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Real Estate Tokenizing

Blockchain Technology in Real Estate

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Abstract

Real estate assets are often considered as illiquid due to capital and transaction barriers. As a response, real estate tokenizing is a rising phenomenon. Real estate tokenizing combines the benefits from the private and the public real estate market, by creating a product with direct real estate commitment to low capital requirements and efficient transaction processes. The product is called real estate token, a digital share of an asset. Real estate tokens enable hypothetical fractionalization of properties with means of blockchain technology and smart contracts. This study investigate the pros and cons of real estate tokenizing as well as the financial performance of publicly traded US residential real estate tokens.

The study states that fractionalization of properties increases access and customizability of real estate investments. Furthermore, the blockchain technology and the smart contracts enable automatization of transaction processes and asset management. Altogether, the benefits may result in a higher liquidity. However, the study also states several drawbacks with real estate tokenizing, such as lack of management and deeds, scalability problems and liquidity paradoxes. Furthermore, this study shows that US residential real estate tokens underperform both S&P 500 and housing index in terms of risk-adjusted return. Moreover, the real estate token market seems to correlate more with the S&P 500 than with the housing market.

The study concludes that the cons with real estate tokenizing exceed the pros, although the phenomenon has great potential in a more mature market. However, real estate tokenizing will face implementation obstacles when converting the real estate industry to blockchain technology. As such, the success of real estate tokenizing is dependent on the global view of blockchain technology.

Examensarbete

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Sammanfattning

Fastigheter betraktas ofta som illikvida på grund av kapital- och transaktionsbarriärer. Som svar på den bristande likviditeten är blockchainteknologi inom fastigheter, även känt som ”real estate tokenizing”, ett växande fenomen. Real estate tokenizing ämnar till att kombinera fördelarna från den privata och den publika fastighetsmarknaden genom att skapa en produkt med direkt fastighetsexponering till låga kapitalkrav och effektiva transaktionsprocesser. Produkten kallas ”real estate token”, en digital andel av en tillgång. Real estate tokens möjliggör hypotetisk fraktionering av fastigheter med hjälp av blockchainteknologi och smarta kontrakt. Denna studie undersöker för- och nackdelar med real estate tokenizing såväl som finansiell prestation av publikt handlade real estate tokens inom det amerikanska bostadssegmentet.

Studien konstaterar att fraktionering av fastigheter ökar tillgängligheten och anpassningsbarheten i fastighetsinvesteringar. Vidare möjliggör blockchainteknologi och smarta kontrakt automatisering av transaktionsprocesser och förvaltning. Sammantaget kan fördelarna med real estate tokenizing leda till högre likviditet. Studien konstaterar emellertid också flera nackdelar med real estate tokenizing, såsom brist på management och panträtt, storskalbarhetsproblem och likviditetsparadoxer. Vidare visar studien på att publikt handlade real estate tokens inom det amerikanska bostadssegmentet underpresterar både S&P 500 och bostadsindex i termer av riskjusterad avkastning. Dessutom verkar marknaden för publikt handlade real estate tokens inom det amerikanska bostadssegmentet korrelera mer med S&P 500 än med bostadsmarknaden.

Studien konkluderar att nackdelarna med real estate tokenizing överstiger fördelarna i dagsläget, även om fenomenet har stor potential på en mer mogen marknad. Real estate tokenizing riskerar dock att möta implementeringshinder när fastighetsbranschen ska konverteras till blockchainteknologi. Således är framgången för real estate tokenizing beroende av den globala synen på blockchainteknologi.

Table of Contents

1 Introduction **1**
1.1 Introduction to Real Estate Tokenizing 1
1.2 Research Gap and Contribution 2
1.3 Research Questions and Limitations 2
2 Background **3**
2.1 Blockchain Technology 3
2.2 Real Estate Tokenizing 5
2.3 Smart Contracts and Blockchain in Real Estate Tokenizing 6
2.4 Valuation of Tokens 6
2.5 Four Quadrants of Real Estate Capital Markets 7
3 Literature Review **8**
3.1 Blockchain Technology 8
3.2 Real Estate Tokenizing 8
4 Theoretical Framework **12**
4.1 Four Central Moments of Distribution 12
4.2 Autocorrelation 12
4.3 Sharpe Ratio 13
4.4 Beta, CAPM and Jensen's Alpha 13
4.5 Confidence Interval 13
5 Methodology **14**
5.1 Qualitative and Quantitative Approach 14
5.2 Data Selection 14
5.3 Coding of Data 15
5.4 Mathematical and Financial Formulas 16
6 Results **20**
6.1 Pros and Cons of Real Estate Tokenizing 20
6.2 Empirical Characteristics 22
7 Analysis and Discussion **26**
7.1 Pros of Real Estate Tokenizing 26
7.2 Cons of Real Estate Tokenizing 27
7.3 Empirical Characteristics 28
7.4 Real Estate Tokenizing and Sustainability 29
8 Conclusion **30**
References **31**

1 Introduction

1.1 Introduction to Real Estate Tokenizing

Modern portfolio theory is based on diversification benefits (Markowitz, 1952). The theory is fulfilled upon mixing assets into an efficient portfolio. According to US stock data, an efficient portfolio allocates up to 30-60% of the assets to real estate investments (Baum & Hartzell, 2012). However, institutional investors allocated only around 10% in real estate investments in 2019 (Baum, 2020). The gap between theory and practice can partly be explained by low liquidity in the real estate market due to high capital requirements and extensive transaction processes (Baum & Saull, 2019).

As a response to transaction and liquidity failure, real estate tokenizing is a rising phenomenon (Benedetti et al., 2019). A token is defined as a blockchain-based digital share of an asset. The share is related to ownership and rights, such as price changes and dividends. In real estate tokenizing, the underlying asset of the token is a property. However, it is still legally impossible to directly own properties through real estate tokens. As such, the property is held by a special purpose vehicle that in turn is the actual tokenized underlying asset (Colliers International et al., 2020).

Some real estate tokens are publicly traded at various exchanges (Jane, 2020). The first issue of a real estate token was the $18M issue of the AspenCoin, a hotel property in Aspen (Rena & Rena, 2018). Although real estate tokenizing is new to the market, the issue of the AspenCoin has been followed by several other initial public offerings, primarily of residential assets in the US (Hoffman, 2019). An initial public offering of a token is also known as a security token offering (Mazy, 2019).

In many aspects, a real estate token is similar to a real estate investment trust (*REIT*) (Gampala & Jyotsna, 2020). Primarily as both the products are shares of publicly traded real estate investments. However, there are also some major differences. First of all, a REIT is most commonly a share of a portfolio, while a real estate token is most commonly a share of a single-asset vehicle. Moreover, the price per share of a REIT is in general derived from the equity value of the property holding, while the price per share of a real estate token is in general derived from the property value of the property holding. Furthermore, a REIT is listed though an initial public offering (*IPO*), while a real estate token is listed through a STO (PWC, 2018). An STO does not require numerous agents to the same extent as an IPO does. Consequently, a real estate token is more manageable compared to a REIT, reducing fees and administration. As such, real estate tokenizing is an interesting complement or alternative to traditional equity raising.

1.2 Research Gap and Contribution

Real estate tokenizing offers several opportunities, both in terms of liquidity and investment aspects. However, the value of a token is realized first upon trading. In January 2021, the concept is still new to the market, with few STOs and exchanges offering tokens. With lack of descriptive research and empirical data, investors may refrain from investing in real estate tokens. Accordingly, property owners may refrain from issuing properties with means of real estate tokenizing.

In chapter 3, Literature Review, the current research and findings in the field of real estate tokenizing are presented. As real estate tokenizing is a new phenomenon, most of the relevant research articles were published as late as in 2019 and 2020. Most research focus on investigating and explaining real estate tokenizing as concept. Yet, few research articles present the advantages and primarily the disadvantages of real estate tokenizing. Furthermore, no research articles present empirical characteristics of real estate tokens, based on historical trading data of publicly traded real estate tokens.

This master thesis aims to investigate the descriptive attributes of real estate tokenizing and the empirical characteristics of real estate tokens. The purpose is to contribute with data, analysis, descriptions and conclusions regarding real estate tokenizing and the financial performance of real estate tokens. Thus, contributing to the development of real estate tokenizing.

1.3 Research Questions and Limitations

In order to full fill the purpose of this study, the following research questions must be answered.

> *Q1: What are the theoretical pros and cons of real estate tokenizing?*

> *Q2: What are the empirical characteristics of publicly traded US residential real estate tokens and how do they perform against US housing index and market index?*

The first research question is limited to the pros and cons of real estate tokenizing in terms of investment, asset management and public interests. The second research question is limited to historical trading data of US residential real estate tokens, available for public trading as of January 2021. US residential real estate tokens are selected since the real estate token market almost exclusively consists of these. While the second research question focuses on publicly traded real estate tokens, the first research question focuses on real estate tokenizing and real estate tokens in both public and private markets.

