property in Oslo is worth a lot more than a square meter of property in Orkanger. NFTs are a unique digital certificate that represent ownership in digitally scarce goods, like pieces of art and collectibles. As soon as an NFT is created, it is possible to digitally trace it forever through the blockchain (Hern, 2021). The tokens are also scarce, and the number of tokens can be verified on the blockchain. Indivisibility is also an important factor, as NFTs cannot be split into smaller denominations, meaning one cannot buy or transfer a fraction of an NFT. Similar to standard tokens, NFTs also guarantee the ownership of the asset. They are also easily transferable and fraud proof, thanks to the blockchain technology (Hern, 2021).

Not all cryptocurrencies and tokens have their own blockchain, and run on other platforms, like Ethereum. Different tokens that are developed on existing platforms require specific standards. What the standards are varies with the kind of token being created. The reason for such standards is to ensure that similar tokens can interact seamlessly with one another and that they

are interchangeable, it also makes it easier for developers to work together and have interoperable applications. Without standards, developers would have to study each other's code bases, which would be impossible in an ecosystem with hundreds of thousands of projects (Blockgeeks, 2019, 1:20). The standard for most fungible tokens created on the Ethereum network is called the “Ethereum Request for Comments 20”-standard, or ERC-20 for short. ERC-20 is a set of rules and regulations for fungible tokens created on the Ethereum network. This standard ensures that every part of the network, like contracts, accounts or wallets, knows what every other token is and what to do with it. It also makes it easier for developers to create tokens, as they have a standard to follow and therefore have a template to work from (Blockgeeks, 2019, 1:47). The ERC-20 standard defines six mandatory functions that a smart contract must implement, along with three optional ones. These functions specify aspects regarding the functionality of the token, like what method is used to transfer them between users, and how users can gain access to the data regarding the token (Reiff, 2020). Over the past couple of years, other standards have been developed, which could lead to a change in the dominance of the ERC-20 standard (Blockgeeks, 2019, 2:12). Non-fungible tokens on the other hand, use the ERC-721 standard for crypto collectibles. The standard ensures that the NFT is immutable. To duplicate a NFT, one would have to overpower the entire Ethereum network, which is not practically possible (Blockgeeks, 2019, 1:23).

2.8.4 Equity, Debt and Asset-Backed Tokens

Security tokens can be constructed differently and serve different purposes. Here, security tokens can be split into three groups: equity, debt, and asset-backed tokens (Blocktrade, 2020, 0:56).

Equity tokens are similar to traditional shares. They are issued by a company and recorded on the blockchain, the owners of these tokens are also entitled to a part of the profit of the company, as well as voting rights (Blocktrade, 2020, 1:03). Meholm points out a potential challenge with equity tokens, namely the dividend payout (L. Meholm, personal communication, March 10, 2021). The company or project mines a given number of tokens for the STO, and to pay a dividend they would have to expand that amount. This is because the dividends are usually paid out in the same token issued by the company, not in dollars or bitcoin. To exemplify, a company launches an STO and issues 1000 tokens. They promise a yearly dividend of 5%, which equals 50 tokens. Those 50 tokens will have to be made because

they don't exist. The company then has to have a mechanism in the smart contracts that mines those tokens and ensures that the company has earned enough money to cover up the value of those 50 tokens. A mechanism that exchanges that earned money into tokens could be a possible solution, but the dividend payout process is still more cumbersome in a tokenized stock market than it is today in the regular market (L. Meholm, personal communication, March 10, 2021).

Debt tokens are the tokenized equivalent of traditional financial debt instruments, like real estate mortgages and corporate bonds. Debt tokens function as a loan to the issuer and represent capital raised through debt. The owners of the tokens usually get paid back the principal, as well as periodic interest. (Blocktrade, 2020, 1:13). Meholm specifies that most debt tokens work like traditional bonds. It is possible to tokenize single loans, like credit loans, as well as assembling multiple loans into one and tokenize it (L. Meholm, personal communication, April 22, 2021). The debt tokens' behavior is usually determined by two factors. The first is similar to coupon payments, as debt tokens normally are structured to produce regular coupons, which would be based on the payments on the underlying debt instrument. The second factor is the risk, as debt tokens are subject to the risk of debtors defaulting their payment and drastic changes in the valuation of the debt. Risk and coupon payments are important factors as they help determine the price of the debt token (Rodriguez, 2018). There are multiple benefits to tokenizing debt. Firstly, one can reach out to the global market thanks to the global nature of blockchain. Secondly, it is possible to program legal obligations into digital assets. This would help ensure that only eligible and legit investors participate. Thirdly, the regular coupon payments would be set up automatically, therefore the relevant corporate actions will be executed digitally. Finally, blockchain technology will allow the time between trading and settlement to be more or less eliminated (Tokeny, n.d.). This will be further discussed in chapter 3.3.

Asset-backed tokens represent ownership of a specific real asset. Assets can vary from real estate to commodities such as oil, gold, or crops. For these commodities' supply chains, blockchain technology is especially important, as it helps simplify transactions, reduces fraud, and makes tracking and monitoring ownership easier (Blocktrade, 2020, 1:33). There are multiple examples of tokenizing gold. OneGram is an example that is noted on multiple exchanges. Investors can buy a token, and its value slavishly follows the price of gold. The company claims to have gold stored in a tax-free zone in an airport in Dubai, which according

to Meholm investors will only have to trust as there is no way to know for sure (L. Meholm, personal communication, April 22, 2021). Another example of an asset-backed token is the stablecoin. A stablecoin is a token that has its value pegged to another asset, typically fiat currencies, but also commodities and cryptocurrencies. Stablecoins provide a level of stability in a rather volatile cryptocurrency market (Bartel, n.d.). USDC or Tether, for example, claims to have a 1:1 value peg against the US Dollar.

2.8.5 Tokenizing Real Estate

Tokenizing real estate means digitally dividing a property into small pieces, everyone with equal value and rights (Brickken, n.d). The process is not dissimilar to taking a private business public, undergoing an IPO. After an IPO, the company is usually divided into thousands of shares, and anyone in the world can invest in it. Every share (usually) has the same value and rights and represents the same level of ownership. By owning a piece of the company, the investors have rights to its profits.

The tokenization of real estate is similar. Investors acquire tokens of the property, and become part owners of the tokenized property. The investors will have the right to a portion of the property's profits, corresponding to the owned proportion of the property. The underlying concept of splitting up property, or joint ownership, is pretty common. Tokenization simply adds a technological layer (Brickken, n.d). For example, three friends can buy a house between them, rent it out and share the profits.

A big issue with the traditional approach for dividing real estate is the rigidity that dominates the process. For starters, you must find an asset you can acquire, meaning the asset must be for sale as you cannot force a property owner into selling. You also need to find the people with whom you will acquire the property, and both you and them must have the capital needed to acquire it. Another issue is the credit process with a bank to secure the mortgage of the property (Brickken, n.d). The more people involved, the more complex the mortgage will become. There could also be possible problems in regard to the severability between the parties. If one of the investors defaults on a payment, the remainder will have to cover for them, or else the bank will take the property. Additionally, if one of the investors wishes to sell their stake in the investment, they will either have to find someone who would want to invest in the same position, or the remaining owners will have to buy the position. If no solution is found, there

may be legal complications (Brickken, n.d). This makes real estate a very illiquid asset to hold as selling real estate is a time-consuming and costly process.

With complications arising, the opportunities for investments shrink. If you do not have sufficient capital you will need a smaller investment, and if you do not know the market well, it might be expensive to conduct research or find someone to do it for you (Brickken, n.d). You may also want to diversify by investing in markets in different countries, which adds further constraints to the process. Furthermore, every investor will likely have a duty of responsibility towards the other investors. This can vary from maintenance, dealing with bills, and finding tenants for the property. An alternative is to pay someone to do this, but this will reduce the profits (Brickken, n.d).

As described, the real estate market is very much rigid and illiquid. The tokenization adds a new dimension, transforming the process by making it flexible and accessible to everyone. As described earlier, tokenization involves dividing a property into multiple pieces with the same rights and values (Brickken, n.d). The tokenization solves all of the issues described above. You do not need as much capital, as the asset can be broken down into smaller and more affordable pieces. As the trading process is automated through token exchanges, you do not have to find the remaining investors yourself. As well as having the same rights, every investor has the same obligations. If any investors fail to fulfill their obligations, the company behind the tokenization is likely to force them to fulfill their duties, or they will take legal action. This tokenization process enhances liquidity in the real estate market, by allowing new investors to come into play while protecting the end-to-end process. This is why many people consider tokenization a new era of investment (Brickken, n.d).

3 Implications of Asset Tokenization for Financial Markets

Tokenization is an aspect that could be an important part of the financial markets in the future (Meholm, L., personal communication, April 21, 2021). But how can the use of blockchain and tokenization make the markets more efficient? Funding a company through an IPO costs millions of dollars, and could take up to two years, and issuing through an STO could potentially be a more efficient alternative to the traditional method. The use of blockchain technology automates a lot of the processes that demand time and money in today's financial markets. By tokenizing assets, one could make the markets more liquid, make the transactions go faster through P2P transactions, increase the transparency in the market through the decentralized blockchain technology and increase investment accessibility. These are some of the aspects that are being discussed in the following chapters, as well as how the implementation of tokenization can help improve the DeFi industry. In addition to this, the chapter will discuss some of the regulatory challenges that come with tokenizing assets.

3.1 Efficiency in Security Token Offering vs. Initial Public Offering

The steps involved in going public through an Initial Public Offering are a complicated and comprehensive matter. The first step of going public the traditional way is to appoint an investment bank as an underwriter (Brealey & Myers, 2003, p. 413). The underwriters are in the business of taking companies public all the time, they are therefore obligated to be careful about which companies to take on, since it may affect their reputation and future business. There are several different arrangements on how the sale of the shares is to be done (Corporate Financial Institute [CFI], 2021). The first arrangement possible is called *firm commitment*. In this case, the underwriter takes on risk by purchasing the entire offering and then reselling the shares to the public. A more common approach is through a *best efforts agreement,* where the risk is in the hands of the issuer. The underwriter does not guarantee a specific amount sold, but sells securities on behalf of the issuing company to the best of their ability. Thirdly, we have an *all or none agreement*, unless all of the shares that are offered can be sold, the whole offering is canceled. Lastly, we have a so-called *syndicate of underwriters*. With the syndicate of underwriters' approach, the public offering can be managed by multiple underwriters. One

investment bank takes up the role as the managing bank and forms a syndicate with other investment banks. This is done in order to diversify the risk of the IPO.

The underwriter possesses an important job for the success of the IPO, and it needs to complete several tasks in the form of documentation. The underwriter needs to draft an *engagement letter* between the company going public and the investment bank of the underwriter. This usually includes a reimbursement clause, which protects the underwriter. As well as information about the gross spread, which is equal to the difference between the sale price from the underwriter to the market and the purchase price from the company to the underwriter. This is usually fixed at 7% of the proceeds (CFI, 2021). In addition to the engagement letter, the underwriter needs to produce a *letter of intent*, an *underwriting agreement,* a *registration statement,* and a *Red Herring document.* The next step in the IPO process is to get the IPO approved by the SEC. This is done through a registration statement which is filed to the SEC (SEC, 2017). According to The Corporate Handbook, issued by the SEC, the timeframe of completion for the registration statement could be up to 15 weeks (SEC, 2006, p. 4). After the registration statement is approved, the effective date is decided, along with what the underwriter pays the company for its shares (CFI, 2021). These decisions are made between the issuing company and the underwriter. The two parties also conclude on a precise number of shares to be issued.

When the company and the underwriter decide the price and number of shares to be issued, they are working with a lot of uncertainty. This uncertainty is directed towards the demand from the public, for the shares in the company. It is difficult to predict how the market is going to respond to the issuing, and to sell all of its shares the underwriter usually ends up with a substantial amount of underpricing. For an average IPO, the cost of underpricing generally surpasses all other issuing costs (Brealey & Myers, 2003, p. 410). The underpricing is also a tool that can be used to increase the demand for the issue, and the company in general. The underpricing is both a way to be certain of full financing, as well as compensation to early investors for taking the risk in investing in a newly issued stock. But no matter what way you look at the underpricing, it is a costly matter for the company. The next two steps in the IPO process consist of stabilizing the stock by providing analyst recommendations and transitioning the IPO to market competition (CFI, 2021).

