The on-chain multi-asset fractional ownership scheme

a viable alternative to the traditional home ownership and rental market

Master thesis MSRE I Amsterdam School of Real Estate

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Preface

In an ever-evolving world, where the dynamics of housing markets and the needs of individuals are constantly shifting, an on-chain multi-asset fractional ownership scheme offers a promising solution. The idea of seamlessly transitioning between homes while gaining equity is more than just an academic interest to me; it's a reflection of my personal aspirations for a more inclusive, adaptable, and fair housing ecosystem.

I've often faced the age-old debate: is renting merely throwing money away while buying is the better investment? But for me, and many like me, renting represents a different kind of value. It grants the freedom to adapt, to evolve, to move without the constraints of a mortgage or the weight of a long-term commitment to one place. Therefore, I believe there's a middle ground—a way to merge the flexibility of renting with the financial benefits of ownership. This scheme is my vision of bridging that divide.

Throughout this research journey, I have had the privilege of receiving guidance and support from 2140 Consulting. I would like to express my deepest gratitude to Maarten van Doorslaer and Marcell de Vries for their expertise in the field of tokenization. Their invaluable insights and inputs have been instrumental in shaping the direction of this research, allowing for a more comprehensive exploration of the subject matter. Furthermore, I extend my heartfelt appreciation to Klaas Bosma from Reasult, who not only provided me with the opportunity to undertake this research but also provided me the time to facilitate its execution.

This thesis represents a year of diligent research, analysis, and critical thinking. It is my sincerest hope that the findings presented herein contribute to the broader understanding of the possibilities and challenges associated with introducing an on-chain multi-asset fractional ownership scheme into the existing housing market. By exploring this novel approach, we may unlock new avenues for empowering households and enabling them to adapt their living conditions with greater convenience and flexibility, ultimately fostering a more dynamic and inclusive housing ecosystem.

Daan Berghmans,
Nijmegen, 2023 August 18th

Management summary

The current housing crisis is partly due to the inherent limitations of traditional home ownership, which hinder households from easily move houses. High transaction costs and long-term mortgage commitments associated with owning an illiquid house, restrict the flexibility required to adapt to changing living circumstances. Blockchain technology offers a novel approach to redefining the concept of home ownership. By introducing an on-chain multi-asset fractional ownership scheme, households have the flexibility to transition between network-owned units, allowing them to adapt their living conditions to changing circumstances with the same convenience as the traditional rental market.

To come up with this new ownership scheme for the housing market, this research answers the question: To what extend can an on-chain multi-asset fractional ownership scheme replace the home ownership and rental market? By conducting an extensive literature study about real estate tokenization and existing fractional ownership schemes, this research found that existing fractional ownership schemes are complex and illiquid. Tokenization emerges as a solution that enhances liquidity and accessibility in cooperative real estate investments, enabling members to transition between houses without needing to sell their tokens. Furthermore, smart contracts can take away the complexity of the scheme by automatization with secure and visible recordkeeping on the blockchain to enhance the transparency.

In light of the absence of on-chain multi-asset fractional ownership schemes, the author examined three off-chain schemes (Mutual home ownership, shared ownership co-op, and Musharakah Mutanagisah Partnership). Drawing on the insights gained from this case study, a sustainable home ownership model should integrate the following design principles: ensuring sufficient capital injections, promoting inclusivity, reducing the initial deposit required, allowing flexible wealth creation, ensuring scheme simplicity, automating cash flows, encouraging member involvement, and separating equity and housing need.

Based on the literature study and case study, the research comes up with an on-chain multi-asset fractional ownership scheme. In this scheme, a token platform oversees multiple SPV's tailored to specific categories of rentable units. When a homeowner transfers legal ownership to an SPV, the economic ownership is tokenized through a security token offering. The SPV retains the legal ownership, while the tokens representing economic ownership are transferred to the homeowner. Homeowners have the option to become tenants and/or investors in the SPV, with the ability to exchange tokens on a secondary market. Tenants pay market rents for the use of rentable units, and a portion of the rent is allocated to cover operational expenses, managed by a management company. By limiting the direct return, received as dividend by token holders, a residue cash flow is channelled into an equity fund to acquire new rentable units. By tokenizing the acquired rentable units and distributing the tokens among tenant based on their contribution to the equity fund, tenants gain wealth which leads to lower living costs through dividends received from owned tokens.

When evaluating the financial feasibility of the proposed scheme, the scheme underperforms against the unfrozen weighted annualized MSCI Europe annual property index with -0.90%. However, the model carries fewer risks compared to a direct real estate fund, primarily due to lower rent losses, which would allow for a higher capped direct return in the model. When compared against the home ownership market, the proposed scheme slightly underperformance by -0.07%. However, the model takes a conservative approach for operational expenses and did not correct for a possible liquidity premium which would increase the token value, subsequently raising the IRR. In comparison to the rental market, the scheme exhibits significantly better results. After 30 years, a tenant would see an equity gain of €687,619. When compared against existing off-chain fractional ownership models, the proposed scheme does not rely on capital injections, provides a more inclusive scheme to enable a broad range of participants to join and ensure accessibility, eliminates initial deposits from participants, allows wealth creation to be amortized at any point in time, and is understandable by participants due to blockchain by which recordkeeping is secure and visible. The complexity is limited because smart contracts enable parties to establish clear and enforceable terms and automate rent collection and dividend distribution in a secure and reliable manner. Moreover, the model promotes active member participation by distributing voting rights. Finally, the model separates equity from housing need so that members can move houses without losing their invested equity.
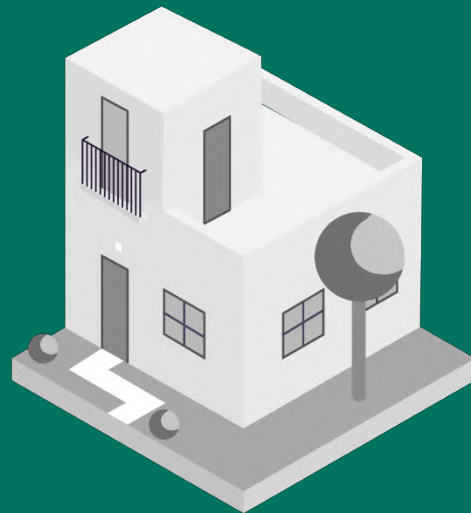
By leveraging the power of blockchain technology, households have the opportunity to seamlessly transition between network-owned rentable units, all the while accumulating equity that progressively reduces their living costs over time. By fostering an ecosystem where blockchain technology and fractional ownership intersect, this scheme opens up new possibilities for individuals to actively participate in the housing market and gain a stake in their living arrangements. It promotes a more inclusive approach to housing, allowing individuals with limited financial resources to access and benefit from the advantages traditionally associated with home ownership.

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1   Introduction

1.1 Reason for investigating

In recent research of Stuart-Fox et al. (2022), 20.6% of the households in the Netherlands have motives to move homes. The most important reason for young couples is to live together, while motives change later in life through the increase in household members, getting a divorce or due to health issues. Purchasing a home for first-time homebuyers usually results in a multi-decade loan repayment in an illiquid asset that hinder their options to switch homes easily. By the time the debt is paid off, usage needs have changed, and the owner is left with a half-empty house. Van der Parre (2021) asked 191 municipalities what the reason is of the current housing crises by which 55% responded that older residents do not switch houses and therefore occupying large houses that are needed for the next generation.

The fact that the process of purchasing and selling a house is inefficient, is accepted as a normal part of the housing market. The complexity of selling and acquiring a home, the increasing initial investment and the high transaction costs, which vary between the range of 6 – 12% in the OECD countries, prohibit households from moving.

The use of tokenization on the blockchain ledger can solve a lot of these issues. Tokens can have many forms but can in general be defined as a process of digital storing and transferring cryptographed and digitally signed rights to an asset on a distributed ledger where the ownership of these rights can be transferred via its protocol (Kasprzak, 2021). Transactions happen on the blockchain (on-chain) through secondary markets which reduce transaction costs. Furthermore, a token can be a fractional part of a property and allows a homebuyer to purchase ownership step-by-step. Instead of a household being a largely debt-financed 100% owner, a household can be a tenant and investor in their home. Households have the flexibility to transition between network-owned units, allowing them to adapt their living conditions to changing circumstances with the same convenience as the traditional rental market.

Fractional ownership is not a new concept. Fractional ownership concepts such as shared-ownership and cooperatives are already widely spread. However, these concepts still use the traditional institutions (off-chain) in which shares are not liquid and therefore less tradable. Furthermore, build-up equity in a housing cooperative scheme is non-transferable when moving houses and if staircasing is allowed, it can't be reversed when capital is needed. The question is if the real estate market is ready to adopt real estate tokenization?

1.2 Research gap

There is limited research conducted in the field of real estate tokenization because it's a new type of financial product. General advantages and disadvantages of different real estate token applications are discussed by Baum (2020) and Smith et al. (2019). Furthermore, recent research is focused on providing methods of tokenizing physical real estate using blockchain technology for retail investments purposes (Chow & Tan, 2022; La Rosa, 2021; Schmidt & González-Briones, 2020), the benefits on transferring property rights (Garcia-Teruel & Simón-Moreno, 2021; Konashevych, 2020; Nasarre-Aznar, 2018; Silfhout, 2020), or quantitative analysis of the performance of tokenized residential real estate in the US (Kull & Naumann, 2022; Lu, 2022; Swinkels, 2022; Wåhlin, 2021). However, all studies are focused on tokenizing a single asset which prohibits a member to move houses without losing its equity.

Based on the conducted research, no research is focused on the application of real estate tokens in a multi-asset fractional ownership scheme. Baum (2020) describes his scepticism regarding the potential of digital fractionalizing assets. However, he finds the use of a tokens in the residential market a more promising application. Baum mentioned that fractionalization of the private residential property, where rent/buy structures can be partially financed through tokens, has a strong growth potential. Using these tokens, a tenant can also be an investor in the asset, rather than the largely debt-financed 100% owner of an individual apartment. This research therefore focusses on the potential of tokenization to improve the liquidity and accessibility of a multi-asset fractional ownership scheme.

1.3 Goal

Recent research describes the potential that tokens have in the residential real estate market. However, as of today, no tokening offering is conducted for a multi-asset fractional ownership scheme. This research therefore tries to identify how a multi-asset tokenized ownership scheme would work. The goal is come up with a feasible concept that describes the required scheme.

1.4 Research question

Research question: To what extend can an on-chain multi-asset fractional ownership scheme replace the home ownership and rental market?

The research question is answered by answering the following sub questions:
1. What are the advantages and disadvantages of utilizing real estate tokens?
2. To what extend are existing fractional ownership schemes sufficient?
3. Which design principles should be incorporated to establish an on-chain multi-asset fractional ownership scheme?
4. What is the conceptual framework for an on-chain multi-asset fractional ownership scheme?

1.5 Scope

Due to the relatively new concept of tokens in the financial market, legislation is defined per country. Tokening offering platforms are therefore often based in Swiss because of the beneficial legislation, set out by Finma (2018). The European Commission (EC, 2022) proposed a specific new framework for which crypto-asset such as utility or payment tokens do not qualify as 'Financial instruments', by which trading would be easier. However, new legislations are not yet finalized. Therefore, the limitations due to legislations will be described briefly but will not be seen as a limitation in the mid- to long term.

1.6 Research methodology

To answer the question to what extend an on-chain multi-asset fractional ownership scheme can replace the home ownership and rental market, an exploratory sequential method approach is adopted. Figure 1 visualizes the research methodology.

Figure 1: Research methodology
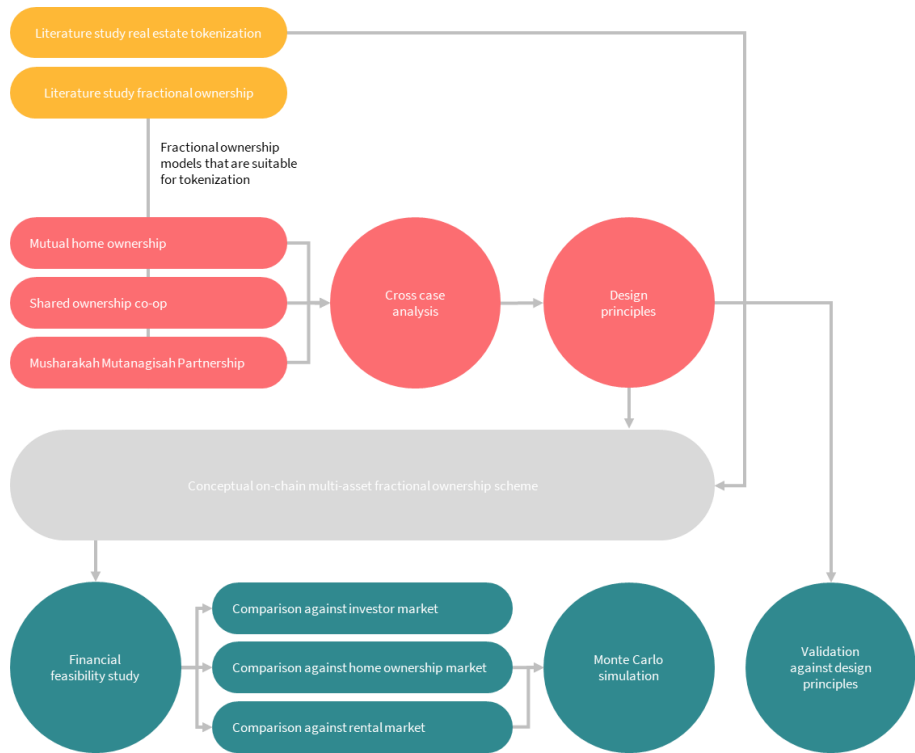
Source: Author

To get a better understanding of a multi-asset fractional ownership scheme, the advantages and disadvantages of utilizing real estate tokenization and existing fractional ownership schemes are analysed through a literature study.

The novelty of on-chain multi-asset fractional ownership schemes means there's no empirical evidence supporting its efficiency. However, on-chain multi-asset fractional ownership schemes share commonalities with their off-chain counterparts. This research therefore examines the working and advantages/limitations of the mutual home ownership, shared ownership co-op and Musharakah Mutanagisah Partnership by conducting a comprehensive case study. The case study largely relied on desk research, with all sourced documents and media being catalogued in Appendix A. By analysing each scheme's advantages and limitation by a cross case analysis, design principles are formulated. Based on the results of the literature study and design principles, a conceptual ownership model is developed.

