FACULTEIT ECONOMIE EN BEDRIJFSKUNDE

IMPACT ASSESSMENT OF DIGITAL ASSETS ON SECURITIES MARKETS

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Preface

My first introduction to the world of cryptography, blockchain and decentralised consensus was in 2017 while reading the whitepaper of Bitcoin by the mysterious Satoshi Nakamoto. At that point in time I barely had any knowledge of financial markets but could sense the revolutionary vision behind blockchain and cryptocurrencies.

As an automation-engineering student I was able to understand the technological workings of blockchain but it was hard to grasp the implications this piece of code would have. Purely out of interest I started researching more and more about financial markets and economics which eventually led to my decision to study economics at the University of Ghent. During these studies my interest in financial markets and macroeconomics was fueled by the enthusiasm of my professors. One of these professors was Prof. Dr. Rudi Vander Vennet who passionately shared his knowledge on banking and finance in an understandable and intuitive manner with his students.

The new economic framework I built up during my studies allowed me to better understand the importance of distributed ledgers, decentralised finance and tokenisation. I am now convinced that decentralisation will engulf many aspects of our life beyond finance. As a result of my great interest in digital assets I wanted to research their impacts on securities markets for my masters dissertation. What you will read is the result of passion and interest with the side effect of hopefully obtaining my degree in economics.

I encountered multiple interesting research subjects during the making of this dissertation and hope that my work triggers the interest for distributed ledgers and decentralisation in others.

I extend great gratitude towards my promotor prof. Rudi Vander Vennet for sharing his passion for financial markets with me and the other students. I would also like to thank him for his advice and insights and for the flexibility he gave me while writing this dissertation.

Furthermore, I cannot thank my parents, family and girlfriend enough for their unconditional support.

Joren Buyse, augustus 2021

Admission to loan

Joren Buyse, August 2021

Impact assessment of digital assets on securities markets

door

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Samenvatting

De bedoeling van dit werk is om de fundamentele opportuniteiten en uitdagingen van *digital assets* met de nadruk op *security tokens* te onderzoeken en evalueren uit het perspectief van zowel investeerder als uitgever. De onderliggende gedachte is om te ontdekken of *security tokens* kunnen fungeren als mogelijke oplossing voor het gebrek aan financiering voor kleine en middelgrote ondernemingen (KMOs) binnen de Europese Unie. Een empirische analyse van historische prijsdata, informatie omtrent de uitgever en andere karaktiristieken van *security tokens* poogt om de uitspraken gemaakt in het kwalitatieve deel kwantitatief te bevestigen. Dit werk draagt bij aan de huidige literatuur door te onderzoeken of *security tokens* deel van de oplossing kunnen zijn voor het gebrek aan financiering voor KMOs aan de hand van een impact analyse vanuit oogpunt van uitgever en investeerder. De resultaten geven aan dat de mate waarin *security tokens* een additionele toestroom van kapitaal voor KMOs kunnen veroorzaken afhangt van verdere ontwikkeling van secundaire markten om liquiditeit te voorzien en van verbetering in standaarden omtrent transparantie en financiële rapportering voor minder asymmetrische informatie.

Trefwoorden

Cryptoassets, digital assets, security tokens, security token offering (STO), tokenisation

Abstract

This article intends to outline and evaluate the fundamental opportunities and challenges of security tokens and digital assets in general from the perspective of both investors and issuers in order to gauge the potential impacts on securities markets. The secondary intention of the research is gauging whether security tokens could help close the SME financing gap in Europe. An empirical analysis based on historical price data, issuer information and issuance characteristics of publicly tradable tokens intends to quantitatively verify the qualitative statements. This study adds to the current literature by incorporating the SME financing gap within the impact assessment and also adds to it by covering advantages and disadvantages within multiple facets of finance from the standpoint of both investors and issuers. The results indicate that the degree of potential increased flow of capital towards SMEs depends on the further development of secondary markets for security tokens to provide liquidity and on improved disclosure standards to decrease information asymmetry.

Impact assessment of digital assets on securities markets: extended abstract

Joren Buyse

Supervisor(s): Rudi Vander Vennet

Abstract— **This article intends to outline and evaluate the fundamental opportunities and challenges of security tokens and digital assets in general from the perspective of both investors and issuers in order to gauge the potential impacts on securities markets. The secondary intention of the research is gauging whether security tokens could help close the SME financing gap in Europe. An empirical analysis based on historical price data, issuer information and issuance characteristics of publicly tradable tokens intends to quantitatively verify the qualitative statements. This study adds to the current literature by incorporating the SME financing gap within the impact assessment and also adds to it by covering advantages and disadvantages within multiple facets of finance from the standpoint of both investors and issuers. The results indicate that the degree of potential increased flow of capital towards SMEs depends on the further development of secondary markets for security tokens to provide liquidity and on improved disclosure standards to decrease information asymmetry.**

Keywords— **Cryptoassets, digital assets, security tokens, security token offering (STO), tokenisation**

I. Introduction

THE term digital asset refers to any asset in digital form using distributed ledger technology (DLT). Three types of digital assets can be discerned: utility tokens, payment tokens and security tokens.

Research by the European Commission and European Investment Bank indicates that there are significant financing gaps for small and mid-sized enterprises across the entire European Union. They also state that financial instruments are part of the solution to close that gap. [1]

In this extended abstract, I will cover opportunities and challenges of digital assets in multiple areas to outline the impacts of digital assets on securities markets with the secondary purpose of discovering to which extent security tokens and digital assets are suitable to close the SME financing gap.

The first section will elaborate on digital assets as an investment, the second on digital assets as an alternative funding mechanism through Security Token Offerings (STO). Afterwards, I will discuss the empirically verified findings of the study regarding secondary market liquidity, token returns, correlations with traditional assets and real estate tokens. Finally, the findings of the study are summarised.

II. Digital assets as an investment

A. Opportunities

Digital assets have the ability to reshape the security settlement cycle by improving settlement time, cutting out intermediaries and lowering costs [2]. The scale of the impact depends on the reaction of Central Securities Depositories (CSD) and other intermediaries. The existence of tokenised stocks illustrates the disruptive nature of DLT within securities settlement. Tokenised stocks are tradable 24/7, are divisible and generally have marginally lower trading costs than their traditional counterpart.

Perfect divisibility is an attractive property of digital assets for investors. It allows for better portfolio optimisation by removing the barriers of imperfect divisibility. The ability to scale an investment to the exact need of the investor will have the largest impact in portfolio management of small portfolios, such as those of retail investors.

Investments in high value assets, such as real estate, through fractional ownership can be improved by DLT and security tokens. Fractional ownership allows investors who lack the funds for the entire asset to share revenue and usage rights with other owners of the asset. Tokenising real estate property improves the liquidity of the investment and allows for distribution of renting revenue and other rights through the distributed ledger.

Research suggests that Bitcoin and other cryptocurrencies can serve as a diversification tool to reduce risk and improve returns in a well-balanced portfolio [3].

Smart contracts, i.e. digital contracts based on decentralised consensus, have the ability to automate multiple facets of securities markets, such as dividend payments, ownership transfers, insurance, voting rights and regulatory know-your-customer (KYC) and anti-money-laundering (AML) implementations.

Furthermore, tokenisation has the potential to provide liquidity for traditionally illiquid assets through creation of tradable tokens and a secondary market for said tokens. Data of publicly tradable tokens suggest that the secondary public market is currently underdeveloped and liquidity is poor for most tradable tokens. However, real estate tokens show promise of improved liquidity.

The most important benefit of security tokens in regards to the SME financing gap is the accessibility of private markets for retail investors. STOs of early stage capital, such as private placements, allow investors to directly allocate their capital in otherwise inaccessible private markets. This could result in an increased flow of retail funds to SMEs.

B. Limitations

Digital assets entail additional technology risk related to DLT, hacks and cyberattacks. Technology risk is manageable but not completely avoidable. On top of this, the risk of human error plays a large role. It is not unheard of that private keys (needed for access of DLT assets) are lost which renders the assets irretrievable.

Cryptocurrency returns, in aggregate, are correlated to Bitcoin returns [4]. It is plausible that this form of systemic risk is also present in security tokens, but there is not enough historical price data to verify or deny this.

Secondary markets for security tokens might be underdeveloped, indicated by the low trading volumes of publicly tradable security tokens. My findings show that decentralised exchanges currently offer greater trading volumes than centralised exchanges due to the presence of Automated Market Makers (AMM).

There is inadequate reliable information available on the issuers of security tokens which leads to information asymmetry in the primary market of security tokens. The lack of information in combination with negative reputation of token offerings due to controversies surrounding Initial Coin Offerings (ICO) results in low credibility of tokenisation markets.

In their current state, security tokens share similarities with over-the-counter (OTC) markets. OTC markets are characterised by low market capitalisations, low liquidity and speculation.

III. Digital assets for funding purposes

Digital assets are applicable to the three main ways of raising capital, namely issuing equity or debt and retained earnings. STOs are suitable for issuance of debt and equity, while ICOs provide temporary revenue for retained earnings.

A. Opportunities

Organising an STO is possible at any stage of a venture, from seed capital to IPO.

Companies in their early stages have access to a broader set of investors on top of venture capitalists and angel investors. STOs launched in the beginning stages can function like crowdfunding to attract a large number of small-sized investments and attract bigger investors, such as venture capitalists, at the same time. Creating liquidity for traditionally illiquid early stage capital could increase flow of capital towards SMEs.

Security tokens can be traded between token-holders on the distributed ledger itself with relative ease, which allows for liquid investments during earlier stages of a venture.

The universal and flexible nature of security tokens allows issuance platforms to cover equity and debt funding with exactly the same infrastructure. This could result in higher overall cost-efficiency of security token issuance compared to the traditional counterparts such as Initial Public Offerings (IPO).

A.1 Limitations

The current state of liquidity on the secondary market raises questions for investors. Low trading volumes and large numbers of zero-volume trading days are not indicative of healthy liquidity. This can drive up the liquidity premium, where investors expect higher returns in order to invest in an illiquid asset. An increased liquidity premium can result in lower amount of funds raised for security token issuers.

The presence of information asymmetry, mainly due to the lack of disclosure standards, introduces inefficiency to the primary market of security tokens. The presence of asymmetric information can impose another premium on the security tokens, further lowering the fundraising possibilities for issuers.

It is unclear which direction the security token markets will take. This depends among other things on technological advancements and the changing regulatory environment. Because of the unpredictability, possible entrants of these markets might be hesitant and take a wait-and-see position before entering.

IV. Empirical verification

The foundation dates of the corporations organising STOs within our sample confirm that STOs can be used as early stage funding as half of the tokens were issued by companies less than 6 years old. The large range of maturities of issuers, 1 to 22 years old, confirms the flexibility of security tokens for funding.

Real estate, funds and digital assets are the three largest industries by number of issuers of security tokens with 5 out of 19 issuers for each of them. Real estate is by far the largest if counting by number of issued security tokens (14 out of 28 tokens in our sample), mainly due to the large number of tokens issued by one issuer (RealT).

The diversification potential of security tokens and the systematic risk (correlation with Bitcoin) can not be confirmed or denied due to the small sample size of historical price data of publicly tradable tokens resulting in statistically insignificant results.

The liquidity concerns for security tokens are confirmed by the the large amount of zero-volume trading days. The weighted average (by market capitalisation) ratio of zero-volume trading days to total trading days since inception was 0,4 for all publicly tradable tokens in our sample. This means that on average, for every 10 trading days there were 4 days with zero volume.

I introduced a metric, the volume-to-market-capitalisation (VMC) ratio to measure and compare trading volumes across assets with different market capitalisations. The VMC ratio was applied to top 100 small-cap stocks and the US OTC market for comparison with security tokens, see table I. At first glance the results indicate that security tokens score better than the US OTC market in regards of liquidity. However, when omitting the top two security tokens by market cap (Overstock and tZERO) the VMC ratio of the sample decreases with factor 10, which indicates poor liquidity for the rest of the sample. Real estate tokens issued by RealT score better than the small caps and the US OTC market, confirming that security tokens posses the ability to bring liquidity to otherwise illiquid assets such as real estate.

Returns of RealT tokens further illustrate the potential of real estate security tokens. Seven out of nine tokens in the sample outperformed the Dow Jones Real Estate (DJRE) index since their issuance.

	VMC Ratio
US OTC market	0,0040
Top 100 Small Caps	0,0179
Security tokens	0,0095
Security tokens (excl. top 2)	0,0010
RealT security tokens (real estate)	0,0455

TABLE I
VMC RATIO COMPARISON

V. Conclusion

Security tokens definitely have the potential to disrupt certain aspects of securities markets. Currently they are held back by underdeveloped secondary markets and a lack of disclosure standards.

The most prominent advantages for investors are the perfect divisibility of tokens, the possibility of improved securities settlement due to DLT, easier access to private markets and fractional ownership and the portfolio diversification potential of cryptocurrencies.

Investors in digital assets have to take into account the additional technology risk, risk of human error and systematic risk (correlation to Bitcoin) and the underdeveloped secondary markets of security tokens in terms of disclosure standards and liquidity.

The possibility to organise STOs during any stage of the venture, the potential for less illiquid early stage capital and access to a broader set of investors are the most prominent advantages for issuers. On the flipside, issuers need to be wary of the legal and technological uncertainty surrounding STOs and the extra premiums investors might impose on security tokens due to low liquidity and poor information disclosure.