As implied, the process of going public through an IPO can be long, usually one or two years, and costly (PwC, 2017, p. 6). Most of the steps explained above come with a cost, and the size

of the cost is dependent on the size of the company. As table 2.1 below informs (PwC, 2017, p. 6), the total average cost of an IPO ranges from $10.1 million to $34.3 million. The matter is quite different for a token offering. If you want to issue your token through an Initial Coin Offering, even though it is a risky offering and associated with fraud, all you need is a business that is based on the blockchain, and a non-regulated white paper (icodata, 2021). Because of the lack of regulation in the ICO market, the issuing costs could be close to zero, if you don't include marketing and PR costs, as mentioned in chapter 2.4.1. But as previously discussed, the ICOs are a concept of the past, and the STOs are more comparable to traditional IPOs due to the presence of regulation.

Table 3.1. Reprinted from "Average Cost by Revenue Range - Summary of Going Public Costs" by PwC, 2017 (https://financetreasury.com.au/wp-content/uploads/2019/02/PWC_cost-of-an-ipo.pdf). Copyright 2017 by PwC.

Average costs by revenue range					
Cost Category	**Less than $100m**	**$100m to $250m**	**$250m to $500m**	**$500m to $1bn**	**Greater than $1bn**
Accounting	0.8	1.2	1.3	1.8	1.9
Legal	1.5	1.9	2.0	3.0	3.0
Printing	0.3	0.4	0.5	0.6	0.6
Other*	0.5	0.8	0.9	1.2	1.6
Underwriting	6.9	10.4	17.4	20.2	27.5
Total Avg IPO cost	**10.1**	**14.6**	**22.1**	**26.5**	**34.3**

The STOs are to be more costly than the ICOs, due to the need for legal competence, as well as third parties needed to issue a successful offering. According to Fitzner Blockchain Consulting, there are six aspects of cost an issuer needs to be aware of when issuing security tokens through an STO (Fitzner, 2019). First of all, the company issuing security tokens will need to hire legal help, this usually lies within the range of $50k-$350k (Fitzner, 2019). In addition to this, the company needs a marketing budget, as well as token architecture and issuance, both of these will come at a price between $10k and $50k. Fourthly, the company needs to engage brokers and dealers, costing between 1-8% of the sale, plus a possible engagement cost upfront. The company also needs to engage a transfer agent, with a signing cost of approximately $10k, plus an additional $5k per month. Lastly, the issued security needs to be a part of an alternative trading system (ATS). The cost of this varies, but Fitzner consulting recommends putting aside $100k-$250k for this purpose. In addition to these six, the consulting firm recommends a minimum budget of $100k to cover different kinds of upfront costs supplemented by a "sizable allocation on the back-end of the raise" (Fitzner, 2019). To

sum up all of these costs, a company will be looking at an issuing cost between $280k-$490k, excluding $5k per month and a percentage of the collected funds. I.e., if a company raises $175 million (which is the center of the second interval in table 3.1), the most expensive brokers will take an eight percent provision of the revenues, making it a total of $14.49 million, including the most expensive alternatives of the aforementioned costs. According to table 3.1, the average cost of an IPO in the same revenue range is $14.6 million, meaning that the differences in cost are quite small. But this is the highest percentage of return brokers are taking. For every percentage point reduction on this expense, the company aiming for $175m, will be able to save $1,75 million. This means that the most expensive STOs could potentially be as expensive as an IPO, but the cheapest STOs could be several million dollars cheaper (Fizner, 2019).

Cost is one aspect that could be more efficient with issuing through STOs, but is the token offering more efficient in time? As mentioned earlier in this chapter, the approval of registration for an IPO with the SEC could take up to 15 weeks. In addition to this, the many aforementioned steps of going public through an IPO take time. In addition to the time of SEC approval, the company spends months planning and executing the offering. In total, the process of going public usually takes between one and two years (PwC, 2017, p. 6). The time it takes for a company to go through with an STO may vary. According to the Swiss security token platform BlockState, a company can get their STO live on their exchange within 10 weeks, by going through four steps (Blockstate, 2021). The first step is *project definition*, which is a preliminary step where the strategy of the tokenization is determined. The second step is *legal setup*, where the exchange itself provides legal help. Thirdly, the *technical setup* is implemented. In this step, the planned strategy and legal basis are used as guidelines for the creation of the tokens and their smart contracts. In this stage, so-called 'Anti-Money Laundering' (AML) measures are implemented to the tokens, including 'Know Your Customers' (KYC). While AML is the framework for preventing money laundering, KYC is a procedure to verify every user of the token and is thereby used to fulfill AML (Getid, 2021). Cryptocurrencies are previously famous for their usage in criminal activity, but according to Forbes, this is a misconception (Lennon, 2021). Fiat currency is still the dominant form of payment within the criminal activity, still, in 2020, around $10 billion worth of cryptocurrencies were connected to criminal activity (Chainalysis, 2021). The AML is therefore important for the company in order to avoid involvement in such cases. The fourth and last step is *issuance.* As mentioned, the total time frame could be as little as 10 weeks, five weeks less than the SEC's involvement in an IPO. But the importance of preliminary work,

including implementing a good marketing campaign, should not be forgotten. The process described above is lacking important aspects, compared to the process described by FiatXS (FiatXS, 2019).

FiatXS includes aspects that could be essential in order to have a successful offering. First of all, they include additional preliminary work of an estimated six months. This half-year step is highlighted as one of the most important steps in the offering process (FiatXS, 2019), and includes the formation of a suitable team. The issuing of a token to fund a project is a comprehensive and costly matter, and it should therefore be done with caution. FiatXS suggests that the issuing company should form a diversified team of experts from several industries, such as the cryptocurrency industry, marketing, project development, sales, and law. The concept of token offerings is relatively new, and it could therefore be challenging to find the right employees or consultants to help with the offering. Another step that is important when issuing a token is the marketing campaign. As token offerings are in an early phase, most investors are still seeking the stock market to find investment opportunities. In addition to this, investors might need more convincing before investing in tokens, compared to traditional stocks. As mentioned in chapter 2.4.2, the reputation of token offerings took a hit in early 2018 due to fraud. Building trust as well as promoting your company and your brand through a marketing campaign is therefore essential to succeed. FiatXS recommends a three-month time frame for marketing alone. With the two additional steps added to the 10-week process, an STO could take up to a year.

To conclude, a security token offering could be more efficient than an initial public offering. The most comprehensive STOs could be as expensive and as time-consuming as an IPO. But as discussed in this chapter, unless the issuer uses the most expensive brokers, an STO would usually be millions of dollars cheaper than an IPO. The full process of an STO could be finished much faster than that of an IPO, and if you are in a hurry, ten weeks would be enough to go public. Because STOs have the ability to be both cheaper and faster than an IPO, one could argue that increased use of STOs could increase efficiency in the market.

3.2 How Asset Tokenization Leads to Greater Market Liquidity

There are three main implications of asset tokenization that can lead to greater market liquidity: the fractionation of assets, the increase in retail investments, and the exploitation of illiquid assets. As explained before, tokenizing an asset makes the asset more divisible, opening up the

room for investment. A digitized asset is fractionable, meaning that an investor, in effect, can freely choose how little he or she wishes to invest. Investing is no longer limited to a fixed amount of stock quantity to invest in. One could, in effect, choose to invest 1/1,000,000 in a company's share. This dramatically increases the amount of liquidity that may be gained from a stock issuance for a company, and lowers the entry barriers for retail investors to trade. Additionally, it gives retail investors access to asset classes and risks that may have been beyond their capacity, e.g., participating in private equity funds, and opens up capital markets with lower minimum entry tickets or portfolio sizes (OECD, 2020, p. 16).

Fractionation leads to an increase in retail investors, which is the second major implication for total market liquidity. Traditionally, if one were to invest in expensive real assets, e.g. real estate, an investor would need enough liquidity to purchase the whole asset. This liquidity could be achieved either by saving up enough capital for the investment, which could cause future liquidity problems, or borrow money, which would cause indebtedness and added costs due to interest payments (Brickken, n.d.). Tokenization on the other hand, dramatically decreases the entry ticket to invest, paving the way for more accessible investments for retail investors. Instead of having to invest in a $1 million building, the asset can be broken down into 10,000 tokens worth $100 each, creating an entry more suitable for investors (Brickken, n.d.). The profitability of an investment like this would then be obtained proportionally to how the building performs, either through leasing income or a traditional house flip. This form of fractional ownership enables global pools of uninvested capital to reach parts of the financial market that traditionally is reserved for large and systematic investors. It democratizes investing and paves way for a more equitable distribution of capital gains. An example of this is small and medium-sized companies (SME) whose external financing is usually restricted to large institutional investors and funds (OECD, 2020, p. 7). Through tokenization, the market for SME financing becomes more liquid through pools of non-institutional retail investment capital, and small investors may enjoy parts of the capital gains that are usually reserved for institutional investors (Marshall, 2020).

The third and last major implication of tokenization on market liquidity is the exploitation of illiquid assets. According to Deloitte, there are trillions of dollars' worth of value trapped in illiquid assets (Burke, Chollet, Laurent & Seers, 2018, p. 2). This figure has been specified by Tim Fries, cofounder of The Tokenist, to $544 trillion (Fries, 2020). Illiquid assets are assets that are hard to sell because of expenses or lack of buyers. The most common examples used are assets such as real estate, fine art, and collectibles like vintage items. But illiquid assets also

encompass other tangible assets like financial securities with low trading volume and intangible assets like intellectual property. What tokenization opens up for is the exploitation of such illiquid assets. A piece of expensive real estate would no longer be confined to a small pool of highly liquid investors, but would rather be made available for retail investments (Fries, 2020). Any small investor with as little capital as possible would have the opportunity to invest in expensive real assets on a secondary market and enjoy capital gains based on their performance. This increases market liquidity as it broadens the base of traders in the market, ultimately benefiting traders who get more investment freedom as well as sellers who benefit from a "liquidity premium", capturing more value from the underlying asset (Burke et al., 2018, p. 2). According to the OECD, tokenization may also be particularly important for assets with near-absent liquidity. This includes the aforementioned SMEs as well as private equity and venture capital investment funds (PE/VC) (OECD, 2020, p. 18). Additionally, the OECD argues that assets that carry the highest illiquidity premia, like SME and PE/VC, may benefit from tokenization as their illiquidity premia are effectively lowered, allowing investors to capture greater value from the assets (OECD, 2020, p. 18).

Enhanced liquidity may also benefit companies looking for single-project financing. In traditional equity ownership, investors are usually required to invest in the whole company. However, as tokenization opens up the room for investable assets, funds can be raised for different departments of a company or even single projects (World Economic Forum, 2020, 18:25). Usually, if a business needs financing for a project, there are mainly three ways to get liquidity assuming that the company does not put money aside in a savings account. The company may either take up a loan, persuade an investor or a group of investors to invest their capital (in the case of a publicly traded company it may issue new stock), or issue company bonds. These alternatives may be inefficient in financing a single entity, like a project or a department, as the logistics of directing the funds may take time. With tokenization, however, the entity seeking financing may issue its own tokens on the blockchain, centralizing the financing operation to its own activity.

3.3 How Asset Tokenization Leads to Faster and Cheaper Transactions

As previously mentioned, the blockchain on which asset-backed tokens are run is compatible with smart contracts. This functionality leads the way for cutting short the financial value chain

and reducing transaction costs. According to Santander Bank, the implementation of such smart contracts could reduce banks' infrastructural costs by between $15-20 billion by 2022 (Perez, 2015). In a traditional financial market, if an investor wishes to buy stock in a company, one could visualize the number of intermediaries needed for this transaction to take place. In practice, the essence of this process can be broken into three parts: execution, clearing, and settlement. Following this transaction, accountants on both sides of the deal must initiate reconciliation and compliance processes to make sure the trades are done by the books. These processes may be inefficient and take longer than expected. A benefit of tokenization is increased efficiencies in clearing and settlement processes, as well as streamlined post-trade processes like reconciliation and compliance work. This will in turn bring total transaction costs down and would reduce, if not eliminate, counterparty risk.