2 Background

2.1 Blockchain Technology

Blockchain was first introduced upon the invention of Bitcoin (Nakamoto, 2008). Blockchain is a specific type of database (Mazonka, 2016). A database is information stored in a computer network. In a traditional database, the information is stored in a centralized computer network (Chattu et al., 2019). In blockchain on the other hand, the information is stored in a de-centralized computer network. Figure 1 shows a centralized and a de-centralized computer network.

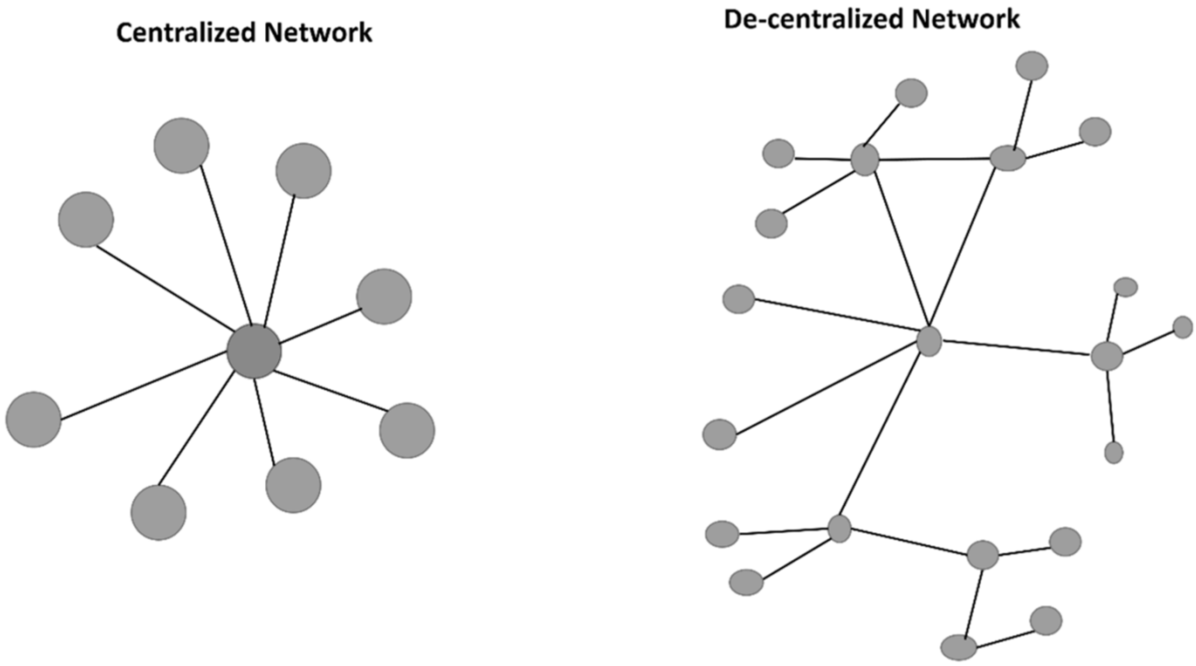

***Figure 1**. Centralized versus decentralized network (Chattu et al., 2019).*

Blockchain is also unique in the way the information is structured (Mazonka, 2016). In general, information is structed in table format. In a blockchain, these tables are structured into blocks that are chronologically added into a chain (Abdolee et al., 2019). Each block has a hash and the hash of the previous block. A hash can be interpreted as a fingerprint verifying the block. If the information in a block is changed or manipulated, the hash of the block also changes. Consequently, the subsequent blocks become invalid, as they refer to an invalid previous hash. As such, information cannot be changed unless the entire blockchain is changed. As the blockchain is stored in each node of the de-centralized computer network, a majority of the nodes must approve or be controlled in order to change the blockchain. Figure 2 shows a visualization of a blockchain.

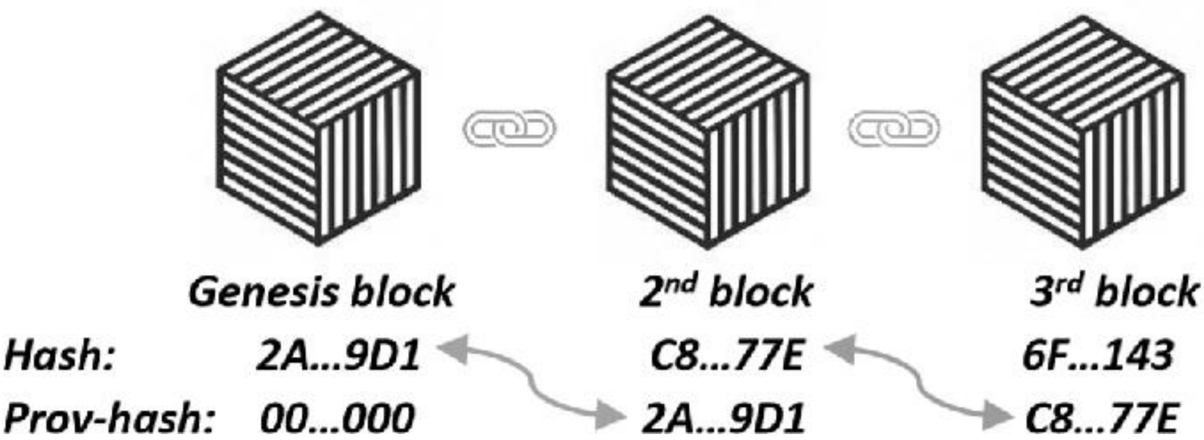

Figure 2. *A blockchain and the hash mechanism (Abdolee et al., 2019).*

In a blockchain, new information is validated through computations (*mining*) (Das et al., 2018). The computations are performed by the nodes (*miners*). Each node holds a copy of the blockchain, forming the de-centralized database. As such, information is validated, structured and stored by several parties. Consequently, the summarization of information is reliable, making blockchain to a trustworthy ledger. Figure 3 shows the entire blockchain process, with a blockchain serving as a ledger of transactions as an example.

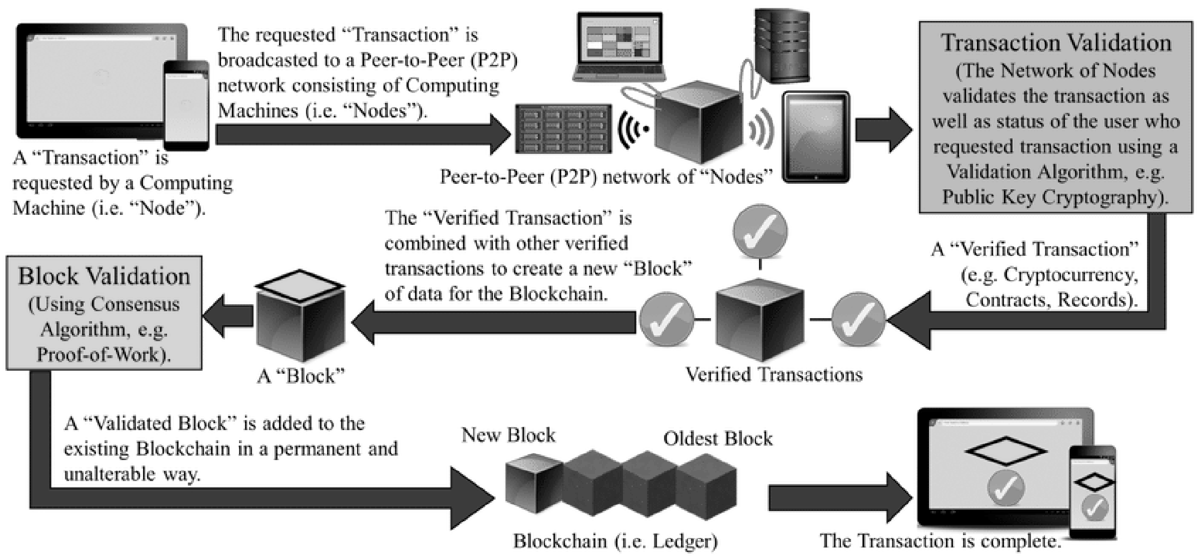

Figure 3. *New information is validated, structured and stored in a blockchain with means of the nodes in a de-centralized computer network (Das et al., 2018).*

2.2 Real Estate Tokenizing

A token is defined as a blockchain-based digital share of an asset (Benedetti et al., 2019). In real estate tokenizing, the underlying asset of the token is a property. The property is held by a holding company through which property managers, valuers, auditors etc. are hired (Colliers International et al., 2020). Furthermore, the net operating income is managed through the holding company. The holding company is controlled by a special purpose vehicle, that in turn was established by the company who originally acquired the property. The special purpose vehicle is the tokenized underlying asset.

The special purpose vehicle is tokenized and divided into tokens through a tokenization platform (Colliers International et al., 2020). Thereafter, the property is indirectly liquidated through divestments of the tokens at the secondary market. If the tokenized asset is issued on an exchange, the tokens are publicly traded. The dividend and ownership of the tokens are distributed, transferred and recorded in a read-only memory (ROM) with means of smart contracts and blockchain (further described in next section). Figure 4 shows the lifecycle of a tokenized property.