To further enhance the validity and reliability of the conceptual model, a financial feasibility study is conducted to analyse the performance against the investor, home ownership and rental market. To analyse the likelihood that the model will outperform the home ownership and rental market, a Monte Carlo simulation is conducted. A Monte Carlo simulation is a computational techniqueused to model and analyse uncertainty in the proposed scheme. and the model is reflected, based on the design principles. Finally, the scheme is validated against the design principles.

To verify the proposed scheme with experts lays outside the scope of this research.

1.7 Reading guide   The following figure shows the proposed research methodology in relation to the research questions.

Figure 2: Reading guide research
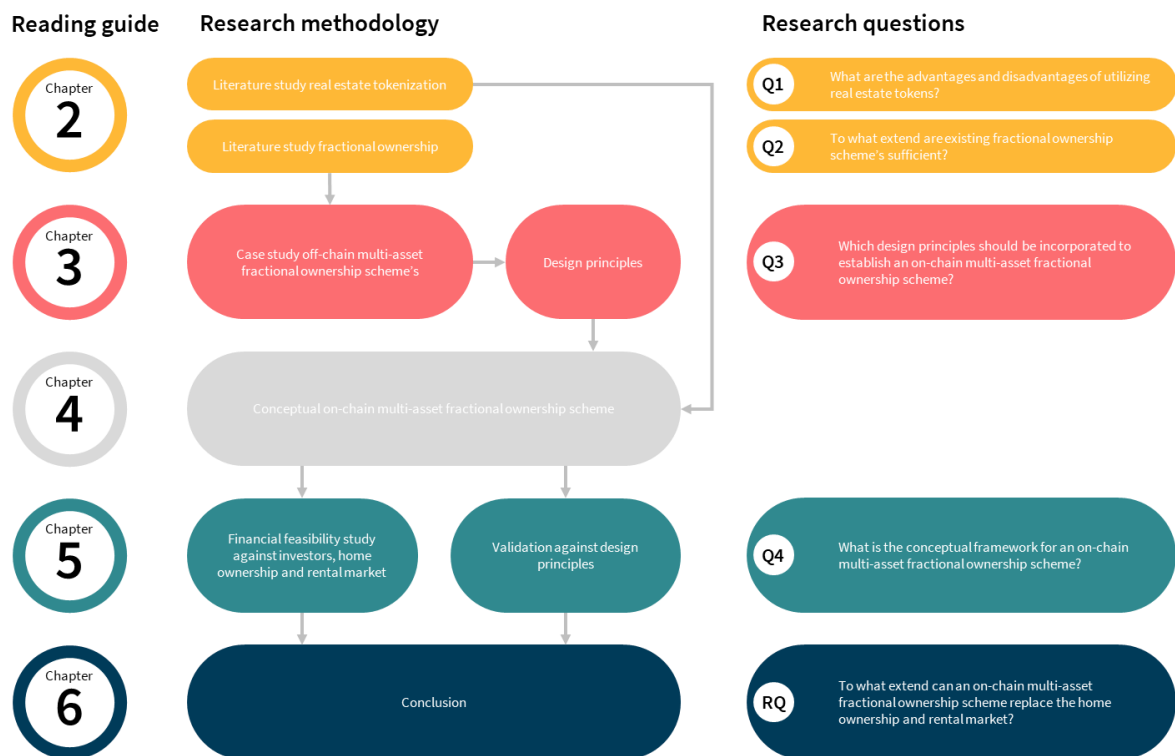
Source: Author

2   Theoretical framework

2   Theoretical framework

2.1 What is tokenization

Tokenization, a process of converting traditional securities into digital form using blockchain technology, is dependent on a thorough understanding of blockchain technology and smart contracts (Liquefy, 2020).

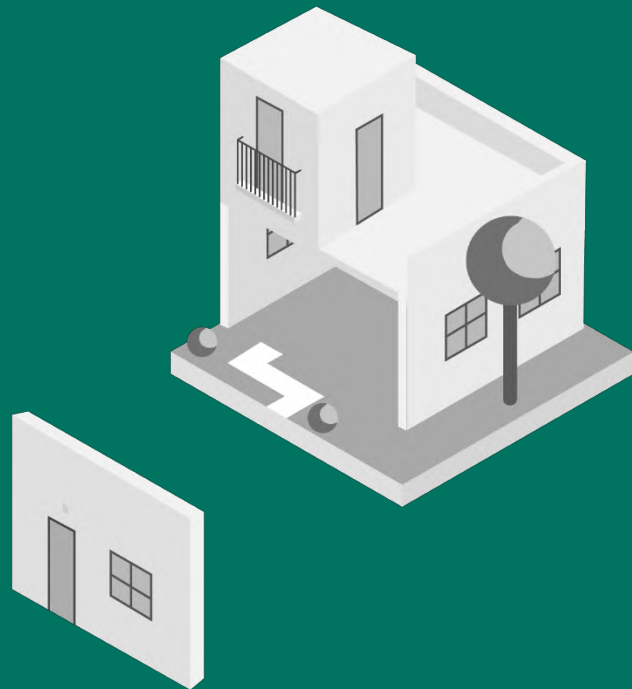Traditional database management systems, which rely on centralized servers, may raise concerns about data integrity (RICS, 2020). Distributed Ledger Technology (DLT) addresses these concerns by distributing data among all members and eliminating centralized authorities (Starr et al., 2020). Blockchain, the most widely used application of DLT in the real estate industry, is a peer-to-peer network of time-stamped, immutable records (Jyotsna & Campala, 2020). Each block in the chain contains data, a timestamp (i.e., a hash), and the hash of the previous block. When data is modified, a new hash is created (RICS, 2020). The proof of work process verifies the chain of hashes. The benefits of blockchain include security, efficiency, transparency, and reduced counterparty risk (Aznar, 2018).

Figure 3: Proof of work Blockchain
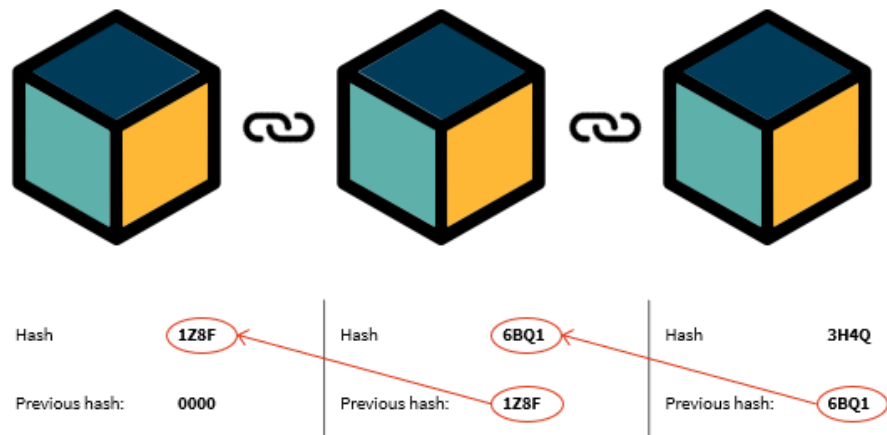
Source: Author

However, blockchain alone is not a transactional platform (Delmolino et al., 2016). Smart contracts must be added to carry out transactions (RICS, 2020). Smart contracts are computer codes that automatically enables the exchange if conditions are met (RICS, 2020), thereby increasing efficiency, reducing costs (Deloitte, 2021) and automating the transaction process (Lecomte, 2021). An example of this is the US firm SmartRealty, which enables parties to solidify terms of agreements, including dates of payments due, amounts due, length of the agreement and penalties for non-compliance, in a smart contract (SmartRealty, 2018). Smart contracts can be pre-programmed to automatically trigger notifications in the case of a violation or termination upon expiration or other protocols as agreed upon by the contract parties. Additionally, these contracts can also be configured to automatically renew upon expiration.

A survey by RICS found that 85% of respondents felt that smart contracts improve transaction efficiency, but 60% also found them difficult to understand. 59% of respondents believed that smart contracts would be adopted in the real estate industry within the next five years (RICS, 2020). However, Hileman & Rauchs (2017) found that 40% of blockchain operators do not support smart contracts, indicating a significant amount of progress is needed before the real estate market can be fully automated by smart contracts. The increase of smart contracts will inevitably become targets of hackers who look to exploit vulnerabilities in smart contract code security. Stacking and composability of smart contracts form a risk. Should an underlying smart contract break, the stack will fall like a house of cards (Blandin et al., 2020). Smart contracts, as a decentralized digital mechanism, are limited in their ability to access and validate information from the physical world. This necessitates the use of Oracles, which act as

intermediaries to provide real-world data to smart contracts (Lecomte, 2021). However, the integration of Oracles into the smart contract system has been met with criticism, as they have been argued to potentially undermine the digital trust established by decentralization (RICS, 2020). Oracles only validate the data but not the source of the data, hence the 'garbage in, garbage out' principle (RICS, 2020) and their data feeding role is prone to manipulation (Blandin et al., 2020). To address these concerns, initiatives such as Chainlink have emerged to expand the capabilities of smart contracts by enabling secure and reliable access to real-world data and off-chain computation, while maintaining the security and reliability guarantees of blockchain technology. These developments have the potential to mitigate the risks associated with the use of Oracles in smart contract systems.

Interactions on a blockchain involve the exchange of value in the form of tokens (RICS, 2020). Real estate tokens, which represent a fraction of a physical asset, are often issued through a Security Token Offering (STO) by the token issuer (RICS, 2020). Tokenization, as previously mentioned, is the process of converting traditional securities into digital form using blockchain technology, allowing token holders to claim a share of the property, associated cash flows, and legal obligations (Kreppmeier et al., 2022).

2.2 Different kind of tokens

Baum (2021) classify tokens into three types: (i) utility token, (ii) security token and (iii) currency token. The combination of utility- and security tokens are called hybrid tokens (Baum, 2021).

    i.   Utility tokens provide token holders rights for a certain product or service and are often issued by an initial coin offering (Kreppmeier et al., 2022; Laurent et al., 2018). These tokens do not transfer ownership and control rights, and regulation is currently non-existent (Momtaz et al., 2019; Baum, 2021).

    ii.   Security tokens are digital representations of securities (Smith et al., 2019) and represent fractions of ownership in corporate equity, commodities, currencies, or real estate (Kreppmeier et al., 2022). Baum (2021) further diversify security tokens into equity tokens (traditional shares) and debt tokens (bonds). Smith et al. (2019) make a distinction between security tokens and tokenized securities. Security tokens represent fractionalized ownership of real-world asset's while tokenized securities represent fractionalized securities that have claims over real world asset's property rights and cash flows (Lecomte, 2021). Smith et al. (2019) argues that it's crucial that any transfer of payment or ownership of an asset is final. While operational finality depends on the consensus mechanism of the underlying blockchain, a framework is needed for security tokens to confer legal finality. This because security tokens can't exist without digitalised land titles. On the other hand, tokenized securities can rely on existing processes using blockchain based systems. It is therefore easier to develop tokenized securities (Baum, 2021). The transfer of the whole cadastral system to the blockchain involves technological, political, organization and legal changes which is not done in a single night. For example, the transfer of property rights on the blockchain would not be possible in Germany and the Netherlands, since the intervention of a notary and further registration is required (Garcia-Teruel & Simón-Moreno, 2021). Konashevych (2020a) states that only the Republic of Georgia has a successful blockchain-based land registry as of 2018.

    iii.   Currency tokens (also referred to payment tokens) are digital currencies, with Bitcoin as the most known example (Momtaz et al., 2019). These tokens do not represent a stake in an asset (Momtaz et al., 2019) and are synonymous with cryptocurrencies (FINMA, 2018).

2.3 Legal status real estate tokens

The concept of tokens in the financial market is relatively new, resulting in varied legislation across different countries. This has led to many token offering platforms being located in Switzerland due to the favorable regulations established by the Swiss Financial Market Supervisory Authority (FINMA, 2018). The European Commission (EC, 2022) has proposed a framework in which certain types of tokens, such as utility or payment tokens, would not be considered "financial instruments" which would make trading them easier. However, it is important to note that these proposed regulations have not yet been finalized.

Sipahi (2020) argues that while it is possible to interpret the laws in a way that aligns with security tokens, there are still issues that need to be addressed for the full application of existing laws to security tokens. These issues include the lack of standardized terminology and taxonomy for security tokens, the hybrid nature of security tokens as both crypto-assets and traditional securities, and the lack of provisions in existing laws to address the technological problems and risks associated with

DLT/Blockchain. Sipahi (2020) suggests that amending existing EU securities legislation to explicitly embrace security tokens and crypto-assets that qualify as financial instruments is the best option, and that a harmonized regulation tailored specifically for security tokens is needed to prevent further discrepancies between Member State jurisdictions.

2.4 Process of tokenizing real estate

This paragraph describes the process of tokenizing securities. This due to the fact that security tokens are not feasible without digitalized land titles, as discussed in the previous paragraph. The process is based on the research of Gupta et al. (2020), Sazandrishvili (2019) and Kreppmeier et al. (2022) and can be divided into 3 steps.

Step 1: Registration of entities

A user (token holder) provides user data to the token platform. The platform sends the user data to a Know Your Customer (KYC) and Anti Money Laundering (AML) verification module. If the KYC/AML module approves the registration, the user has access to the token platform and receives a permissioned wallet.

**Step 2: Creating a Special Purpose Vehicle (SPV)**

As mentioned before, a SPV is needed that owns the asset property rights. The soon to be token issuer submits all necessary documents and paperwork (including a valuation) to the token platform. The token platform submits the documents and paperwork to the concerned authorities. After verification, a SPV is created. The deal is called off for noncompliance with legal requirements in the event that there are any discrepancies with the asset's or SPV information. The SPV is managed by a management company[1].

Step 3: Security Token Offering (STO)

Through the token platform, an STO is initiated. The tokens are imbedded with a smart contract that contains the conditions on which the tokens are offered and rent is distributed. The tokens are offered to token holders. Optional, the smart contracts could contain a required target for the number of transferred tokens. If the demand is low, and the required target isn't achieved, the amount paid by the token holders is refunded and the title ownership still lie in name of the token issuer. However, when the target is achieved, the token issuer receives payment for the asset, the token holders receive tokens and the title ownership is transferred to the SPV off-chain. The token holder receives payment, based on the distribution of the net rent, set out in the smart contract. Tokens can additionally be traded on secondary platforms.

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[1] The requirement for a crowdfunding license for a third-party management company is contingent upon its affiliation with the token issuer. If the management company is not affiliated with the token issuer, it may be obligated to obtain a crowdfunding license, as per the EU regulation on crowdfunding (2020/1503). This regulation mandates the issuance of a prospectus when the tokenized securities surpass 5 million EUR. Conversely, if the management company is affiliated with the token issuer, the requirement for a crowdfunding license may not apply. However, it should be noted that the absence of a crowdfunding license in such cases could limit the growth potential of the platform, as it would restrict the ability of other real estate owners to offer their properties through the platform.