Whether security tokens can increase the flow of capital towards SMEs depends on the further development of secondary markets to provide liquidity and disclosure standards to decrease information asymmetry.

One area where security tokens have fully proven their potential is in the real estate market where their liquidity and returns outperform the traditional counterparts.

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Abbreviations

AMM	Automated Market Makers
AML	Anti-Money-Laundering
ATS	Alternative Trading System
CAGR	Compounded Annual Growth Rate
CCP	Central Counter Party
DCC-GARCH	Dynamic Conditional Correlation General Autoregressive Con-ditional Heteroskedas
DEX	Decentralised Exchange
DJRE	Dow Jones US Real Estate
DLT	Distributed Ledger Technology
ERC-20	Ethereum Requests for Comments 20
ETF	Exchange Traded Fund
FINRA	Financial Industry Regulatory Authority
ICO	Initial Coin Offering
(I)CSD	(International) Central Securities Depository
IPO	Initial Public Offering
KYC	Know-Your-Customer
MiCA	Markets in Cryptoassets regulation
MiFID	Markets in Financial Instruments Directive
OECD	Organisation for Economic Co-operation and Development
OTC	Over-The-Counter
PoS	Proof of Stake
PoW	Proof of Work

REIT	Real Estate Investment Trusts
SEC	Securities and Exchange Commission
SME	Small and Mid-size Enterprises
STO	Security Token Offering
USD	United States Dollar
VAR	Vector Autoregressive
VMC Ratio	(Monthly) Volume to Market Capitalisation Ratio

Chapter 1

Introduction

1.1 Defining security tokens, utility tokens and payment tokens

There are three types of digital assets that are relevant in the context of this dissertation, namely security tokens, payment tokens and utility tokens. There are multiple terminologies and definitions used to discern these three. Differentiating these tokens based on their purpose, rather than their technological implementation or any other criteria allows for clear distinctions to be made among them. As such, the following paragraphs describe the different token types based on their purpose. The main characteristics of the token-types are shown in table 1.1.

	Security tokens	Payment tokens	Utility tokens
What	Investment product	Currency for transactions	Consumption rights within ecosystem
Used for	Tokenising securities	Payments	Interacting with ecosystem
Underlying asset	Security or asset	None (other currency in case of stablecoins)	None
Issuance	Security token offering	Initial coin offering	Initial coin offering
Security regulation	Yes	No	No

Table 1.1: Security tokens, payment tokens and utility tokens

"A security token is a digital representation of an investment product, recorded on a distributed leger, subject to regulation under securities laws." (Lambert *et al.*, 2021, p.5). This definition outlines the purpose of security tokens, as well as the technology and regulation. In order to clearly explain what is understood under security tokens, the definition proposed by Lambert *et al.* (2021) is dissected in the following paragraph.

A digital representation is an electronic record of a certain contract. The current securities clearing and settlement is based on electronic book-entries at central securities depositories (CSDs) or other intermediaries. Tokenisation could alter some structures of the securities settlement value chain and move them to distributed ledger technology. The purposes of an investment product are capital gains and/or income generation. Securities such as stocks, bonds, derivatives or other fall under this umbrella. Lambert *et al.* (2021) discern equity tokens, debt tokens, income-share tokens and fund tokens. The use of distributed ledger technology (DLT) for both issuance and transactions is a key component of the definition of security tokens and differentiates centralised book-entries of securities from security tokens. Section 1.2.2 contains more information about distributed ledger technology. The final part of the definition states that the tokens need to fall under relevant securities regulations and need to have the legal status of a security to be considered a security token.

OECD defines two types of 'security tokens', namely 'tokens representing a pre-existing real asset' and 'tokens "native" to the blockchain' (Nassr, 2020, p.13-15). This differentiation could be generalised by replacing 'blockchain' with 'distributed ledger'. Thus, two types of security tokens exist, those who are the sole securitised form of an asset, issued through a security token offering (STO) and tokenised securities which are tokenised versions of securities already existing outside of the distributed ledger. For clarity purposes, the former will be referred to as security tokens, the latter as tokenised securities.

Tokenised securities are digital representations of pre-existing traditional assets using DLT. Tokenised stocks are an example of this. On the other hand, security tokens do not represent a security that exists outside of the distributed ledger, they are the sole representation of the underlying asset (Van der Loo *et al.*, 2019, p.9).

Technologically these tokens are much alike but the difference in origination has implications on the public accessibility, regulation and possibly liquidity on secondary markets. Security token offerings are often exclusively for accredited or professional investors, similar to private placements. Tokenised securities are most often the representation of publicly accessible securities such as stocks or bonds of public companies or governments. Figure 1.1 is a schematic representation of the linkages between security tokens, tokenised securities and traditional assets.

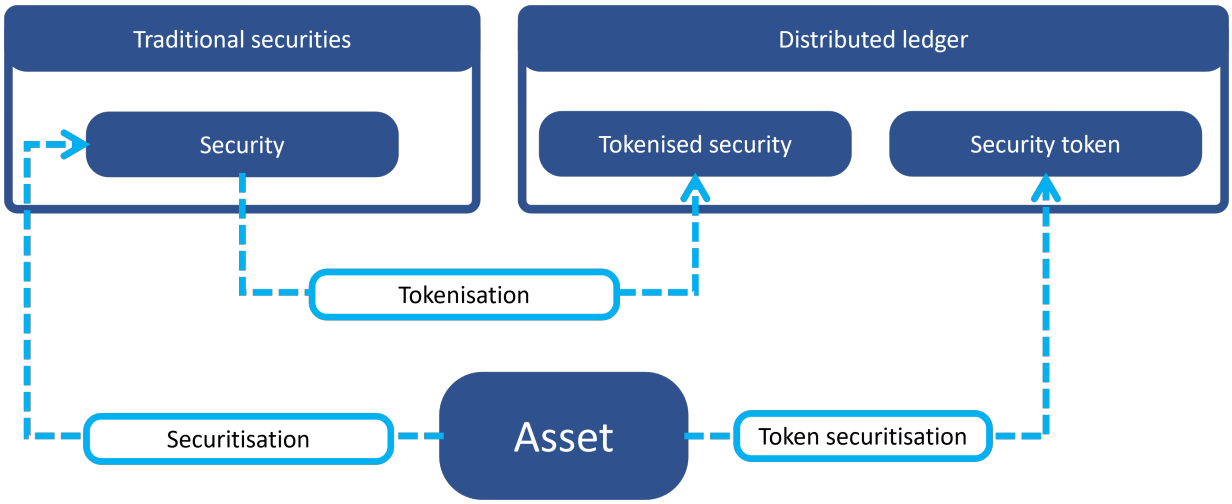


Figure 1.1: Linkages between an asset, traditional securities, tokenised securities and security tokens

Utility tokens have a different purpose, they represent consumptive rights in a certain ecosystem to its holders. Utility tokens are often issued by non-profit foundations through an ICO and are comparable to reward-based crowdfunding, while STOs are comparable to equity-based crowdfunding (Block *et al.*, 2021, p.871). Utility tokens are not subject to securities regulations.

Payment tokens, commonly referred to as cryptocurrencies, enable payments on a distributed ledger, often within their own ecosystem. Payment tokens do not grant any rights to the holder and are solely used for payment. They are not considered securities and as such do not fall under securities laws.

1.2 Tokenisation and distributed ledger technology

1.2.1 Tokenisation

Tokenisation refers to the digital representation of asset ownership on a network that is not governed by a central authority, such as security tokens on a distributed ledger. Tokenisation is thus comparable to securitisation in the traditional sense but is differentiated by the fact that the tokens are created and exist on a decentralised network. The decentralised network should be designed in such a way that tokens are non-falsifiable, storable and transferable. Distributed ledgers meet these demands. The word decentralised implies that no central authority controls the network and its tokens, yet most networks have some form of centralised governance for development and maintenance of the network. The network can be structured as such that the decentralised nature (i.e. no need for trusted intermediaries) is not jeopardised by centralised governance of development. Compliance with regulation can be ensured by implementation of said regulation through smart contracts on the network. The key takeaway here is that there is no central authority responsible for validation and transaction of digital assets and thus some intermediaries can be eliminated when compared to traditional assets.

1.2.2 Distributed ledger technology

"A DLT system is a system of electronic records that enables a network of independent participants to establish a consensus around the authoritative ordering of cryptographically-validated transactions. These records are made persistent by replicating the data across multiple nodes, and tamper-evident by linking them by cryptographic hashes. The shared result of the reconciliation/consensus process – the 'ledger' – serves as the authoritative version for these records" (Rauchs *et al.*, 2018, p.24). The network of independent participants (nodes) are contributing to the working of the ledger by providing consensus through a Proof of Work (PoW), Proof of Stake (PoS) or other consensus protocols. For most distributed ledgers, these participants are rewarded in some way (for example with a native utility token) for their contribution. As such, an incentive is created to contribute to the network. There is only one valid version of the transaction history across the entire network. Transactions are validated based on cryptographic computations, there are multiple types of cryptographic implementations that facilitate this, one of such is asymmetric cryptography. The record of transactions is either replicated entirely or partially on each

node. It is possible to determine the validity of certain transactions without needing access to the whole transaction-chain, for example with the use of Merkle trees (Becker, 2008).

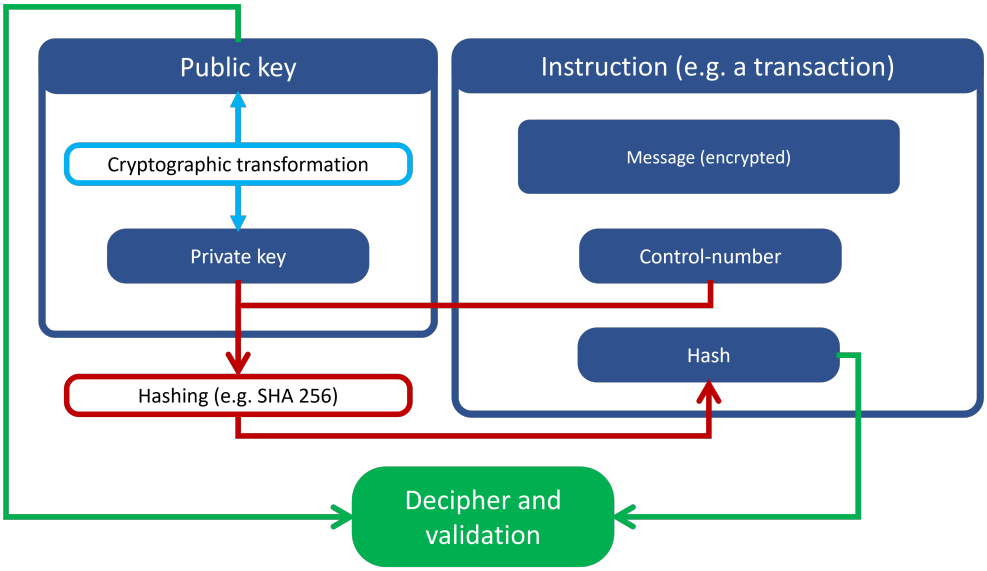


Figure 1.2: Asymmetric cryptography

A lot of distributed ledgers are based on asymmetric cryptography, using public and private keys. The private key is used to sign (encipher) instructions on the ledger while the public key is used to validate (decipher) the identity of the sender. Figure 1.2 is a simplified schematic representation of the process. Private and public keys are a one-way cryptographic transformation of each other, meaning that a private key cannot be deciphered based on the associated public key, and that the public key can be used to validate messages signed with the private key. Added to an instruction on the ledger is a control-number and an enciphered version of it, which is a hashed combination of the control-number and the private key. A hash is the output of a cryptographic transformation of a certain input, in this case a combination of the control number and private key (red arrows on figure 1.2). The public key associated with the sender of the instruction can then be used in combination with the hash to decipher the message and validate it (green arrows on figure 1.2). This process ensures that the instruction is immutable by participants who don't have access to the private key and that everyone with access to the public key can validate the sender of the instruction.

Distributed ledgers work on three layers, a protocol layer, a network layer and an application layer (Demirors, 2017). The protocol layer contains the foundations and rules of the distributed ledger, actors on this layer are researchers, academics and developers. The network layer is the actual implementation of the protocol. The main actors on the network layer are controllers of nodes, traders, regulators and other network operators. The application layer contains the actual use-cases of the protocol for the end-user. On this layer, the actors include application developers, investors and the end-users.

1.2.3 Platforms for tokenisation

There are multiple platforms that facilitate creation of tokens, each with their own token protocol. One of such platforms is the opensource platform Ethereum, whose protocol is designed for building decentralised applications and creating tokens to use within this application (Buterin, 2014). A common token standard for Ethereum-based applications is Ethereum Requests for Comments 20 (ERC-20). Other examples of token platforms include Stellar, Cardano and Polkadot. It is not within the scope of this paper to analyse and discuss these platforms in depth.

Issuance platforms catered towards security tokens often work with an in-house token protocol, with the intent to allow full customisation and optimalisation of smart contracts. Examples of issuance platforms are Polymath, Swarm, Bankex, Harbor and Securitize. The possibility of including compliance (KYC and AML) on-chain with smart contracts is a major selling point for issuance platforms and as such is present on most issuance platforms.