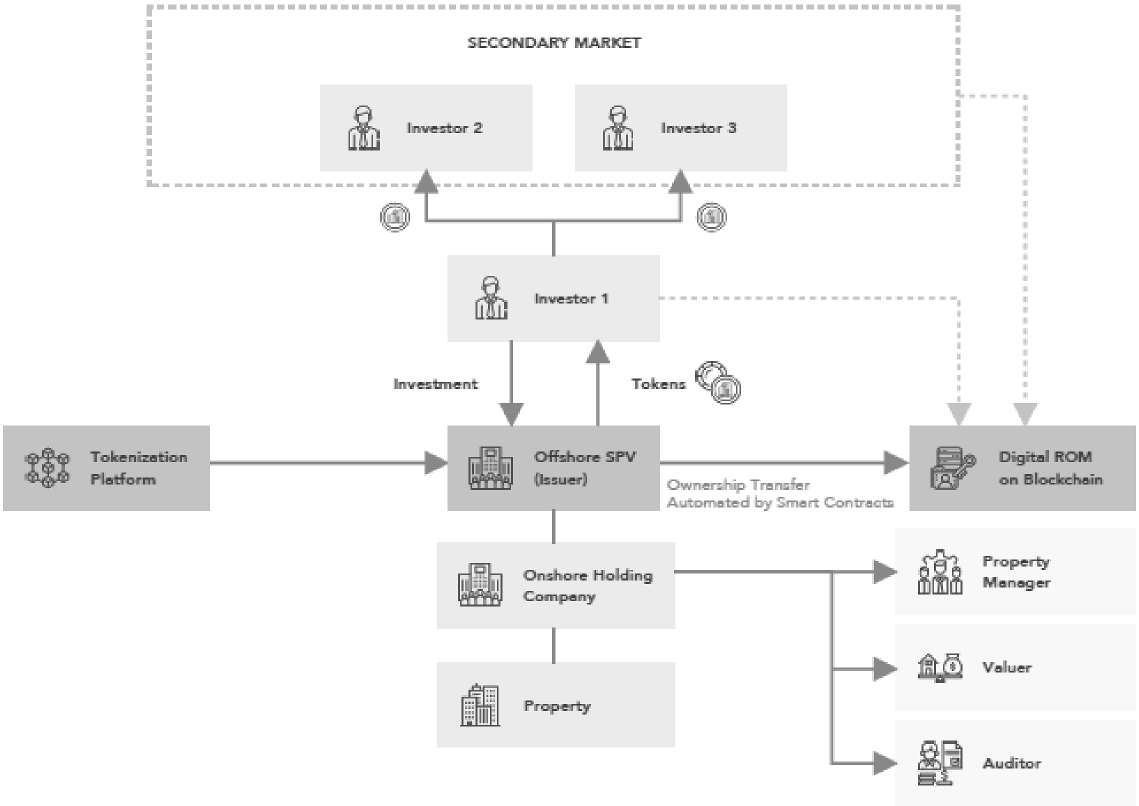

***Figure 4**. Lifecycle of a tokenized property (Colliers International et al., 2020).*

2.3 Smart Contracts and Blockchain in Real Estate Tokenizing

The core components of tokenizing are smart contracts and blockchain (Colliers International et al., 2020). A smart contract is as a transaction protocol automatically executing the terms in a contract upon fulfilled conditions (Szabo, 1994). A smart contract can be attathced to a blockchain, most commonly to the Ethereum blockchain (Antonopoulos & Wood, 2018). Ethereum is a platform for smart contracts and the crypto currency Ether. Once connected to the Ethereum blockchain, the smart contract can send and receive Ether. As such, the smart contract can automatically execute and settle transactions or corporate management actions such as dividend distributions, upon fulfilled conditions. Furthermore, the actions of the smart contracts are recorded in the Ethereum blockchain, serving as a ledger.

In real estate tokenizing, smart contracts are designed to automatically transfer net operating income and indirect ownership of properties through the connection to the Ethereum blockchain, also recording the ownership history as a ledger (Shabbir, 2021).

2.4 Valuation of Tokens

In macroeconomics, the equation of exchange shows the relationship between the money supply, the velocity of money, the price level and the transaction volume (Persons, 1911). The equation is defined as:

$$MV = PT$$

$M = Money\ supply$
$V = Velocity\ of\ money$
$P = Price\ level$
$Q = Transaction\ volume$

In token economics, the equations is modified in order to illustrate the relationship between the price and the liquidity of a token (Buterin, 2017). The new equation is defined as:

$$MC = TH$$

$M = Token\ supply$
$C = Price\ of\ the\ Token\ \left(\frac{1}{P}\right)$
$T = Transaction\ volume$
$H = Holding\ Period\ of\ the\ Token\ \left(\frac{1}{V}\right)$

Solving for C, the price of the token, gives:

$$C = \frac{TH}{M}$$

The equation shows that the price of the token is inversely proportional to the velocity of the token. Or simpler analyzed, the longer holding period of a token, the higher price of the token.

2.5 Four Quadrants of Real Estate Capital Markets

The four quadrants of real estate capital markets show different investors and investments in commercial real estate (Hudson-Wilson et al., 2003). The four quadrants are presented in figure 5.

	Private (Directly Held)	***Public (Indirectly Held)***
Equity (Owners)	Property companies, private equity funds and institutional investors through direct real estate investments	General investors through indirect real estate investments such as publicly traded vehicles and equity REITs
Debt (Lenders)	Commercial banks, private debt funds and savings institutions through private senior and subordinated debt	General investors through publicly traded bonds, collateralized mortgage-backed securities and debt REITs

Figure 5*. The four quadrants of real estate capital markets (Hudson-Wilson et al., 2003).*

On the private side, there are investors such as property companies, private equity and debt funds and different institutions. The placements are directly committed to entire and specific properties. As such, the required capital is often large, and the transaction process is often extensive and expensive. On the public side, there are several different investors in publicly traded vehicles and structured products. The placements are indirectly committed to fractions of property portfolios. As such, the required capital is often lower, and the transactions process is often efficient. On the other hand, the placements are indirect and are most commonly not concerning a specific property.

Real estate tokenizing aims to combine the benefits of the quadrants by creating a new product committed to a specific property, but with low capital requirements and efficient transaction processes due to fractionalization (Benedetti et al., 2019).

3 Literature Review

3.1 Blockchain Technology

In 2008, the pseudonym Satoshi Nakamoto published the paper “Bitcoin: A Peer-to-Peer Electronic Cash System”. The paper introduces blockchain through the invention of Bitcoin (Nakamoto, 2008). The paper became the launch of a new research field, with 41 peer-reviewed journal articles published by 2015 (Choi et al., 2016). Since 2015, Blockchain has received rapidly increased attention, with over 23,000 newspaper articles and 2,000 peer-reviewed journal articles published in 2018 already (Anascavage & Davis, 2018).

In many articles, the fundamentals of blockchain are described, analyzed and discussed. Amongst others, Mazonka (2016) describes the fundamentals of blockchain in the step-to-step paper “Blockchain: Simple Explanation”. This is followed by a general description of blockchain using Bitcoin as an example in Das et al (2018) article “Everything you Wanted to Know about the Blockchain”. Chattu et al. (2019) move on with a more detailed description of storage and the de-centralized network system blockchain is based on, in the article “The Emerging Role of Blockchain Technology Applications in Routine Disease Surveillance Systems to Strengthen Global Health Security”. Abdolee et al (2019) also go detailed, but with focus on the structure of a blockchain in the article “On the Convergence of Blockchain and Internet of Things (IoT) Technologies”.

In other articles, different areas of application are described, analyzed and discussed. Until 2015, 80% of the peer-reviewed journal articles focused on Bitcoin and less than 20% on other areas of application (Choi et al., 2016). However, banking and finance are now a days frequently researched areas of application, as the research field has expanded (Anascavage & Davis, 2018). di Carlo et al. (2018), conclude that blockchain has the potential to ensure global access to the banking and finance system. However, the authors also conclude that there are several regulatory, technical and resource-related obstacles with blockchain in banking and finance. The obstacles are further investigated by Abadi and Brunnermeier (2018) where a blockchain trilemma is discussed and proven: “it is impossible for any digital record-keeping system to simultaneously be self-sufficient, rent-free, and resource-efficient” (Abadi & Brunnermeier, 2018). The authors conclude that an external source of trust is necessary in order to achieve a blockchain, also referred to as a record-keeping system, that has all the three attributes simultaneously. In a centralized record-keeping system, all the three attributes are achieved simultaneously through trust to the centralized actor, example given a clearing house or a bank.

3.2 Real Estate Tokenizing

In 2019, MIT Digital Currency Initiative published “Tokenized Securities & Commercial Real Estate”. The report concludes several benefits with examples of processes where the benefits are applicable or achieved through (Benedetti et al., 2019). Amongst the most highlighted benefits, increased liquidity, access, fractionalization and customizability are mentioned. Through the issuance of real estate tokens and real estate token trading, a broader investor group get access to real estate investments. Furthermore, several investors can get access to the same property or portfolio of properties as the assets are fractionalized, creating customizability. Taking the fractionalization and customizability into account, real estate tokenizing has the potential to increase the liquidity in the real estate market.