Diagram 1: Process of tokenizing real estate
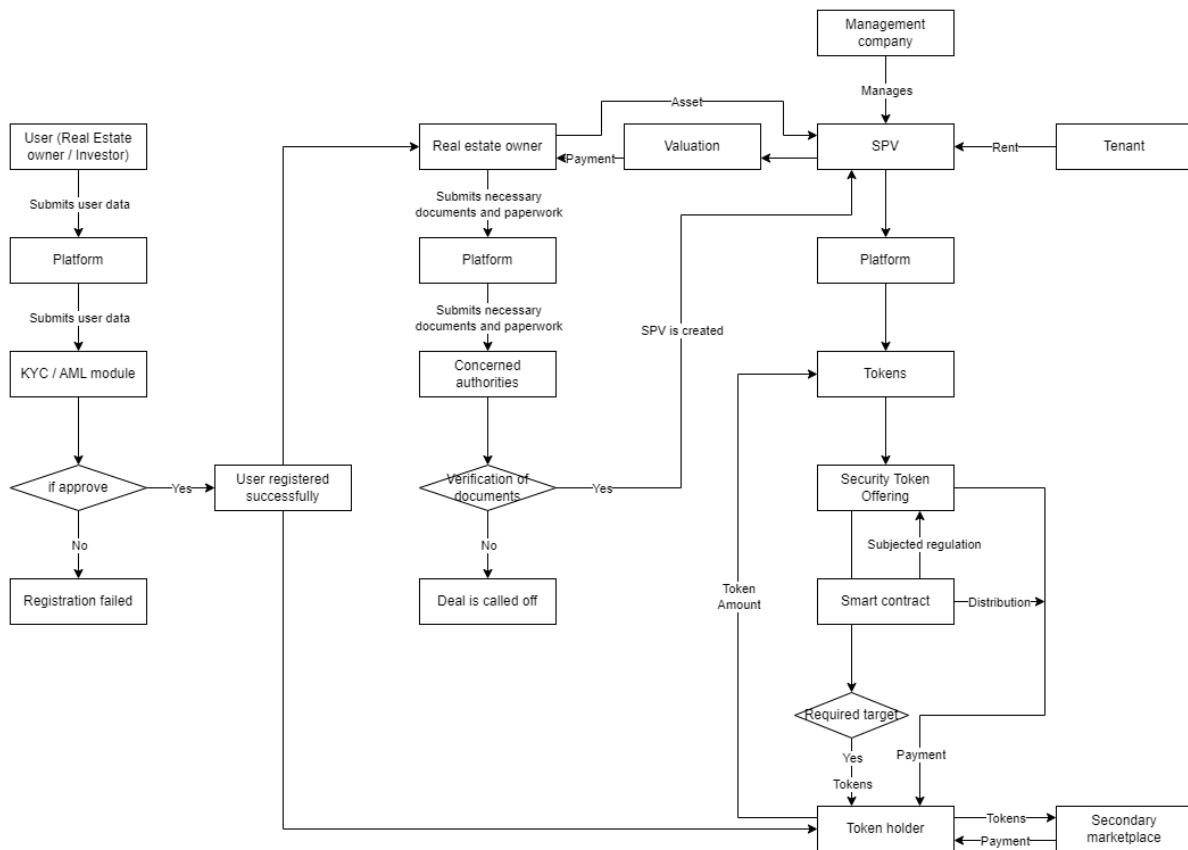
Source: Author

2.5	Advantages and disadvantages of tokenization

To answer the question of what the advantages and disadvantages of utilizing real estate tokens in the real estate industry are, this chapter presents an in-depth exploration of their implications, thoroughly examining the potential benefits and drawbacks from multiple perspectives. As real estate tokenization is a relatively novel concept, empirical research on the topic is limited. However, several studies have been conducted on the subject, with findings suggesting that market-weighted indexes with reinvested dividends of real estate tokens outperform the S&P 500 in terms of aggregated and risk-adjusted returns (Kull & Naumann, 2022). Additionally, Lu (2022) found that the economic performance of token portfolios is higher than that of the market portfolio and the housing price index. Swinkels (2022) discovered that token prices mirror housing prices, allowing for fractionally owned residential real estate properties to act as smaller scale real estate investments. Wåhlin (2021) found that equally weighted real estate token indexes outperformance market indexes such as the S&P 500, but attributes this to dividends. All research mentioned the limitations of their research because they all used the RealT dataset, which consists of residential properties located in Chicago and Detroit, and have a limitation of 1 year of data with a limited sample size. As a result, the majority of research in this area focuses on conceptual evidence rather than empirical data. Therefore, this literature review will examine the advantages and disadvantages of utilizing real estate tokens based on topics liquidity, efficiency, costs, customizable diversification, accessibility, risk control, and transparency.

Liquidity

Blockchain technology has the potential to improve the liquidity of real estate assets, however, it does not change the underlying characteristics of real estate such as its fixed location and difficulty to move. These factors impact demand and cannot be easily overcome. Additionally, tokenization alone does not change the fact that real estate assets are individually unique on a granular level, which can make it difficult to have clear and transparent markets and data feeds. Furthermore, it is important to note that tokenizing real estate assets does not change the subjectivity of these shares to securities regulation, as is sometimes a common misconception in blockchain circles (Kanen, 2019). As a result, real estate assets cannot generate liquidity by themselves. A solution to this issue is the implementation of regulated

security token exchanges, which make programmable governance and built-in regulatory compliance possible.

Additionally, by tokenizing assets, the tokens can be then traded on a secondary market of the issuer's choice, with a global investor base, increasing liquidity (Smith et al. 2019). However, it is important to note that a dual market (on and off-chain market) could lead to liquidity bifurcation between off-chain and on-chain markets (OECD, 2020), resulting in liquidity mismatch between tokens and the underlying assets (Financial Stability Board [FSB], 2019).

The liquidity-enabling tokenization of real estate assets can also unlock value by releasing the so-called liquidity premium embedded in real estate prices (Laurent et al., 2018, Ferreira, 2020, Smith et al. 2019). By increasing liquidity, tokenization could also increase the value of assets (Baum, 2021). However, it is important to note that as theory suggests, the illiquidity of property means that its required – and expected – return is higher than it would otherwise be, introducing liquidity to property may damage returns, as the illiquidity premium may be eroded (Baum, 2021). Furthermore, there will likely be low liquidity and a high illiquidity premium for shares in single buildings due to the small market size (Smith et al. 2019).

Additionally, tokenization can improve secondary trading on a private market, ATS or peer-to-peer if enabled by token protocol (Smith et al. 2019). Tokenizing allows smaller carve-outs of an asset to be sold, creating more liquidity for majority-share owners and developers (Won, 2019).
Furthermore, tokenization offers unmatched liquidity globally as it allows for easy and secure cross-border exchanges of tokens (Jyotsna & Campala, 2020). With single-asset or specific revenue streams being tokenized, investors could now readily turn their illiquid assets that generate economic benefits into something transferable and traded (Chow & Tan, 2021).

Efficiency

One of the key advantages of tokenization is the ability to settle transactions in a much shorter time frame than traditional methods. Tokens can settle in minutes or hours (Smith et al. 2019; Chow & Tan, 2021), unlocking the capital that is tied in the market. This increased efficiency is further enhanced by 24/7 exchanges (Lu, 2022).

Smart contracts can automate steps such as compliance, document verification, trading, and escrow (Smith et al. 2019). Smart contracts can also be programmed to automate pre-issuance matters like compliance checks, comply with know-your-customer (KYC) and anti-money laundering (AML) regulations, and post-issuance matters like dividend distribution and customizable fee structures (Chow & Tan, 2021; Liquefy, 2020; Smith et al. 2019).

Tokenization also has the potential to reduce the transaction complexity of real estate assets by creating a publicly auditable history (Won, 2019). Incorporating smart contracts into the transaction process can create automated protocols that are in compliance with relevant regulations (Won, 2019) and reduce the administrative burden involved in buying and selling, with fewer intermediaries needed, leading to not only faster deal execution but also lower transaction fees (Cupta et al., 2020).

However, it should be noted that at present, unlike stocks, there is no centralized marketplace to facilitate the trading of the tokens (Chow & Tan, 2021). The lack of a centralized marketplace could lead to excessive search costs and transaction costs for investors in finding the right exchanges to trade their various real estate tokens. Finally, tokenization eliminates human errors (Lu, 2022).

Costs

In literature, tokenization is often touted for its ability to reduce issuance and operational costs for real estate assets (Smith et al., 2019; Kreppmeier et al., 2022; Freedman & Fetner, 2019). However, a thorough cost-benefit analysis is still lacking in the literature (RICS, 2020). The use of smart contracts in tokenization can streamline and automate processes, resulting in lower operating costs (Liquefy, 2020; Lu, 2022). Additionally, by removing intermediaries, transaction costs can also be lowered (Baum, 2021; Smith et al., 2019; Kreppmeier et al., 2022). However, it is important to note that transfer taxes, such as those for real estate transactions, still apply in tokenization (Baum, 2021).

According to RICS (2020), tokenization of assets is less expensive compared to REITs, and the process can be easily scaled. This means that future tokenization can make use of the existing platform, however, due to the use of new technology, new requirements will arise on a constant basis. Gartner (2019) suggests that many current blockchain platforms will need to be replaced by 2021, which will lead to high development and implementation costs until there is consensus in the industry on the product concept. Baum (2021) argues that the costs will be made preparing for the STO but that the benefits will be made through secondary market liquidity. However, tokenization can provide new revenue streams for token issuers through listing fees, trading fees, asset management fees, and the potential sale of data (Freedman & Fetner, 2019).

Baum (2021) has addressed the issue who is responsible for the refurbishing a property or offering incentives for tenants to renew their leases is a complex one. The involvement of a management company may serve as a solution. However, it is important to note that engaging a management company also increases operational costs. Smith et al. (2019) have highlighted the risk that direct real estate owners may work together with management companies in order to ensure that the investment retains its value. This is particularly relevant when there are multiple token holders involved, as management companies may prioritize speed of completion over maximizing the long-term value of the property as an investment.

Finally, it is also important to note that tokenization utilizes blockchain technology, which has an increasing significant energy consumption (see graph 1). The Cambridge Centre for Alternative Finance guesses that the annual electricity usage for crypto-assets is around 110 Terawatt Hour per year, which is the equivalent of 0.55% of the annual global electricity usage. This is a factor that should be considered in any cost-benefit analysis of tokenization. However, blockchain is an evolutionary technology. Current blockchain solutions only use a fraction of the energy, compared to 10 years ago. When Ethereum switch form the consensus algorithm Proof of Work to Proof of Stake, energy consumption was reduced by more than 99.988% (Ethereum, 2023).

Graph 1: Historical Bitcoin network power demand (in GW per day)
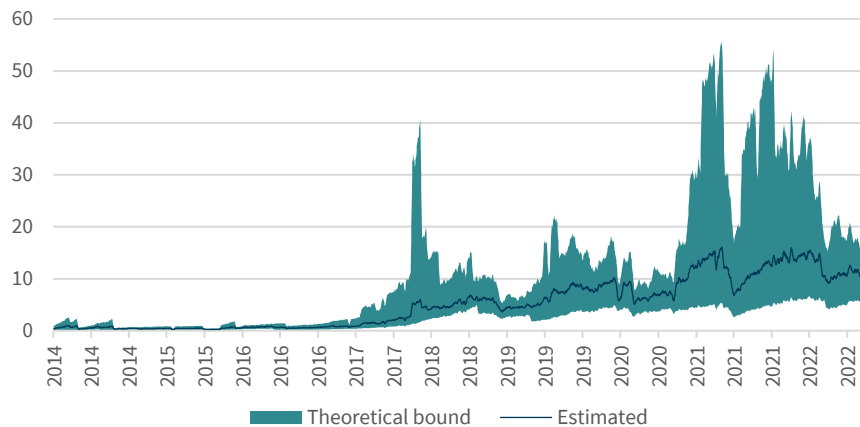
Source: Cambridge Bitcoin Electricity Consumption Index

Customisable diversification

The tokenization of real estate assets has the potential to increase investment diversification for investors, allowing them to customize their portfolio by purchasing fractionalized ownership of specific properties (Baum, 2021; Lu, 2022). This can be achieved through peer-to-peer transactions, bypassing traditional brokers and reducing overhead costs (Smith et al, 2019). Furthermore, tokenization allows for the creation of additional financial products such as basket of assets or derivatives (Smith et al, 2019; Lu, 2022). One example is the ability for investors to invest in senior tokens on fixed lease payments and junior tokens for the variable components of commercial leases, thus increasing risk (Smith et al, 2019).

However, it should also be noted that diversification of real estate tokens may be similar to the creation of collateralized debt obligations (CDOs) during the financial crisis of 2008, where investors had little knowledge of the assets they invested in (Pylarinou, 2018). Tokenization, however, offers three advantages over CDOs: transparency through blockchain technology, easy access to single tokens, and streamlined distribution of cash flows through the use of smart contracts (Chang, 2020).

Accessibility

The tokenization of real estate assets has the potential to make investments more accessible to a wider range of investors by fractionalizing high-barrier properties and lowering the investment minimums (Baum, 2021; Smith et al., 2019; Cupta et al., 2020; Jyotsna & Campala, 2020; Lu, 2022). This can also attract new, tech-savvy young investors to enter the market on a platform that they are comfortable with (Chow & Tan, 2021). However, there are also concerns about the level of demand for real estate tokens, as many investors may not have the knowledge or comfort level with blockchain technology and the security of tokenization (Baum, 2021; Won, 2019). Additionally, the failures of smart contracts and negative associations with blockchain and bitcoin due to volatility, illicit activities, and energy consumption may also hinder mainstream adoption (Baum, 2021). Furthermore, the demand for crowdfunding may also be an indication of the potential demand for real estate tokens (Smith et al., 2019). One potential solution is to partner with institutional buyers to overcome liquidity challenges (Freedman & Fetner, 2019). Additionally, the fact that blockchain networks run 24/7, reaching more investors worldwide, may increase demand (Chow & Tan, 2021; Smith et al., 2019; Kreppmeier et al., 2022). However, it should be noted that accessibility for retail investors remains uncertain, as participants currently need to be accredited investors with KYC and AML verification (Smith et al.,2019).