1.3 The financing gap for small and mid-sized enterprises (SMEs)

Research by the European Commission & European Investment Bank (2019) indicates that there are significant SME financing gaps across the European Union. This financing gap applies to both debt and equity financing.

One of their conclusions regarding financial instruments that is relevant within this study is the following: "Financial instruments can play an important role in facilitating SMEs' access to finance in the current economic context, given their capacity to address a higher

level of risk and leverage private sector resources." (European Commission & European Investment Bank, 2019, p.40). Security tokens are capable of leveraging private sector resources by providing access to retail investors and could thus play an important role.

Analysing the distribution of financing gaps in the EU is not within the scope of this paper. The presence of gaps justifies researching whether security tokens could improve the situation.

Chapter 2

Security tokens

In short, a security token is the digital representation (on a distributed ledger) of either a debt, equity, derivative or hybrid security. It can thus represent a plethora of assets, such as stocks, bonds, ownership and voting rights in a company, real estate equity or loans.

2.1 Security token origination

OECD defines two types of tokens, namely 'tokens representing a pre-existing real asset' and 'tokens "native" to the blockchain' (Nassr, 2020).

Tokens native to the distributed ledger have no pre-existing security and are the sole representation of the underlying asset. These are security tokens and are issued through a security token offering (STO), which is comparable to an initial public offering (IPO) in terms of structuring and legal requirements.

The main differences between an IPO and STO are the manner of issuance (investment banks for IPOs, issuance platforms for STOs), accessibility for retail investors and the fact that STOs can be launched earlier during the equity funding stages than IPOs, which are typically the last step for a company to attract equity capital. IPOs are public offerings and are accessible for retail investors and institutional investors whereas the current STO landscape has a mixture of offerings exclusively for accreditted and institutional investors (such as Aspencoin and REICG) as well as offerings completely accessible to the public (such as Overstock and Tzero). In our sample of security tokens eight out of sixteen STOs were accessible to retail investors, six were exclusively for accredited investors and no information was available on the other two.

Tokenised securities are based on a pre-existing security and the token is only the digital representation of the traditional security rather than of the asset itself. These tokens are not issued through an STO. Tokenising securities is a transformation of the security to a distributed ledger and not a funding mechanism. This is an important distinction between tokenised securities and security tokens. It is implied that existing securities are compliant with regulation, in which case the tokenised securities need only be compliant with additional regulation regarding tokenisation specifically. An example of this type of origination are tokenised stocks, which are already publicly available on multiple trading platforms.

Securities issuance requires compliance with relevant security laws, such as MiFID and prospectus directive in EU. Section 2.3 outlines the current regulatory environment for STOs in Europe.

2.2 Security tokens in different markets

Due to the versatile nature of security tokens, they can be adapted to fit in different types of securities markets. In 2019 the issuance of securities through STOs consisted of 54% company equity, 16% participation certificate, 9% equity funds, 9% real estate investment and 8% bond/fixed income (Fintech Advisory Services, 2020).

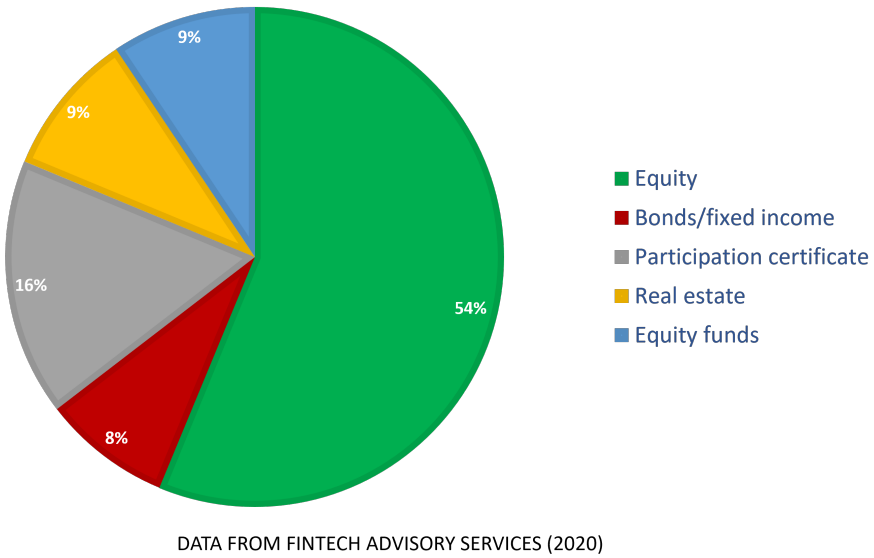


Figure 2.1: Issuance of security token in 2019

According to Security Token Group the market capitalisation of security tokens exceeded $740 million in June 2021, while the total trading volume in that month was around $8 million (Security Token Group, 2021). It must be noted that only publicly tradable security tokens are included in this report and that it thus does not reflect the entirety of the security token market.

Following paragraphs contain selected examples of security tokens in different markets. These tokens are included in the empirical study in this dissertation.

An example of a debt security token is Bitbond Token (BB1). The Bitbond Token was issued in Germany in 2019 as subordinated unsecured debt with a maturity of 10 years, a fixed annual coupon rate of 4% and a floating annual coupon rate of 60% of the pre-tax profit of issuer Bitbond Finance GmbH. The coupons are denominated in EUR but paid in Stellar Lumens (XLM) on the Stellar network. BB1 is compliant with the EU prospectus regulation. (Bitbond, 2019a) (Bitbond, 2019b)

In the equity markets, in 2019 MERJ issued a $4 million in ordinary tokenized shares with a subscription price of $2.42 and par value of $0.03 (MERJ Exchange Limited, 2021b). The token, MERJ-S, grants voting rights to the holder. The token has a market cap of $24 million as of March 16 2021 (MERJ Exchange, 2021).

Security tokens have the possibility to transform the traditionally illiquid nature of real estate investments. An example of this is the US company RealT, which tokenises real estate. Each real estate property is tokenised through a limited liability corporation and is managed by RealT. This enables fractional real estate investing for investors worldwide. Token holders receive rent automatically via the Ethereum network (RealT, 2021).

An example of security tokens used for equity funds is Arcoin. This token is the digital security representing equity participation in the Arca U.S. Treasury Fund (Arca Labs, 2021). The fund mainly invests in U.S. Treasury securities. Other examples of funds that make use of security tokens are Blockchain Capital, 22X Fund and Protos.

2.3 Regulation

This section serves as an indicative overview of the current regulatory environment in the European Union and is entirely based on a report by Scaglioni (2020).

The EU has no uniform definition on digital assets, security tokens or STOs. In general, security tokens fall under exactly the same regulation as tradional securities (MiFid and others) but depending on the jurisdiction there might be additional regulations specifically for STOs and digital assets. Currently there is no overarching EU regulatory framework for STOs, which results in differing legislation across jurisdictions.

A proposal for regulations regarding cryptoassets was drafted in September 2020 under the name MiCA. The intention of this proposal is for harmonisation across the EU.

The current regulatory environment entails inefficiency and extra hurdles for STO issuers. "For any individual STO, the regulatory analysis will need to be considered on a case-by-case basis and will be affected by various factors, including the specific laws and regulations of the relevant jurisdiction(s) in relation to STOs or cryptoassets and DLT more generally, and its application by local regulators and the fact that the technical infrastructure and nature of STOs may change or evolve very quickly." (Scaglioni, 2020, p.9). The need for a case-by-case analysis results in delays and extra costs for the issuance process which might deter potential issuers from participating in the market.

This is also confirmed by a working document by European Commission Staff (2020) regarding markets in cryptoassets that outlines what the European Commission regards as drivers, problems and consequences within the cryptoasset landscape. The main drivers are lack of uncertainty as how existing EU rules apply, absence of rules at EU level and divergence in national rules within EU.

Regulatory obstacles for implementation of DLT and gaps in existing legislation are identified as the main problem for cryptoassets covered by EU regulation. Potential increases in efficiency regarding issuance and trading are missed as a consequence. The European Commission also considers missed funding opportunities for start-ups and companies (through low level of ICOs/STOs) as another consequence thereof. Cryptoassets that do not fall under EU regulation impose risks for investor protection, market integrity and unfair competition between cryptoassets. There are concerns regarding financial stability and monetary policy in the context of stablecoins. (European Commission Staff, 2020).

2.4 Tokenisation ecosystem

The tokenisation ecosystem is complex, continuously evolving and consists of many different types of participants.

The main actors of the primary market of security tokens are issuance platforms. These platforms facilitate the security token offerings technologically and often offer assistance for other aspects relating to the issuance of tokens, such as AML, KYC and regulation. Issuance platforms can either issue tokens through their own distributed ledger protocol or depend on third-party protocols, such as Ethereum or Stellar.

The secondary market for security tokens consists of centralised and decentralised exchanges. Decentralised exchanges run on a distributed ledger and are constructed with smart contracts. Exchanges provide the connection between supply and demand and are beneficial for trading even though tokens can be transacted on their proper distributed ledger network.

Other actors on the secondary market are broker-dealers, who either trade on their own behalf or for clients. Their activities can also include market making, which provides liquidity to the markets. Market making can also occur in the form of Automated Market Making (AMM), in this case an algorithm is responsible for the trading. AMM is often found on decentralised exchanges to provide liquidity.

Platforms offering tokenised securities often partner with custodians, whose responsibility is the safekeeping of securities and tokens. The platform is then responsible for all on-chain activities, while the custodian is responsible for the underlying securities.

Market participants within the compliance department have multiple responsibilities, under which identification of investors, KYC and AML. Implementation of on-chain compliance is an important use-case of digital assets and could streamline the compliance process.

Chapter 3

Digital assets for investment purposes

This chapter will go over the use cases, limitations and opportunities of digital assets for retail and institutional investors. Firstly, the advantages and opportunities of digital assets in comparison to traditional assets will be listed and analysed from a fundamental perspective. The next section describes the weaknesses and limitations of digital assets. If possible, findings from this fundamental analysis will be tested empirically in the final section by using a collection of data of publicly tradable digital assets.

Digital assets exist as utility tokens, payment tokens or security tokens. The main focus of this chapter is on security tokens but certain aspects of utility and payment tokens will also be discussed when relevant.

3.1 Fundamental/qualitative analysis

3.1.1 Opportunities

Perfect divisibility

The first fundamental advantage of security tokens is the fact that they are in theory perfectly divisible. This perfect divisibility allows investors to precisely scale the investment to their needs. Klein (1973) argued that imperfect divisibility of primary securities is a necessary condition for the emergence of certain financial intermediaries (Klein, 1973, p. 930). Take an Exchange Traded Fund (ETF) of a stock-index as an example. The ETF gives

diversified exposure to an underlying index (or investment theme). With the assumptions of no trading costs and perfect divisibility of securities, the demand for an index-ETF would dramatically shrink, as investors could mimic the distribution of an index themselves (or through automated smart-contracts) with divisible assets. Furthermore, perfect divisibility eliminates the need for stock splits, whose purpose is to lower the trading price of stocks with the intent to increase liquidity. Stocks with a high trading price are often overlooked by retail investors because the weight of these stocks in a portfolio cannot be balanced or simply because the price of the stock is bigger than the available funds for investing. An example that illustrates this disadvantage of imperfect divisibility is the Lotus Bakeries stock, priced at €4865 on Euronext Brussels while writing (Euronext Brussels, 2021). For some retail investors buying just one share would overweight Lotus Bakeries in their portfolio, while a divisible token gives them the opportunity to appropriately size their investment. Digital assets such as tokenised stocks can thus solve issues related to imperfect divisibility.

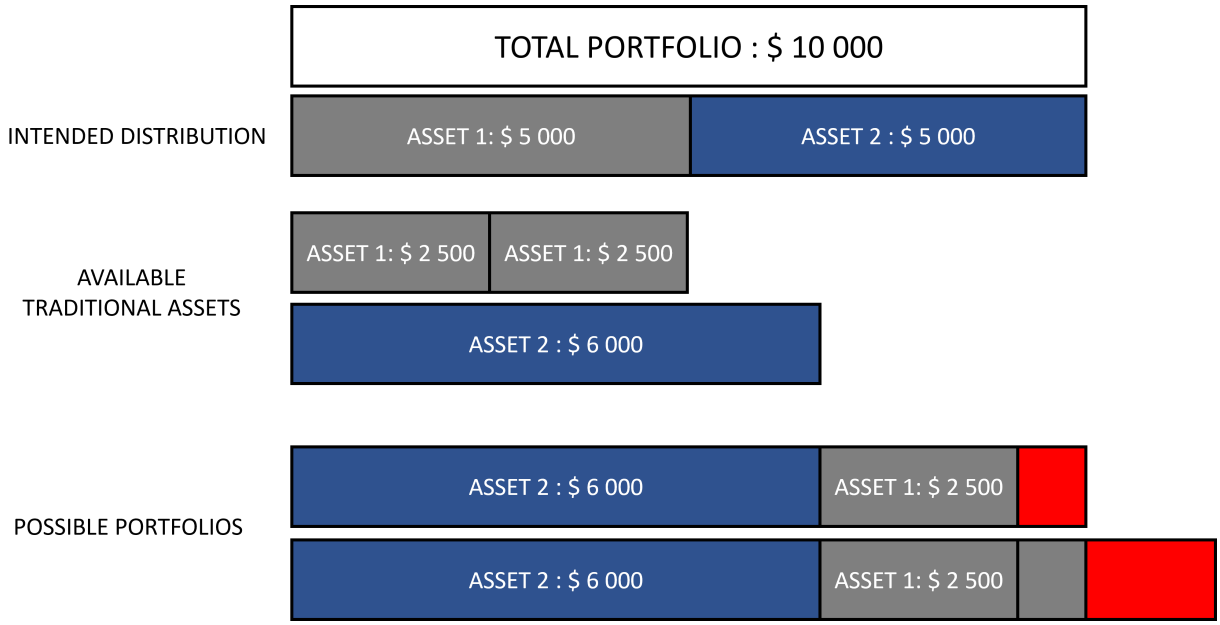


Figure 3.1: Illustration of portfolio misalignment due to imperfect divisibility

A hypothetical portfolio of two assets will be constructed as a demonstration of imperfect divisibility. Two conditions are imposed on the portfolio. The total portfolio should amount to $10000 and the intended distribution is 50% of asset 1 and 50% of asset 2. The price of asset 1 is $2500 while the price of asset 2 is $6000. It is impossible to construct a portfolio that fulfils both conditions as a result of indivisibility. This problem is illustrated in figure

3.1. The red rectangles indicate the deviation from intended portfolio size. Comparable problems for portfolio management would not occur with tokens.