Firstly, when an investor is interested in purchasing stock, a market order is made by an investor to buy the stock. A stockbroker must then verify that the investor has enough money to buy the stock, and find a compatible seller of the same stock. As the trade is executed, a clearinghouse related to the brokerage firm must update the accounts of the trading parties and arrange for the transfer of money and securities (Spaulding, n.d.). Finally, the trade must be settled, where the actual exchange of money and securities is completed (Spaulding, n.d.). Today, this chain of events happens electronically and is usually conducted by closely integrated parties, making the transaction fast. However, there are two main issues with this traditional method. Firstly, the time used to execute and clear a trade may be delayed if the transaction activity at the brokerage firm or investment bank suddenly experiences a surge. This will cause IT systems and servers to slow down or even crash, and may cause long delays for the completion of trades. With blockchain, however, all trades are conducted on a global decentralized platform. Here, anyone who has mining privilege can verify a transaction, and no single surge in trading activity will cause a delay for the whole blockchain. Secondly, the settlement process may also at times fail. This happens "when a buyer fails to deliver funds or a seller fails to deliver an asset by the settlement date" (Mitchell, 2021). When all trades are verified through blockchain, it is not possible for a trade to be initiated if these inconsistencies exist. Given that blockchain fixes the double-spending problem, as described in chapter 2.1(blockchain explained), mismatches between an order and the balance of the wallet or supply of stock will be detected before the verification process and will be made void. Additionally, as may be the case in some trades, settlement time may take a couple of days. With blockchain, as the trade is verified, the

settlement will happen instantaneously. This will make trading more time-efficient and will reduce unnecessary administration costs.

As the trade is verified and settled, traditional post-trade operations like reconciliation and compliance must be done to ensure legitimacy. Accountants on both sides of the trade are hired to ensure financial consistency between both ledgers as well as legal adherence. These processes are usually quite time-consuming, inefficient, and costly. However, tokenization increases the efficiency of both these operations. Firstly, the reconciliation process is effectivized through what is called “atomic swaps”. An atomic swap is a technology based on smart contracts that allow for two digital assets to simultaneously change hands across different blockchains without the need for a centralized intermediary (OECD, 2020, p. 18). An example follows. An investor is interested in investing in an equity token issued by company A. Company A is interested in selling its equity tokens for a stable coin, say Tether, which mirrors the value of $1. Most tokens are based on the Ethereum blockchain using the token standard ERC-20, and Tether is based on the Bitcoin blockchain. This incompatibility would make trades impossible within traditional stock markets. An investor cannot buy one stock in a listed company at the New York Stock Exchange and sell it for another stock in a listed company at the Oslo Stock Exchange. However, with atomic swaps, the blockchain can be programmed in a way that would make such a trade compatible and efficient. Secondly, compliance work can be done much faster through the smart contract technology on the blockchain. Here, rules and regulations can be programmed into the code that controls the verification of the transaction. So instead of an accountant tediously going through each trade to determine if the transactions are compliant with a legal framework, this process can be automated. This automation can reduce the administrative burden, reducing the need for intermediaries, and will lead to not only faster deal execution, but also lower transaction fees (Burke et al., 2018, p. 2).

3.4 How Asset Tokenization Leads to Greater Transparency

It is not the tokenization itself that leads to greater transparency, but rather the blockchain technology it is based upon. The degree of transparency the blockchain technology can provide is viewed by many as one of its most appealing aspects, as it can provide an auditable and valid ledger of transactions (Kritikos, 2018, p. 1). There are three main characteristics of blockchain that make it transparent (Tsai, n.d.). Firstly, anyone participating in the blockchain can view all information and transactions which are stored in the blocks. Many blockchains are also

public, and open for anyone to view. Secondly, blockchains are decentralized, meaning no single party controls them. This means that all participants must reach consensus, which happens via algorithms, for any transaction to be added to the chain. This strengthens the trust in the data stored in the blockchain. Thirdly, blockchain stores information in a way that cannot be tampered with without recording the changes on the blockchain. Every node involved has a copy of the chain, which gets updated as soon as a new block gets confirmed and added (Conway, 2020). This helps to safeguard the blockchain's transparency and to make it highly secure (Tsai, n.d.). Due to blockchains' immutability, the technology can make payment systems more transparent and more accountable. The details and terms of every transaction are irrevocable, as participants, or in some cases, anyone can inspect them in a way that has not been witnessed before (Kritikos, 2018, p. 1). For tokens, the blockchain transparency offers the opportunity to look at the history of all previous transactions.

With the transparency of blockchain, valuations can explicitly be determined on companies' ability to manage assets, debt, and equity, as the blockchain will provide a trustable and unbiased look into the company's health. For security tokens, all transactions regarding the underlying asset will be available for any participant to view, helping investors monitor their tokens and make rational investment decisions (Silver, 2020). The token holders' legal responsibilities and rights, along with the immutable ownership record, are also embedded directly onto the token. This helps add transparency to the transactions, allowing investors to know who they are dealing with, the rights of both parties, and who has previously owned the token (Burke et al., 2018, p. 2).

Throughout history, a lack of transparency has negatively affected financial institutions and the market as a whole. The financial crisis in 2008 is an example of a lack of transparency in the financial sector. Several crypto enthusiasts, like former vice president of JP Morgan Chase, Pang Huadong, believe that the crisis would never have taken place if blockchain existed and was implemented before 2008. Some also believe that its current presence will help prevent the next Great Depression from happening (Ibrahim, 2019). One of the strategies that were used by investment bank Lehman Brothers prior to their bankruptcy, was to run two parallel ledgers, one internal and one for the public. This allowed them to hide their debt and overvalue their assets, in order to deceive regulators and the public (Ibrahim, 2019). Writing for Cointelegraph, Kirill Bryanov proposes distributing the banking sector's ledgers as a "promising solution" (Bryanov, 2018). He argues that as soon as all assets' value and ownership are immutably

recorded in a transparent and shared database, illegal strategies, like those used by Lehman Brothers, will become close to impossible (Bryanov, 2018). As Alex Tapscott presents in his 2016 book Blockchain Revolution, "maintaining financial security via increased transparency of capital flows is one of the key areas in which blockchain technology may play its part in avoiding the next big financial disaster" (Bryanov, 2018).

However, blockchain technology may not be bulletproof protection against future financial crises. Running parallel ledgers is also possible with blockchain, limiting transparency and access to only a set of members on a consortium platform, which are partially private blockchains (Ibrahim, 2019). Nevertheless, the full potential of this technology is yet to be discovered, and different areas of the financial sector are still experimenting with its application. The transparency and accountability that blockchain can provide can help transform the economy. According to Mihalis Kritikos, in the Scientific Foresight Unit of the European Parliamentary Research Service, "As transparency is fundamentally concerned with the quality of being clear, obvious and understandable without doubt or ambiguity, improving accountability through blockchain will help us build an inclusive, transparent, and accountable digital economy" (Kritikos, 2018, p. 1).

3.5 How Asset Tokenization Leads to More Accessible Investment Opportunities

Tokenization leads to more accessible investment opportunities in several different ways. First of all, the token market never closes. The stock market in the US opens at 9:30 am and closes at 4 pm every open day. This gives the market six and a half hours to trade. In addition to this, the market is closed on weekends and up to ten holidays such as Washington's birthday and Christmas Day (NYSE, 2021). This practice is common on stock exchanges all over the world. In several exchanges in Asia, and on the London Stock Exchange, it is also common to close the market for a 'lunch break' (Beers, 2021). This makes the market inaccessible for trading regularly. On the contrary, the token market never closes. The market is open 24 hours a day, seven days a week, all year. If a token holder wants to sell his or her tokens in the middle of the night, they can do so in a matter of minutes. A stockholder would need to wait until the morning, to do the same, which gives plenty of other shareholders time to find out about potential downsides to the stock in the given time. This makes the token market more accessible since a token holder could sell or buy securities at any time.

In addition to the availability of the market, the tokenized securities are more accessible for smaller investors, due to the ability to fractionate the tokens. As mentioned in chapter 3.2 tokens can be fractionated into smaller pieces than traditional investment opportunities. Stocks like Amazon and Alphabet Inc. are at the time of writing trading for respectively $3,309 and $2,253 (Yahoo Finance, 2021). With a single stock selling for such a large amount, it excludes the majority of small investors from directly trading the stocks. In order to be a part of the potential growth of these companies, the investors would need to invest through a mutual fund, or take a high risk by putting a majority of their funds in the expensive stock. This problem of exclusion of small investors is not an issue with the security token market. The fact that an investor could own a fraction of a security or a piece of real estate, gives every participant in the market access to all investment opportunities.

In addition to this, the value chain of the token market is also shorter than in the stock market, making the transactions faster and liquidity more accessible. As explained in chapter 3.3, the shortened value chain in the token market will reduce the transaction costs and also reduce the counterparty risk through the use of smart contracts. Because of the blockchain's use of P2P, meaning that the transaction goes directly from the wallet to wallet, no intermediaries are taking a fee for administering the transaction. The only intermediary in the token market is the exchange of which the trade is happening. This means that the shareholder register is updated automatically in the blockchain, and the brokers and accountants from both the sellers and the buyer's banks are not needed due to the decentralized verification in the mining process (Meholm, L., personal communication, April 21, 2021). With transaction costs lowered, and decreased processing time with every purchase, it is easier for investors to trade on the token market and thereby making it more accessible.

3.6 Usage of Tokenization in DeFi

What asset tokenization has contributed to developing is, as previously mentioned, the market for decentralized finance. DeFi aims to use technology to remove intermediaries between parties in a financial transaction. This is done by using smart contracts on a blockchain, mainly on the Ethereum platform (Martin, 2020, 2:34). Services that can be built on the Ethereum network include areas like exchanges, lending, insurance, and other financial services that don't have any owner and won't be controlled by any single person (Martin, 2020, 2:10). The

following figure shows that per April 27th, 2021, the total value locked in DeFi is $61.81 billion.

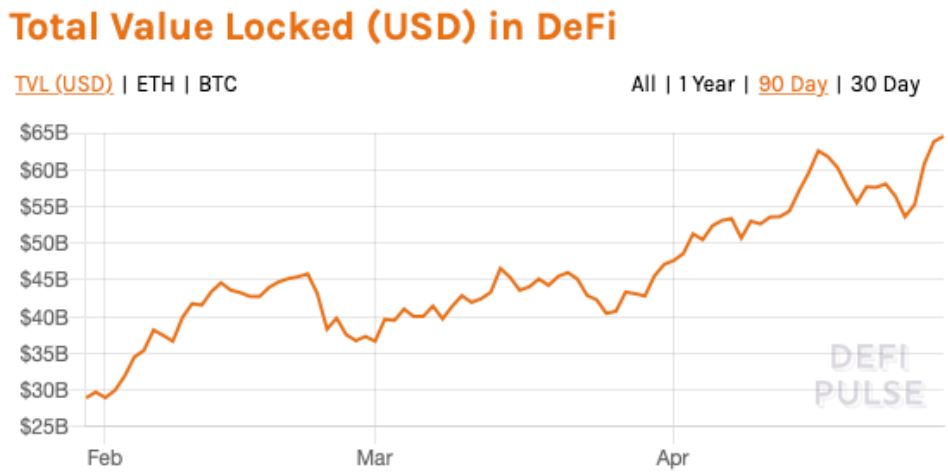

Fig. 3.1: Reprinted from *"*Total Value Locked (USD) in DeFi*"*, by defipulse, 2021 *(https://defipulse.com/)*. Copyright 2021 by defipulse.