Automatization, data transparency, secure recordkeeping and anti-money laundry are also mentioned as crucial benefits. Through smart contracts, automatization of ownership transfer, dividend distribution and debt payments etc. can potentially be achieved. Furthermore, the data transparency simplifies loan syndication, due-diligence processes and leasing processes, due to secure record keeping of and transparent access to property information. The secure record keeping may also automate title registration in the future. The combination of data transparency and record keeping has the potential to contribute to anti-money laundry.

While the MIT report conclude several benefits with real estate tokenizing, the report also concludes that real estate tokenizing has partly negative impact on some stakeholders in the real estate industry (Benedetti et al., 2019). Amongst others, institutional investors may lose large-scale benefits, as smaller investors may catch up the information asymmetry due to the data transparency. Furthermore, some stakeholders, such as administrative firms and consultancy firms may be negatively impacted, as administrative services may become non-relevant, outsourced or automated by the blockchain technology and the smart contracts. Debt services may lose market shares due to automated payments, brokers may lose information advantage due to data transparency and law firms may partly be preplaced by automated and standardized smart contracts. Governments may also lose control over title registration. Thus, the game plan in the real estate industry is facing significant changes, which will benefit some stakeholders and disadvantage others. The report also mentions the classification problem of real estate tokens. In the US, there is a debate whether to classify a real estate tokens as a security, property, commodity or a new type of asset. Depending on future classification, real estate tokens will be subject to different regulations, which could possibly threat the flexibility advantage of real estate tokens compared to real estate equities.

In 2020, Oxford Future of Real Estate Initiative published "Tokenisation: the future of real estate investments?". The report refers to the report "Tokenized Securities & Commercial Real Estate", published by MIT Digital Currency Initiative and adds several new relevant angles (Baum, 2020). In similarity with the MIT report, the Oxford report mentions increased liquidity, access, fractionalization, customizability, automatization, data transparency and secure record keeping as crucial benefits. The report concludes that the real estate market has high barriers, due to high requirements of capital. As such, fractionalization of properties will democratize the access to real estate investments. Furthermore, fractionalization creates customizability, where investors can access certain properties instead of portfolios through a certain REIT. In turn, the fractionalization and customizability enable increased liquidity. The Oxford report also adds that the secondary market play an important role in the increased liquidity, where higher liquidity may imply a liquidity premium on the asset. Through smart contracts, automatization of trading, cash flows, compliance and document verification etc. may be achieved. Thus, increasing the cost efficiency. Furthermore, the data transparency and the secure record keeping have the potential to simplify the access to property information and automatization of title registration. In addition to the MIT report, the Oxford report mention structured products as a potential benefit with real estate tokenizing, where additional value can be realized through derivatives and other financial products.

The Oxford report states that real estate tokenizing is at an early stage and that time is necessary in order for the real estate industry to adapt (Baum, 2020). However, there are two major threats against the development and adaption of the real estate industry. First, there must be a demand for fractionalization of single properties. To date, there is no research confirming the demand. Secondly, the in general traditional and conservative real estate industry must rely on and be comfortable with the blockchain technology. Despite this, the report also mention several disadvantages with real estate tokenizing. One major disadvantage is the fact that direct ownership of land cannot be legally fractionalized in most countries. As such, the deed is not held by the investors. This is managed through tokenization and fractionalization of a SPV holding the property. Although this is a common structure, agreement needs to be reached regarding the management and control of the vehicle. This either requires a complex solution adapted for several owners, or an expensive intermediate ownership structure. Other mentioned disadvantages cover single-asset vehicle risk and problems regarding the public secondary trading. As a real estate token is a non-diversified asset, investors are exposed to single-asset vehicle risk. While professional investors manage the risk by combining real estate tokens into a portfolio, non-professional investors may lack of experience, which makes a real estate token riskier for the public than a REIT. There are also question marks whether the real estate industry desires a liquid and volatile secondary market. Furthermore, the empirical characteristics of real estate tokens are yet unexplored. How do they perform?

In 2020, the Royal Institution of Chartered Surveyors (RICS) published “A critical review of distributed ledger technology and its applications in real estate”. While previous research mainly have focused on benefits with real estate tokenizing, the RICS report adds a more critical review to the phenomenon. The report conclude that the transactions process in the real estate market is often considered as inefficient, untransparent, and expensive (Chapman et al., 2020). The issue causes an illiquid market, where blockchain technology has got attention in the real estate sector through real estate tokenizing. Amongst the benefits, improved speed, efficiency, transparency and trust in transactions are mentioned. As in the MIT and Oxford reports, this is motivated by fractionalization, customizability, automatization, data transparency and secure record keeping, potentially resulting in higher liquidity.

However, the RICS report also conclude some major disadvantages with the technology. Amongst others, the long-term efficiency of the technology is questioned due to the scalability problem, that limits the number of transactions per second. This is further emphasized by the fact that the technology is very energy intensive. Furthermore, transactions still need manual handling due to verification needs of data and sources. There are also some threats against the technology, which cover legal and social aspects. Regarding the legal aspects, existing laws are still catching up with the technology. For example, it is still legally impossible to directly own properties through real estate tokens in most countries. As such, there is no actual change in the deed upon a transaction. Regarding the social aspects, the technology is dependent on several stakeholders, which requires guidance from governments and regulations in order to fully implement the technology.

In addition to the MTI, Oxford and RICS reports, real estate tokenizing are described and discussed in several other articles. Konashevych (2020) presents legal, technological, and organizational aspects with blockchain technology serving as an alternative or a complement to traditional title registration. Furthermore, blockchain technology in real estate is presented as a solution to corruption, inefficient governance and bureaucratic procedures. Opdenakker and Wouda (2019) add a more transaction focused perspective by investigating blockchain application in office transactions in the Netherlands, where the office transactions are considered as extensive and inefficient, partly due to lack of market transparency. A blockchain based application is proposed, in order to improve the access and transparency to physical and contractual property information, which guarantees the quality of the data and consequently the quality of the entire transaction process. Nijland and Veuger (2019) move on by concluding that the transaction process is dependent on third parties, due to a localized, segmented and private real estate market, which causes high transaction costs and an illiquid market. As such, blockchain as a data sharing program has the potential to change the game plan, where third parties are outsourced. Thus, reducing costs and adding value and efficiency to the real estate market through higher transparency, safety and reliability. However, blockchain technology is still at an early stage in the real estate sector. Grigoryev et al. (2020) add another angle by observing the actual outcome and experience of global real estate transactions performed with means of blockchain technology. The result showed that real estate transactions may proceed faster, safer and cheaper when involving blockchain technology in real estate transactions. Shabbir (2021) agrees with previous authors in his view of the benefits of real estate tokenizing. However, an eventual threat might be the general data protection regulation (*GDPR*). The regulation allows the right to remove data when no longer necessary. However, data stored in a public blockchain cannot be removed. An eventual conflict with GDPR could be mitigated through private blockchains though (IBM, 2021).

4 Theoretical Framework

4.1 Four Central Moments of Distribution

The shape of a distribution is primarily described by the four central moments (Griffiths et al., 2017). The first moment is the mean (*Equation 3, Section 5.4*). The mean is a measure of the center of a distribution. In financial context, the mean is also known as average return. The average return is a measure of past performance of a security or a portfolio. The second moment is the variance. The variance is a measure of the deviation from the mean or the center of a distribution. In other words, the variance measures the spread of the values. In financial context, the square root of the variance is known as volatility (*Equation 4, Section 5.4*). Volatility is a measure of price fluctuations and represents risk. The third moment is the skewness (*Equation 5, Section 5.4*). The skewness is a measure of the asymmetry of a distribution. If the skewness is negative, the left tail is longer, meaning that the mass is concentrated to right of the distribution. If the skewness is positive, the right tail is longer, meaning that the mass is concentrated to the left of the distribution. In financial context, a negative skewness of historical returns means that there were frequent small gains and a few large losses. A positive skewness of the historical returns on the other hand, means that there were frequent small losses and a few large gains. The fourth moment is the kurtosis (*Equation 6, Section 5.4*). The kurtosis is a measure of the thickness of the tails and the height of the peak of a distribution. If the kurtosis is low, most values lie around the mean. If the kurtosis is high, most values lie apart from the mean. In financial context, a low kurtosis of historical returns means that there were even returns. A high kurtosis of historical returns on the other hand, means that there were extreme returns, either positive or negative. As such, high kurtosis is also known as kurtosis risk.

4.2 Autocorrelation

The autocorrelation (*Equation 7, Section 5.4*) is a measure of the correlation between a time series of observations and a lagged version of the same time series of observations. The autocorrelation ranges from -1 to +1, where -1 represents a perfect negative correlation while +1 represents a perfect positive correlation. In financial context, autocorrelation is applied in order to analyze how much impact historical returns have on future returns, where the current returns are dependent on the lagged returns. If the autocorrelation is positive, the returns are expected to move on as previous. If the autocorrelation is negative on the other hand, the returns are expected to move opposite as previous. If the autocorrelation is around zero, historical movements do not affect future movements.