Risk control

According to Baum (2021), tokenization provides investors with a way to manage risk. Kreppmeier et al. (2022) found in their study that the success of a real estate STO largely depends on the property-specific possibilities for idiosyncratic cash-flow risk of an investment, such as having multiple tenants and rental housing assistance. Lee & Hong (2021) note that in traditional fractional ownership models, co-owners may exhibit unpredictable behavior, such as failure to fulfill contract terms. Smart contracts can help mitigate this concern by automatically taking action when contract terms are not met, thereby reducing risk. Another risk is that the retail investor lacks the skill to properly value real estate investments, even if the necessary data is available (Smith et al., 2019). Why not invest in a REIT and let a manager with the required skills pick a stock? (Baum, 2021).

Real estate tokens are also subjected to security risks. Jyotsna & Gampala (2020) state that the programmers are a risk to computerized tokens. The guardianship of computerized tokens and the security encompassing them should be worked on. Other security risks can be an eclipse attack – isolating a user's network connection by flooding them with false data bout the blockchain network (Heilman et al., 2015), selfish mining – the process in which a selfish miner withholds block in a private chain (which results in a fork) and releases them to the public chain before it caught up with the fork, creating a loss to the honest miner (Eyal & Sirer, 2018) and a 51%-attack – the process in which a group of miners control more than 50% of the network's mining hash rate, resulting in excluding or reverse transactions on the blockchain. Finally, blockchains are secure in the sense that data storage and permissions are distributed, but private keys can be stolen and lost (RICS, 2020).

Transparency

The use of blockchain technology has been proposed as a means to increase transparency (Baum, 2021). According to Smith et al. (2019), secure and visible recordkeeping on blockchain can increase transparency to the underlying data, particularly for complex derivative products. This is because blockchain allows for the ability to clearly link a security to its underlying value drivers. Additionally, tokenization can improve investor management and information disclosure by enabling the tracking of investors in real-time and pushing information directly to their addresses.

However, tokenization also presents some challenges, such as the accessibility of the ledger to participants and the potential frequency of token ownership changes, which may deter developers who do not want to share information with competitors (Won, 2019). These issues can be addressed by developing a secure system where information is not fully decentralized and by implementing structures within the blockchain that allow only certain information to be shared with participants (i.e., permission blocks).

In terms of governance, tokenization can also provide benefits. A sponsor (developer) will have less governance (but more control) with many small shareholders compared to having a handful of institutional investors. This is because a typical real estate deal will have major rights and decisions that

are governed by the "lead investor" (e.g., when to sell or refinance) (Won, 2019). One solution is to incorporate negotiated market terms into operating agreements (Freedman & Fetner, 2019). Tokenization can furthermore minimize inefficient governance and bureaucratic procedures, reducing the possibility of corruption (Smith et al., 2019).

Security tokens, which are created through tokenization, have the capability to embed the token holder's rights and legal responsibilities directly onto the token, along with an immutable record of ownership. These characteristics promise to add transparency to transactions and allow for better understanding of who the parties involved are, what their rights are, and who has previously owned the token (Cupta et al., 2020).

Furthermore, the greatest advantage of tokenization is that it eliminates the need for intermediaries, thus reducing red-tapism and speeding up the process (Jyotsna & Campala, 2020). Blockchain technology in real estate increases security and transparency for investors by eliminating debasement (Chow & Tan, 2021). Additionally, all information is recorded and captured via DLTs, while security keys and digital addresses ensure data anonymity. This greatly reduces compliance and verification costs and facilitates due diligence for investors (Chow & Tan, 2021; Lu, 2022). Moving forward, DLTs could reduce costs by centralizing all property information, including land purchase records, liens, title registry, expenses, and revenues, as stated by Chow & Tan (2021).

## 2.6 Other fractional ownership concepts

Fractionalization of single-asset properties is not an entirely new concept (Lee & Hong, 2021). The freehold ownership of a single property has traditionally been divided up among numerous entities in a variety of ways (Lecomte, 2021) such as: Joint ownership, strata tile, time sharing, leasehold, tranching & syndication (Baum, 2021). Numerous attempts to establish markets for fractional ownership of a single property have been made over the years as a result of the concept of fractionalization, e.g., Single Property Ownership Trusts (SPOTs), Single Asset Property Companies (SAPCos) and Property Income Certificates (PINCs) (Baum, 2021). None of these attempts have succeeded because of low demand for real estate investments at times of extreme market weakness (Baum, 2021) and technical concerns about the relationship of property valuation and market prices for the divided units (Roche, 1995).

Another example for fractional ownership are Real Estate Investment Trusts (REITs), Real Estate Investment Funds (REIFs) and Real Estate Exchange Traded Funds (ETFs). However, in case of REITs, institutional and retail investors do not own the properties and cannot influence the decision to invest in a particular property (Kreppmeier et al. 2022) and therefore customize their real estate exposure (Smith et al., 2019). Additionally, Lu (2022) state that the performance of REITs are not as good as expected. REITs historically trade at a premium to the underlying Net Asset Value (NAV) (Smith et al., 2019). While private REITs overperform public REITs (Smith et al., 2019), the minimum investment amount of a Privat REIT is often in the order of $ 25k and higher, which exclude many retail investors (Rena & Rena, 2018). Also, the setup costs for an IPO are expensive (Rena & Rena, 2018) and involve a large number of agents (PWC, 2018). Furthermore, Chow & Tan (2021) pointed the nonalignment of interest between shareholders and asset managers (non-yield-accretive acquisitions that increase the NAV) and governance problems related to sponsor-satellite relationships as problems with REITs. Finally, due to diversification requirements, most (but not all) regulations governing REIT limit the potential of single-asset fractionalization (Baum, 2021).

Since the passing of the Jump Start Our Business Act (JOBs Act) crowdfunding raises capital with reduced minimum deal sizes and without geographical barriers (Smith et al., 2019; Baum, 2021). Depending on the platform, investors can invest in a single-asset property. According to Smith et al. (2019) real estate crowdfunding failed to take off mainly due to adverse selection of properties. Platforms for crowdfunding offer assets that were unable to raise money through conventional sources of financing (smith et al., 2019). Other issues are multi-year lock in periods (Smith et al., 2019). While some investors offer secondary marketplaces, overall liquidity is lacking. Polaris (2022) expect a compound annual growth rate of 45.6 %. Baum (2021) argues that due to several failures, real evidence of scale is elusive. Initial Coin Offerings (ICOs) were the first form of blockchain-based crowdfunding, but they were a failure because almost all of them were speculative, requiring investors to raise money before finding assets, and because the companies behind them lacked the necessary experience to manage and acquire assets once the money had been raised (Chow & Tan, 2021). Significant dangers were associated with these highly speculative ICOs, which prompted regulators to take regulatory action and provide public warnings.

Finally, there are different rent-to-buy concept by which the tenant gradually gains ownership, hence fractional ownership. The most common is the shared ownership concept. Shared ownership is a property ownership initiative of the UK government's low-cost home ownership policy (Cowan et al., 2018), that enables people (hereafter called shared owners) to buy a share of a property and pay a subsidised rent on the remaining share (Cromarty, 2021). The shared owners can increase their shares in a process called 'staircasing' to eventually own 100%, by which ownership is transferred to the shared owner. While a minimum of 10% initial equity stake is required (Ministry Housing Communities & Local Government [HCLG], 2020), on average, shared owners purchase 41% initial equity in their home in 2020/21. The initial equity stake is steady for the last 13 years (graph 2). However, the number of shared owners staircasing to own 100% is fairly low (Cromarty, 2021). In the period 2020/21, 4,298 shared owners staircased to 100%, while 12,576 purchased an initial equity stake (graph 3). In a survey, carried out by YouGov (2018), 10% of the shared owners have increased their ownership share. 63% had cited affordability to be the biggest issue.

Graph 2: Initial equity stake purchased
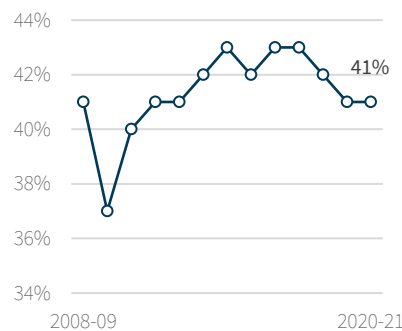
Graph 3: Initial stake vs 100% staircased
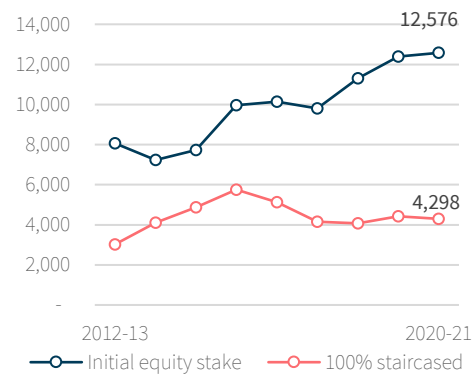
Graph 4: Number of new supply low cost home ownership products
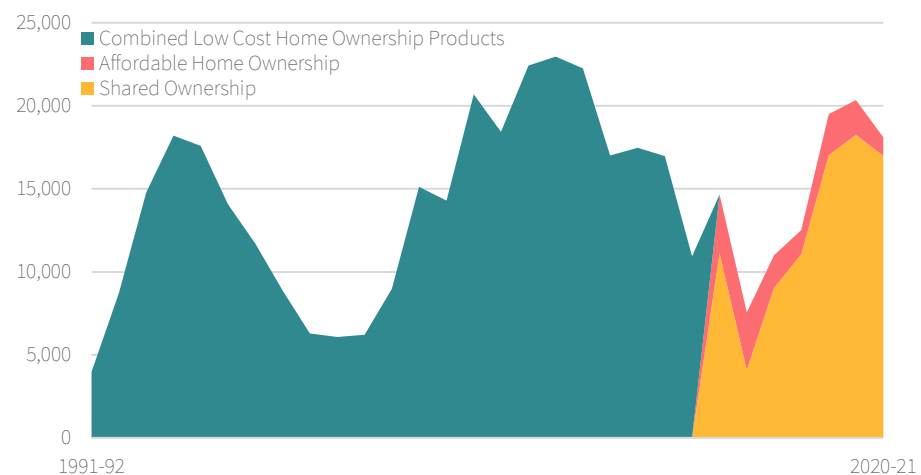
Source: DLUHC (2021) Table: 1000, 697 & Homes England (multiple years)

Starting from 1979, there are around 200,000 shared ownership houses in the UK (Savills, 2019). Due to the demand, the UK government will provide 11.5 billion funding, for which half will be used to deliver up to 90,000 new shared ownership homes in the period 2021-26 (Cromarty, 2021). This is 24% more than the completion of new developed shared homes in the previous 5 years (graph 4). While shared ownership is intended as a subsidised product for household with an income up to (£ 80,000), several Proptech firms such as Up&Up, Divvy, Verbhouse, Zerodown, StrideUp and Heylo have commercialized the rent-to-buy solution (Savills, 2019). Investments by CBRE IM in 2022 (63 homes) and Heylo Homes (3,000 homes) shows also the interest of private capital in this market. Savills (2021) predicts that for-profit registered providers (FPRPs) could commit up to £ 36 billion for shared ownership and general needs rent by 2026. Shared ownership remains attractive to FPRPs because it provides long-term income streams, less repair obligations and the increase of returns due to house price inflation (Savills, 2021). Fintech company Noah Homes (Noah-Homes, n.d.) added an additional incentive for members to

keep up with the terms. For each year that a member pays the rent on time, a 1% additional increase of shares is rewarded.

An advantage of shared ownership is that it enables household to lower the costs for the initial deposit compared to full ownership (Savills 2019). When you compare the total amount paid after 25 years versus the value owned, shared ownership is however less attractive than full ownership (Clarke, 2017). Bramley & Dunmore (2015) provides evidence that Shared ownership is 20-25% more expensive than full-ownership in the long run. Bramley & Dunmore (2015) states that the most distinctive advantage of shared ownership is that it could provide a framework for the sensible and flexible management of risk (Bramley & Dunmore, 2015). By reverse staircasing, a shared owner could reduce their ownership share, which result is reduced debt and mortgage payment and substituted with rents. However, there are no known provisions in shared ownership leases as to reverse staircasing. Cromarty (2021) argues that shared ownership is a complicated hybrid tenure, which can be difficult for potential shared owners, providers and lenders to understand. According to YouGov research (2017), 40% of the 2,000 respondents don't understand the main benefits of shared ownership. Finally, if the shared owner didn't reached 100% equity ownership, shared must be sold when the shared owner decides to live elsewhere. Cromarty (2021) state that the secondary market for shared ownership is small, which makes it difficult for a shared owner to sell the acquired shares. Conaty et al. (2004) nuances this statement by saying that shared ownership has a place but does not lock in the subsidy for the benefit of future occupiers. It also requires relatively high levels of social housing grant, the long-term benefit of which accrues to the landlord rather than occupiers.

While the concept of fractional ownership is not new, the combination of distributed digital ledger and smart contract is however a new frontier (Lee & Hong, 2021). The next section describes two tokenization companies that offer a rent-to-buy model.

HAUX T is a Spanish company that offers a rent-to-buy model, based on the Gnosis Chain. HAUX T buys a selected house by the tenant. The tenant pays a down payment of 5% of the value and a monthly rent. The rent can be reduced by buying fractional ownership (1 token = 1 EUR). HAUX T charges a management fee of 10% of the gross rent. The staircase price is fixed at the time of the initial down payment and the tenant can always decide to leave the property without losing its equity. It is unknown if the tenant can sell its share to HAUX T.

ReTok is a real estate tokenization company based in Switzerland that allows tenants to purchase shares of their homes. The company has currently tokenized three properties, with plans to acquire six more in 2023. Tenants can buy shares in their homes at the property's market price, and as they increase their share ratio, they receive a proportional discount on their rent. If they reach a share ratio of 100%, they can become the legal owner of the property, with the advantage of no foreclosure or eviction as long as they continue to pay their rent. The properties are managed by ReTok, with tenants able to sell shares back to the company if they need cash. ReTok partners is entitled to a fee of 1.5% per annum on the net asset value of the portfolio and 5% on gross rent collected from tenants for managing the properties.

A recurrent problem with acquiring equity in a single-asset property is the lack of liquidity when the tenant decides to sell its share. There is no secondary market without losing the rent-to-buy characteristic for feature tenants. Once the tokens are sold on a secondary market, it is impossible for a new tenant to acquire 100% ownership.

Hitchcock (2021) suggest the solution can be found in crypto housing cooperatives. The concept of housing cooperatives, commonly referred to as co-ops, presents a distinct form of property ownership where residents jointly possess and manage the property. As opposed to the traditional model of apartment rental, where a single landlord owns the entire building and leases out individual units, in a co-op, the members collectively own the structure. Based on the data of CECODHAS, there are more than 12 million co-ops in Europe, with single co-ops expending over 15,000 dwellings. Graph 5 shows the number of cooperative houses as a percentage of the total housing stock per country.