By integrating security tokens into DeFi protocols, the functions of for example liquidity pools, a collection of funds locked in a smart contract used to facilitate decentralized lending and trading, can be effectively applied to real-world assets (Binance, 2021; The Capital, 2021). This can help for the mainstream adoption of DeFi. Furthermore, through tokenization, features like the aforementioned atomic swap can become possible for real-world assets. This can help in the struggle to fix the current illiquidity problem in the DeFi sector, as well as enabling more diverse investment opportunities (The Capital, 2021).

Another relevant use for DeFi is collateral, which is a big feature in some of the most established DeFi protocols like MakerDAO, a decentralized platform that is built on Ethereum to allow borrowing and lending without a middleman (Tran, 2020). Traditionally, one would have to contact a bank, which would require some collateral, like real estate. Banks are constrained by a high degree of regulation, limited lending offerings, and low interest rates (The Capital, 2021). In the DeFi ecosystem, on the other hand, the rules are decided by the community, and no middleman is needed for taking a loan. The process as a whole is also more dynamic as fractions of the respective assets are tradable 24 hours a day (The Capital, 2021).

NFTs can unlock more potential for DeFi. Currently in DeFi, the majority of lending protocols are collateralized, as no one has any form of credit score or formal identity associated with the

loan taken out. DeFi loans are also usually overcollateralized. On many platforms, the collateral required is worth 150% of the loan (Defirate, n.d.). A new idea is to use NFTs as collateral (Finematics, 2020, 7:05). This means that one would be able to supply an NFT representing a piece of art, digital land, or even tokenized real estate, as collateral, and borrow money against it. There is a problem with this idea, though. In the standard lending and borrowing DeFi platforms, the value of supplied collateral can be easily measured by integrating "price oracles" (Finematics, 2020, 7:25). Price oracles are methods used to value the collateral. When it comes to NFTs, the market for particular tokens is very often less liquid than the market for fungible tokens. This makes it more difficult to calculate a fair price. This is one reason why some of the projects that offer NFT collateralized loans use a slightly different model of P2P loans. In this marketplace model, borrowers can offer up NFTs as collateral, and lenders can choose which NFT they are willing to accept before initializing a loan. The NFT that is used as collateral is kept in an escrow contract, and if the borrower defaults on the loan by not paying the borrowed amount plus interest on time, the NFT is transferred to the lender (Finematics, 2020, 8:55). Besides being used as collateral, NFTs can also represent more complex financial products, like insurance, bonds, or options. Yinsure is a good example of the usage of NFT within the insurance space. In Yinsure, each insurance contract is represented as an NFT that also can be traded on a secondary market (Finematics, 2020, 9:40).

3.7 Regulatory Challenges Faced by Tokenizers

Regulatory uncertainty is one of the biggest obstacles standing in the way of asset tokenization proliferation. Given that asset tokenization is such a new phenomenon, it is not clear whether the current regulatory and supervisory framework encompasses the activity taking place using blockchain technology. For regulators, it will be important to ensure that future tokenized markets stay consistent with financial stability, market integrity, and investor protection (Unrug, 2020). However, as pointed out by BNP Paribas, this presents a regulatory quandary as to how a sufficient regulatory framework can be set in place without squandering innovative opportunities. A pronounced characteristic of regulatory actors is that they often lag behind in producing feasible regulations for new innovations. When they finally manage to produce some form of regulation, the technological scene has often experienced changes that make some aspects of the regulatory framework irrelevant. Therefore, for asset tokenization to be utilized to its fullest potential, regulators must work proactively and enforce effective regulation. This is easier said than done. Constantly having a finger on the pulse of the industry may require a

lot of resources, and there will be certain challenges that regulators will encounter when working with tokenized assets.

One of the first major challenges that may arise for regulators will be to produce a framework that encapsulates international markets. The need for international regulatory consistency is based on the underlying technology, blockchain. As blockchain is a global system, anyone, anywhere in the world, can trade and mine on the network. A person in the USA could in theory buy a percentage stake in a Vietnamese building through tokenization. The problem arises when the regulatory and supervisory framework is different on national levels. Therefore, what is needed are compliant methods of creating and exchanging tokens with an international scope (Burke et al., 2018, p. 3). Harbor, a company focusing on streamlining alternative investment processes like tokenization, is, according to Deloitte, currently working on embedding compliance at the token level (Burke et al., 2018, p. 3; Harbor, n.d.). In this case, the buyer, seller, and trade location are analyzed to check if the trade is compliant with the rules governing the countries involved. If the trade is found compliant to both sets of jurisdictions, the trade can happen on any token exchange (Burke et al., 2018, p. 3).

Another challenge regards that of successfully creating nuanced regulatory policies for individual tokens. In order to not undermine the advantages of tokenization, security regulations must take into account the individual characteristics of individual tokens. Security regulations usually are technological agnostic (Burke et al., 2018, p. 3). This means that, depending on their exact feature, security tokens, or in general crypto-assets, may fall under the full scope of relevant security regulations (Burke et al., 2018, p. 3). This can lead to regulatory difficulty. Even though crypto-assets like security tokens, utility tokens, cryptocurrencies, stablecoins, etc. are based on the same technology, they do not share the same function and characteristics and do not carry the same risk (Unrug, 2020). It is therefore important that a feasible individualistic crypto-asset classification framework is created in order to determine what rules should apply (Unrug, 2020). Current EU law will, if a token qualifies as a financial instrument, apply general financial services rules that also apply for more traditional financial instruments. This does not take into account the decentralized nature of the DLT system that the tokens are based on (Unrug, 2020). The consequence of this is a regulatory framework that does not consider the implications of disintermediation and cross-border trades. This may foster asymmetric regulatory consequences and regulatory arbitrage for one trading traditional equity stocks and one trading security token. However, as these

issues have been picked up by regulators, the EU has initiated an effort to create a “Regulation on Markets in Crypto- Assets”-framework, or in short MiCa. The European Commission states that to tackle the issue of crypto-assets, the EU with its member states must “create an EU framework that both enables markets in crypto-assets as well as the tokenization of traditional financial assets and wider use of DLT in financial services” (European Commission, 2020). For this to be successful, the framework must have four general and related objectives: legal certainty, support for innovation and fair competition, appropriate levels of consumer and investor protection and market integrity, and to ensure financial stability (European Commission, 2020).

As regulatory frameworks, like MiCa, are successfully developed, one aspect of tokenization and blockchain will make enforcing this framework much easier for regulators: smart contracts. With smart contracts, regulators have the capability of programming regulations directly into the software. Contrary to traditional regulations and rules encoded in law and the need for large legal departments to correctly interpret policies, blockchain technology is by its nature a self-regulating technology (World Economic Forum, 2020, 20:40). Regulators can program certain regulatory and supervisory policies into the software, like automatically deducting taxes or applying a limit to the number of investors allowed to participate in an offering (World Economic Forum, 2020, 20:53; OECD, 2020, p. 17).

4 Portfolio Analysis Using Security Tokens

While examining the impact of asset tokenization on financial market efficiency, the improvements seem obvious. Blockchain technology can be seen as a contributing factor to increased liquidity and transparency in markets, as well as cheaper and faster transactions. However, the security tokens will also have an impact on stock market investments. As the proliferation of tokens happens, investors will look for opportunities to implement these new securities in their portfolios. The motivation for this will depend on their risk appetites. If a risk-averse investor enters the token market, they will look for opportunities to use tokens in order to diversify their portfolio, focusing on bringing down unsystematic risk. On the other hand, a risk-seeking investor will focus more on maximizing the return of the investment. In the following, a portfolio analysis will be conducted, in order to examine whether security tokens can be used in combination with stocks to form a diversified portfolio. The data used in the following chapter is retrieved from Yahoo Finance and CoinMarketCap (Yahoo Finance, 2021; CoinMarketCap, 2021).

4.2 Methodology

4.2.1 General Methodology

In order to compare stock prices and token prices, some measures are needed. Firstly, as mentioned in chapter 3.5, token markets are open 24/7, meaning that the tokens are traded on weekends and holidays, as well as throughout the night. This makes up some complications with comparing the two. To implement this comparison, weekends are added to the stock prices, with a 0% return and risk. It would be possible to remove the weekend prices from the tokens, but by doing so, one could remove important trading days from the token market. This became clear through the analysis. When the weekends were removed, the standard deviation of the tokens increased by an average of 140% and the expected return increased by an average of 28%. With adding the weekends to the stock prices, the standard deviation decreased by an average of 0.46% and the expected return decreased by 0.07%. To not compromise the data, weekends were added to the stock data due to the changes being minor, in comparison to the alternative. In addition to this, by adding a non-profitable weekend for the stock prices, one comes closer to reflecting the reality of the market, underlining the fact that tokens are traded 24/7. Within statistics, there are multiple ways of handling missing data, like through interpolation or arithmetic averages. But in order to simplify this analysis and minimize affecting the results, non-profitable weekends for stocks were chosen as the approach.

In order to calculate the variables needed to analyze the portfolios, a risk-free rate was needed. Firstly, a two-year treasury rate was found to be 2.5%, starting January 2019 (Ycharts, 2021). To find the daily rate, this was divided by the 731 days in the respective years. Then, a daily treasury rate from January 2nd to April 28th, 2021, had to be calculated. Both the three- and six-month treasury rate starting January 2021 was found to be 0.07% (Norges Bank, 2020). This number had to be divided by the 114 days between those respective dates. Finally, the weighted average between those treasury rates had to be found. This was done by dividing the number of days by the total amount of days in the relevant period, and multiplying this proportion with the corresponding daily treasury rate. This was done for both periods, and the sum of those equals the average daily treasury rate from January 2nd, 2019, to April 28th, 2021.

$$Daily\ Treasury_{Jan\ '19-Jan\ '21} = \frac{2\ Year\ Treasury}{731\ Days} = \frac{2.5\%}{731} = 0.00342\%$$

$$Daily\ Treasury_{Jan\ '21-Apr\ '21} = \frac{3\ Months\ Treasury}{114\ Days} = 0.00061\%$$

Calculating weighted average:

$$Risk\ Free\ Rate = \frac{731}{845} * 0.00342\% + \frac{114}{845} * 0.00061\% = 0.00304\%$$

4.2.2 Token Choices

Tokens are, like cryptocurrencies, known for their high volatility. As can be seen on CoinMarketCap, the world's most referenced price tracking website for cryptocurrencies, the price of most tokenized assets fluctuates a lot (CoinMarketCap, 2021). To make up for this volatility, investors demand a higher rate of return than in the stock market. There exists a plethora of different tokens to invest in. Investors can pick anything from decentralized video streaming tokens to football club fan tokens. However, for this thesis, there has largely been a focus on real estate tokenization. Therefore, for the portfolio analysis, five different real estate tokens were picked to examine their impact on a traditional stock portfolio. The tokens chosen are the five most traded real estate tokens in the market. These include Propy [PRO], IHT Real Estate Protocol [IHT], Atlant [ATL], Primalbase [PBT], and Ecoreal Estate [ECOREAL]. The common denominator for all these tokens is, as previously mentioned, their underlying asset:

real estate. A note must be made regarding Ecoreal Estate. This token is the seventh most traded real estate token. The reason for this choice over the fifth and sixth most traded tokens, respectively “imbrex” and “SYB Coin”, is the lack of a whitepaper for imbrex and sufficient data for SYB Coin. The rest of the tokens were chosen because they all share two important features: they all have whitepapers describing the purpose of the project and sufficient market data covering at least 2 years.

4.2.3 Stock Choices

The stocks picked for the portfolio were: Tesla [TSLA], Amazon [AMZN], General Motors [GM], Facebook [FB], and McDonald’s [MCD]. The reason for these choices is that they are familiar companies, in addition to this, they are all highly traded stocks with vastly different risk profiles. With all the stocks being traded at a high volume, the portfolio is likely to represent an actual portfolio used by traders in the market. In addition to this, the stocks represent all parts of the risk spectrum. Tesla is a highly volatile stock, with a daily standard deviation of 3.77%. On the other side of the scale, McDonald’s is a low-risk stock with a standard deviation of 1.51%. This provides the opportunity to observe the token’s effect on an already diversified portfolio. Which stocks to be discarded when adding the tokens to the portfolios were chosen at random. The effect of this order was noticeable on the data. As shown in table 4.1, the most volatile stock in the stock portfolio is Tesla. This is also the first stock to be discarded when introducing token securities. Table 4.2 presents the tangency portfolios. This table illustrates that the Sharpe ratio decreases with the first token introduction, and then continuously increases. This is due to the volatility of the Tesla stock, and the result would probably be different if i.e. McDonald’s, the least volatile, was the first to be removed.