Improved securities settlement

Another opportunity for distributed ledger technology is improving the settlement and clearing of securities. Bank for International Settlements *et al.* (2020) discusses the implications of distributed ledgers for the future of securities settlement and the properties of a suitable distributed ledger. Bank for International Settlements & Committee on Payments and Market Infrastructures (2017) approaches the matter from a technical angle. Currently, most securities are held in electronic book-entry accounts at (international) centralised securities depositories ((I)CSD) (Bank for International Settlements *et al.*, 2020). These CSDs are an extra intermediary, resulting in higher trading costs and longer settlement times. In a direct holding system, the owner of the security has an account directly with the CSD. However, in most cases another intermediary holds the owner's securities with the CSDs (Benos *et al.*, 2019, p.124). With the use of DLT, it is possible to track ownership of securities on ledgers accessible to all necessary parties. The ability to record ownership and transactions in a non-falsifiable, accessible and trustworthy manner on a distributed ledger could lower or change the need for intermediaries for trading securities, resulting in decreasing costs for trading and shorter settlement cycles (Bank for International Settlements *et al.*, 2020).

Bank of International Settlements (BIS) discuss the features that a distributed ledger for securities settlement should posses (Bank for International Settlements *et al.*, 2020). They argue that a distributed ledger built for securities settlement will most likely be permissioned, private and hierarchal. A permissioned ledger means that participants on the network need permission to change and update the ledger in order to validate transactions. As a result it is possible to give validation rights only to trusted parties. This also means that the parties with validation rights can be held accountable for breaching regulations. A private ledger means that transactions can only be initiated by participants with permission to do so, for example a ledger where participants need to create an account before being able to initiate transactions. A hierarchal structure pertains viewing rights of the ledger, each participant has a role with associated rights which allow them to view information relevant for their role. This means that certain data, such as the identity of security holders, could be made accessible to intermediaries while they are inaccessible for others. This could improve the total transparency of the settlement ecosystem and allow for smoother dataflow across market participants. A hierarchal structure is likely to be expedient for compliance

with privacy and bank secrecy law.

To pinpoint all the effects distributed ledgers could have on securities settlement, it is necessary to analyse them across the whole value chain. The first impact is disrupting the intermediation on securities settlement. The possibility of transactions and data transfer on and between different distributed ledgers weakens the necessity of CSDs and other intermediaries. The validation of securities and the central authority of CSDs could be replaced with partly decentralised validation and unfalsifiable data on the ledger. A lower amount of intermediaries results in lower overhead costs and faster settlement cycles because each stage of intermediation coincides with extra settlement time. From another perspective, distributed ledgers could impact the securities settlement market by granting individuals the possibility to write smart-contracts and automate securities settlement in their own way rather than relying on the automation done by intermediaries. It must be noted that self-executing smart contracts could trigger contagion and adverse feedback loops (Bank for International Settlements & Committee on Payments and Market Infrastructures, 2017).

However, there are arguments for the necessity of intermediaries in these markets because they smooth trade flows and provide liquidity in times of uncertainty and distress (OECD, 2020). The current centralised structure around CSDs will likely be mimicked by permissioned, private, hierarchal distributed ledgers. To avoid becoming obsolete, CSDs could lead the transformation of the securities settlement infrastructure and implement distributed ledger technology compatible with the traditional systems. The interoperability between token-based systems and the account-based system will be an important aspect of the transition. Another type of intermediaries that could be impacted by tokenisation of securities are Central Counterparties (CCP), who mitigate replacement risk (replacement costs due to price deviations of securities during settlement) during clearing of securities. Instantaneous settlement greatly decreases replacement risk and renders CCPs unnecessary.

Private market access for non-institutional investors

Digital assets could facilitate easier and wider access to private markets (Kühnel *et al.*, 2020). Kühnel *et al.* (2020) argue that the biggest opportunities for digital assets lie within private markets, rather than public markets. For example, security token offerings can provide access for retail investors to private placements, which are traditionally exclusively for institutional investors. This is a benefit for both investors and issuers.

Public markets are characterised by fairly efficient technologies while private markets are often inefficient and have limited interoperability. It should be noted that digital assets have to adhere to investor protection, which means that giving retail investors complete access to private markets is not feasible nor desirable. By improving the efficiency, accessibility, transparency and most importantly the liquidity of private markets, digital assets could allow for new types of private market products to be developed and made available to a wide range of investors, for example by automating workflows, data transfer and payments (Kühnel *et al.*, 2020). The accessibility of private markets results in a new flow of capital towards issuers, discussed in section 4.2.1. Security tokens are applicable for early stage funding for SMEs. By increasing the accessibility of private markets to non-institutional investors, such as private equity and seed capital, SMEs have access to a larger group of potential investors to attract capital which could help close the financing gap. Furthermore, an increase in liquidity in private markets improves the attractiveness and lowers the liquidity premium of early stage investments.

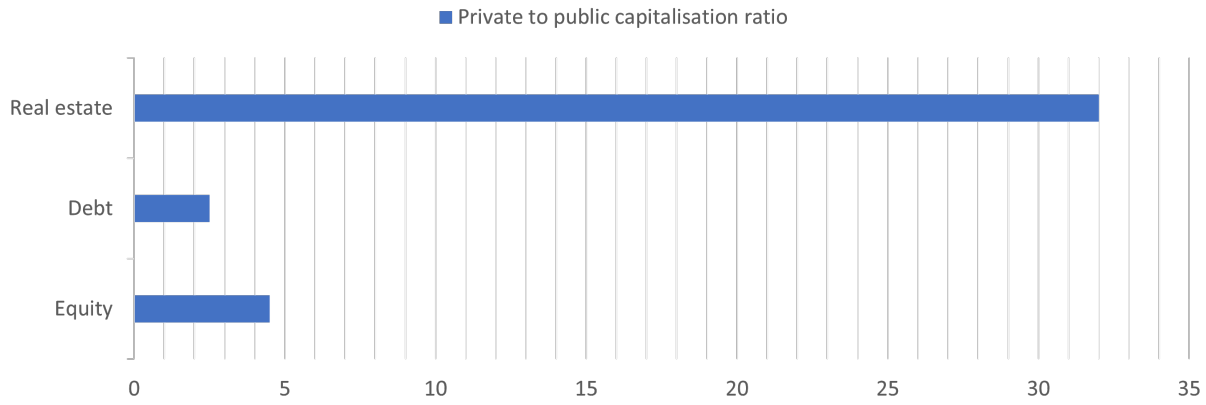


Figure 3.2: Private to public capitalisation ratios of real estate, debt and equity

The private to public market capitalisation ratios in 2019, shown in figure 3.2, were 4,5 for equity, 2,5 for debt and 32 for real estate, based on data from OECD, SIFMA, IIF, MSCI and Savills (Kühnel *et al.*, 2020). Analysis from Kühnel *et al.* (2020) of data provided by Preqin and World Bank concludes that the compounded annual growth rate (CAGR) of private market net asset value is around four times the CAGR of public market capitalisation. Considering the size and potential growth rate of private markets, an argument can be made that the most prominent impact of digital assets could be situated in private markets. With a new inflow of non-institutional capital towards private markets, the size and growth rate could increase even further. Regulators and market participants should

anticipate the possibility of structural changes within this landscape.

However, the lack of a reputable regulatory framework for financial reporting and financial requirements for security tokens entails information asymmetry risk for investors. In this regard, security tokens could be seen as a modernised form of pink sheets or OTC Pink shares. Currently, security tokens are thus not a revolutionary form of access to private markets for retail investors, unless regulatory frameworks are implemented to greatly reduce information asymmetry.

Fractional ownership

Fractional ownership is a structure where multiple parties invest in shares of the same asset, hereby sharing ownership and risks. Rights related to the asset, such as profit sharing or usage rights, are also divided among the investors. Most often the shared asset has high value, common examples are jets, yachts and real estate. To manage the asset and rights of the owners, there is often an intermediary.

The use of DLT could improve the transparency and efficiency of fractional ownership structures, mainly with built-in smart-contracts to automatically handle profit pay-outs, ownership transfers or usage rights.

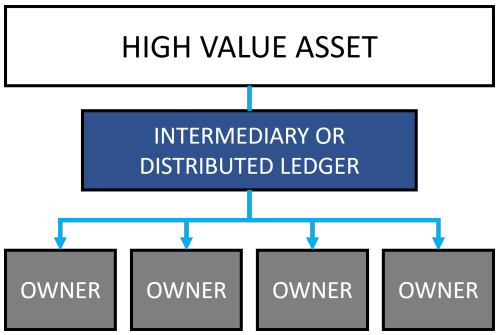


Figure 3.3: Fractional ownership

Real estate is one market where security tokens create opportunities for tokenised fractional ownership. Not unlike Real Estate Investment Trusts (REIT) or real estate funds, fractional ownership can allow for diversification and exposure to real estate within a portfolio, without the need to concentrate a lot of funds in one asset. Smart contracts built into the security tokens can ensure automated payments to the property manager and distribute rent profits to the owners. An example of real estate fractional ownership is RealT, which

tokenises real estate properties in the United States. Each real estate property is owned by a limited liability corporation, which issues tokenised equity through RealT (RealT, 2021). These tokens represent rights of ownership and rent profit sharing and they are transferable on the Uniswap exchange. A project like this creates opportunities for investors to invest small amounts into real estate in a diversified, liquid manner. A highly illiquid property is turned into a liquid fractional ownership token. Tokenisation of real estate could thus democratise real estate investments to a broad set of investors and create opportunities for diversification by giving rise to new financial products as alternatives to real estate funds and REITs, and by giving investors the ability to pick and choose their allocation and properties to invest in.

The empirical findings in 5.3 support the claims of increased liquidity in real estate markets and show that the sample of real estate tokens outperformed the Dow Jones Real Estate (DJRE) index.

Alternative investments and diversification opportunities

Based on the analysis and projections from Hays *et al.* (2021, p43-44) the tokenisation market is still in its nascent phase with ample room for growth. Most security token issuers are active within the ecosystem and thus present an investment opportunity into the market itself. Examples are Blockchain Capital, a venture fund focused on blockchain-related investments and MERJ exchange, a public exchange which provides access to both traditional and digital assets (MERJ Exchange Limited, 2021a). Exposure to the security token market is possible by either participating in a security token offering (primary market) or by buying publicly traded tokens (secondary market). Venture funds are a another way to get diversified exposure to the security token market. Most digital asset-focused venture funds are closed-end and realise their funding through multiple rounds of STOs.

When investigating which digital assets are suitable as alternative investment vehicles, cryptocurrencies should not be overlooked. Kostika & Laopodis (2019) apply a Vector Autoregressive (VAR) model and a Dynamic Conditional Correlation General Autoregressive Conditional Heteroskedasticity (DCC-GARCH) model on price data from major cryptocurrencies, currency exchange rates and equity indexes. Their findings suggest that cryptocurrencies are not cointegrated between themselves and that reactions on exchange rate and equity market shocks differ between cryptocurrencies. They conclude that cryptocurrencies can increase returns and reduce the overall risk of a well-balanced portfolio (Kostika & Laopodis, 2019). Colombo *et al.* (2021) analysed whether well-diversified por-

tolios (both local and global portfolios, with allocations in bonds, stocks, commodities and real estate) can benefit from allocating a portion in a basket of cryptocurrencies. They found that mean-variance portfolios with an allocation in cryptocurrencies consistently outperformed portolios without cryptocurrencies with otherwise identical asset allocations in a risk-adjusted returns framework. These findings are also confirmed by Bakry *et al.* (2021). "The results suggest that Bitcoin has some potential to act as a diversifier because in almost all the portfolio optimization frameworks, the performance attributes of the portfolios with Bitcoin were considerably higher compared to portfolios without Bitcoin." (Bakry *et al.*, 2021, p19).

Pearson correlation coefficients of daily Bitcoin returns with daily returns of S&P 500 index, Nasdaq Composite index and Gold/USD for the period 1/01/2019 until 17/03/2021 are shown in table 3.1. The coefficients between Bitcoin and the traditional instruments are positive but small. This suggests that Bitcoin can serve as a viable instrument for diversification.