Graph 5: Number of cooperative houses as a percentage of the total housing stock per country
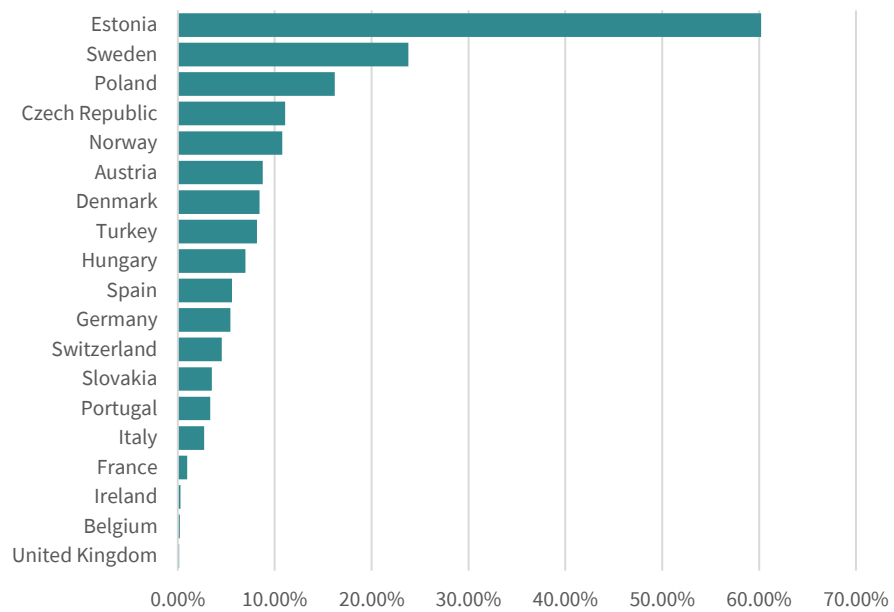
There are 3 main types of co-ops: i) Market-equity cooperative, ii) Limited equity cooperative, and iii) Leasehold cooperatives (Crabtree et al., 2019). Because in a leasehold cooperative, the ownership lays with an outside investor and Crabtree et al. (2021) suggest that housing cooperatives must been seen as a cost-efficient housing alternative for middle-income household and not as social or public housing, this research focusses on the market-equity co-op.

In a market-equity co-op, a member purchases a share at market price in a cooperative, along with the non-time-restricted right to occupy a specific unit (Hjalmarsson & Hjalmarsson, 2009) and a periodic fee for operation and capital expenditures (Ereveit et al., 2016). Capital expenditures consist of a regular monthly instalment of their share in the total unpaid debt that a cooperative can have (Hjalmarsson & Hjalmarsson, 2009), unexpected expenses or improvements. Market-equity cooperatives are typically owned and controlled by the residents who live in them. Most market-rate cooperatives, by contrast, assign votes on the basis of the number and value of shares. The occupants of more valuable units control more shares and cast more votes than those who occupy less valuable units (Davis, 2006). It is important to note that the process for selling shares in a market-equity cooperative may vary depending on the specific bylaws and regulations of the cooperative (Simpson, 1993). Due to the higher restrictions compared to the open market, co-ops could expect a longer marketing period (Goodman & Goodman, 1997) and are therefore less liquid (Simpson, 1993). Additionally, a number of dwellings may be kept by the initial investor or developer as sponsor dwellings, which are rented to tenants.

Overall, market-equity cooperatives provide an alternative form of tenure that can offer some of the benefits of home ownership, such as social capital, housing quality and stability, affiliated services, and reduced costs (Crabtree et al., 2019; CHFV, 2012). A study from 2003 showed that co-ops in Canada have 14 percent less operating costs then public or private non-profit housing (Crabtree et al., 2019). However, it is worth noting that co-ops have a higher risk than other tenure models. While some suggest that members are required to make up any shortfall if another member can't make his/her mortgage payments (Goodman & Goodman, 1997), others disagree, stating that a co-op can exclude members who breach the statutes, making it a stronger position compared to a tenure models and members are less exposed to the risk of high mortgages (Adam, 2021). Approximately 80% of the initial capital is obtained by a loan, provided to the housing cooperative. This means that members only have to get a loan for the remaining 20%. Zonneveld (2020) describes this as one of the most important bottlenecks. The possibilities for a housing cooperative to obtain an 80% LTV is limited. Simpson (1993) and Goodman & Goodman (1997) state that third-party real estate financing has almost completely vanished for co-ops which result in higher interest rates and fees due to the lack of competition. Adam (2021) agrees and says that when membership is not linked to state support or advantageous privatization, it becomes less attractive as banks do not grant loans for the purchase of a membership share without other real estate

as collateral. As a solution, Zonneveld suggests specials funds from which housing cooperatives could obtain loans on favourable terms. Goodman & Goodman (1997) point out that, in case there are enough third-party real estate financers, a blanket loan on a housing cooperative is less expensive than the sum of individual loans in other ownership models.

Co-operatives Australia (2012) suggests that co-operative rental housing can provide a range of social, economic, and psychological benefits for tenant members. Some of these benefits include: social benefits such as a sense of community and increased social connections; economic benefits such as more affordable housing options and more stable and secure housing; and psychological benefits such as reduced stress and anxiety related to housing insecurity and a sense of empowerment and control over one's living situation. It's also worth mentioning that Co-operative rental housing can also help to increase the overall supply of affordable housing, as they can be owned and managed by the member tenants themselves, which could in turn create a sustainable and affordable housing system. Balmer & Gerber (2018) agrees and states that decommodified co-ops could be built gradually, from below, and could shape a new economy, based on mutual aid and self-management. Cabré & Andrés (2018) found through their case study of the co-op La Borda in Spain that it is a socially innovative because it addresses unmet social needs, has a bottom-up governance model, and promotes socio-political empowerment among its members. Balmer & Gerber (2018) stated that due to the lack of public interventions against the housing shortage crisis, housing cooperatives are a private, self-organized solution to a public problem.

On the contrasting side, Hjalmarsson & Hjalmarsson (2009) and Eretveit & Theisen (2016) show that there is some systematic failure to properly discount the future stream of rent payments relative to the upfront sales price, by which the co-op market is inefficient. Blaszke & Skotarczak (2022) state that legal changes, which include the right to transform a cooperative right into separate ownership of premises, the right to change the property manager from a cooperative to a competitive commercial entity and others, will allow co-ops to compete in the housing market. Crabtree et al. (2021) suggests that in light of persistent affordability issues and the exploration of intermediate tenure models such as shared equity, there is an opportunity for the cooperative sector to learn from the past and from international jurisdictions to maintain its role in providing perpetually affordable and socially beneficial housing, while also exploring shared ownership models.

Overall, the literature suggests that co-ops have the potential to provide a range of benefits for their members and could even shape a new economy. However, the literature also notes that there are limitations to the scalability and efficiency of the model, and that it may be subject to legal and financial restrictions. The exploration of combining shared ownership models with co-ops could solve part of the limitations. However, the investment process could be complex and illiquid, which may limit access for potential residents and investors. Tokenization has the potential to improve the liquidity and accessibility of co-op investment in real estate. Hitchcock (2021) suggest that members can move houses within a co-op without selling their tokens.

2.7 STO market

In a survey, carried out by SeyFarth (2022), 128 real estate executives where asked if they considered tokenization as a capital strategy in their CRE transactions. 97% are not considering tokenization as a capital strategy. 67% of the respondents point to the lack of understanding while 19% are hesitant without clear regulation. Asifma (2021) conducted a similar survey between 27 stakeholders, located in APAC. The respondents highlighted regulatory and legal uncertainty as the main challenges to tokenization. Finally, RICS (2020) asked 34 stakeholders, of which 65% responded that they are likely to adopt tokenization in the next 5 years. 65% of the respondents stated that the transaction of small fractions is a benefit. However, 65% also stated that the uncertainty on how value is determined is an issue. These surveys show that CRE executives and stakeholders are reserved regarding investing in real estate tokens. As far known, there has been no STO for a co-op or otherwise shared ownership models. However, STOMarket, monthly tracks the market cap and trading volume of real estate STO's (graph 6), which could provide an insight about the market interest for real estate tokens. Over the last 2 years, the market cap has increased with 234%, which could indicate the interest from the market. However, with a total market cap of 60 million, it is still a relatively small market.

Graph 6: Market cap & trading volume real estate STOs in 1,000 EUR
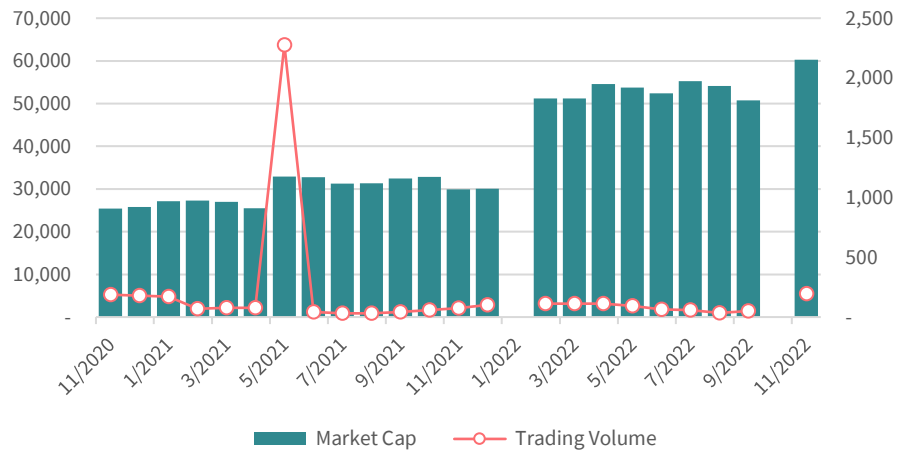
Source: STOMarket I Security Token Market Real Estate Report (multiple months)

3   Analysis
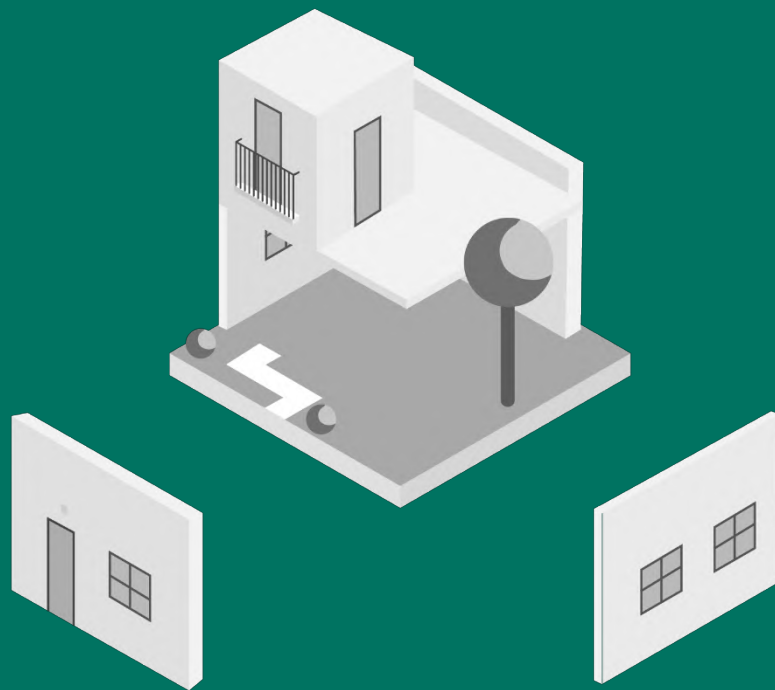
3   Analysis

3.1 On-chain ownership schemes

To answer the question of whether an on-chain multi-asset fractional ownership scheme could potentially replace the home ownership and rental market, an exploratory research approach is adopted. This due to the lack of previous research on this topic. In the previous chapter, the potential of combining shared ownership with a housing cooperative is discussed. The complexity as a result of a combined scheme could be resolved with tokenization.

Before the research method is described, it is imported to highlight the current market of tokenized co-ops. After conducting extensive research (appendix A), DOMA is the only initiative in which shares in a housing cooperative are tokenized. DOMA is a non-profit housing platform, founded in 2017, that aims to provide affordable, flexible, and sustainable housing to users by turning them into homeowners. The platform operates as a housing cooperative, purchasing housing stock and making it available to new and existing users. DOMA offers affordable housing units to its users for a monthly price that decreases over time, providing equity shares in return for monthly payments and progressively turning users into homeowners. Unlike traditional home ownership models, DOMA allows users to move between network-owned units while accumulating steady debt-free equity, which maintains value based on the distributed network's holdings. In the core of DOMA, smart contracts are used to facilitate and record all interactions between users and the platform. These blockchain-based protocols keep track of every user's share of equity within the network and collect anonymous pooled data that is used to optimize the platform's performance.

The platform issues DOMA tokens, which are sold to investors and entitle them to equity shares, monthly dividends, and a DOMA ID. Money raised from selling tokens is used to purchase new apartments, enabling those who are currently priced out of the property market to enter it as one collective agent. Users log in with their DOMA ID and face a single online interface that allows them to keep track of their investment, purchase and trade tokens, explore the portfolio of DOMA properties, share tips and insights with the community, and apply to live in a DOMA housing unit. Each DOMA tenant is automatically integrated as a shareholder, gaining a DOMA ID and Wallet. Tenants generate DOMA tokens in return for every rent payment they make, and the cost of rent decreases over time as they incrementally build equity within the DOMA platform.

In an Interview with UN studio, DOMA stated that after spending time designing the platform, it seems that the concept is financially feasible. However, recent years, there is little communication about the progress from DOMA. After contacting Francesco Sebregondi (founder of DOMA), its seems that the company is no longer active. It is therefore not possible to research on-chain housing co-ops. Therefore, the author adopts an alternative research approach which will be discussed in the following chapter.

3.2 Research methodology

This research employs an exploratory sequential methods approach to explore of whether an on-chain multi-asset fractional ownership scheme could potentially replace the home ownership and rental market. Given the limited number of on-chain multi-asset fractional ownership schemes, as discussed in the previous paragraph, this study initially conducts a case study of off-chain multi-asset fractional ownership schemes. The case study aims to analyse the advantages and limitations of each scheme, resulting in design principles for a new model. Based on the results of the case study, a conceptual ownership model is developed. To further enhance the validity and reliability of the conceptual model, a financial feasibility study is conducted to analyse the performance against the home ownership and rental market and the model is reflected, based on the design principles.

| 3.3 Case study off-chain ownership schemes | This chapter conducts a case study toward 3 different off-chain ownership schemes: Mutual Home Ownership, Shared ownership co-op and Musharakah Mutanaqisah Partnership. The literature, necessary for conducting this case study can be found in appendix A. |

Case: Mutual Home Ownership

A Mutual Home Ownership (MHO) is a form of collective ownership that allows individual members to accumulate equity shares in a Co-operative Society (Community Led Housing London, 2020). The model was originally conceived by Conaty et al. (2004) who got their inspiration from the Swedish Tenant Ownership Cooperative system and the American Community Land Trust system, and later perfected by Rodgers (2004). A distinguishing feature of an MHO, as opposed to other housing cooperatives, is that a portion of the rent paid by individual members is allocated towards equity shares in the property, similar to paying off a personal mortgage. This results in the accumulation of equity units that can be sold for financial gain upon departure from the cooperative. Bright & Hopkins (2011) state that de-coupling of the wealth creation function of home ownership from property values and the fact that what is owned is not the home but shares, are the differences between traditional home ownership and a MHO from a member's perspective.