4.2.4 Tangency Portfolio

In order to capture the differences in the portfolios, the Sharpe ratio will be taken into account. The Sharpe ratio illustrates the relationship between expected return and standard deviation, adjusted for risk-free rate. Sharpe ratio is calculated by the following formula.

$$Sharpe\ Ratio\ = \frac{(Expected\ Return\ -\ Risk\ Free\ Rate)}{Standard\ Deviation}$$

Looking at the relationship between expected return and standard deviation gives the ability to compare portfolios with different risk profiles. I.e., The Sharpe ratio for Portfolio 1, containing five stocks, is 9.92%. This indicates that for every percentage of increased risk, or standard

deviation, you could expect an increase in return of 9.92%. The weights of the portfolios presented in table 4.2 are chosen by maximizing the Sharpe ratio. The tangency portfolio makes it possible to draw the capital market line, as shown in the figures 4.1-4.6. The intercept between this line and the efficient frontier indicates the optimal portfolio, the tangency portfolio, where risk-adjusted return is maximized.

4.2.5 Value at Risk

The standard deviation is a good measure used to determine the risk of a stock. But the standard deviation only indicates the presence of risk, not the direction of it. I.e., If a stock or a token experiences massive growth for a year, the standard deviation would be high, because of the fluctuation of the price. But investors would still be interested in investing in the security, given that they don't believe it will fall shortly after investing. By using the Value at Risk [VaR] measure, the investor can calculate the risk of potential downside to their investment. In this analysis, "K" is set to 5%, making the selected probability 95%. In effect, this means that the number provided by the VaR shows, with a 95% certainty, the maximum downside possible for one day. Including VaR in the analysis, enables the possibility of determining the direction of the risk.

4.2.6 Minimum Standard Deviation Portfolio

To examine possible investment opportunities for risk-averse investors, minimum standard deviation portfolios will be included for all six combinations of stocks and tokens. Here, the standard deviation will be minimized in order to see, by including tokens in a portfolio, if investors can reduce risk by diversification. By looking at the weights of the minimization problem, one could determine whether tokens could be used to diversify, and thereby hedge against potential loss.

4.3 Presentation of Findings

Table 4.1: Expected return, standard deviation and Sharpe ratio for stocks and tokens.

	TSLA	AMZN	GM	FB	MCD
Expected Return	0,36%	0,10%	0,10%	0,11%	0,05%
Standard Dev.	3,77%	1,62%	2,42%	1,94%	1,51%
Variance	0,14%	0,03%	0,06%	0,04%	0,02%
Sharpe Ratio	9,5522%	6,2961%	3,9738%	5,6818%	3,2325%

	PRO	IHT	ATL	PBT	ECOREAL
Expected Return	0,66%	0,92%	2,66%	2,87%	1,68%
Standard Dev.	10,88%	15,55%	26,88%	32,70%	18,91%
Variance	1,18%	2,42%	7,23%	10,69%	3,58%
Sharpe Ratio	6,0466%	5,8976%	9,8812%	8,7621%	8,8909%

Risk Free Rate	0,0030%

Table 4.2: Comparison of tangency portfolios.

Weights - Stock/Token	5 Stocks	4 Stokcs + 1 Token	3 Stocks + 2 Tokens	2 Stocks + 3 Tokens	1 Stocks + 4 Tokens	5 Tokens
Weight 1 - TSLA/PRO	52,3%	10,5%	12,2%	12,3%	16,8%	25,2%
Weight 2 - AMZN/IHT	26,1%	56,2%	8,2%	8,4%	12,4%	14,3%
Weight 3 - GM/ATL	5,2%	15,6%	18,7%	10,0%	14,2%	19,5%
Weight 4 - FB/PBT	16,4%	17,7%	60,9%	66,8%	10,8%	14,3%
Weight 5 - MCD/ECOREAL	0,0%	0,0%	0,0%	2,5%	45,8%	26,6%
SUM	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Exp. Ret	0,24%	0,16%	0,24%	0,50%	0,94%	1,68%
StDev	2,40%	1,81%	2,54%	3,89%	6,33%	9,84%
VaR - 5%	-3,27%	-1,11%	-1,49%	-2,43%	-3,51%	-5,31%
Sharpe Ratio	9,92%	8,86%	9,47%	12,81%	14,74%	17,01%
Risk Free Rate	0,00304%	0,00304%	0,00304%	0,00304%	0,00304%	0,00304%

	Stock
	Token

Table 4.3: Comparison of minimum standard deviation portfolios.

Weights - Stock/Token	5 Stocks	4 Stokcs + 1 Token	3 Stocks + 2 Tokens	2 Stocks + 3 Tokens	1 Stocks + 4 Tokens	5 Tokens
Weight 1 - TSLA/PRO	0,0%	0,5%	0,7%	0,7%	0,9%	50,7%
Weight 2 - AMZN/IHT	44,7%	44,5%	0,1%	0,1%	0,3%	19,5%
Weight 3 - GM/ATL	1,1%	0,9%	0,4%	0,0%	0,0%	6,6%
Weight 4 - FB/PBT	0,0%	0,0%	26,0%	25,1%	0,0%	5,1%
Weight 5 - MCD/ECOREAL	54,2%	54,1%	72,7%	74,0%	98,8%	18,1%
SUM	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Exp. Ret	0,08%	0,08%	0,07%	0,07%	0,06%	1,14%
StDev	1,28%	1,28%	1,43%	1,43%	1,50%	8,11%
VaR - 5%	-1,63%	-0,65%	-0,55%	-0,54%	-0,58%	-4,29%
Sharpe Ratio	5,71%	5,95%	4,93%	4,87%	3,79%	14,03%
Risk Free Rate	0,00304%	0,00304%	0,00304%	0,00304%	0,00304%	0,00304%

	Stock
	Token

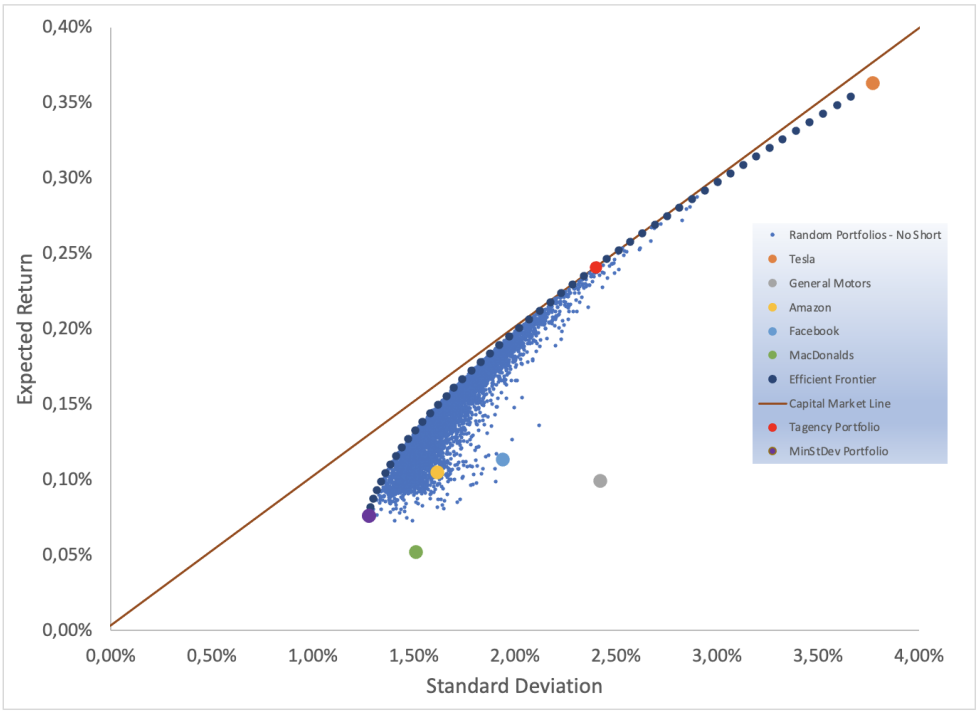

Figure 4.1: Efficient frontier, capital market line and tangency portfolio for Portfolio 1, containing 5 stocks.

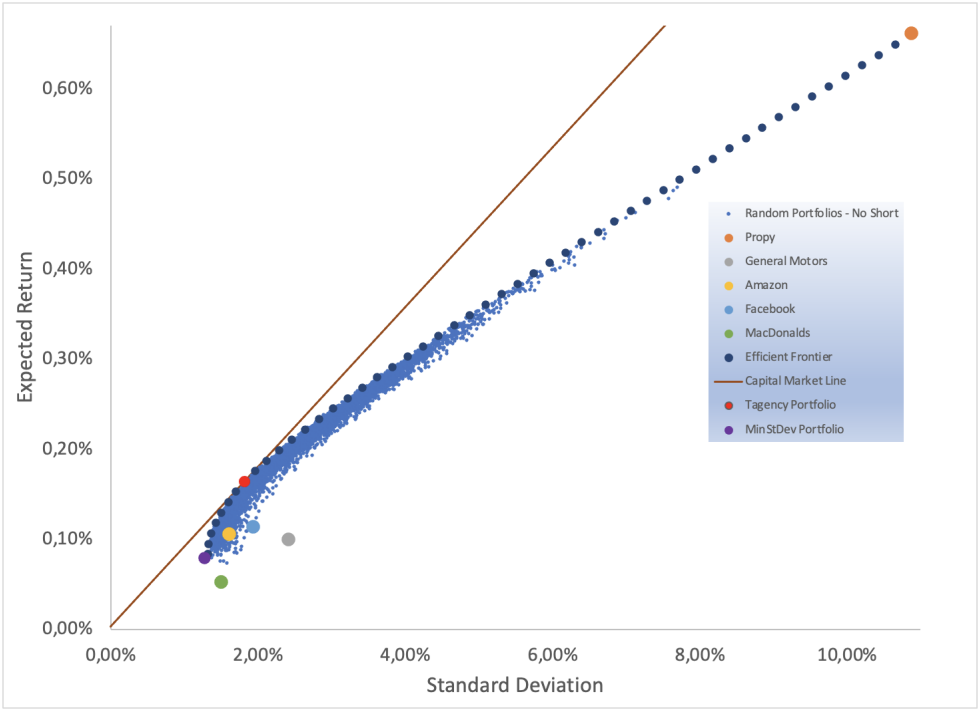

Figure 4.2: Efficient frontier, capital market line and tangency portfolio for Portfolio 2, containing 4 stocks and 1 token

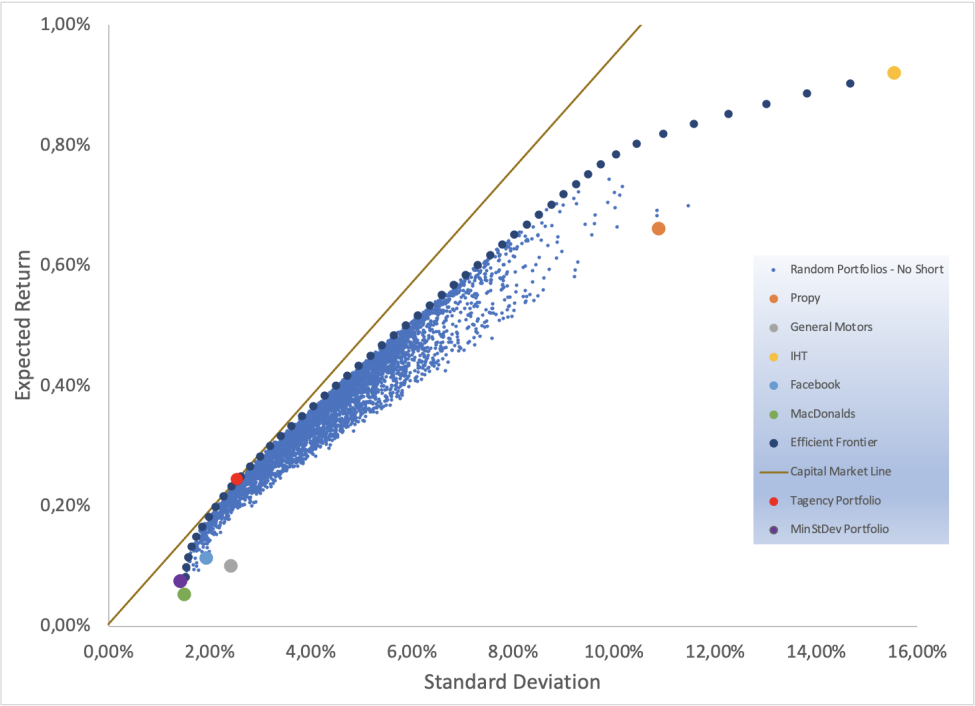

Figure 4.3: Efficient frontier, capital market line and tangency portfolio for Portfolio 3, containing 3 stocks and 2 tokens.