4.3 Sharpe Ratio

The Sharpe Ratio (*Equation 9, Section 5.4*) is a measure of an asset's return per unit of risk (Sharpe, 1994). The measure is defined as the arithmetic mean of the difference between the asset's return and the risk-free rate, divided by the volatility of the excess return. The ratio only holds for several investment returns. The ratio also only holds under the assumption that returns are normally distributed.

With means of the Sharpe Ratio, the performance of different portfolios can be evaluated and compared in terms of risk-adjusted return, based on historical data. The Sharpe Ratio indicates whether the excess return was achieved by undertaking high risk or through smart investment decisions. The higher Sharpe Ratio, the higher risk-adjusted return. If the Sharpe Ratio is negative, the return was lower than the risk-free rate.

4.4 Beta, CAPM and Jensen's Alpha

The capital asset pricing model, CAPM (*Equation 11, Section 5.4*) is a measure of an asset's expected return given time value of money and risk (Sharpe, 1964). The time value of money is represented by the risk-free rate. The risk is represented by Beta (*Equation 10, Section 5.4*) times the excess return of a market or a reference index.

Jensen's Alpha (*Equation 12, Section 5.4*) is a measure of an asset's risk-adjusted return (Jensen, 1967). The measure is defined as the difference between the asset's realized return and the return predicted by CAPM. If the Alpha is positive, the asset is earning excess return to the market or reference index. If the Alpha is negative on the other hand, the asset is underperforming the market or reference index.

4.5 Confidence Interval

The t-statistic t is defined as $t = \frac{b_k - \beta_k}{se(b_k)} \sim t_{(n-2)}$, where b_k is the estimation of the true but unknown parameter β_k in a statistical model and $se(b_k)$ is the standard deviation of the estimation b_k. In a t-distribution, there is a critical value t_c such that $P(-t_c \leq t \leq t_c) = (1 - \alpha)$, where α is a significance level in terms of probability. Substituting t with the definition of t and rearranging the expression gives $P\big(b_k - t_c se(b_k) \leq \beta_k \leq b_k + t_c se(b_k)\big) = (1 - \alpha)$ (*Equation 13, Section 5.4*). As such, there is $(1 - \alpha)$ probability that the interval $b_k \pm t_c se(b_k)$ contains the true but unknown value of β_k. Assume a null hypothesis $H_0: \beta_k = c$ and an alternative hypothesis $H_1: \beta_k > c$. If $t < t_{(\alpha,N-2)}$, then the null hypothesis is not rejected at the level of significance α, as the interval $b_k \pm t_{(\alpha,N-2)} se(b_k)$ contains the constant c at $(1 - \alpha)$ probability. If $t > t_{(\alpha,N-2)}$ on the other hand, then the null hypothesis is rejected at the level of significance α, as the interval $b_k \pm t_{(\alpha,N-2)} se(b_k)$ not contains the constant c at $(1 - \alpha)$ probability. When testing the significancy of Jensen's Alpha, the null hypothesis is $H_0: \beta_k = 0$ and the alternative hypothesis is $H_1: \beta_k > 0$. If the t-statistic for Jensen's Alpha, that is to say the ratio between the Alpha estimation minus zero and the standard deviation of the Alpha estimation, is larger than the critical value for the level of significance α, then the confidence interval is not containing the value 0 at $(1 - \alpha)$ probability. As such, the null hypothesis is rejected at the level of significance α as Jensen's Alpha is significantly larger than 0. Another way to decide significancy of Jensen's Alpha is through the p-value, indicating the probability that Jensen's Alpha is a random number.

5 Methodology

5.1 Qualitative and Quantitative Approach

The qualitative method is applied to understand phenomena from a certain point of view, with means of descriptive research, interviews and observations (Slevitch, 2011). The quantitative method is applied to create objectivity and generalizability, with means of mathematics and large amounts of data. This study aims to investigate the descriptive attributes and empirical characteristics of real estate tokens. The descriptive attributes are ambiguous and subjective. Furthermore, the attributes are analyzed from a certain point of view, with means of descriptive research. The empirical characteristics on the other hand, are unambiguous and objective. Furthermore, the empirical characteristics are analyzed objectively, with means of mathematics and large amounts of data. Thus, both a qualitative and a quantitative approach are selected for this study. The qualitative approach will be applied answering the first research question (*Q1*) and the quantitative approach will be applied answering the second research question (*Q2*).

5.2 Data Selection

The data selection for the first research question (*Q1*) is primarily limited to academic literature, such as published research articles, papers and reports. The data selection for the second research question (*Q2*) is limited to the entire trading history of all US residential real estate tokens, available for public trading as of January 2021. The real estate tokens are selected from Security Token Market, a listing website that summarizes market data from other exchanges. The selected US housing reference index is the S&P/Case-Shiller Michigan-Detroit Home Price Index (*DEXRNSA*), as all US residential real estate tokens, available for public trading as of January 2021 originate from Detroit. The selected market indexes are S&P 500 Price Return (*SPX*) and S&P 500 Total Return (*SPXTR*). The selected risk-free rate is the US 3 Month Treasury Bill (*TMUBMUSD03M*). The selected real estate tokens are listed in Table 1 below.

Name	**STO Volume**	**STO Date**
16200 Fullerton Ave	$615,000	2019/10/01
10024 28 Appoline St	$582,000	2020/02/03
8342 Schaefer Hwy	$203,333	2020/02/05
25097 Andover Dr	$74,389	2020/03/03
18276 Appoline St	$73,244	2020/03/30
20200 Lesure St	$69,400	2019/11/01
9943 Marlowe St	$63,750	2019/11/01
9336 Patton St	$62,700	2020/02/04
5942 Audubon Rd	$58,300	2019/10/04

Table 1. *Selected Real Estate Tokens (Security Token Market, 2021).*

5.3 Coding of Data

In order to present the pros and cons of real estate tokenizing, according to the first research question (*Q1),* the gathered material is summarized and concluded into a pros and cons grid in terms of investment, asset management and public interests.

In the second research question (*Q2*), the empirical characteristics of publicly traded US residential real estate tokens and their performance against US housing index and market index are presented. As such, the historical trading data of the selected real estate tokens are downloaded from Security Token Market's website (https://stomarket.com/). The monthly returns excluding and including dividend are calculated for each of the selected real estate tokens according to equation 1. The selected real estate tokens are then combined into four real estate token indexes. The indexes are either equally or market weighted and exclude or include dividend. The monthly returns of the indexes are calculated according to equation 2. The real estate token indexes are presented below:

Equally Weighted Real Estate Token Price Index (*EWRETPI)*
Equally Weighted Real Estate Token Gross Index (*EWRETGI*)
Market-Value Weighted Real Estate Token Price Index (*MWRETPI*)
Market-Value Weighted Real Estate Token Gross Index (*MWRETGI*)

Furthermore, the US housing reference index DEXRNSA and the risk-free rate TMUBMUSD03M are downloaded from the Federal Reserve Bank of St. Louis' website (https://fred.stlouisfed.org/). The market indexes SPX and SPXTR are downloaded from Standard and Poors' website (https://www.spglobal.com/).

The four central moments of distribution are then calculated for the monthly returns of all indexes according to equations 3, 4, 5 and 6. The autocorrelations with one period of lag are also calculated for the real estate token indexes according to equation 7. Furthermore, the excess returns of all indexes are calculated for every return according to equation 8. The Sharpe Ratio of all indexes are then calculated and compared according to equation 9. Finally, Beta, CAPM, Jensen's Alpha and a 95% confidence interval of Beta and Jensen's Alpha are calculated for all real estate token indexes with DEXRNSA, SPX and SPXTR serving as the market portfolios according to equations 10, 11, 12 and 13.