The ownership model works as followed: The government gifted a vacant plot to a Community Land Trust (CLT), which holds the freehold into perpetuity. The CLT leaseholds for £ 0 the land to Mutual Home Ownership Trust (MHOT) with obligations to build a specific MHO project and rules about the mutual ownership scheme. A shell co-op builds under a building license from the CLT the building. On completion, the shell co-op transfers the building to the MHOT. The MHOT gets a mortgage which is guaranteed by the Co-operative Housing Finance Society Ltd. The MHOT creates equity shares (£ 1 per share) and divides the shares, based on the value of each individual dwelling (value is originally based on the building costs and yearly indexed with the National Average Earning index). The dwellings are rented in a 99-year lease contract to the residents.

Diagram 2: Ownership model MHOs
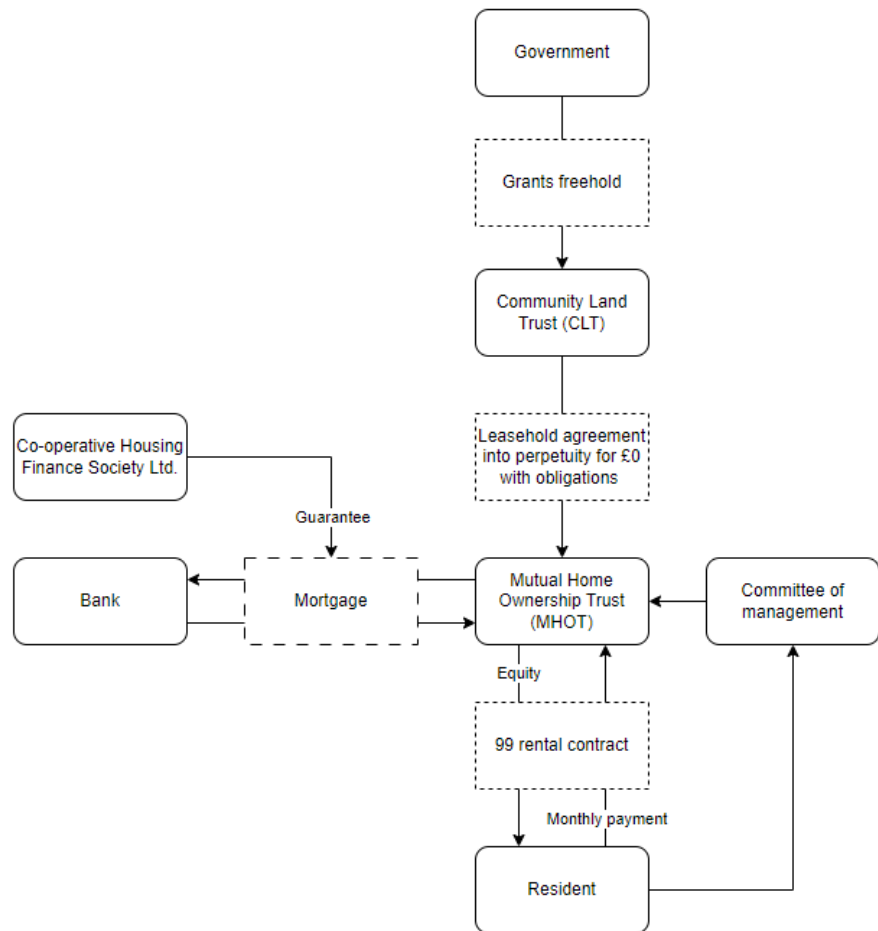
Source: Conaty et al. (2004), updated by author

LILAC is the first MHO that was realised in 2013 in Leeds (UK). The area consists of 1.5 acre site with in total 20 residential dwellings. It took 7.5 years to develop with a total development cost of £ 3 million, of which £ 0.5 million was granted. Because LILAC is focused around affordability, the lease contract is set up as followed: A resident must take on equity of the value of their dwelling when moving into the MHOT. The resident can only acquire equity between 90 – 110% of the dwelling value. However, on average 100% of the equity has to be distributed between the residents. The rent is always 35% of the net income until the debt of your shares of equity are paid. Afterwards the rent equals 10% that is put into the LILAC Equity Fund (LEF). The LEF is used for benefit of the society to improve sustainability and affordability. When 35% of the net income of a resident is greater than the house charge and debt repayments needed to cover shares to the value of 110%, or the resident made an additional capital investment to pay of additional debt, a high earners policy is applied. 50% of the excess (caped at 1.5% of household's allocated share value) is put in LEF. The remainder will be uses to increase the resident's debt repayment.

Figure 4: Equity share diagram
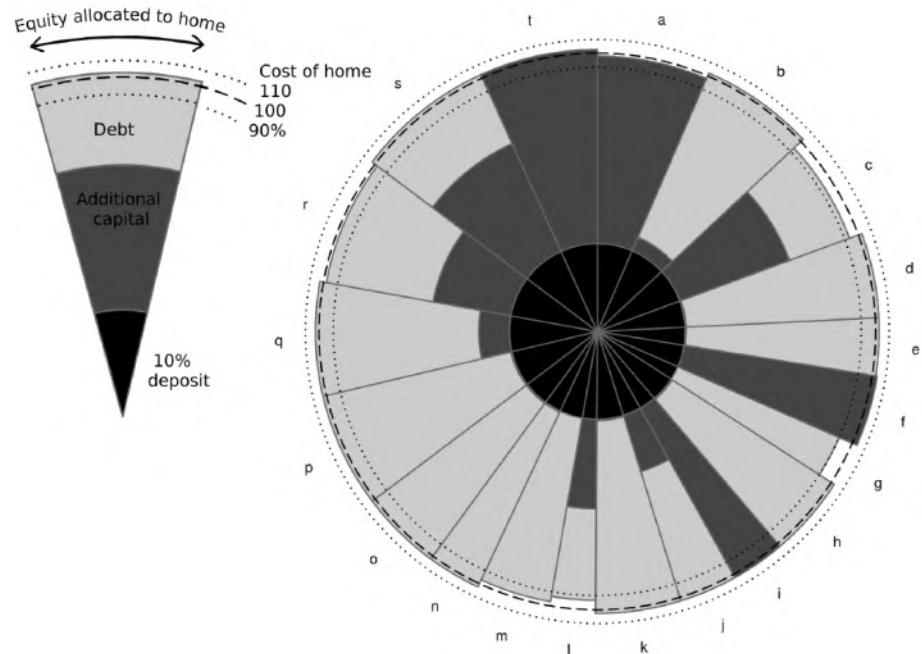
Example: income check new resident
A dwellings value equals £ 150.000. After the deposit of 10%, the mortgage is £ 135.000. With 35% of the net income, the resident has to support the mortgage (25 years at 4.4% at Triodos) and on average 1% of the net income to housing charges. This means that the resident needs a net income of £ 2.185 per month with a maximum of £ 2.427 (without high earners policy) and a minimum of £ 1.986.

Source: LILAC

When a resident decided to leave within a period of 3 years, the original deposit and building op equity shares are returned. If the resident decides to leave after a period of 3 years, the resident also received 75% of increase in share value (based on the National Average Earning index). The other 25% goes back into the LEF. In the new resident cannot replace the outgoing equity, the MHOT could use the build-up equity in the LEF to pay out the previous resident or increase the mortgage. This makes the dwellings affordable for others in the long term, but the leaving resident miss out on capturing the full market value.

In July 2021, 100% of the LILAC residents were satisfied with the tenure type, while 50% of the residents were satisfied with their previous tenure. It is worth noting that LILAC is the sole MHOS in existence. During a presentation by LILAC in 2016, it was revealed that the model's intricacy was the most challenging aspect, with over 1,000 hours of discussion required to finalize it. Even after implementation, residents must invest considerable time into managing and comprehending the tenure scheme's complexity. LILAC even build software to manage all cash flows.

Quaggy is another MHOS that is currently in their setup face. The ability for members to accumulate equity shares and the flexible apportionment of debt and equity between members of the Society is different to LILAC. For Quaggy monthly rent will be the higher of the minimum share of monthly costs for the society, or 35% of net income if this is higher. Given that Quaggy is still in its initial phases of development, there will be no further discussion on the subject. Other features of a MHOS can be that residents can reduce their outgoing by taking over responsibility for management, maintenance and cleaning.

In the case of LILAC, the land was granted by the government. YorSpace is a community-led housing organization that acts as a hub for identifying opportunities for MHOS in the city of York. Their primary focus is to act as a hub for MHOS. They work to raise community share capital (£50 per share) to purchase and develop sites and engage consultants to assess viability and undertake planning applications. YorSpace retains the freehold of the land, which is held in a CLT to make sure that the

MHOS benefits low-income households. During the development phase, YorSpace leases the land to a MHOS for 999 years. The MHOS develops the building with assistance from YorSpace. Once the residents move in, they sign individual leases with the MHOS, and the MHOS begins repaying the loan for the premium to YorSpace. YorSpace uses the capital repayments from the MHOS to repay share capital to investors and uses the interest income to pay interest on share capital, pay overheads, and provide an ongoing source of seed funding to develop new sites for further community-led housing projects. YorSpace's initial MHOS project is the Lowfield Green Housing Co-Operative (LGHC). It's a 0.75 acres site in York which holds 19 homes. LGHC's business model closely resembles that of LILAC. However, LGHC links its monthly payments to the Net Development Costs (i.e., costs after deducting any grants, equivalent to the total scheme borrowing) of each property. This approach enables MHOS to sell homes at a price that covers the cost of construction, management, and maintenance, spread over a fixed period, regardless of the household or local income. In addition, the residents make a monthly contribution for maintenance and overhead costs in addition to a payment in the capital replacement fund. While the planning permission was granted in March 2019, LGHC is still in its pre-development stage.

Diagram 3: Ownership model YorSpace
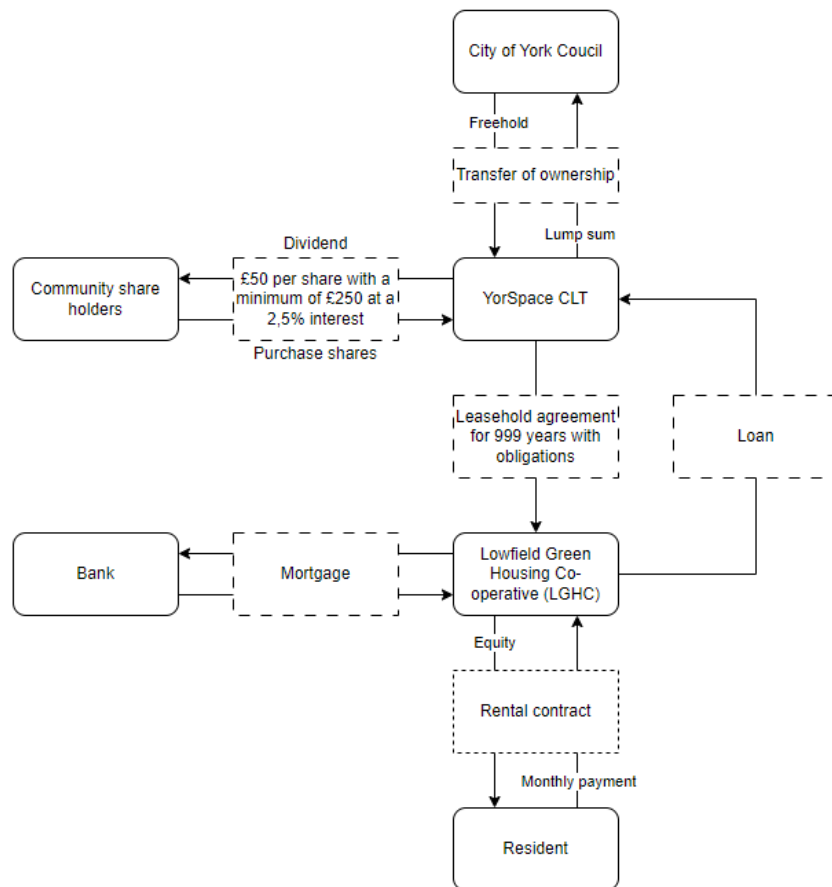
Source: Author

MHOS offers unique advantages and limitations. According to the Community Led Homes London (2020), every member has an equal vote in decision-making, regardless of their contributions in terms of time and money. The flexible approach to debt and cost-sharing allows higher earners to help subsidize affordability for lower-income members. However, creating a viable and affordable MHOS can be challenging, even with grant funding available.

Conaty et al. (2004) suggest that if the financial benefits of cooperation can only be realized by leaving, it may result in high turnover rates after the qualifying period, leading to a crisis in participation and high costs of socializing new members. If the financial benefits calculation is too complicated or set too high, it may lead to uncertainty and lack of legitimacy or co-ops may not be able to finance payouts.

Moreover, introducing a new form of tenure may result in high costs, misunderstandings, legal fees, disputes, and a need for new legislation. Finally, the costs associated with MHOS can become high if the cooperative involves a new form of tenure, leading to misunderstandings, high legal fees, unwarranted disputes, and the necessity for new legislation.

Bright & Hopkins (2013) report that in some MHOS models, the growth of the shares is linked to local wage levels, making it possible for occupiers to remain in their homes during times of income hardship. However, the wealth creation potential of MHOS may be capped, such as being linked to regional average wage index rather than property values, making it unaffordable for individuals to leave the co-op. Additionally, MHOS is not mainstream and does not aim to be, but rather offers a shared sense of belonging, identity in communities, and mutual support structures for those who choose this option. The table 1 shows a summary of the advantages and limitations of a MHOS.

Table 1: Advantages & limitations MHOS

Advantages	Limitations
Equal voting power for all members	Funding challenges
Flexible debt and cost-sharing	High turnover rates after qualifying period
Wage-based growth for outgoing members	Lack of legitimacy through complicity
	High costs and legal fees with new tenure forms
	Capped wealth creation potential
	Non-mainstream option with shared sense of belonging and community identity.