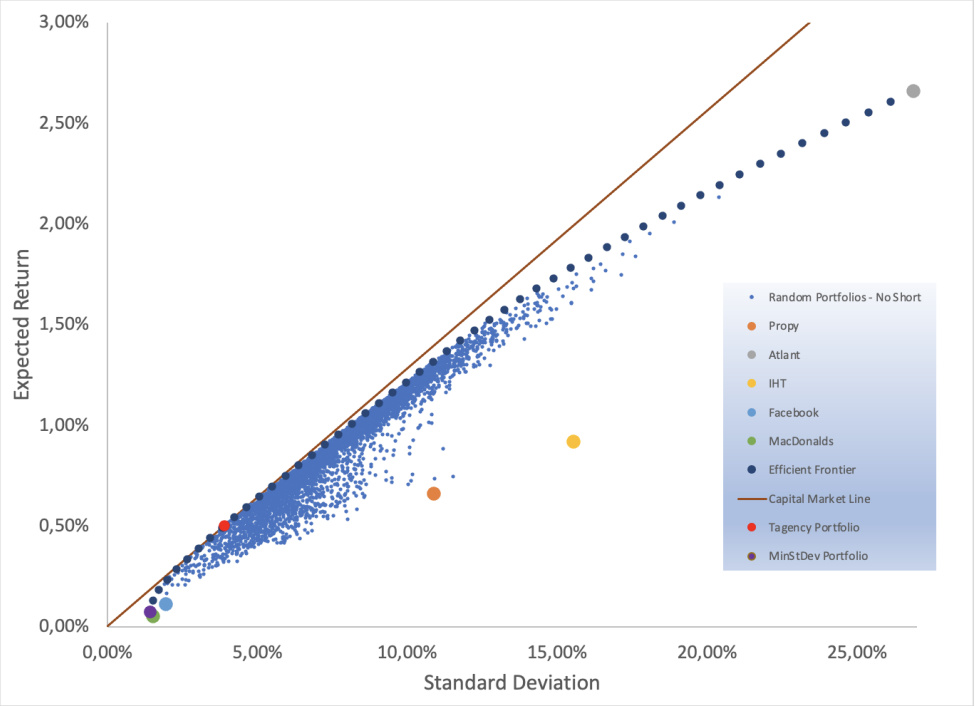

Figure 4.4: Efficient frontier, capital market line and tangency portfolio for Portfolio 4, containing 2 stocks and 3 Tokens.

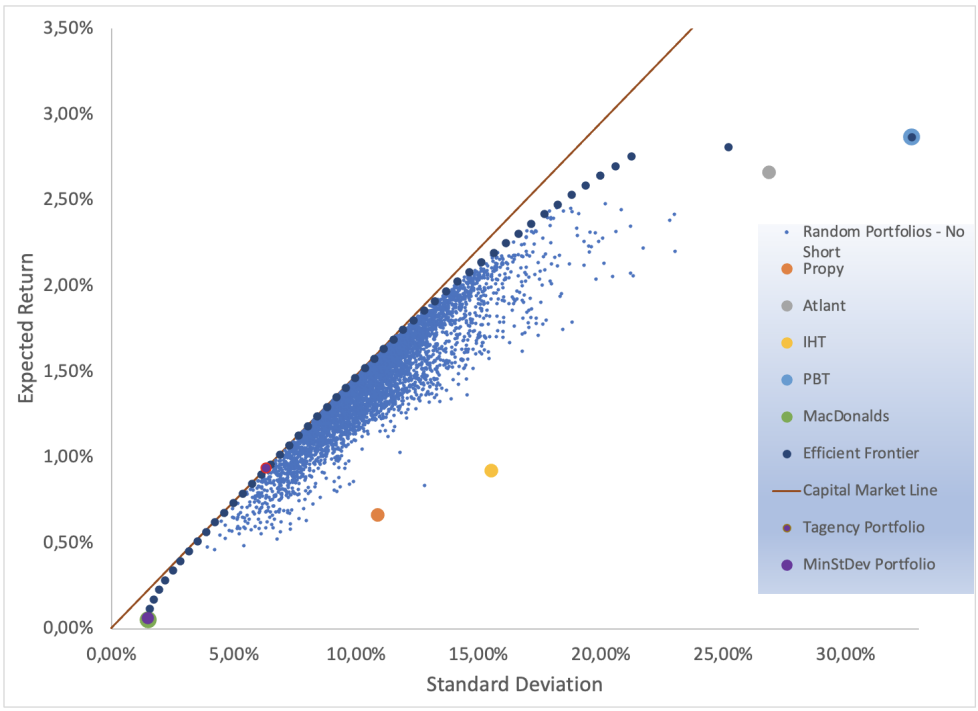

Figure 4.5: Efficient frontier, capital market line and tangency portfolio for Portfolio 5, containing 1 stocks and 4 Tokens.

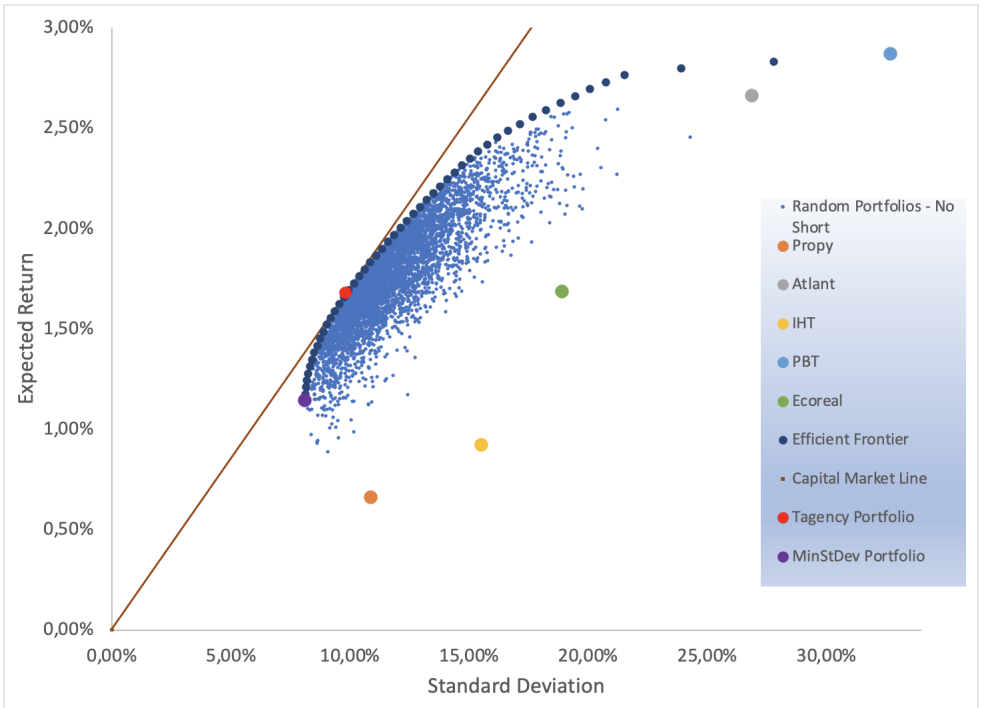

Figure 4.6: Efficient frontier, capital market line and tangency portfolio for Portfolio 6, containing 5 tokens.

4.4 Discussion

Looking at table 4.1, one could compare the individual securities more clearly. As mentioned in chapter 4.2.3, Tesla is the most volatile of the five stocks with a standard deviation of 3.77% and an expected return of 0.36%. Furthermore, the least volatile stock is McDonald's with a daily standard deviation of 1.51% and an expected return of 0.05%. The Sharpe ratios for the mentioned stocks stand at 9.55% and 3.23%, respectively. As mentioned before, this indicates that for an increase in the standard deviation of 1%, the expected return will increase by 9.55% and 3.23% for Tesla and McDonald's, respectively. Facebook has the second highest expected return with 0.11%, and a standard deviation of 1.94%. Amazon and General Motors have the same expected return of 0.10%, however, General Motors is more volatile with a standard deviation of 2.42% versus Amazon's 1.62%.

When compared to the stock data, the statistical analysis of the tokens paints a stark difference. The expected returns are much higher than those of the stocks, but it comes with a price. In some of the cases, almost 14 times more risk. Primalbase leads the table with a daily expected return of 2.87% against a staggering 32.7% standard deviation. Its less risky counterpart on the other end of the scale is Propy, with an expected return of 0.66% and a standard deviation of 10.88%. The second highest return can be traced to Atlant with an expected return of 2.66% and a standard deviation of 26.88%. Ecoreal and IHT Real Estate have expected returns of 1.68% and 0.92%, and standard deviations of 18.91% and 15.55%, respectively. What can be pointed out is that even though Atlant is the token with the second-highest expected return, it has the highest Sharpe ratio. This can be seen as a consequence of the much higher risk of investing in Primalbase for a modest difference in expected return (at least in terms of the token returns).

As mentioned in chapter 4.2.4, the tangency portfolios can help to compare the return of portfolios with different risk profiles. The value used to compare the portfolios is the mentioned Sharpe ratio. As shown in table 4.2, the Sharpe ratios start at 9.92%, indicating that a one percent increase in standard deviation on average will result in a 9.92% increase in expected return. As mentioned in chapter 4.2.3, due to the high volatility of Tesla, the Sharpe ratio decreases with the first token involvement. After Portfolio 2, there is a steady increase in the Sharp ratio, indicating that the tokens possess a higher expected return per unit of risk than the stocks. This is confirmed by the high Sharp ratio value shown in table 4.1.

If you decide to invest in Portfolio 4, containing two stocks and three tokens, you could expect a standard deviation of 3.89% and a return of 0.5%. In Portfolio 3, the standard deviation is slightly lower, at 2.54%, and the expected return is halved compared to Portfolio 4. In addition to this, the expected return of Portfolios 1 and 3 is the same, with Portfolio 1 having lower risk. This could indicate that for a portfolio containing both stocks and tokens to be efficient, one would need at least three tokens. For a risk-seeking investor, choosing one of the last two portfolios could be recommended, based on the Sharpe ratio. Both the Sharpe ratios are significantly greater than in the first couple of portfolios, and so is the expected return. On the other hand, the VaR indicates that the two latter are riskier when it comes to the downside, as will be discussed in the next passage.

The general trend of VaR is negative when adding tokens to the portfolio, according to table 4.2. This means that the more tokens included, the larger the risk of loss. The combination with the lowest VaR is the one with four stocks and one token. The interpretation is that one can with 95% certainty, from one day to another, say that the loss of the portfolio will not be greater than 1.11%. If the notoriously volatile Tesla stock was not the first one removed, the combination of five stocks would probably have the lowest VaR. The two combinations with respectively four and five tokens are the most likely to experience loss, with the combination of five tokens one can say with 95% certainty that the loss will not exceed 5.31%.