5.4 Mathematical and Financial Formulas

Return (1)

$$R_t = \frac{(P_t - P_{t-1}) + D_t}{P_{t-1}}$$

$R_t = Return$
$P_{t-1} = Ingoing\ Price$
$P_t = Outgoing\ Price$
$D_t = Dividends$
$t = Time$

Portfolio Return (2)

$$R_{p,t} = \sum_{i=1}^{N} R_{i,t} W_i$$

$R_{p,t} = Portfolio\ Return$
$R_{i,t} = Return\ of\ Asset\ i$
$W_i = Weight\ of\ Asset\ i$
$N = Number\ of\ Assets$

Arithmetic Return (3)

$$\bar{R} = \frac{1}{T} \sum_{t=1}^{T} R_t$$

$\bar{R} = Arithmetic\ Return$
$R_t = Return$
$T = Number\ of\ Periods$

Volatility (4)

$$\sigma = \sqrt{\frac{1}{T-1} \sum_{t=1}^{T} (R_t - \bar{R})^2}$$

$\sigma = Volatility$
$\bar{R} = Arithmetic\ Return$
$R_t = Return$
$T = Number\ of\ Periods$

Skewness (5)

$$S = \frac{\sum_{t=1}^{T}(R_t - \bar{R})^3}{(T-1)\sigma^3}$$

$S = Skewness$
$\sigma = Volatility$
$\bar{R} = Arithmetic\ Return$
$R_t = Return$
$T = Number\ of\ Periods$

Kurtosis (6)

$$K = \frac{\sum_{t=1}^{T}(R_t - \bar{R})^4}{(T-1)\sigma^4}$$

$K = Kurtosis$
$\sigma = Volatility$
$\bar{R} = Arithmetic\ Return$
$R_t = Return$
$T = Number\ of\ Periods$

Autocorrelation (7)

$$ACF = \frac{\sum_{t=1+k}^{T}(R_t - \bar{R})(R_{t-k} - \bar{R})}{\sum_{t=1}^{T}(R_t - \bar{R})^2}$$

$ACF = Auotocorrelation$
$k = Number\ of\ Lags$
$\bar{R} = Arithmetic\ Return$
$R_t = Return$
$T = Number\ of\ Periods$

Portfolio Excess Return (8)

$$R_{p,e,t} = R_{p,t} - R_{f,t}$$

$R_{p,e,t} = Portfolio\ Excess\ Return$
$R_{p,t} = Portfolio\ Return$
$R_{f,t} = Risk\text{-}Free\ Rate$

Sharpe Ratio (9)

$$S = \frac{\overline{R_{p,e}}}{\sigma_{p,e}}$$

$S = Sharpe\ Ratio$
$\overline{R_{p,e}} = Arithmetic\ Portfolio\ Excess\ Return$
$\sigma_{p,e} = Volatility\ of\ Portfolio\ Excess\ Return$

Beta (10)

$$\beta = \frac{\frac{1}{T-1}\sum_{t=1}^{T}\left(R_{p,e,t} - \overline{R_{p,e}}\right)\left(R_{m,e,t} - \overline{R_{m,e}}\right)}{{\sigma_{m,e}}^{2}}$$

$\beta = Beta$
$R_{p,e,t} = Portfolio\ Excess\ Return$
$\overline{R_{p,e}} = Arithmetic\ Portfolio\ Excess\ Return$
$R_{m,e,t} = Market\ Excess\ Return$
$\overline{R_{m,e}} = Arithmetic\ Market\ Excess\ Return$
$\sigma_{m,e} = Volatility\ of\ Market\ Excess\ Return$
$T = Number\ of\ Periods$

CAPM (11)

$$E\left(\overline{R_p}\right) = \overline{R_f} + \beta\overline{R_{m,e}}$$

$E\left(\overline{R_p}\right) = CAPM\ Predicted\ Arithmetic\ Portfolio\ Return$
$\beta = Beta$
$\overline{R_f} = Arithmetic\ Risk\text{-}Free\ Rate$
$\overline{R_{m,e}} = Arithmetic\ Market\ Excess\ Return$

Alpha (12)

$$\alpha = \overline{R_p} - (\overline{R_f} + \beta\overline{R_{m,e}})$$

$\alpha = Alpha$
$\beta = Beta$
$\overline{R_p} = Arithmetic\ Portfolio\ Return$
$\overline{R_f} = Arithmetic\ Risk\text{-}Free\ Rate$
$\overline{R_{m,e}} = Arithmetic\ Market\ Excess\ Return$

Confidence Interval (13)

$$P\left(b_k - t_c se(b_k) \leq \beta_k \leq b_k + t_c se(b_k)\right) = 1 - \alpha$$

$\beta_k = True\ but\ Unknown\ Parameter$
$b_k = Estimation\ of\ \beta_k$
$se(b_k) = Standard\ Deviation\ of\ b_k$
$t_c = Critical\ Value\ following\ Student's\ t\text{-}Distribution$
$\alpha = Probability$

6 Results

6.1 Pros and Cons of Real Estate Tokenizing

In section 6.1, the pros and cons in terms of investment, asset management and public interest are presented. The pros and cons are listed in table 2 below.

	Investment	*Asset Management*	*Public Interests*
Pros	**Fractionalization** Fractionalization creates customizability in the acquisition of a portfolio **Access** Further access to properties **Data Transparency** Data transparency in market information, debt financing and DD processes **Transaction Efficiency** More efficient transaction processes **Liquidity** Liquid environment for acquisitions and divestments **Structured Products** Additional value through structured products and derivatives	**Fractionalization** Fractionalization creates customizability in the management of a portfolio **Data Transparency** Data transparency in the leasing process and benchmarking of property performance **Automatization** Automatization of cashflows, dividend distributions and ownership **Record Keeping** Safe and secure record keeping of ownership **AM Efficiency** More efficient asset management	**Access** Public access to real estate investments due to lower capital requirements **Governmental Efficiency** Governmental efficiency in title registration and surveillance **Governance** Anti-corruption and minimization of inefficient governance and bureaucratic procedures **AML** Validation of identity and monitoring of token owners prevents money laundering

	Investment	*Asset Management*	*Public Interests*
Cons	**Demand** Low demand for fractionalization in practice **Trust** Real estate industry must rely on blockchain technology **Data Transparency** Loss of secrecy and of large-scale benefits for institutional investors **Debt Financing** Lack of deed gives no security in debt financing **Secondary Trading** Liquid and volatile public secondary market with uncertain trading to NAV **Liquidity Paradox** Lower liquidity increases the value of real estate tokens	**Scalability Problem** Scalability problem due to general limitations in blockchain technology **Management** Lack of management and responsibility **Deed** No transfer of deed due to legal obstacles in fractionalization of land **Manual verification** Still need to verify data manually	**Classification** Digital representation of a property or a financial derivative of a property? **Singe-asset Vehicle Risk** Increased risk for non-professional investors **Sustainability** Energy intensive blockchain technology **GDPR** No possibility to delete or remove information in public blockchain **Changed game plan** A changed game plan brings uncertainty to several players and stakeholders

Table 2. *Pros and cons grid.*

6.2 Empirical Characteristics

In section 6.2, the empirical characteristics are presented, starting with the aggregated returns. Over the one-year period, from February 2020 to February 2021, SPXTR had the highest aggregated return, followed by SPX that ended up slightly above EWRETGI. EWRETGI had highest aggregated return amongst the real estate tokens indexes, while MWRETPI had lowest aggregated return of all indexes. DEXRNSA had a relatively low but on the other hand stable aggregated return compared to the other indexes. The aggregated returns of all indexes are presented in figure 6.

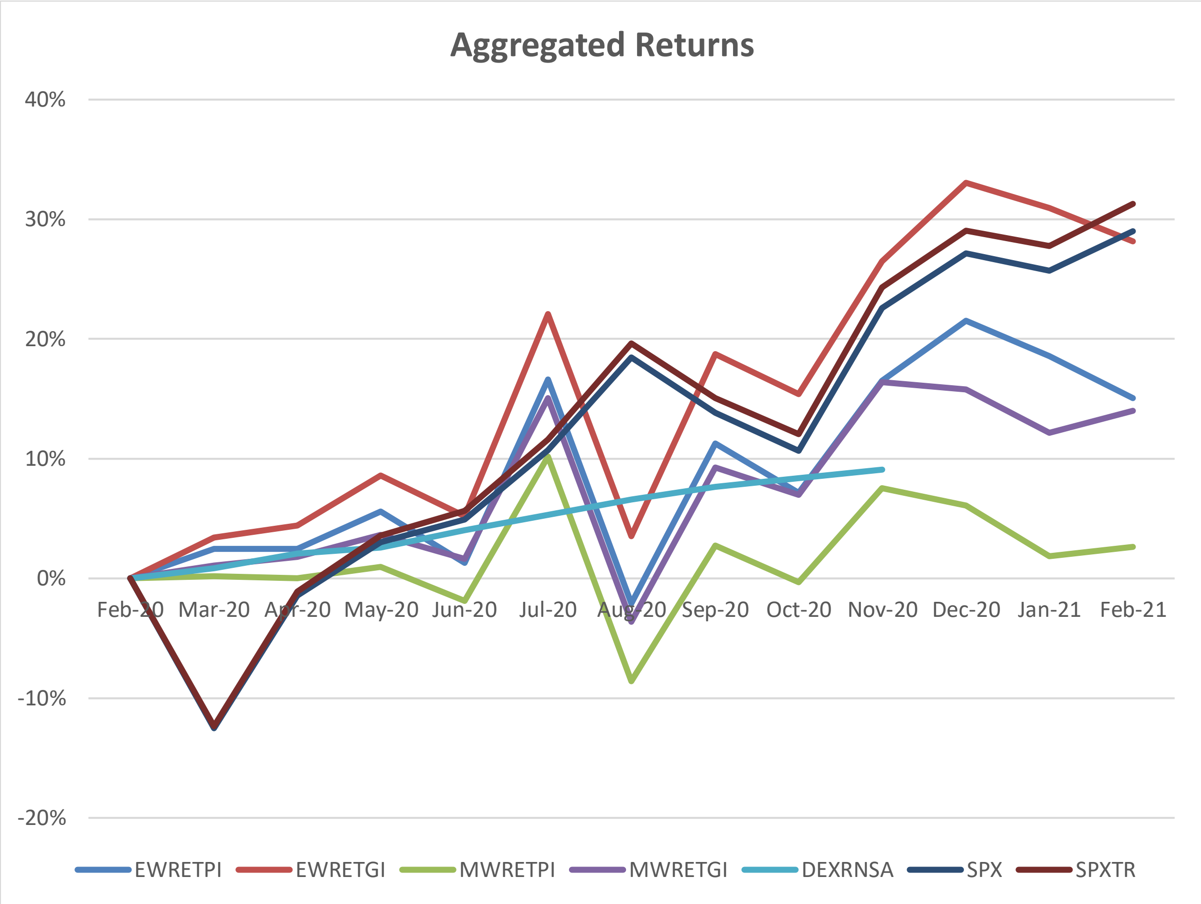

Figure 6. *Aggregated returns.*

Table 3 shows the descriptive statistics of the returns for the real estate tokens indexes. All real estate token indexes had high standard deviation relative the mean, especially the market weighted indexes. All real estate token indexes also had positive kurtosis and negative skewness. Furthermore, all real estate token indexes had a high negative autocorrelation.