	S&P 500	Nasdaq Composite	Gold/USD
Pearson Correlation	,267**	,280**	,222**
Sig. (2-tailed)	,000	,000	,000

Table 3.1: Bitcoin daily returns Pearson correlation coefficients (1/01/2019 - 17/03/2021)

Although cryptocurrencies might at first glance seem suitable only for risk-seeking retail investors because of their volatile nature and susceptibility for speculative bubbles, a growing base of institutional investors is getting involved. The Grayscale Bitcoin Trust currently has around $35 billion under management (Grascale, 2021). Grayscale, an SEC reporting company, also has trusts for other major cryptocurrencies, such as Ethereum, Bitcoin Cash and others. A couple of publicly listed companies such as MicroStrategy and Tesla are starting to invest in Bitcoin. "Cryptoassets have potential. But for them to realize this potential, institutionalization is needed. Institutionalization is the at-scale participation in the crypto market of banks, broker dealers, exchanges, payment providers, fintechs, and other entities in the global financial services ecosystem. We believe this is a necessary next step for crypto to create trust and scale." (Ghosh *et al.*, 2020). While more and more institutional players, under which JP Morgan Chase, Morgan Stanley and Blackrock, are getting involved in cryptocurrencies, one might wonder whether the necessary conditions are met for widescale adoption of cryptocurrencies (Ramaswamy, 22 July 2021) (Securities and Exchange Commission, 2021)(Massa, 20 January 2021).

The growing institutional attention for digital assets in general could make the ecosystem seem more trustworthy and could result in more companies using security tokens to issue equity or debt. This could in turn attract more attention towards the tokenisation markets (issuance platforms, exchanges, smart contract developers and more) which would result in increased liquidity and demand. The growing institutional interest for cryptocurrencies could thus be a catalyst for growth and increasing maturity of the tokenisation markets.

Automation through smart contracts

"Smart contracts are digital contracts allowing terms contingent on decentralized consensus that are tamper-proof and typically self-enforcing through automated execution" (Cong & He, 2018, p.11). Smart contracts have the ability to automate multiple facets of securities markets, such as dividend payments, ownership transfers, insurance, voting rights and regulatory know-your-customer (KYC) and anti-money-laundering (AML) implementations.

The fact that smart contracts are unfalsifiable and based on decentralized consensus makes them ideal for usage in securities markets. Because smart contracts do not rely on a trusted central authority, ensuring the safety and integrity of smart contracts should be a key aspect of regulation. Access to reliable and tamper-proof data is mandatory for trustworthy smart contracts, since smart contracts can automatically execute actions based on the input of data. Having a reliable decentral source of consensus decreases uncertainty and reliance on intermediaries. Because of their disruptive nature, smart contracts will likely reshape parts of financial markets, including securities markets. A plethora of existing or new financial products can be designed by implementation of smart contracts.

One major use-case of smart contracts to enable growth in the security token landscape is built-in regulation and financial reporting. Companies with shares listed on public exchanges have to adhere to securities regulations in their jurisdiction and fulfil the strict requirements imposed by the exchanges. This results in a trustworthy system where investors have regulated information available for their investment decisions. The current generation of security tokens does not have this reputation and often lacks accessible updated information on the issuer. A widely trusted standard for governance and financial reporting, to which the issuer needs to adhere, embedded into the security token through smart-contracts, in combination with institutional bodies or a decentral validation protocol to monitor the compliance of the issuer to this standard could solve this issue. Such a standard would be a large improvement on the current security token landscape in terms of transparency and trustworthiness.

Tokenised stocks

A tokenised stock is the representation on a distributed ledger of the underlying traditional share of a company. These tokens are non-fungible, meaning that for each traditional share that is tokenised there is only one representative token. Tokenised stocks should be backed by shares, held by a custodian. Depending on the custodian, the non-fungible tokens might be redeemable for the underlying shares.

Stock brokerage fees in the United States are 0,13% on average, with substantial variation in fees between brokers (Di Maggio *et al.*, 2019). The variation can be explained by extra services certain brokers provide, such as automatically handling tax regulations, providing educational material or sharing research. On top of the stock brokerage fee, investors might have to pay stock market tax depending on their jurisdiction. For comparison, the exchange fee for tokenised stocks on digital asset exchange currency.com is 0,05% (Currency.com, 2021). There is a weak argument that tokenised stocks might lower costs of transactions on the stock market in the future through efficiency gains. Tokenisation and DLT could facilitate simpler, more direct securities holding systems with less intermediaries which would result in lower overhead costs for trading (Bank for International Settlements *et al.*, 2020). Whether tokenised stocks will have lower trading costs compared to traditional stocks largely depends on how the securities markets will adapt to DLT. The possible cost-efficiency gains for stock brokerage through tokenised stocks might be too minimal to be worthwhile.

Tokenised securities can be traded 24/7, while traditional securities are limited by the operating hours of settlement systems and brokerages (Van der Loo *et al.*, 2019).

Most tokenised stocks have multiple listed trading pairs, often with USD stablecoins and other major cryptocurrencies. This allows investors to invest in assets without needing access to the domestic currency the asset is listed in.

Price deviations of tokenised stocks to their underlying asset would render them useless. The correlation of tokenised stocks to their traditional counterparts is analysed in section 5.6. The majority of tokenised stocks have a Pearson correlation coefficient higher than 0,95 and thus do not deviate much from their underlying.

The promise of liquidity

In current literature on tokenisation the potential of improved liquidity created by tokens is often brought up and is often stated as one of the key promises of tokenisation. However, the current state of the liquidity in public secondary security token markets greatly contradicts this statement. The empirical part of this chapter covers the lack of liquidity in public markets.

Tokenisation in itself will not improve liquidity, for this to happen there needs to be better market infrastructure. "Whilst tokenisation offers many benefits that are likely to drive liquidity in illiquid asset classes, the mere act of token generation to represent ownership claims on a traditional asset does not impact liquidity in and of itself. If a token is thinly traded it is still relatively illiquid. A benign environment that creates additional liquidity depends on the tokenised security's design (tokenisation vs fractionalisation) and the maturity of the market players." (Van der Loo *et al.*, 2019, p.64). Currently, publicly tradable tokens are traded very thinly. This could improve with a maturing market, yet it should be noted that the technology at the moment cannot deliver on one of its main promises. Instead of better technology there is need for trusted and mature markets for security tokens. More info on the current state of liquidity can be found in the section 5.4.

For this study it was not manageable to measure the liquidity of security tokens in private markets. Security tokens of otherwise illiquid assets, such as private equity, venture capital and real estate, are tradable on the network of issuance and thus directly improve liquidity for these assets. This fundamental characteristic of security tokens could prove crucial for their proliferation within private markets.

3.1.2 Limitations and challenges

Technology and human error risk

Holding digital assets or doing transactions with them will entail extra risk in the form of technology risk or risk of human error. The risks differ when holding or doing transactions with assets through a wallet or an intermediary such as an exchange.

Holding assets on an exchange, custody platform or any intermediary exposes investors mainly to hacks and cyberattacks, where uninsured investors can incur heavy losses. For example, in 2019 a total of $292,665,886 was stolen from cryptocurrency exchanges (Selfkey, 2020). Digital asset exchanges are prime targets for cyberattacks, simply because

of the large amount of funds that they store. These exchanges are responsible for secure storage of private keys and log-in credentials which means that a well organised, effective cybersecurity program is key for the proliferation of these exchanges. Psaila (2018) considers internal control weaknesses as a main driver for exchange hacks, crypto fraud and money laundering. These internal control weaknesses can manifest as poor cybersecurity programs, inadequate key/wallet management processes and weak due diligence procedures (Psaila, 2018). While major digital asset exchanges are audited for cybersecurity, there is still risk involved in storing digital assets on an intermediary.

On the other hand, holding assets on a wallet exposes the investors to hardware failure, human error during transactions and loss of private keys. For individuals, key management is as important as for exchanges. Losing the private key for a digital asset equates to a loss of funds and should thus be avoided at all costs. While exchanges have to handle a large amount of private keys electronically, for individual investors it is possible to manage their keys on paper to avoid being hacked. Improper storage, be it electronically or on paper, of private keys is not uncommon. Around one fifth of the circulating supply of Bitcoin would be located in inaccessible wallets, according to data from Chainanalysis (Popper, 13 January 2021).

Systematic risk

Research from Hu *et al.* (2019) shows that cryptocurrencies, in aggregate, have systematic risk being correlated with Bitcoin returns. Investors should take this into account when considering portfolio diversification. It is unclear whether this systematic risk is also present in security tokens and most likely depends on the type of underlying security and whether the issuer is active within the cryptocurrency and/or tokenisation sector or not. At present, there is not enough reliable historical price data on public security tokens to make any verifiable claims regarding this issue. Section 5.3.2 describes the process of calculating the correlations with Bitcoin and equity indices for publicly tradable security tokens.

Future research could elaborate on the severity of systematic risk in security tokens.

Underdeveloped secondary markets

In order to compare trading volumes of assets with different market capitalisation a new ratio is introduced. Dividing monthly trading volumes by their respective market capitalisation results in a normalised measure for trading volume, the volume-to-market-

capitalisation ratio (VMC Ratio). This ratio was applied to the US OTC market, the top 100 small cap stocks and a sample of publicly tradable tokens. Section 5.4.2 elaborates on the research method. The results are shown in table 3.2.

	Avg. monthly volume	Market cap	VMC Ratio
US OTC market	865 mil $	219505 mil $	0,00395
Top 100 Small Caps	654 mil $	36524 mil $	0,01793
Security tokens	5,84 mil $	612 mil $	0,00955
Security tokens (excl. top 2)	0,154 mil $	162 mil $	0,0010

Table 3.2: Volume comparison

The VMC ratio of the sample of publicly tradable security tokens is higher than the VMC ratio of the US OTC market and smaller of the VMC ratio of the 100 largest small caps. These findings suggests that security tokens have decent liquidity. However, when removing the two largest security tokens by market capitalisation from the sample, the VMC ratio decreases with a factor 10. This indicates that the other tokens in the sample have abysmal trading volumes.

There are multiple possible explanations for the low trading volumes of publicly tradable security tokens. The first explanation is that only a fraction of investors (both institutional and retail) are aware of security token markets. In addition to this, the investors that do know these market may decide to not invest in them because of a lack of trust or liquidity. Thirdly, a lack of market-makers could explain low volumes and liquidity. For market-makers, who fall under regulation of the Financial Industry Regulatory Authority (FINRA), it is illegal to accept payment from issuers or associates for market-making services for the issued security (Financial Industry Regulatory Authority (FINRA), 2021). This means that security token issuers cannot boost the liquidity of their token by hiring market-makers. The liquidity of the asset thus depends on which exchange the security token is listed and on the presence or absence of market-makers on the exchange willing to service their security token. Depending on regulation regarding trading venue of securities, decentralised exchanges (DEX) with Automated Market Makers (AMM) could be interesting for issuers who want to have an acceptable amount of liquidity for their token. MiFid II imposes the requirement for the trading venue of securities to have a platform manager or operator that is a legal entity, as such it might be impossible for certain issuers to rely on a DEX to solve their liquidity issues at the moment.

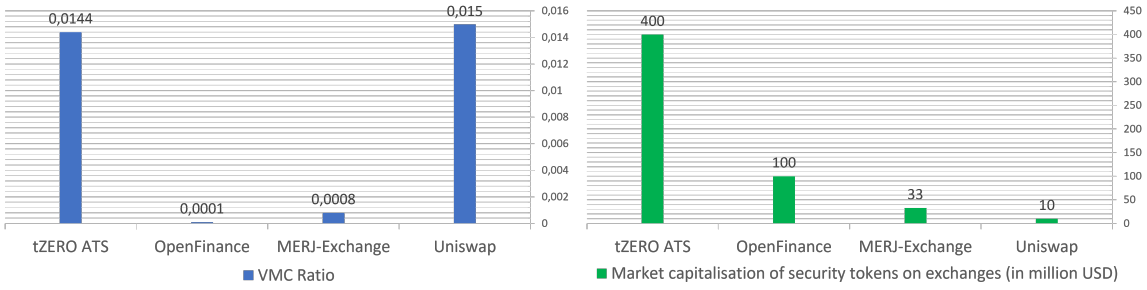


Figure 3.4: VMC ratios and market capitalisations of security token exchanges

The total monthly trading volume of the three largest centralised security token exchanges, namely tZERO ATS, OpenFinance and MERJ-Exchange, was respectively $ 7,199,726.25, $10,002.58 and $ 28,991.07 in June 2021 according to aggregator stomarket.com (Security Token Group, 2021). The latter two have remarkably low monthly volumes, and June 2021 was not an exceptional month when comparing to earlier data. An explanation for the major difference in volume between these exchanges might be the maturity of the tZERO ATS, its reputation as a centralised exchange and token issuer and its listings. The biggest listings on tZERO ATS include Overstock token (OSTKO) and the token of tZERO (TZEROP), with a combined market capitalisation above $ 400 million. The total market capitalisation of the listings on OpenFinance and MERJ-Exchange are respectively around $ 100 million and $ 33 million. The DEX Uniswap had a total monthly volume of $ 153,872.65 for listed security tokens in that same month and a total market capitalisation of $10 million. When comparing the market capitalisations with trading volumes an argument in favor of decentralised exchanges could be made. The VMC Ratio (total monthly volume divided by market capitalisation of listings) for tZERO ATS, OpenFinance, MERJ-Exchange and Uniswap are respectively 0.0144, 0.0001, 0.0008 and 0.015. The established corporation tZERO has been around since 2013 and has been able to portray itself as one of the frontrunners of the blockchain capital markets and as a result has plenty of liquidity in its marketplace. The decentralised exchange Uniswap has only been around since 2018 and has the same VMC ratio as tZERO. This could be explained by the presence of automated market making. The ratios for OpenFinance and MERJ-Exchange are very low in comparison.