For the last part of the analysis, minimum standard deviation portfolios were created to construct the ideal combination of stocks and tokens when the main objective is to minimize risk, as can be seen in table 4.3. As expected, because of the high volatility of Tesla and the tokens, as shown in table 4.1, the weights of these securities are close to zero throughout the table. The most ideal combination for risk-averse investors is Portfolio 2, containing four stocks and one token. This combination generates the same expected return and standard deviation as Portfolio 1, but has a lower VaR and higher Sharpe ratio. In addition to this, Portfolio 2 has a higher expected return and a lower standard deviation than Portfolio 3-5. Portfolio 6 on the other hand, has the highest expected return and standard deviation because it can not hedge against token risk by including stocks. This makes Portfolios 2 and 6 the only rational options for an investor.

5 Conclusion

Even though the idea of blockchain was introduced in 1982, it did not gain a foothold before the introduction of Bitcoin in 2009. This is because of its previous incompleteness, which Satoshi Nakamoto fixed before launching Bitcoin. Ever since the first cryptocurrency was brought into the limelight, the blockchain technology that it is based upon has been adopted by some actors within the financial sector, and is viewed by many to have the potential to revolutionize the financial industry. The technology has made it possible to tokenize assets, giving them digital value representation. How tokenization of assets can affect and change financial markets as we know them today has been the main focus of this thesis. Extensive research, along with two interviews with Lasse Meholm, one of the leading figures within the cryptocurrency industry in Norway, has been used as methods to gather information.

The market for offering tokens is under constant change and development. In the early token offering days, new ventures generally conducted ICOs to raise capital. This method reached its peak in 2018 before it was discovered to be a problematic way of raising capital. Because of its lack of regulation, many investors lost a lot of money due to fraud. This paved the way for the offering of security tokens, STOs, which is a more regulated practice. Security tokens, contrary to utility tokens, are bought as an investment with the expectation of profit.

Tokenizing assets and the implementation of blockchain can, as discussed, have multiple implications on the financial markets. Firstly, the traditional way of raising capital for companies, IPOs, is a long and cumbersome process. Conducting an STO can be a more effective method, but this is not guaranteed. The most expensive and time-consuming STOs can equal the level of capital and time needed for an IPO, but it is possible to make them faster and cheaper. Furthermore, tokenizing assets can allow for greater liquidity. Tokenization allows for assets to be fractioned, increases the level of retail investments, and exploits traditionally illiquid assets. These are factors that help increase market liquidity. Tokenization can also lead to faster and cheaper transactions. It increases efficiencies in the clearing and settlement process, as well as streamlining post-trade processes like reconciliation and compliance work. This brings down transaction costs and more or less eliminates counterparty risk. The fractionation and reduced transaction costs also make for more accessible investment opportunities. Fractionation allows for smaller investors to buy parts of assets they otherwise would not be able to afford, and the aforementioned shortened value chain makes investments

faster and cheaper. In addition to this, in the token market, one has the opportunity to trade 24/7. This is contrary to traditional stock exchanges, which are usually open 6,5 hours, five days a week. Moreover, the decentralized nature of blockchain technology can help increase transparency in the financial sector. This can help improve accountability in the economy, and some crypto experts believe the transparency blockchain offers can help prevent future financial crises. Tokenization can also help to fix the existing illiquidity problem in another sector rooted in blockchain, DeFi. As described, tokenizing assets has many benefits, but it does not come without regulatory challenges. Producing a framework that encapsulates international markets and creating nuanced regulatory policies for individual tokens are essential for the token economy to reach its full potential.

Finally, the possibility to include real estate tokens in traditional stock portfolios, in order to diversify, has been examined. Generally, the tokens generate a higher expected return for investors, but they also come with a greater risk. But, as the analysis presented, risk-averse investors could still use a small amount of tokens in their portfolio. The portfolios that include tokens generally generate a higher Sharpe ratio than those who don't. Therefore, for risk-neutral and risk-seeking investors, including tokens in their portfolio could be a profitable investment opportunity.

The tokenization of assets and the implementation of a blockchain-based infrastructure in the financial sector is still in its infancy stage, but its potential is unprecedented. It can allow the creation of a more efficient, democratic, and vast financial system (Burke et al., 2018, p. 2). Those who do not prepare for this movement may be left behind, as it may completely revolutionize the financial industry we know today.

6 Bibliography

Frankenfield, J. (2021, February 18). Bitcoin Definition. Retrieved from https://www.investopedia.com/terms/b/bitcoin.asp

Daley, S. (2021, April 9). 30 Blockchain Applications and Real-World use Cases Disrupting the Status Quo. Retrieved from https://builtin.com/blockchain/blockchain-applications

Chaum, D. (1985). Security without identification: transaction systems to make big brother obsolete. *Communications of the ACM*, 28(10), 1030-1044. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=B31AF7856AF06FD937FCDFB9A055FE64?doi=10.1.1.319.3690&rep=rep1&type=pdf

Haber, S. & Stornetta, W.S. (1991). How to time-stamp a digital document. *Journal of Cryptology*, 3, 99-111. Retrieved from https://link.springer.com/content/pdf/10.1007/BF00196791.pdf

Bayer, D., Haber, S. & Stornetta, W.S. (1992). Improving the Efficiency and Reliability of Digital Time-Stamping. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.71.4891&rep=rep1&type=pdf

The Economist, Briefing. (2015, 31. October). The great chain of being sure about things. Retrieved from https://www.economist.com/briefing/2015/10/31/the-great-chain-of-being-sure-about-things

Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. Retrieved from https://bitcoin.org/bitcoin.pdf

Ofir, M. & Sadeh, I. (2019). ICO vs. IPO: Empirical Findings, Information Asymmetry, and the Appropriate Regulatory Framework. *Vanderbilt Journal of Transnational Law*

Meholm, L. (2018). Kryptovaluta, bitcoin, ICOer og blockchain (1. edition). Oslo: Hegnar Media

Szabo, N. (1996). Smart Contracts: Building Blocks for Digital Markets. Retrieved from https://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/smart_contracts_2.html

Schulpen, R. (2018). *Smart contracts in the Netherlands: A legal research regarding the use of smart contracts within Dutch contract law and legal framework* (Master Thesis). Tilburg University, Tilburg. Retrieved from http://arno.uvt.nl/show.cgi?fid=146860

Simply Explained. (2017, 20. November). *Smart contracts - Simply Explained* [Videoclip]. Retrieved from https://www.youtube.com/watch?v=ZE2HxTmxfrI

Buterin, V. (2013). *Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform*. Retrieved from https://ethereum.org/en/whitepaper/

Brickken. (n.d.). Asset Tokenization: The Future of Investing. Retrieved from https://brickken.com/asset-tokenization/

International Financing Review. (2015, 11. June). Bitcoin technology will disrupt derivatives, says banker. Retrieved from https://www.ifre.com/story/1378466/bitcoin-technology-will-disrupt-derivatives-says-banker-qv3qsx1w13

Fisch, C. (2019 January). Initial coin offerings (ICOs) to finance new ventures. *Journal of Business Venturing,* Volume 34 (Issue 1). Retrieved from https://www.sciencedirect.com/science/article/pii/S0883902618301721

Dell'Erba, M. (2018). Initial coin offerings. a primer. the first response of regulatory authorities. *NYU Journal of Law & Business*, 14, 1109.

Di Angelo, M., & Salzer, G. (2020, August). Tokens, types, and standards: identification and utilization in Ethereum. In *2020 IEEE International Conference on Decentralized Applications and Infrastructures (DAPPS)* (pp. 1-10). IEEE.

Frankenfield, J. (2020, November 3). Initial Coin Offering (ICO). Retrieved from https://www.investopedia.com/terms/i/initial-coin-offering-ico.asp

Tiwari, M., Gepp, A. & Kumar, K. (2019). The future of raising finance - a new opportunity to commit fraud: a review of initial coin offering (ICOs) scams. *Crime Law Soc Change,* 73, 417–441. https://doi.org/10.1007/s10611-019-09873-2

Matthews, M. (2019, January 31). *5 biggets ICO Scams of 2018| Blockchain Central* [Video clip]. Retrieved from 5 Biggest ICO Scams of 2018 | Blockchain Central

Jenkinson, G. (2019, February 4). From Ponzi Schemes to ICO Exits, Ehtereum's Blockchain Has Been the Platform of Choice for Scammers. Retrieved from https://cointelegraph.com/news/from-ponzi-schemes-to-ico-exits-ethereums-blockchain-has-been-the-platform-of-choice-for-scammers

Underhill, J. (2018, March/April). Initial coin offering. Retrieved from https://www.fraud-magazine.com/article.aspx?id=4295000887

Roy, L. (2018, October 6). Pincoin: a $660 million ICO Scam That Deceived 32,000 People. Retrieved from https://totalcrypto.io/pincoin/#Conclusion

Jenkinson, G. (2018, April 18). Unpacking the 5 Biggest Cryptocurrency Scams. Retrieved from https://cointelegraph.com/news/unpacking-the-5-biggest-cryptocurrency-scams

Zhang, L. (2018, June). Regulation of Cryptocurrency: China. Retrieved from https://www.loc.gov/law/help/cryptocurrency/china.php#_ftnref6

Statista (2019). Total funding raised by blockchain initial coin offerings (ICO) worldwide in 2017 and 2019, by quarter (in million USD) [Figure]. Retrieved from https://www.statista.com/statistics/804748/worldwide-amount-crytocurrency-ico-projects/

Icodata. (2021, March 02). What is an Initial Exchange Offering?. Retrieved from https://www.icodata.io/what-is-an-initial-exchange-offering-ieo

U.S. Securities and Exchange Commission. (2017). Report of Investigation Pursuant to Section 21(a) of the Securities Exchange Act of 1934: The DAO. (Release No. 81207). Retrieved from https://www.sec.gov/litigation/investreport/34-81207.pdf

Clayton, J. (2017, December 11). Statement on Cryptocurrencies and Initial Coin Offerings. Retrieved from https://www.sec.gov/news/public-statement/statement-clayton-2017-12-11.

Amoils, N. (2021, January 25). Security Token Industry in 2021. Retrieved from https://www.forbes.com/sites/nisaamoils/2021/01/25/security-token-industry-in-2021/?sh=2ce31d9661cb

World Economic Forum. (2020, 21. January). *From Token Assets to a Token Economy* [Video]. Retrieved from https://www.weforum.org/events/world-economic-forum-annual-meeting-2020/sessions/from-token-assets-to-a-token-economy

Sharma, R. (2021). Decentralized finance (DeFi) Definition. Retrieved from https://www.investopedia.com/decentralized-finance-defi-5113835

OECD (2020), The Tokenisation of Assets and Potential Implications for Financial Markets, OECD Blockchain Policy Series, https://www.oecd.org/finance/The-Tokenisation-of-Assets-and-Potential-Implications-for-Financial-Markets.htm

Agudelo, L.F. (2019, 14. December). What is an Asset-Backed Token? - Security Tokens for Beginners. Retrieved from https://micobo.medium.com/what-is-an-asset-backed-token-security-tokens-for-beginners-b77adf3a9710