Descriptive Statistics – Real Estate Token Indexes				
	EWRETPI	***EWRETGI***	***MWRETPI***	***MWRETGI***
Mean	0.0151	0.0242	0.0051	0.0139
Median	0.0123	0.0219	0.0001	0.0090
Standard Deviation	0.0851	0.0855	0.0792	0.0796
Skewness	-0.2074	-0.2050	-0.4110	-0.4084
Kurtosis	0.6195	0.6149	1.4712	1.4683
Range	0.3109	0.3122	0.2941	0.2959
Minimum	-0.1603	-0.1518	-0.1703	-0.1623
Maximum	0.1507	0.1603	0.1238	0.1337
Count	12	12	12	12
Autocorrelation	-0.7888	-0.7889	-0.7673	-0.7673

Table 3. *Descriptive statistics for the real estate token indexes.*

Table 4 shows the descriptive statistics of the returns for the reference indexes. The reference indexes had low standard deviation relative the mean, especially DEXRNSA. All reference indexes had positive kurtosis, except DEXRSNA, and negative skewness. Furthermore, all reference indexes had, in accordance with the real estate token indexes, a negative autocorrelation, although less negative.

Descriptive Statistics – Reference Indexes			
	DEXRNSA	***SPX***	***SPXTR***
Mean	0.0097	0.0236	0.0251
Median	0.0097	0.0316	0.0330
Standard Deviation	0.0032	0.0684	0.0685
Skewness	-0.1774	-0.6409	-0.6359
Kurtosis	-1.5817	0.8829	0.8487
Range	0.0089	0.2520	0.2517
Minimum	0.0050	-0.1251	-0.1235
Maximum	0.0139	0.1268	0.1282
Count	9	12	12
Autocorrelation	-0.1836	-0.2988	-0.2968

Table 4. *Descriptive statistics for the reference indexes.*

Table 5 shows the arithmetic index excess return, volatility of index excess return and Sharpe ratio of each index. According with the descriptive statistics, DEXRSNA had the highest Sharpe ratio and MWRETPI had the lowest Sharpe ratio. In fact, all reference indexes outperformed the real estate tokens indexes in terms of Sharpe ratio. All reference indexes had a Sharpe ratio above one while all real estate token indexes had a Sharpe ratio below one.

Sharpe Ratio			
	$\overline{R_{p,e}}$	$\sigma_{p,e}$	***Sharpe Ratio***
EWRETPI	0.0139	0.0246	0.5648
EWRETGI	0.0230	0.0247	0.9318
MWRETPI	0.0039	0.0229	0.1701
MWRETGI	0.0127	0.0230	0.5536
DEXRNSA	0.0083	0.0011	7.8357
SPX	0.0224	0.0198	1.1289
SPXTR	0.0239	0.0199	1.2025

Table 5. *Arithmetic index excess return, volatility of index excess return and Sharpe ratio of all indexes.*

Table 6 shows the Beta and Jensen's Alpha of all real estate token indexes, with DEXRNSA, SPX and SPXTR serving as reference indexes. The results show that all real estate token indexes had a negative Beta and a positive Alpha in all cases. However, due to limited data points from the monthly returns of the one-year period, the significance is low. Table 7 and table 8 show a 95% confidence interval for Beta and Alpha in all outcomes. The confidence intervals contain both positive and negative values for both Beta and Alpha. As such, it is not possible to conclude that the real estate token indexes outperform the reference indexes in terms of Jensen's Alpha.

Beta and Jensen's Alpha						
	DEXRNSA		**SPX**		**SPXTR**	
	β	α	β	α	β	α
EWRETPI	-5.7770	0.0681	-0.0646	0.0153	-0.0650	0.0154
EWRETGI	-5.8016	0.0776	-0.0661	0.0245	-0.0666	0.0246
MWRETPI	-4.5749	0.0486	-0.0445	0.0049	-0.0451	0.0050
MWRETGI	-4.5983	0.0577	-0.0459	0.0137	-0.0465	0.0138

Table 6. *Beta and Jensen's Alpha, real estate token indexes against the reference indexes.*

Confidence Interval Beta						
	DEXRNSA		***SPX***		***SPXTR***	
	Lower	***Upper***	***Lower***	***Upper***	***Lower***	***Upper***
EWRETPI	-32.4196	20.8656	-0.9358	0.8067	-0.9349	0.8048
EWRETGI	-32.5575	20.9543	-0.9414	0.8092	-0.9405	0.8073
MWRETPI	-29.7383	20.5885	-0.8558	0.7669	-0.8551	0.7650
MWRETGI	-29.8755	20.6789	-0.8611	0.7693	-0.8604	0.7674

Table 7. *95% confidence interval for Beta, real estate token indexes against the reference indexes.*

Confidence Interval Jensen's Alpha						
	DEXRNSA		***SPX***		***SPXTR***	
	Lower	***Upper***	***Lower***	***Upper***	***Lower***	***Upper***
EWRETPI	-0.1679	0.3040	-0.0452	0.0759	-0.0455	0.0764
EWRETGI	-0.1593	0.3146	-0.0364	0.0853	-0.0367	0.0858
MWRETPI	-0.1742	0.2715	-0.0515	0.0613	-0.0518	0.0617
MWRETGI	-0.1661	0.2816	-0.0429	0.0704	-0.0432	0.0709

Table 8. *95% confidence interval for Jensen's Alpha, real estate token indexes against the reference indexes.*

7 Analysis and Discussion

7.1 Pros of Real Estate Tokenizing

Real estate tokenizing makes fractionalization of properties as funds, REITs etc. possible (Benedetti et al., 2019). One of the main ideas is to increase the liquidity in the real estate capital market, by reducing the capital requirements and increasing the access to certain properties. Thus, making real estate investments accessible for a broader investor group. Furthermore, fractionalization creates customizability for investors in the acquisition and composition of a property portfolio (Baum, 2020). Accordingly, fractionalization creates customizability in the management of a portfolio.

The blockchain technology also enables increased data transparency in the transaction market as transactions can be traced in the block chain (Opdenakker & Wouda, 2019). As such, market information become more transparent. Furthermore, property information can be structured and stored in the blockchain (Konashevych, 2020). Thus, reliable and verified property information can easily be accessed and used in due diligence processes, leasing processes or in debt financing processes. Consequently, the transaction process becomes more efficient, both in terms of time and money, as several stages and agency costs can be cut (Grigoryev et al., 2020). The benefits enable a more liquid investment environment for acquisitions and divestments of properties. A liquid investment environment attracts new and more investors. Thus, increasing the demand, potentially resulting in a liquidity premium. In addition to that, additional value can potentially be added through structured products or derivatives of real estate tokens (Baum, 2020).

With means of the smart contracts, cashflows and dividend distributions are automatically executed upon fulfilled conditions in the smart contract (Shabbir, 2021). This is especially useful for vehicles with several investors and continuous distributions, where time is of essence for the internal rate of return (Baum, 2020). Accordingly, the transfer of the token ownership is automatically executed. Thus, making the asset management more efficient. Furthermore, the asset management processes are executed and stored in a blockchain, with safe and secure record keeping of ownership.

In similarity with the private sector, the public sector can benefit from automated title registration processes (Chapman et al., 2020). Although the legal system makes actual transfer of deed impossible today, real estate tokenizing has the potential to automate title registration in the future. As such, increasing the governmental efficiency and reducing bureaucratic bottlenecks delaying property development. Furthermore, there are public interest in terms of anti-corruption in countries where ownership of properties is weak and where several parties make claim on the same property. Accordingly, there are public interests in terms of anti-money laundry as well due to easier surveillance and monitoring of property transactions as well as identification validation requirements of investors.