Case: Shared ownership co-op

The shared ownership co-op scheme is a type of affordable housing scheme that allows individuals to part-own and part-rent their home. In this scheme, the property is owned by a housing co-op, and the resident has the option to purchase a share of the property. In a shared ownership co-op scheme, residents have a say in the management and governance of the co-operative. They can be involved in decision-making processes and have a say in the maintenance and upkeep of the property. This provides a sense of community and involvement in the management of the property, which can be beneficial for residents.

CDS Cooperative Housing has produced 8 shared-ownership co-ops. The owner-tenants have to buy from 50 to 75 percent of the equity initially, and then can 'staircase' their way to full ownership in leaps of at least 10 percent. As the dwelling is sold leasehold, presumably some kind of co-op will remain even if 100 percent of the equity is eventually taken up. Unusually, prospective members are not involved at the design stage, and are selected according to their ability to pay the monthly mortgage and rent. When they leave the scheme, either they must find a buyer for their share of the property or must buy the whole of the equity on the same day that they sell it on to the new member. If the latter method is often used, one would expect that the scheme would become quickly less of a co-operative and more an ordinary owner-occupied estate.

And example of a shared-ownership co-op is Shearwood Housing Co-operative. Shearwood is a housing cooperative located in Grayford, UK, founded in 1983 that works under a shared ownership co-op scheme. The cooperative is comprised of 111 properties, including one bed flats and one, two, and three bed houses. Each member holds 1 share in the society, and new members are approved by a committee. Members can exercise an option granted within the lease to purchase the freehold interest in the house. Shares are neither withdrawable nor transferable. Under the shared ownership co-op scheme, the freeholder of the scheme is a Co-operative Society, of which all the shared-ownership owners are members. The shared-owners have their own mortgages for their share of ownership, and they also pay rent to the co-op for the share they do not own of their individual flats. In addition, they pay a service charge set by the freeholder (i.e., the co-op of which they are members) and are responsible for setting the service charge and ensuring the maintenance in relation to that. The co-op also has its own long-term loan for the "unsold" share of ownership, which the rents help to pay down. It is important to note that the legal protection in perpetuity is likely imposed externally through a grant condition, although it may allow staircasing. The cooperative has a committee responsible for communal maintenance issues on the estate. The shared ownership co-op scheme has been successful in providing affordable and sustainable housing to its members while allowing them to participate in

the governance of the co-op. There is limited information available about the Shearwood Housing Co-operative. After contacting the Community Led Houding in London, they stated that Shearwood is a traditional UK co-op where members can acquire 1 share for £1. Furthermore, the tenure is based on a standard Shared Ownership Lease, which is set by the UK government.

The problem with the model in conventional applications (e.g., as practiced by housing associations today) is that through staircasing, as the members gradually buy out the co-op interest, they can correspondingly lose a commonality of spirit, the commitment to member co-operation and participation in co-management.

A different approach of the shared ownership co-op scheme is the Glenkerry House (diagram 4). Founded in 1979, the Glenkerry Co-operative Housing Association Ltd (GCHA) consists of 78 flats, located in the East End of London. GCHA bought a 99-year lease of the Greater London Council and received 2 grants from the Housing corporation and the Great London Council. The residue was provided through a mortgage. What distinguishes GCHA from a regular shared ownership co-op is that a member can only acquire 50% of the district valuer's valuation of the flat and receives therefore 50% equity. It is not possible to staircase to 100%. The 50% equity can be mortgaged by the member. When the member decides to leave the flat, the selling price equals again 50% of the district valuer's valuation. Sales are kept off the open market, by which new members are selected by the committee. The reason for setting the selling price to the district valuer's valuation instead of open market prices is that the valuation lags behind the market, which keep rices reasonable and keeps the scheme affordable for new members. In research, carried out by Birchall (1983), 59 % had been sold again since the first sale, of which 11 had been sold twice over. Birchall concludes that the co-op is achieving its aim of being a stepping-stone for those who cannot initially afford to buy their own house.

In April 1980 an 8-member consultative committee was formed from among the first residents, and an educational programme was run by GLSHA staff, attended by 46 members, which took over the housing management from the Utopian Housing Association, and is since then self-managed.

Diagram 4: Ownership model Glenkerry House
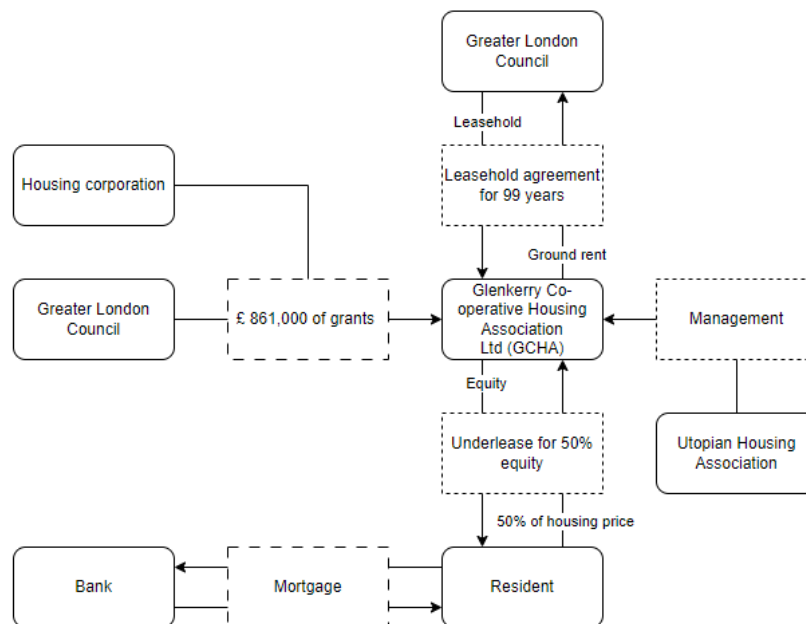
Source: Author

The scheme can be seen as a steppingstone in the housing market but is less used throughout a member's lifecycle because its caped at 50% (in case of GLSHA). In similar scheme's it's possible to staircase to 100% by which full ownership is acquired which result only is a co-op in paper without any equity. Furthermore, GLSHA heavily relied on grants from Housing Corporation (£717,000) and Greater

London Council (£144,000), which accumulates to 60% of the total building and legal costs (£1,435,000). Table 2 provides a summary of the advantages and limitations of a shared ownership co-op.

Table 2: Advantages & limitations shared ownership co-op

Advantages	Limitations
Low threshold for households	No scalability after 50 – or 100% by member
Voting power for each member	Difficult to move out of scheme when equity is built
Bought equity can be mortgaged by member	Less commitment to participate in co-management

Case: Musharakah Mutanagisah Partnership

Musharakah Mutanaqisah Partnership (MMP) is a contract of partnership between two parties, where one partner gradually buys the whole parts of the property. The construct was created because in Islamic Finance, it is both illegal and unethical to charge interest, which is the case in a traditional debt-based mortgage. The Islamic Cooperative Housing Corporation (ICHC) in Toronto, Canada, established in 1981, is a successful example of the MMP. It operates on a system where members buy shares in a single equity pool to join the cooperative. As members accumulate more shares, the co-op buys a house in which the member's family can live, while paying proportional rent to the co-op. Members are required to increase their ownership by investing more money in the co-op shares, and the rent goes down proportionally until payments phase out. Diagram 5 describes the ownership model of the MMP ICHC.

Diagram 5: Ownership model MMP in case of ICHC
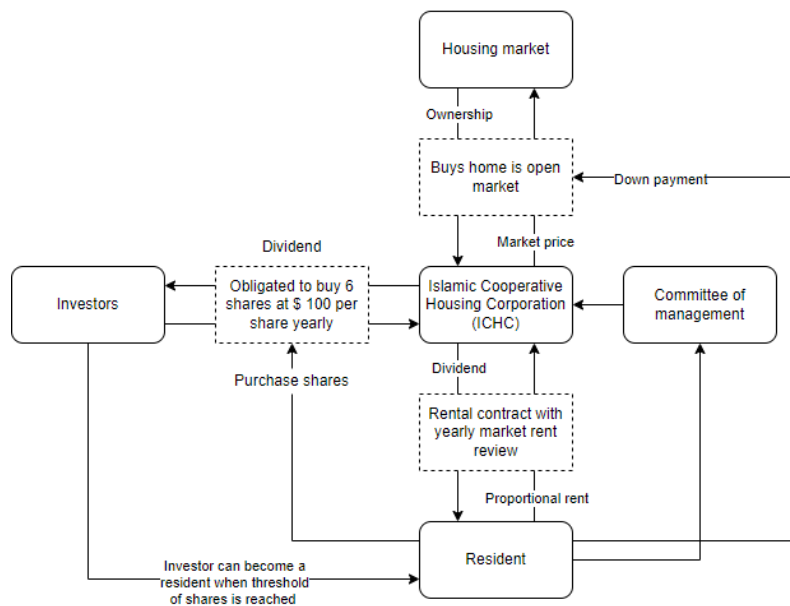
Source: Author

After having sold $ 30 million worth of MMPs, a few years back, ICHC ran out of its total authorized capital under the Co-operative Corporations Act. Another co-op, Ansar Cooperative Housing Corporation (ACHC) had to be set up with another $ 30 million of authorized capital. As of 2022, ICHC and ACHC have combined purchased 629 dwellings (graph 7).

Graph 7: Number of members and dwellings within ICHC & ACHC

To become a member of ICHC/ACHC, you need to pay a $ 75 membership fee and a minimum of 6 shares (share price equals $ 100 per share). A member must buy 6 shares per calendar year to retain its membership. Shares can only be sold to active members. A member receives a quarterly dividend of 4% (2021). A member can become also a home buyer. ICHC/ACHC buys the desired dwelling when the member acquired enough shares (figure 4). The initial rent is determined based on the market rental value multi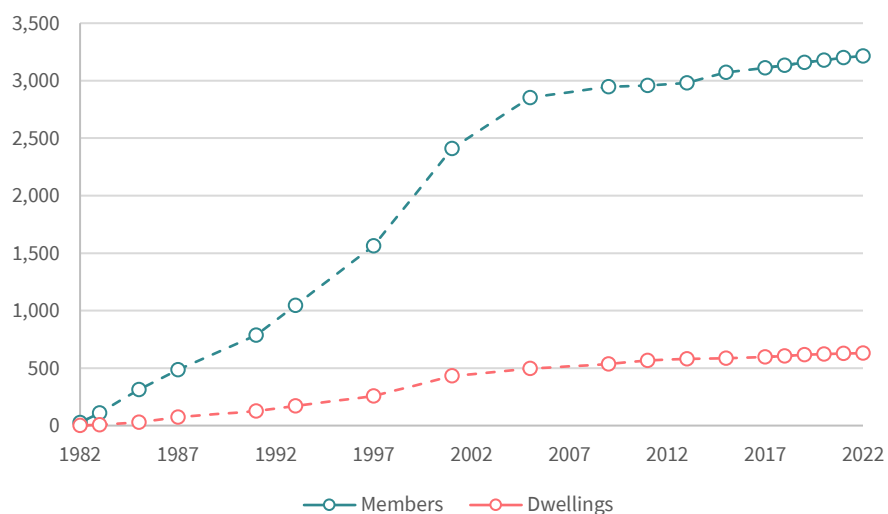plied with the proportional ownership percentage of ICHC/ACHC and yearly index with a rental index. The proportional ownership percentage is calculated based on the shares that are hold by the home buyer, divided by the initial purchase price of the house. ACHC state that some members acquire 100% ownership after a period of 7.5 years. When the member reaches 100% ownership and wants to acquire the deed, the costs of ownership equals between 10% of the difference between the current market value and the initial housing price, minus the costs of major improvements and legal expenses.

Figure 5: ACHC financial model

Example: Housing price equals $ 350,000. Member must have at least ($ 100,000 x 20% + $ 100,000 x 25% + $ 100,000 x 30% + ($ 350,000 - $ 300,000) x 100% = $ 125,000 in shares for more then 6 months.
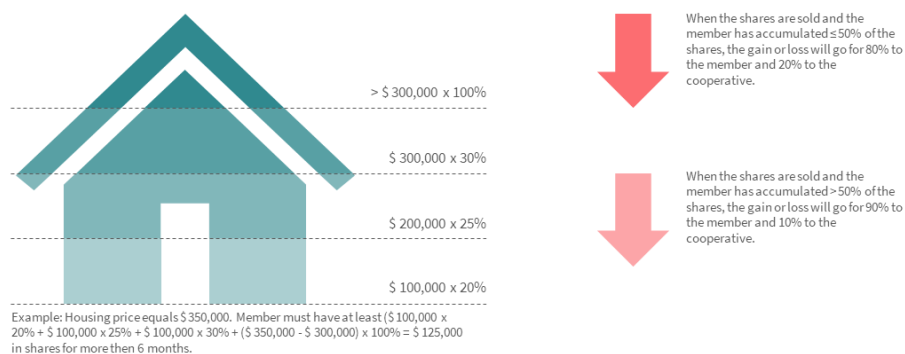
The MMP model offers several advantages and limitations that should be taken into account when considering its implementation. According to Ma & Taib (2023), the cooperative financial system provides a low threshold for disadvantaged households to balance supply and demand, making it an effective institutional arrangement for economic development. Additionally, housing cooperatives can offer opportunity structures for bottom-linked citizen participation, linking and cohering social capital. However, there are also limitations that need to be considered. ICHC/ACHC really on capital injections by home buyers and investors to acquire new dwellings for feature home owners. Abdul-Rahman (2014) states that the growth is limited because of the lack of liquidity. As the need for housing continues to expand, AHC may confront scalability challenges. Suleiman (2016) agrees and argues that ICHC/ACHC

can only support approximately 20 homes per year due to the dependence on actual cash deposits. Hotiana (2007) says if the option is available but the cost of availing it is unreasonably high or waiting period too long then it is in essence no real access or option. Short supply of funds will also continue to pull MMP rates much higher than conventional mortgages in Canada, currently the difference being between 100 and 300 basis points more expensive than conventional mortgages.

Table 3: Advantages & limitations Musharakah Mutanaqisah Partnership

Advantages	Limitations
Low threshold for households	Scalability issues
Cohering social capital	Low liquidity
Shared profit & loss	Higher costs than conventional mortgages
	Capital rationing issues

3.4 Cross case analysis

The three models discussed in this study aim to make homeownership more accessible to households with limited financial resources, thereby reducing barriers to homeownership. The MHO and shared ownership co-op are focused on low-income households, while the MMP does not have a specific target group, except for religious organizations. All three models involve shared ownership or partnership between the resident and the housing co-op, where the resident can gradually acquire equity over time. Community building is emphasized by all models, and members work together to maintain and improve their properties, which fosters a sense of community and ownership.