Future research could analyse the drivers of trading volume of security tokens on exchanges and the impact of automated market making on trading volume of DEXs.

Another indication of poor liquidity is the large amount of zero-volume trading days for publicly tradable security tokens. On average, 40% of trading days had zero volume. The method of calculating this average is explained in section 5.4

Poor information availability, transparency and financial reporting

When reliable information is not readily available in a market, it can lead to inefficiency. Information asymmetry causes uncertainty and distrust for potential investors and can entail asset mispricing. From an investors standpoint transparent and trustworthy information flows are crucial to correctly determine the value of an investment and subsequently make an investment decision.

There were nine out of nineteen STOs for which no prospectus or placement memorandum could be retrieved online after searching rigorously. This lack of information availability is further discussed in section 5.5. The poor information availability of publicly tradable tokens is a red flag for the state of disclosures in current the security token market.

Security tokens have the technological possibility of disclosure standards embedded into the distributed ledger protocol. An overarching disclosure protocol for security tokens could solve the problems regarding reliable information availability when implemented correctly.

Section 4.2.2 elaborates further on information asymmetry and proposes a potential solution.

Credibility is low

Another potential hurdle for tokenisation could be the negative connotation associated with tokens, a repercussion of the controversies surrounding ICOs (Zetzsche *et al.*, 2017) among other factors. This negative reputation is not entirely unfounded, multiple scams during the ICO craze, frequent exchange hacks, lack of trustworthy and transparent data on companies, absence of established authorities for asset servicing and custody, uncertainty about investor protection on digital exchanges and lack of clear regulation on digital assets in general all contribute to this distrust.

Security token markets have similarities to OTC markets

Securities traded on over-the-counter (OTC) markets are generally characterised by low market capitalisations, low liquidity and are often speculative in nature. Companies who

want to issue equity but are unwilling/unable to meet the requirements for listing on exchanges and/or unwilling to pay listing fees have the option to sell shares on OTC markets.

There are different types of OTC markets for equity, namely OTCQX, OTCQB and OTC Pink. Both OTCQB and OTCQX have requirements for listing, such as following reporting standards and meeting high financial standards. The current generation of security tokens share resemblance with the least stringent market, OTC Pink. OTC Pink shares are highly speculative due to information asymmetry. For shares on the OTC Pink markets there is no obligation to file financial reports regularly or to communicate the financial situation of the company to potential investors. OTC Pink markets are also characterised by low trading volumes, which exposes investors to liquidity risk.

The lack of disclosure standards/requirements, low market capitalisations and low trading volumes of security tokens puts them in the same speculative basket as OTC Pink shares. If issuers of security tokens want to appeal to a broader group of investors, there might be need for structural changes regarding reporting standards to lower information asymmetry.

Chapter 4

Digital assets for funding

4.1 Raising capital with digital assets

There are three ways for businesses to raise capital: retained earnings, issuance of debt and issuance of equity. Retained earnings is an impractical way to increase capital for SMEs because of low or negative revenues during the early stages of the business. One of the most important ways for European SMEs to attract capital is through bank loans. Other means of raising capital with debt are issuance of debt securities or alternative lending. Attracting capital by issuing equity requires a willing party to acquire this equity, which in turn requires an already profitable SME or at the least a prospect of future profits.

ICOs are relevant in the context of retained earnings, while STOs are applicable to issue debt or equity.

4.1.1 Retained earnings from ICOs

Early literature on ICOs regards STOs as a subset of ICOs (Zetzsche *et al.*, 2017). In this dissertation, the term ICO only applies to the offering of utility tokens or payment tokens. Issuance of security tokens will be referred to as an STO.

Analysis of ICOs for fundraising purposes makes the most sense when regarding utility tokens and payment tokens as products for consumptive purposes (like vouchers), rather than investment products. As such, the company should register the sale of tokens as revenue. This results in extra capital through retained earnings. However, one could argue that these tokens have properties of investment products since the value of utility/payment

tokens depends on the consumption rights it gives to its holders and the ecosystem they are used in.

The assumption to not regard utility tokens and payment tokens as investment products is grounded on the fact that these tokens are either bought to participate in an ecosystem (consumption) or for short-term speculative gains. The speculative motive is that the value of the utility/payment tokens might increase when the ecosystem in which they are issued prospers. Zetzsche *et al.* (2017) state "Many ICOs are offered on the basis of utterly inadequate disclosure of information; more than half the ICO white papers are either silent on the initiators or backers or do not provide contact details, and an even greater share do not elaborate on the applicable law, segregation or pooling of client funds, and the existence of an external auditor. Accordingly, the decision to invest in them often cannot be the outcome of a rational calculus." (Zetzsche *et al.*, 2017, abstract).

An ICO could be considered an indirect fundraising mechanism through retained earnings because of the temporary revenue it provides to the issuer. This alternative financing channel is only relevant for enterprises active within the digital assets industry as utility and payment tokens with no use-case are worthless.

4.1.2 Debt and equity issuance with STOs

Digital assets enable funding by issuance of debt or equity through STOs. Security token offerings are a flexible means of raising capital since tokens can take the form of any type of security, be it debt, equity or a hybrid. An STO can be entirely public, in which case it is similar to an IPO, or an STO can be held privately or for accredited investors only. Security token offerings are fit for fundraising throughout the entire lifetime of a company, from seed capital until IPO.

For equity issuance during the early funding stages, STOs would function as a private placement to which traditionally only accredited investors have access. Security tokens could increase the accessibility of private equity for non-institutional investors, as discussed in 3.2. At the later stages of a venture, STOs could be structured like an IPO.

STOs can also be used to issue debt at any stage. The flexible nature of security tokens allows them to be designed to replicate any type of existing debt security instrument.

	STO	ICO	IPO	Bank loan	Private placement
Debt/equity	Both	None	Equity	Debt	Equity
DLT	Yes	Yes	No	No	No
Early/late stage	Any	Any	Late	Any	Early
Private/public	Both	Public	Public	Private	Private
Secondary market	Yes	Yes	Yes	Securitisation	No

Table 4.1: Characteristics of STOs, ICOs, IPOs, bank loans and private placements

Table 4.1 provides an overview of the main characteristics of STOs, ICOs, IPOs, bank loans and private placements. The table also illustrates the universality of STOs in comparison to the other funding channels.

Funds raised by STOs

The amount of funds raised by STOs has increased over the years, as illustrated in figure 4.1. In 2020 almost $ 5 billion was raised, while the total target amount in the same year was around $6 billion. A slight uptrend in the success rate of STO fundraising is noticable, as indicated by the orange line on figure 4.1. The compound annual growth rate (CAGR) of fundraising by STOs from 2018 until 2020 is around %55.

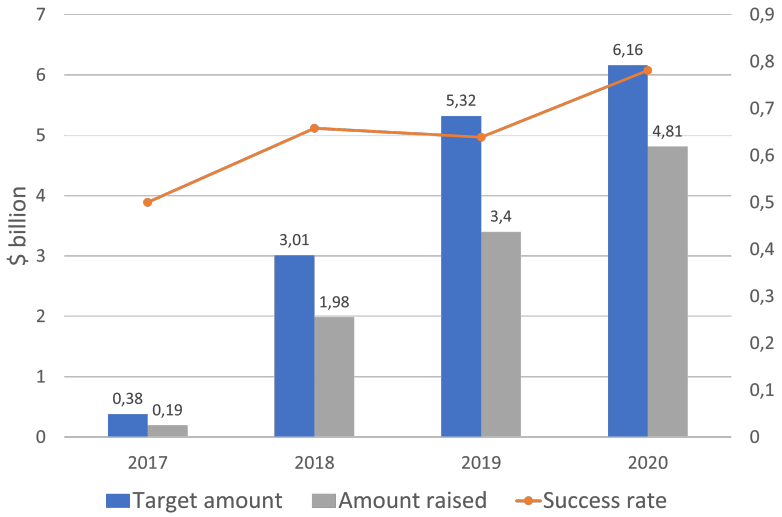


Figure 4.1: Target amount, amount raised and success ratio for STOs, source: Hays *et al.* (2021)

4.1.3 Comparison between security tokens and penny stocks

Lack of transparent information, illiquid markets and low market capitalisations are only some of the similarities between security token offerings and penny stock offerings. The secondary markets of both instruments are mostly OTC markets. Out of 204 issuers, only 9 have tokens that are publicly tradable (Hays *et al.*, 2021). Private security tokens are either traded privately through the distributed ledger itself or on OTC-like exchanges (e.g. BnkToTheFuture). The similarities of security tokens to OTC markets could be a transitory phenomenon due to the immaturity of the markets and disappear when both primary and secondary markets mature and attract broader interest from issuers and investors. Improved information disclosure policies could be a catalyst for the maturing of security token markets. Lambert *et al.* (2021) state that information disclosure is one of the success factors of ICOs and STOs.

The strength of security tokens lies in their flexibility. It is entirely possible to build separate types of markets on the underlying technology, where one market might serve the OTC-niche, while another serves more a more trustworthy mature market with companies that meet a set of requirements such as disclosure and governance policies .

4.2 Fundamental/qualitative analysis

4.2.1 Opportunities

Most benefits of STOs from an investment perspective discussed in chapter 3.1.1 are indirectly carried through to the issuer by increasing the appeal of the security to investors.

Improving liquidity for early stage capital

In current environment of low liquidity on public secondary markets for security tokens, the claim of increased liquidity for security tokens is hard to make. However, when these nascent markets mature and establish more trust an increase in liquidity and a subsequent decrease of the liquidity premium could be expected.

While the low liquidity of publicly traded security tokens disprove the claim of improved liquidity, the inherent tradability of security tokens allows for more liquidity in private secondary markets. Improving already efficient public markets is not the prime use-case of security tokens. The potential to provide liquidity for otherwise illiquid assets such as private equity or real estate will entail the largest impact of security tokens.

Security tokens can be traded between token-holders on the distributed ledger itself with relative ease, which allows for more liquid investments during earlier stages of a venture. It could thus be stated that the impact of security tokens on liquidity will be most prominent in private securities markets. For example, when venture capital or seed capital firms have easier means to exit positions, facilitated by tokenisation, this might decrease the liquidity premium and result in better terms for the company.

Fractional ownership and tokenisation increases access for a broad spectrum of investors to high-cost assets such as real estate, which should logically improve liquidity in these markets.

Access to a broader set of investors

As discussed in section 3.2, security tokens are more inclusive towards retail investors for private markets. OECD research states "In addition to enhancing inclusiveness in markets that were previously restricted to larger or institutional investors, a potential proliferation of tokenisation of such securities may enhance access to finance for SMEs by potentially allowing any type of investor, including retail ones, to indirectly or directly fund SME projects." (Nassr, 2020, p.19). Nassr (2020) further state that this could result in more efficient allocation of capital in the economy.

The inclusion of retail investors in private markets thus results in a more inclusive environment for issuers as well.

The potential of increased liquidity for otherwise illiquid assets, such as private equity and venture capital for SMEs, opens these markets for investors who could or would otherwise not invest in these types of assets. The added liquidity for early stage capital could thus promote a flow of capital towards SMEs (Nassr, 2020).

Funding at any stage of the venture

STOs are suitable for issuing equity or debt at any stage of the venture. Raising capital through private placements during the early stages of a company or through an IPO for a mature company and anything in between is facilitated by security token offerings.

Lower costs for issuance

The applicability of security token offerings during the entire lifetime of a venture results in a more universal approach to funding. Another advantage is the fact that debt, equity

or any form of hybrid token can be issued through the same platform with minor adjustments. A token issuance platform facilitating universal funding would most likely have lower issuance fees than its traditional counterparties. The traditional issuers have built their organisation's structure to facilitate one aspect of funding, while a security token platform can theoretically cover all aspects within the same structure. The development, maintenance and operational costs of a security token platform would be spread across more instances of issuance, which would decrease the fees per issuance. Securities offerings have to adhere to the securities legislation which means that the potential of on-chain compliance further increases the flexibility and universality of security tokens. Only minor adjustments need to be made by the issuance platform to cover the differences between a private placement or an IPO.

An argument along the same lines is made by Nassr (2020) "Automation introduced in the issuance, distribution, management of securities but also around securities servicing and corporate actions may reduce costs throughout the securities transaction lifetime, benefiting issuers and investors alike." (Nassr, 2020, p.18).

Capturing network effects

Nassr (2019) states the following about SMES active within the tokenisation industry in the context of ICOs: "SMEs with direct access to an unlimited investor pool, offering near-immediate liquidity and the potential to create economic value that goes beyond the value of the company through the creation and monetisation of network effects." (Nassr, 2019, p.40).

When an issuer of an ICO keeps a portion of the tokens as a reserve within the company/-foundation, it can sell these for liquidity or financing later on. Assuming that the issuer of an ICO can create value on its network, the value of utility tokens or payment tokens should rise. By keeping tokens as a reserve the issuer can capture and monetise network effects.