Nelson, D. (2020, 27. July). NBA Player Spencer Dinwiddie's Token Sale hits 10% of $13.5M goal. Retrieved from https://www.coindesk.com/nba-player-spencer-dinwiddies-token-sale-hits-10-of-13-5m-goal
Martin, N. (2019, February 5). *STOs and Security Tokens Explained (simply)* [Video clip]. Retrieved from https://www.youtube.com/watch?v=-h4SZ7Jb8E0
Liebkind, J. (2020, December 30). Is 2020 the Year of the Security Token?. Retrieved from https://www.investopedia.com/tech/2018-year-security-token/
Mitra, R. Utility Tokens vs Security Tokens: Learn The Difference - Ultimate Guide. Retrieved from https://blockgeeks.com/guides/utility-tokens-vs-security-tokens/#Utility_Tokens_vs_Security_Tokens
Blockgeeks. (2019, April 5). *Utility Tokens vs. Security Tokens - Learn the Difference* [Video clip]. Retrieved from https://www.youtube.com/watch?v=nGXxHAj_IL8
Prstek, S. (2021, February 9). *Crypto Topic: How not to fail the Howey Test* [Video clip]. Retrieved from https://www.youtube.com/watch?v=tsyBLiqbuzY
Frankenfield, J. (2021, April 22). Howey Test. Retrieved from https://www.investopedia.com/terms/h/howey-test.asp
Finematics. (2020, September 29). *What are NFTs and How Can They Be Used in Decentralized Finance? DEFI Explained* [Video clip]. Retrieved from https://www.youtube.com/watch?v=Xdkkux6OxfM
Digital Asset News. (2019, December 9). *What is a Non Fungible Token NFT vs. A Fungible Token?* [Video clip]. Retrieved from https://www.youtube.com/watch?v=gbsewBbW3Jk
Hern A. (2021, March 12). Non-fungible tokens are revolutionising the art world - and art theft. Retrieved from https://www.theguardian.com/technology/2021/mar/12/non-fungible-tokens-revolutionising-art-world-theft?fbclid=IwAR0QUH75AOan1kGicbK5rAGl_QutzXVQSM4BCONOQcFsgOQu8tcwwlZiU9Y
Blockgeeks. (2019, April 12). *What is an ERC-20 Token?* [Video clip]. Retrieved from https://www.youtube.com/watch?v=g3IKJnInY4k
Reiff, N. (2020, September 6). What Is ERC-20 and What Does It Mean for Ethereum?. Retrieved from https://www.investopedia.com/news/what-erc20-and-what-does-it-mean-ethereum/
Blockgeeks. (2019, January 3). *What is an ERC-721 Token?* [Video clip]. Retrieved from https://www.youtube.com/watch?v=HTm-1JtI0fA
Blocktrade. (2020, February 11). *What is an STO?* [Video clip]. Retrieved from https://www.youtube.com/watch?v=55sjUBNrO8M
Rodriguez, J. (2018, August 21). Security Token 2.0 Protocols: Debt Tokens. Retrieved from https://hackernoon.com/security-token-2-0-protocols-debt-tokens-af17d5c91a25
Tokeny (n.d.). Benefits of digitizing debt. Retrieved from https://tokeny.com/tokenized-debt/
Bartel, G.(n.d.). What's the Point of a Stablecoin? (A Simple Explanation). Retrieved from https://www.grantbartel.com/blog/what-is-the-point-of-a-stablecoin/
Brickken. (n.d.) How does asset tokenization work for real estate? Retrieved from https://brickken.com/asset-tokenization/?fbclid=IwAR2I9BScmZPUEEBnhRO4gEvO6fVck7KiWSZU4kr8-D5L7yX9LpUgIkwIMmo
Brealey, R. A. & Myers, S. C. (2003). *Principles of Corporate Finance* (7th Edition). New York: The McGraw-Hill.

Corporate Finance Institute. (2021). IPO Process, The first-time sale of new or existing securities to the public. Retrieved from https://corporatefinanceinstitute.com/resources/knowledge/finance/ipo-process/
U.S. Securities and Exchange Commission. (2017, Nov 29). Going Public - What is a Registration Statement?. Retrieved from https://www.sec.gov/smallbusiness/goingpublic/registrationstatement
U.S. Securities and Exchange Commission. (2006). *The Corporate Handbook Series - Going Public.* Retrieved from https://www.sec.gov/info/smallbus/gbfor25_2006/goingpublic.pdf
PwC. (2017). *Average Cost By Revenue Range - Summary of Going Public* [Table]. Retreived from https://financetreasury.com.au/wp-content/uploads/2019/02/PWC_cost-of-an-ipo.pdf
Icodata. (2021, March 02). What is an ICO?. Retrieved from https://www.icodata.io/what-is-an-initial-exchange-offering-ieo
PwC. (2017, November). *Considering an IPO to fuel your company's future? - Insight into the costs of going public and being public* [Table]. Retrieved from https://financetreasury.com.au/wp-content/uploads/2019/02/PWC_cost-of-an-ipo.pdf
Fitzner Blockchain Consulting (2019, April 10). A Guide to Launching a Security Token Offering. Retrieved from https://medium.com/fitzner-blockchain-consulting/a-guide-to-launching-a-security-token-offering-e55f77be2874
Blockstate. (2021). Get your STO live in as little as 10 weeks. Retrieved from https://blockstate.com/
Getid. (2021, January 05). KYC and AML. Retrieved from https://getid.ee/kyc-and-aml/
Lennon, H. (2021, January 19). The False Narrative of Bitcoin's Role in Illicit Activity. *Forbes*. Retrieved from https://www.forbes.com/sites/haileylennon/2021/01/19/the-false-narrative-of-bitcoins-role-in-illicit-activity/?sh=5b6ad65b3432
Chainalysis. (2021, January 19). *Chainalysis 2021 Crypto Crime Report.* Retrieved from Chainalysis database: https://go.chainalysis.com/2021-Crypto-Crime-Report.html
FiatXS Financial. (2019, August 30). The Full Timeline of Launching a Security Token Offering. Retrieved from https://medium.com/fiatxs/the-full-timeline-of-launching-a-security-token-offering-6e786c018f03
Marshall, J. (2020, 20 August). How tokenization could change how US companies raise capital. Retrieved from https://www.pwc.com/us/en/services/deals/blog/tokenization.html
Burke, M., Chollet, T., Laurent, P. & Seers, T. (2018). The tokenization of assets is disrupting the financial industry. Are you ready?. Inside Magazine 19(2). https://www2.deloitte.com/lu/en/pages/technology/articles/tokenization-assets-disrupting-financial-industry.html
Fries, T. (2020, 24. November). How $544 Trillion Worth of Assets Could Become Tokenized. Retrieved from https://tokenist.com/how-544-trillion-worth-of-assets-could-become-tokenized/
Perez, Y.B. (2015, 16 June). Santander: Blockchain Tech Can Save Banks $20 Billion a Year. Retrieved from https://www.coindesk.com/santander-blockchain-tech-can-save-banks-20-billion-a-year
Spaulding, W.C. (n.d.). Execution, Clearing, and Settlement. Retrieved from https://thismatter.com/money/stocks/settlement-and-clearing.htm
Mitchell, C. (2021, 6 April). Fail. Retrieved from https://www.investopedia.com/terms/f/fail.asp
Kritikos, M. (2018, September). What if blockchain offered a way to reconcile privacy with transparency? *Scientific Foresight Unit (STOA); European Parliment.* Retrieved

from https://www.europarl.europa.eu/RegData/etudes/ATAG/2018/624254/EPRS_ATA(2018)624254_EN.pdf
Tsai, K (n.d.). Your Public Value. Retrieved from https://yourpublicvalue.org/supply-chain-transparency-and-the-role-of-blockchain/
Conway, L. (2020, November 17). Blockchain Explained. Retrieved from https://www.investopedia.com/terms/b/blockchain.asp
Silver, C. (2020, February 14). How The Transparency Of Blockchain Drives Value. Retrieved from https://www.forbes.com/sites/forbestechcouncil/2020/02/14/how-the-transparency-of-blockchain-drives-value/?sh=49d6dc9531a6
Ibrahim, A. (2019, February 2). Does blockchain mean higher transparency in the financial sector?. *Blockchain, bitcoin y criptomonedas: Bases conceptuales y aplicaciones prácticas*, *27*, 71. Retrieved from https://accid.org/wp-content/uploads/2019/04/Does_Blockchain_mean_higher_transparency_in_the_financial_sectorlogo.pdf
Bryanov, K. (2018, July 28). Will Blockchain Technology Protect the World Economy from Financial Crises?. Retrieved from https://cointelegraph.com/news/will-blockchain-protect-the-world-economy-from-financial-crises
NYSE. (2021). Holidays & Trading Hours. Retrieved from https://www.nyse.com/markets/hours-calendars
Beers, B. (2021, April 2). Trading Hours of the World's Major Stock Exchanges. Retrieved from https://www.investopedia.com/ask/answers/040115/when-do-stock-market-exchanges-close.aspc
NASDAQ. (2021, April 23). *Amazon.com, Inc. (AMZN).* [Stock quote]. Retrieved from https://finance.yahoo.com/quote/AMZN?.tsrc=applewf
NASDAQ. (2021, April 23). *Tesla, Inc. (TSLA)*. [Stock quote]. Retrieved from https://finance.yahoo.com/quote/TSLA?.tsrc=applewf
Martin, N. (2020, September 8). *What is DeFi? A Beginner's Guide to Decentralized Finance* [Video clip]. Retrieved from https://www.youtube.com/watch?v=btB__oHQ0sU
defipule.(2021). Total Value Locked (USD) in DeFi. Retrieved from https://defipulse.com/
Binance Academy. (2021, April 23). What Are Liquidity Pools in DeFi and How Do They Work?. Retrieved from https://academy.binance.com/en/articles/what-are-liquidity-pools-in-defi
The Capital. (2021, March 10). DeFi and tokenization together reshape the financial system. Retrieved from https://medium.com/the-capital/defi-and-tokenization-together-reshape-the-financial-system-ca8e8939c167
Tran, K., C. (2020, April 2). What is MakerDAO?. Retrieved from https://decrypt.co/resources/makerdao-guide-learn-explained-decrypt-3-minutes
Defirate. (n.d.). Collateralized Loans in DeFi. Retrieved from https://defirate.com/collateralized-loan/
Unrug, W. (2020, October 23). The future of asset tokenization is in regulators' hands. Retrieved from https://securities.cib.bnpparibas/the-future-of-asset-tokenization-is-in-regulators-hands/
Harbor. (n.d.). About us. Retrieved from https://harbor.com/about
European Commission. (2020). Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Markets in Crypto-assets, and amending Directive (EU) 2019/1937. Brussels, Belgium. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020PC0593

Yahoo! Finance. (2021, April 25). *Tesla, Inc. (TSLA)*. [Stock quote]. Retrieved from https://finance.yahoo.com/quote/TSLA/history?p=TSLA
Yahoo! Finance. (2021, April 25). *Amazon.com, Inc. (AMZN)*. [Stock quote]. Retrieved from https://finance.yahoo.com/quote/AMZN/history?p=AMZN
Yahoo! Finance. (2021, April 25). *General Motors Company (GM)*. [Stock quote]. Retrieved from https://finance.yahoo.com/quote/GM/history?p=GM
Yahoo! Finance. (2021, April 25). *Facebook, Inc. (FB)*. [Stock quote]. Retrieved from https://finance.yahoo.com/quote/FB/history?p=FB
Yahoo! Finance. (2021, April 25). *McDonald's Corporation (MCD)*. [Stock quote]. Retrieved from https://finance.yahoo.com/quote/MCD/history?p=MCD
CoinMarketCap. (2021, April 25). *Propy (PRO)*. [Token quote]. Retrieved from https://coinmarketcap.com/currencies/propy/historical-data/
CoinMarketCap. (2021, April 25). *IHT Real Estate Protocol (IHT)*. [Token quote]. Retrieved from https://coinmarketcap.com/currencies/iht-real-estate-protocol/
CoinMarketCap. (2021, April 25). *Atlant (ATL)*. [Token quote]. Retrieved from https://coinmarketcap.com/currencies/atlant/
CoinMarketCap. (2021, April 25). *Primalbase Token (PBT)*. [Token quote]. Retrieved from https://coinmarketcap.com/currencies/primalbase/historical-data/
CoinMarketCap. (2021, April 25). *Ecoreal Estate (ECOREAL)*. [Token quote]. Retrieved from https://coinmarketcap.com/currencies/ecoreal-estate/historical-data/
Ycharts. (n.d). *2 Year Treasury Rate*. [Treasury bill]. Retrieved from https://ycharts.com/indicators/2_year_treasury_rate
Norges Bank. (2020, June). *Treasury bills monthly average.* [Treasury bill]. Retrieved from https://www.norges-bank.no/en/topics/Statistics/Interest-rates/Treasury-bills-monthly/
CoinMarketCap. (2021, April 25). About CoinMarketCap. Retrieved from https://coinmarketcap.com/about/

NTNU

Norwegian University of
Science and Technology