7.2 Cons of Real Estate Tokenizing

Real estate tokenizing offers several benefits and opportunities, mostly through fractionalization of properties. However, as the real estate market has been formed by and is dominated by big players, the actual demand for fractionalization is low in practice (Baum, 2020). A low demand in a conservative market creates initial obstacles for real estate tokenizing, which is dependent of a real estate conversion to blockchain technology. Especially when institutions and other big players may lose secrecy and large-scale benefits due to a more transparent market (Benedetti et al., 2019). In addition to this, there are several question marks regarding real estate tokenizing in practice and primarily on a larger scale. One of the problems is the scalability problem, a general blockchain dilemma caused by the limited number of transactions per second in a blockchain (Abadi & Brunnermeier, 2018). As the use of real estate tokenizing and blockchain technology in general increase, the efficiency risk to decrease (Chapman et al., 2020). Another problem is the management of the property, partly caused by the fact that the deed is not transferred (Baum, 2020).

One solution to the management issue is to assign the property an organization, forming a property company (Baum, 2020). However, then investors invest in a property company, like in the first quadrant of the four quadrants of real estate capital markets, rather than in a property (Hudson-Wilson et al., 2003). Furthermore, this requires a minimum volume of the property in order to be profitable. Another solution is a third-party issuer, who issues real estate tokens and manages the tokenized properties. However, this creates limitations and dependency of the third-party issuer, which is a paradox since one of the main ideas with real estate tokenizing is to outsource third parties (Nijland & Veuger, 2019). Another paradox is the liquidity paradox. While real estate tokenizing aims to solve liquidity issues, low liquidity increases the value of tokens according to token valuation theory (Buterin, 2017).

The fact that the deed is not transferred also creates other problems, for example in debt financing (Baum, 2020). When investing in real estate tokens, the investors buy equities in an unlevered special purpose vehicle that represents the property (Colliers International et al., 2020). The special purpose vehicle is the actual tokenized asset. However, as the deed does not follow the investor, there is no security for the debt financier. As such, there is a financing risk which is one of the most crucial factors in real estate investments. Furthermore, there is a risk for fraud as investors need to verify that the tokenized special purpose vehicle actually holds the property. Accordingly, data still need to be verified manually, reducing automatization benefits from asset management.

Another problem is the legal classification of real estate tokens (Benedetti et al., 2019). It is discussed whether a real estate token is a digital representation of a property or a financial derivative of a property. For example, the empirical characteristics in this study indicate that the real estate token indexes are more similar to the S&P 500 than to the housing index. Consequently, tokens may qualify as a financial product, requiring more extensive frameworks and regulations, reducing the benefits against the traditional equity market. Furthermore, it is relevant to ask whether the real estate industry and the public desire a liquid and volatile real estate market with uncertain trading to NAV. Accordingly, real estate tokens entail a single-asset vehicle risk for non-professional investors.

7.3 Empirical Characteristics

The aggregated returns, measured over the one-year period February 2020 to February 2021, show that the market indexes S&P 500 performed best in terms of total return. The equally weighted real estate token indexes performed best amongst the real estate token indexes in terms of total return. Compared to the market indexes S&P 500, who had a difference of 2.28 percentage units in total return, the equally weighted real estate token indexes had a significantly higher difference in total return of 13.09 percentage units. As such, it is possible to conclude that the total return of the selected real estate tokens where highly driven by the dividend during the selected period of time. Furthermore, the equally weighted real estate token indexes performed better than the market-value weighted indexes in terms of total return. As such, it is possible to conclude that the selected real estate tokens with lower market cap performed better than the selected real estate tokens with higher market cap during the selected period of time.

With exception from the market-value weighted real estate token price index who performed worst in terms of total return, the Detroit housing index showed the lowest total return. In addition to the difference in total return between the real estate tokens indexes and the Detroit housing index, figure 6 also shows differences in the movements of the returns. In fact, figure 6 shows that the real estate token indexes seem to have more similar movements with the market indexes S&P 500 than with the housing index. This indicates that real estate tokens are rather a new type of financial product than a blockchain-based digital share of an asset, which strengthens the problem with the legal classification of real estate tokens.

The descriptive statistics show in accordance with the aggregated returns, that the market indexes S&P 500 performed best in terms of mean of the returns, followed by the equally weighted real estate indexes, the market-value weighted real estate indexes and the Detroit housing index. However, the Detroit housing index showed lowest standard deviation of the returns, followed by the market indexes S&P 500, the market-value weighted real estate token indexes and the equally weighted real estate token indexes. Furthermore, all the indexes showed a negative skewness, indicating frequent small gains and a few large losses. Moreover, all indexes despite the Detroit housing index showed a positive kurtosis, indicating higher risk.

The Sharpe ratios show in accordance with the descriptive statistics that the Detroit housing index performed best in terms of risk-adjusted return, followed by the market indexes S&P 500, the equally weighted real estate token indexes and the market-value weighted real estate token indexes. As such, the Sharpe ratios indicate that the real estate tokens indexes underperformed the market indexes S&P 500 and the Detroit housing index in terms of risk-adjusted return. However, all real estate token indexes showed positive Alpha against the market indexes S&P 500 and the Detroit housing index, serving as reference indexes. Thus, indicating that the real estate token indexes earned excess return to the market indexes S&P 500 and the Detroit housing index. However, the confidence interval for Alpha contains both positive and negative values. As such, it is not possible to conclude that the real estate token indexes outperform the reference indexes in terms of Jensen’s Alpha on a significant level. The same issue applies for Beta, why it is not possible to conclude that the real estate token indexes have more similar movements with the market indexes S&P 500 than with the housing index on a significant level.

7.4 Real Estate Tokenizing and Sustainability

Although there are many question marks regarding real estate tokenizing, it is mostly important to predict the impact of real estate tokenizing on a sustainability level in the best possible manner. While real estate tokenizing has the potential to contribute to sustainability through anti-corruption and anti-money laundry, there are several drawbacks in terms of sustainability as well (Baum, 2020). Amongst others, blockchain technology is highly energy-intensive due to the decentralized computer network (Chapman et al., 2020). Furthermore, there is no possibility to delete or remove information in public blockchain, which may conflict with integrity policies such as GDPR (Shabbir, 2021). However, an eventual conflict with GDPR could be mitigated through private blockchains (IBM, 2021). It is also a fact that real estate tokenizing and blockchain technology in general have the potential to change the game plan in both the real estate industry and the global world and bring uncertainty to several players and stakeholders.

8 Conclusion

Real estate tokenizing is an interesting phenomenon with the potential to change the entire real estate industry. From the perspective of investors, the most central benefits are fractionalization and efficiency in the transactions process. Through fractionalization, the access to properties and customizability in the acquisition of a property portfolio is increased (Benedetti et al., 2019). Furthermore, the required capital for direct real estate investments is reduced. Through the blockchain technology, reliable property information is structured and easily accessed (Shabbir, 2021). Thus, reducing agent costs and creating an efficient transaction process (Nijland & Veuger, 2019). Altogether, the attributes aim to increase the liquidity in real estate investments, potentially resulting in a liquidity premium and new structured products (Baum, 2020). From the same perspective, the most central drawbacks are the lack of deed and the liquidity paradox. With lack of deed there is not security in debt financing. As such, investor may lose access to debt financing which as a crucial factor in real estate investments. Furthermore, there is a liquidity paradox, as low liquidity increases the value of tokens according to token valuation theory (Buterin, 2017).

From the perspective of asset managers, the most central benefits are automatization and efficiency in the asset management. Through blockchain technology and smart contracts, transfers of dividend and ownership are automatically executed, increasing the efficiency in the asset management (Shabbir, 2021). On the other hand, real estate tokenizing may cause a situation with lack of management due to several owners of the same property (Baum, 2020). Accordingly, the responsibility may fail. Furthermore, there are a scalability problem where the efficiency of blockchain is reduced upon increasing number of users (Brunnermeier & Abadi, 2018).

From the perspective of the public, the most central benefits are governance and AML. In countries with unreliable governments, blockchain technology has the potential to secure a safe record keeping system of the owner right to properties (Benedetti et al., 2019). Accordingly, AML can be supported with better monitoring of transactions. However, there are also major drawbacks form the same perspective, with financial and environmental sustainability being the two most central. The financial stability may be threatened by a volatile secondary market (Chapman et al., 2020). The environmental sustainability may be threatened as blockchain technology is very energy intensive.

The financial analysis shows that the total return of the real estate token indexes where in between S&P 500 and the Detroit housing index. However, the real estate token indexes underperformed both S&P 500 and the Detroit housing index in terms of risk-adjusted return, measured with the Sharpe ratio. No conclusion regarding financial performance can be drawn with means of Jensen's Alpha due to a too low level of significance. Moreover, the real estate token market seems to correlate more with the S&P 500 than the with the housing market. Further improvements of this study would be repeating the methodology in the future with a larger data set of historical returns.

The final conclusion reached is that although real estate tokenizing has great potential in a more mature market, the cons of real estate tokenizing exceed the pros to date. In a conservative real estate market, the success of real estate tokenizing is also dependent on the global view on blockchain technology.

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