An ICO thus opens two alternative channels of financing: retained earnings from selling tokens during the ICO itself and selling reserve tokens afterwards with the possibility of increased value due to network effects.

4.2.2 Limitations

Liquidity premium

Illiquid investment products have a liquidity premium related to the higher amount of liquidity risk. Investors expect greater returns in order to invest in illiquid securities. The current low trading volume of the public security token exchanges is worrisome for issuers in that regard.

Figuring out a solution to the problematic lack of trading volume and liquidity for security tokens is not within the scope of this paper. However, from the data that was gathered some suggestions can be made. Firstly, the presence of market making in the form of AMM on decentralised exchanges ensures greater liquidity than on centralised exchanges. If legal within the jurisdiction of the issuer, listing the token on decentralised exchanges should lower the liquidity premium. Centralised exchanges might have to depend on market makers as well in order to increase liquidity. Secondly, financial reporting standards and other measures to decrease information asymmetry might attract more investors and thus improve liquidity.

Information asymmetry

Information asymmetry, a situation where one party in a transaction has more information than the other, leads to inefficient markets. Rodriguez (2018) states "Markets in which asymmetric information prevails are conducive to bad behaviors such as insider trading or market manipulation in which a small subset of the population with a disproportional access to information take advantage of retail investors." (Rodriguez, 2018). Potential entrants, i.e. issuers, of security token markets might opt to not enter based on the fact that they would enter inefficient markets.

Information disclosure currently happens in a centralised manner by the issuance platforms or exchanges. Rodriguez (2018) states the following: "Making security token issuance platforms or exchanges the custodian of disclosure information relevant to security tokens doesn't address the information asymmetry in the market; quite the opposite.". There is a conflict of interest present when exchanges and issuance platforms are responsible for the validity of information disclosure, yet in the early stages of a market it is better than nothing.

At the moment, there is no overarching disclosure protocol for security tokens. As an extension of current tokenisation protocols, there could be a programmable protocol that handles and validates the information disclosure in a decentralised manner. Comparable to how distributed ledgers achieve consensus on the history of transactions, it is technologically possible to achieve consensus on the validity of information disclosure with the use of validators. It is necessary to provide an incentive (e.g. recieving a fraction of transaction fees of the relevant security tokens) for correctly validating the information. Besides a reward for validating, there should be a penalty (e.g. liquidating collateral of the validator) when a validator is corrupt.

For now, token issuers can only try to minimise information asymmetry for their own token by being as transparent as possible when providing information. This decreases uncertainty and should in theory attract more investors to their security.

Uncertainty

Issuing security tokens involves multiple risks. Quantifiable risks (e.g. liquidity risk) can be taken into account when deciding to issue security tokens or to attract capital in another way. Possible issuers will only enter the markets when the possible advantages outweigh the known risks. Risks that are hard to predict and quantify cannot be accounted for during the decision-making process and raise the threshold for potential issuers.

It is unclear which direction the security token markets will take. This depends among other things on technological advancements and changes within the regulatory environment. Because of the unpredictability of these markets, possible entrants might be hesitant and take a wait-and-see position before entering.

Ambiguous, unclear or changing legislation is a problem, as discussed in section 2.3. Issuers need to know to which regulations they need to adhere and whether these will change in the future in order to be able to assess utility of organising an STO. The current state of uncertainty around regulation creates extra friction for issuers resulting in inefficiency in primary and secondary markets (European Commission Staff, 2020).

Chapter 5

Empirical validation

This section aims to confirm or deny the statements made in the qualitative research, depending on data availability. Certain aspects of the qualitative research, such as predictions of the impact of digital assets, are hard to quantify and verify empirically. As such, certain statements made in the qualitative research remain unverified. The empirical study focuses solely on data from security tokens.

5.1 Sample selection

The first sample of securities all security tokens publicly accessible price data. For this sample of tokens information was gathered from securities prospectuses, public offering memoranda or white papers. When none of those were publicly available, data was collected from the issuers website. Price data was gathered from aggregator stomarket.com (2021) in May 2021. Tokens that were delisted from public exchanges and abandoned projects were removed from the sample. The resulting sample with historical price data consists of 11 security tokens. This sample will be referred to as sample one.

The restriction of having publicly accessible price data was lifted for sample two. This sample consists of 30 security tokens, including those of sample one and sample three.

The third sample contains the nine earliest real estate security tokens issued by RealT. These tokens have publicly available historical price data. Only the first nine RealT token were included because their price data was publicly available on stomarket.com (2021) during data gathering, the other tokens were not listed at that time.

5.2 Descriptive statistics

This part is based on sample two, with STOs grouped by issuer. That way the number of tokens issued by RealT does not skew the results. The resulting sample consists of 21 token issuers. When data of a token was not available for a certain category, the token was disregarded for that category.

5.2.1 Number of STOs

As illustrated in figure 5.1 the total number of STOs has increased with more than 50% per year in the period from 2017 until 2019, while the number of STOs for publicly tradable tokens only increased slightly. The growth of STOs has stagnated in 2020, possibly due to COVID-19.

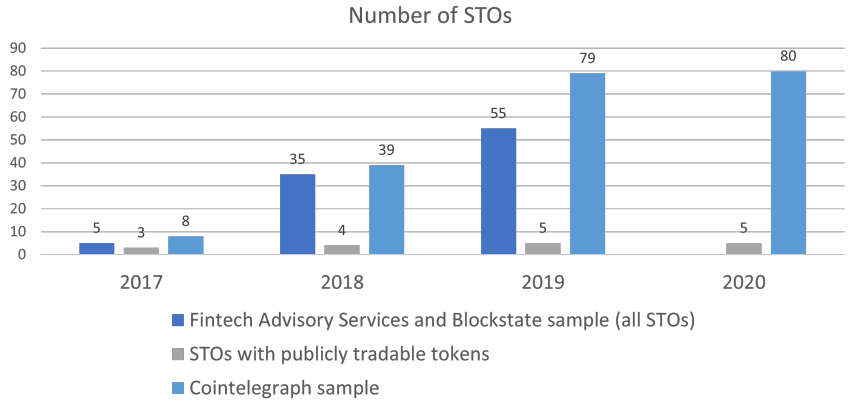


Figure 5.1: Number of STOs per year, sources: stomarket.com (2021), Fintech Advisory Services (2020), Hays *et al.* (2021)

5.2.2 Maturity of STOs and issuers

For the STOs in our sample, the median end year is 2019 while the earliest STO ended in 2017. Security token offerings are thus relatively recent. This matches the findings from STO reports from Fintech Advisory Services (2020) and Blockstate (2020).

Data on the foundation year of all corporations issuing STOs from our sample was gathered from Crunchbase.com (2021). It is noticeable that the maturity of the corporations behind the offerings is low. There is corporation maturities range from 22 years old to 2 years

Issuer founded in	Frequency
1999	1
2010	1
2011	1
2013	2
2015	1
2016	2
2017	3
2018	4
2019	1
Total	**16**

Table 5.1: Corporation maturity, source: crunchbase.com

old. The median corporation is founded in 2015 which means that the majority of security token offerings in the sample have been launched by companies in their early stages. The outlier here is Overstock which was founded in 1999 and initially distributed their token as a dividend for shareholders in 2018.

The data confirms that STOs are primarily, but not exclusively, used as early stage funding.

5.2.3 Security token issuers by industry

Industry	Frequency
Digital assets	5
E-commerce	1
Financial publishing/research	1
Fund	5
Gambling	1
Real estate (RealT tokens counted as 1)	5
Startups	1
Total	**19**

Table 5.2: STO issuers by industry

Table 5.2 shows the distribution of industries among STOs. Out of 19 token issuers, five are active within the digital assets ecosystem, e.g. as an exchange or token issuance

platform, five are funds and another five are issuers active in the real estate industry. It should be noted that the real estate security token issuer RealT has over twenty active real estate tokens. It is clear that security tokens are being applied in the real estate industry. These findings are also confirmed in the security token report by Hays *et al.* where real estate is the largest industry in terms of numbers of STOs and funds raised (Hays *et al.*, 2021, p. 28).

5.3 Analysis of historical price data

The analysis in this section uses sample one. The historical data for the sample was gathered from aggregator stomarket.com (2021). The data-set includes 24 hour volume, circulating token supply, highest and lowest price of the trading day and the closing price. Daily returns were calculated with closing prices.

The data of stomarket.com (2021) excludes trading days with zero 24 hour trading volume. For these trading days, the data-set was filled with the latest available closing price. These days offered zero return to the investor, so it is not incorrect to include these prices in the dataset. Incorporating the zero-return trading days was done to make the time series data more complete.

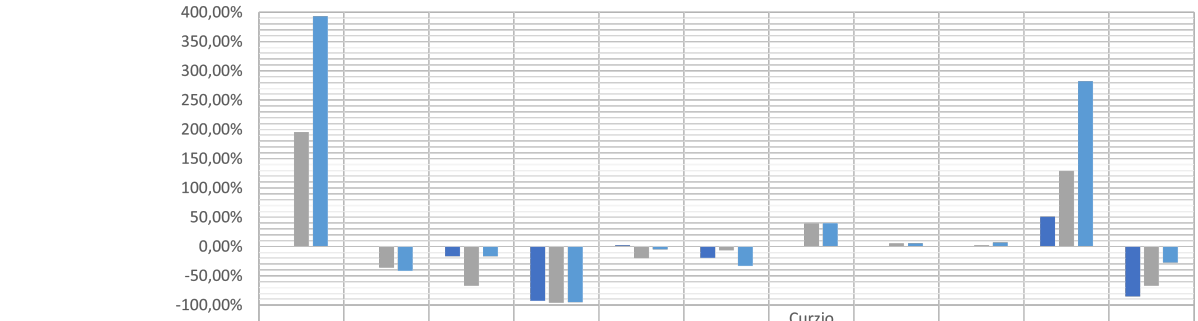
5.3.1 Returns

Security token returns

To assess the returns from the security tokens two ranges will be considered: firstly the total return for all tokens from the first trading day until 31/12/2020, secondly from the first trading day until 31/12/2020 and lastly from the first trading day until 17/03/2021. The results are plotted in figure 5.2. Five out of eleven tokens had positive returns, the remaining six had negative returns over the entire period.

Over the entire sample period the Overstock token has the largest positive return of +393,33%, followed by Blockchain Capital with a return of +282,44%. On the flipside, Lottery Token has the largest negative return, -94,85% followed by Mt Pelerin with a return of -41,3%.

A portfolio with even distribution across all eleven security tokens would have return of 46% over the entire period. For comparison, the returns of S&P 500 and Nasdaq Composite over the same time period are respectively +58,81% and +102,90%. The portfolio of security tokens did not outperform the equity indices.



	Overstock	Mt Pelerin	Protos	Lottery Token	Startup Bootcamp	Spice VC	Curzio Equity Research	Aspencoin	MERJ	Blockchain Capital	tZEROP
Return 1/01/2019 - 31/12/2019	0,00%	0,00%	-16,67%	-92,78%	2,50%	-19,46%	0,00%	0,00%	0,00%	51,15%	-85,14%
Return 1/01/2019 - 31/12/2020	195,00%	-35,99%	-66,67%	-95,88%	-20,00%	-6,04%	40,00%	4,96%	1,98%	129,01%	-66,86%
Return 1/01/2019 - 17/3/2021	393,33%	-41,30%	-16,67%	-94,85%	-5,00%	-32,89%	40,00%	5,79%	7,14%	282,44%	-27,43%

Figure 5.2: Total return on secondary market for security tokens

Real estate token returns

The returns of RealT real estate tokens and the Dow Jones US Real Estate Index (DJRE) are shown in table 5.3. The start date for all returns was set on 4/11/2019, the earliest trading day for the RealT tokens. The latest available trading day during data-collection was 17/05/2021. Returns from the entire period indicate that 7 out of 9 real estate tokens have outperformed the DJRE index for the same period. The unweighted average return of the RealT tokens in this sample is 29,68% for the period 4/11/2019 until 17/05/2021, while the DJRE return for the same period is only 2,58%. Based on the historical outperformance of the DJRE, RealT tokens could serve as a solid investment.

Start date	**4/11/2019**	**4/11/2019**	**4/11/2019**
End date	**31/12/2019**	**31/12/2020**	**17/05/2021**
8342 Sch. Hwy.		14,33%	-12,84%
9943 Marl. St.	10,60%	16,22%	3,84%
18900 Mans, St.		24,73%	44,19%
183276 App. St.		26,22%	18,06%
20200 Les. St.		19,18%	25,92%
15634 Lib. St.		7,02%	27,95%
9336 Patt. St.		37,78%	74,25%
5942 Aud. Rd.	-4,10%	53,36%	96,22%
16200 Full. Ave.	0,26%	-0,09%	-10,51%
Dow Jones Real Estate Index	-0,86%	-9,41%	2,58%

Table 5.3: RealT token returns

5.3.2 Correlations and betas

In order to verify the diversification potential of security tokens and cryptocurrencies, their relation to other assets needs to be examined. The focus lies on US equities, US real estate, commodities and cryptocurrencies. The S&P500 Index and Nasdaq Composite Index were used as proxies for US equities. The Dow Jones United States Real Estate Index was included in the analysis of security tokens in the US real estate sector. The largest cryptocurrency by market capitalisation, namely Bitcoin, was used for gauging the correlation of security tokens with cryptocurrencies.

The estimation of betas and correlation was done through simple linear regression based on the daily returns from sample one. The security tokens are tradeable 24/7, while traditional assets are not. Data of non-trading days for the traditional assets were excluded.

The results are shown in table 5.4. In general, the betas are close to zero and for some even negative, this would suggest some diversification potential. However, the results of the linear regression are statistically insignificant which means that the null hypothesis of no correlation between returns of the tokens and major equity indices and Bitcoin can be accepted. This does not necessarily imply that security tokens are a good diversification opportunity, since the insignificance can be explained by imperfections of the sample.

The statistical insignificance can be explained by three factors. The first factor is the low amount of data points of daily returns for some tokens. The average timespan between

Token	Beta S&P500	Sig.	Beta Nasdaq Comp.	Sig.	Beta BTC	Sig.
Aspencoin	0,023	,800	-0,002	,978	-0,83	,352
Blockchain Capital	-0,035	,693	-0,111	,212	0,029	,747
Curzio Equity Research	-0,083	,351	0,008	,926	0,057	,524
LotteryToken	-0,167	,060	-0,127	,154	-0,108	,226
Merj Token	-0,072	,422	-0,031	,728	0,112	,208
Mt Pelerin	-0,039	,664	-0,015	,864	0,094	,290
Overstock	0,121	,175	0,192	,031	0,212	,016
Protos	/	/	-0,138	,120	0,067	,449
Startup Bootcamp	0,109	,219	0,020	,827	-0,148	,095
SpiceVC	/	/	0,020	,824	-0,052	,559
Tzerop	0,090	,311	0,103	0,247	0,027	,765

Table 5.4: Betas and sig. values for security tokens

issuance and the last trading day (17/03/2021) of the dataset is only 519 days. The second and probably most important factor is the amount of zero-return trading days for the security tokens. The majority of zero-return trading days coincide with zero-liquidity trading days. Of the average 519 calendar days since issuance there were only 183 trading days with non-zero liquidity on average for the security tokens. The large amount of zero return data points skews the results of the regression analysis and explains the low/negative betas. Omitting the zero return data reduces the sample size even further. A potential third factor are price distortions due to speculation, information asymmetry and illiquidity. This could be an avenue of future research.

5.3.3 Cost of capital for STO issuers

This section describes the process that was undertaken as an attempt to calculate the cost of capital for issuers of STOs.

Correctly estimating the cost of capital with the original CAPM is based on correct pricing of the asset in accordance to CAPM. Incorrect pricing due to speculation, information asymmetry and illiquidity render the original CAPM useless. The calculated betas of the security tokens are statistically insignificant which means that the results of CAPM would be useless.

As alternatives, following methods were attempted. The implied cost of capital model, based on dividend growth rate, is not applicable due to a lack of dividends and/or financial information on the companies in our sample. Estimating cost of equity using the internal rate of return (IRR) as a proxy is not viable due to a lack of information on future cash flows to estimate the IRR.

The final attempt, a comparable method to estimate betas of the tokens based on similar companies that are publicly listed could prove useful. Finding publicly listed companies with a profile similar to these in the sample however is not an easy task due to the profile of the companies in the sample. The closest proxy would be a control group of penny stocks. This does not fall within the scope of this dissertation but could be an interesting topic for future research.

5.4 Liquidity concerns

Improved liquidity on secondary markets is be considered as one of the golden promises of security tokens, yet currently this advantage has not manifested itself. The observable liquidity of the secondary market for security tokens, which is the liquidity on exchanges of publicly traded tokens, is inadequate.

5.4.1 Zero-volume trading days

As already mentioned in section 5.3.2 there were on average 183 non-zero volume trading days out of an average of 519 days since inception for all the security tokens in sample one.

Following procedure outlines the steps that were taken to get a more accurate gauge of the illiquidity problem. Firstly, for each of the tokens the ratio of zero-volume trading days to total trading days (i.e. days since inception) was calculated. Afterwards all the tokens were given a weight according to their average market capitalisation during the whole period (from inception until 17/03/2021). The average market capitalisation was calculated by taking the sum of the market capitalisation for each trading day of the token and dividing this by the total amount of trading days. Finally, a weighted average of the zero-volume to total trading days ratio of each of the tokens was calculated, resulting in a ratio of 0,4. This means that for the sample, on average, for every 10 trading days there were 4 days with zero volume.

5.4.2 Trading volume comparison to OTC markets and small-cap stocks

This section will compare the monthly trading volume of security tokens with the monthly trading volumes of the United States OTC market and top 100 US small cap stocks by market capitalisation. The absolute trading volumes depend on the market capitalisation of the asset and are thus not a good metric for comparison. Instead, dividing the monthly trading volumes by the market capitalisation results in a comparable measure for trading volume, the volume-to-market-capitalisation ratio (VMC Ratio). The VMC ratio represents the fraction of the market capitalisation that is traded in one month.

Data on the market capitalisation of the OTC market was gathered from Stock Market MBA (2021). Note that not all OTC stocks are included in that sample, the data is used as an approximation. The sum of the market capitalisation of all stocks in the sample is used as a proxy for the total market capitalisation of the OTC market. The trading volumes were pulled from Financial Industry Regulatory Authority (2021). FINRA provides aggregated data of the OTC market, such as the aggregated monthly trading volume. The latest (June 2021) monthly aggregated trading volume of all domestic US OTC stocks was used since the data from Stock Market MBA (2021) contains only US stocks.

Yahoo Stock Screener was used to gather the data for the top 100 US small cap stocks on 4/08/2021 (Yahoo Finance, 2021). Following criteria were imposed: region is United States, market cap is small cap. The resulting stocks were sorted by market cap and the 100 largest were used as the sample. The 3-month daily trading volume was multiplied by 30,437 (average days in a month) to get the average monthly trading volume. The sum of the market capitalisations was used in the calculation of the VMC ratio.

Sample one of the security tokens was used for this analysis. The average monthly trading volume for each token was calculated by summing up the historical daily volumes, dividing this by the number of trading days and multiplying by 30,437. The average market capitalisation during the lifetime of the security token was used to calculate the VMC ratio.

The sample of small cap stocks scores the best with a VMC ratio of 0,01793. The second best results are for the security tokens with a VMC ratio of 0,00953. OTC markets perform the worst with a VMC ratio of 0.00395. However, when excluding the two largest

	Avg. monthly volume	Market cap	VMC Ratio
US OTC market	865 mil $	219505 mil $	0,00395
Top 100 Small Caps	654 mil $	36524 mil $	0,01793
Security tokens	5,84 mil $	612 mil $	0,00955
Security tokens (excl. top 2)	0,154 mil $	162 mil $	0,00101

Table 5.5: Volume comparison

security tokens by market cap, namely Overstock and tZERO, the VMC ratio of the sample decreases by a factor 10. The sample selection of security tokens heavily impacts the results of this analysis. The low VMC ratio for the security tokens, excluding Overstock and tZERO, is an indication of the lack of volume and liquidity in the secondary market for security tokens. Only four out of eleven tokens in the sample have a higher VMC ratio than OTC markets, while the VMC ratio of each lower scoring token is at least 75% lower. The VMC ratios of the individual tokens are shown in table 5.6.

	VMC ratio (monthly volume)
Overstock	0,0131
Tzero	0,0113
Blockchain Capital	0,0003
Aspencoin	0,0046
MERJ	0,0001
Curzio Equity Research	0,0011
Spice VC	0,0004
Lottery Token	0,0004
Startup Bootcamp	0,0008
Protos	0.0000
Mt Pelerin	0,0063

Table 5.6: Monthly VMC ratio of security tokens

5.4.3 Liquidity for real estate

The same method as in section 5.4.2 was applied to the nine earliest real estate security tokens issued by RealT. The results of applying the VMC formula to these tokens are shown in table 5.7. In this sample, 8 out of 9 tokens have a higher VMC ratio than the 100 largest US small cap stocks. These findings confirm that security tokens can provide liquidity in illiquid asset classes such as real estate.

RealT token	**VMC**	**RealT token**	**VMC**
8342 Sch. Hwy.	0,0704	15634 Lib. St.	0,0296
9943 Marl. St.	0,0641	9336 Patt. St.	0,0800
18900 Mans. St.	0,0210	5942 Aud. Rd.	0,0299
18276 App. St.	0,0158	16200 Full. Ave.	0,0343
20200 Les. St.	0,0640	Average	0,0454

Table 5.7: RealT VMC ratios

5.5 Information availability

Prospectus availability	**Frequency**
No	10
Yes	8
Yes (private placement)	1
Total	**19**

Table 5.8: Prospectus availability

Out of 19 STOs in the sample, only 9 had a publicly available prospectus or offering memorandum. This indicates low information availability and poor disclosure standards.

5.6 Correlation between stocks and tokenised stocks

Tokenised stocks are an alternative to their traditional counterpart. In order for tokenised stocks to be a perfect substitute the price of tokenised stocks has to be perfectly correlated to the price of the traditional stock.

The analysis is based on 20 randomly selected tokenised stocks with a varying market cap and liquidity. The data for the historical stock price is imported with the built-in 'Stock History' function from Microsoft Excel which is based on data from Refinitiv. The historical price data for the tokenised stocks is gathered from the aggregator Coincodex.com (Coincodex.com, 2021).

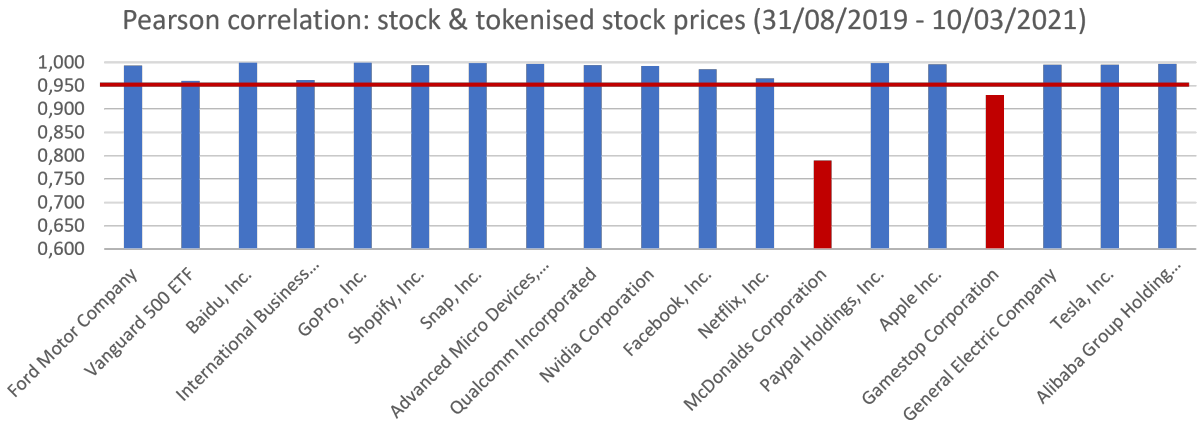


Figure 5.3: Pearson correlation of historical stock prices and tokenised stock prices

The results, illustrated in figure 5.3, indicate that the majority of correlation coefficients are situated between 0,95 and 1. Only two out of twenty tokens have correlations beneath this threshold, namely McDonalds Corporation and Gamestop Corporation with respective correlation coefficients of 0,79 and 0,93.

Chapter 6

Conclusion

In this dissertation the potential impacts of tokenisation, digital assets and security tokens on securities markets were discussed. The research attempted to cover as much facets as possible in order to provide a thorough overview of the influence security tokens and distributed ledger technology might have on finance. The secondary research objective was gauging the potential of security tokens to close the SME financing gap in the EU.

This work is not exhaustive and more research needs to be done to map the entire impacts of the distributed ledger technology on finance. Certain aspects were hard to quantitatively verify mainly due to the lack of sufficient historical price data on security tokens.

The most important findings of the study, based on the information that was available at the time of research are discussed in following paragraphs.

The most prominent advantages for investors are the perfect divisibility of tokens, the possibility of improved securities settlement due to DLT, easier access to private markets, streamlining and facilitating fractional ownership and the potential of portfolio diversification of cryptocurrencies.

Investors in digital assets have to take into account the additional technology risk, risk of human error and systematic risk (correlation to Bitcoin) and the underdeveloped secondary markets of security tokens in terms of disclosure standards and liquidity.

The possibility to organise STOs during any stage of the venture, the potential for less illiquid early stage capital and access to a broader set of investors which unlocks a flow of funds towards issuers are the most prominent advantages for issuers. On the flipside,

issuers need to be wary of the legal and technological uncertainty surrounding STOs and the extra premiums investors might impose on security tokens due to low liquidity and poor information disclosure.

One area where security tokens have fully proven their potential is in the real estate market where their liquidity and returns outperform the traditional counterparts.

The main conclusion of this research is that security tokens definitely have potential to disrupt multiple aspects of securities markets and the economy as a whole, with the most profound impact in private markets. Providing liquidity in private markets could result in a flow of funds towards SMEs and ultimately result in more efficient allocation of capital. The main challenges at the moment are underdeveloped secondary public markets and a lack of disclosure standards. To which extent security tokens could increase the flow of capital towards SMEs thus depends on further development of secondary markets to provide liquidity and disclosure standards to decrease information asymmetry.

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