However, there are also some differences between the models. Firstly, the initial investment needed to start op a scheme and realize the first properties for its residents is heavily relying on public grants, by which a CLT is set-up to assure the grants are used for which they are intent, namely housing low-income households. With the concept of YorSpace or in a MMP, the initial investment is generated through investors. Both YorSpace and MMP have problems to attract enough investors by which liquidity is low. The demand for affordable housing is high which results in scaling issues. Secondly, all three models have specific eligibility criteria that must be met in order to participate, which may limit access for some individuals or households. Thirdly, there are differences in the initial deposit required by the resident, the monthly contribution calculation formula, and the equity shares allocated towards the property. Lilac charges a 10% deposit, while MMP charges a minimum of 20% and in GLSHA, a resident is obligated to buy 50% (which can be mortgaged). When discussing the monthly contribution, MHO and MMP allocate a portion of the rent paid by individual residents towards equity shares in the property, similar to paying off a personal mortgage. A shared ownership co-op allows a resident to staircase for which the required equity can be mortgages. GLSHA only allows to staircase to 50% to guarantee affordability for the next resident. However, other shared ownership co-ops allow a resident to staircase to 100% by which full ownership can be gained that results in a less sense of community and ownership between the residents. This is also the case for a MMP. When the resident gained 100%, the deed can be transferred by which the property leaves the housing co-op. When a resident leaves the scheme, capital gain distribution is handled differently. In case of Lilac, capital gain is only received for 75% after a period of 3 years and based on the National Average Earning index. For GLSHA, capital gains are based on the district valuer's valuation instead of the housing market. A leaving resident of ICHC receives 80% till 90% of the capital gain, based on the equity percentage gained by the resident. All these formulas add to the complexity, which make these scheme time consuming for current members and could even result new members from entering the schemes. Finally, residents in all three models are not allowed to decrease shares or move houses within the housing co-op, limiting their ability to adapt to changing living needs due to personal circumstances. Additionally, residents cannot staircase beyond 100% of the property's value, except for in the case of Lilac where the limit is 110%. This restriction may lead to residents seeking alternative investment options when they reach the ceiling. Increasing the equity allowed beyond the property's value could potentially solve liquidity and scaling issues faced by these models.

Based on this case study, for a tokenized housing co-op to establish a sustainable housing model, it must incorporate the following design principles:

1. Sufficient capital injections to provide low barriers for entry to the housing market for new residents.
2. Inclusivity to enable a broad range of participants to join and ensure accessibility.
3. Lower the initial deposit required to allow residents to participate without having to possess a minimum of 10% starting capital.

4. Allow wealth creation to be amortized at any point in time by the resident to guarantee long-term commitment.
5. Ensure that the scheme is simple to understand by a wide audience of members.
6. Automate cash flows to track, distribute, and secure money distribution between all stakeholders.
7. Encourage member involvement by distributing voting rights.
8. Separate equity and housing need so that members can move houses without losing their invested equity.

4   Conceptual ownership model
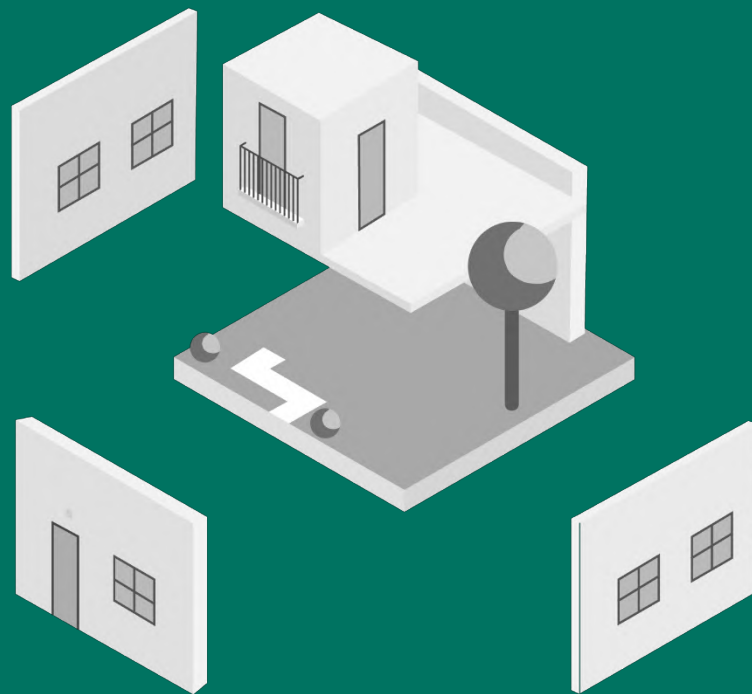
4   Conceptual ownership model

4.1 Introduction

The author proposes a novel ownership model that integrates tokenization into a housing co-operative. The primary objective of this proposed model is to disentangle housing need from equity as an investment by utilizing tokenization as a central component. The concept draws inspiration from DOMA, wherein tenants can also become homeowners and freely transition between network-owned units to adapt their living conditions to changing life circumstances. This unique model entails members paying rent while also owning equity, which grants them the right to receive dividends. The dividends are calculated based on the revenue stream generated from members' rent payments. By introducing this innovative approach, the author seeks to address the complex interplay between housing, ownership, and investment, providing a potential solution for more flexible and inclusive housing arrangements.

4.2 Proposed scheme

The authors' model is visualized in Figure 5, illustrating the overall structure and flow. The token platform, which is owned by the tokenization company, serves as the central entity responsible for managing one or multiple Special Purpose Vehicles (SPVs). Each SPV can be tailored to accommodate a specific category of rentable units, aligning with market demands. The SPV holds the legal ownership while the tokens represent the economic ownership of a rentable unit. The day-to-day management of these units, including tasks such as tax management, maintenance, and property management, is handled by a dedicated management company. This ensures the efficient operation and upkeep of the rentable units within the SPV.

When a previous homeowner transfers legal ownership of a rentable unit to a SPV, the economic ownership is tokenized by the SPV through a security token offering facilitated by a token platform. These tokens are then securely stored in the homeowner's permissioned wallet after completing registration and successfully undergoing a Know Your Customer (KYC)/Anti-Money Laundering (AML) verification process. If the homeowner decides to continue residing in the rentable unit, they can become a tenant. Otherwise, they become an investor. The tokens can be sold to retail investors on a secondary market platform. A tenants can rent these units and make regular rent payments in exchange for the right of use.

Investors receive dividends through smart contracts, based on the number of tokens they own. However, these dividends are limited to a level where the available cash flow is adequate to acquire new rentable units within the SPV, without requiring additional investments. This is accomplished by allocating the remaining rent after deduction of operational expenses and dividends to an equity fund.

The distinctive feature of this model lies in the tokenization and distribution of newly acquired rentable units based on the proportion of investments in the equity fund. Since only tenants contribute rent payments, the capital growth achieved through acquiring new units is shared among the tenants rather than the investors. This mechanism enables tenants to accumulate equity over time and lower their living costs by receiving dividend. Tenants are automatically granted tokens, and like investors, they receive a permissioned wallet upon registration and successful completion of KYC/AML checks. However, it's unfair that newly acquired tokenized dwellings are divided equally among all tenants in case the equity fund has grown over time. Furthermore, the SPV could contain different types of rentable units with different net rents. Therefore, the contribution into the equity fund by each tenant is different. The accumulated contribution by a tenant divided by the total equity fund, multiplied by the net capital value of the acquired rentable units equals the token-distribution towards the tenant.

To facilitate decision-making regarding the acquisition of new rentable units, a voting system must be established. In a housing cooperative model, each member holds one voting share. In the case of tokenization, where ownership is fractionalized, each token can represent one voting share. By acquiring more tokens, individuals can increase their voting rights through a process known as staircasing. However, a challenge arises when large real estate investors acquire a significant portion of

the equity through secondary markets, potentially obtaining a majority interest. This situation may not always align with the best interests of the tenants. To address this, certain regulations need to be implemented to prevent investors or investor collectives from gaining a majority interest. Potential solutions include ensuring that at least 51% of the voting shares are held by tenants (after the initial startup phase) or imposing limits on the maximum percentage of voting shares an individual member can acquire. However, restricting the number of tokens a member can obtain may result in a discount on the token price compared to housing prices. Nonetheless, as the SPV accumulates more dwellings and members, it becomes less likely that an investor could acquire a majority interest, thus safeguarding the cooperative's decision-making process.

Figure 6: Proposed scheme author
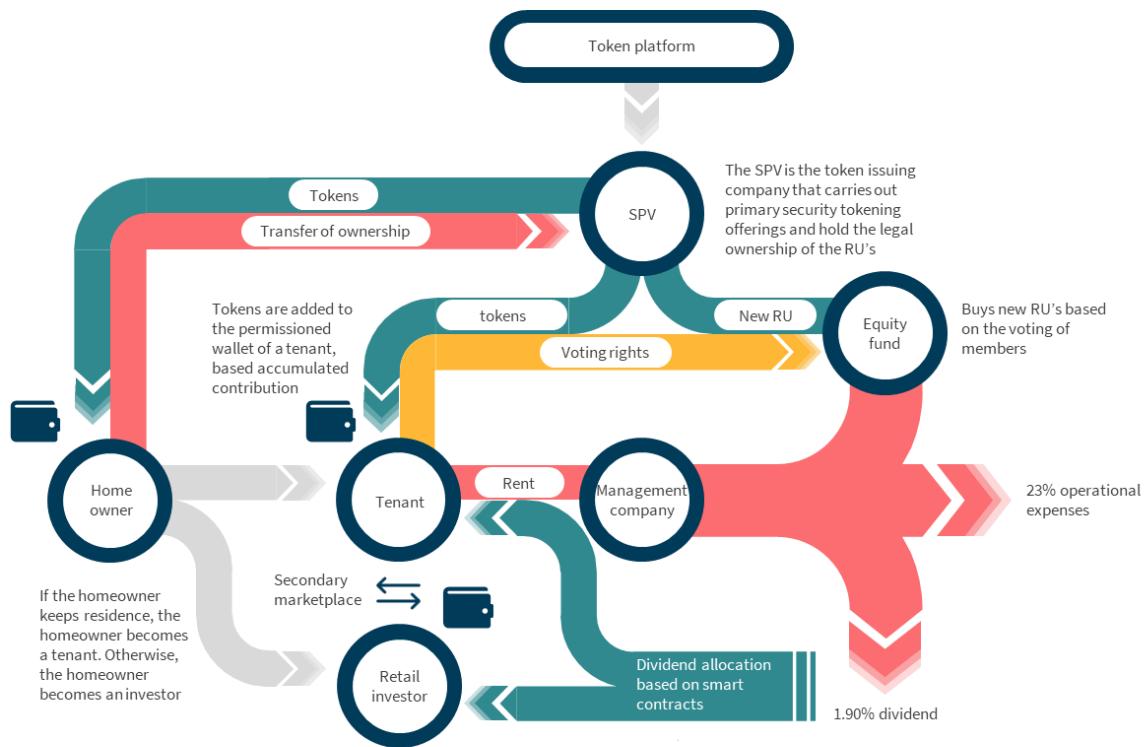
Source: Author

A rentable unit could enter a SPV into multiple ways:

i) A direct residential real estate portfolio held by a real estate investor can be transferred to a Special Purpose Vehicle (SPV). In exchange, the investor receives a permissioned wallet and tokens automatically. Each token is valued at 1 unit of fiat currency (for simplicity, let's assume 1 token = €1). The current tenants of the real estate investor also receive a permissioned wallet, although their wallets initially do not contain any tokens. The real estate investor has the option to gradually trade tokens to the tenants, a practice that is not new. In the Netherlands, it is common for real estate investors to offer ownership to their tenants, often providing them with a discount on the market value.

Research conducted in paragraph 2.5 indicates that tokenized residential real estate reflects housing prices accurately. This implies that tokens are traded on the secondary market at their market value, without any discounts. Moreover, tokens represent fractionalized parts of the properties. In the current practice, tenants are required to purchase the entire property at market value (minus a discount). If tenants cannot secure sufficient financing to obtain a mortgage, the deal falls through. The real estate investor has limited options to sell the ownership to another party (except for another real estate investor) until the tenant decides to vacate the property. This scheme resolves these issues.

The remaining fraction of the property that is not purchased by the tenants can be traded to retail investors. Since tokens are traded on a fractional basis, the pool of potential investors is larger

compared to selling the portfolio to another real estate investor. This creates a potential liquidity premium, offering increased liquidity for the real estate investor.
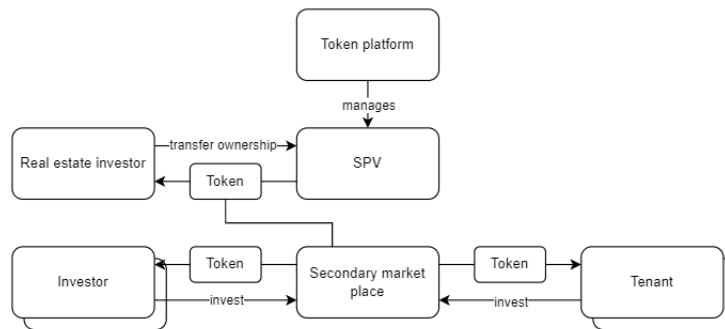
ii) When a homeowner transfers the title ownership of their property to the SPV, they have the option to continue residing in the dwelling as a tenant. In such cases, the homeowner-turned-tenant is provided with a permissioned wallet and tokens equivalent to the appraised value of the property. The tenant (previously the homeowner) is then responsible for paying periodic rent. The tenant can sell tokens on the secondary market to other investors.
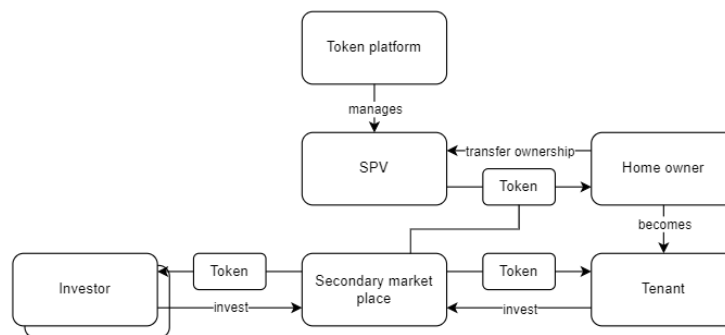
iii) A SPV can acquire new rentable units. The equity, needed for acquiring rentable units arrives from the equity fund. Based on the voting system, token holders can vote which rentable units should be acquired. Smart contracts track the net rent after deduction of dividend that each tenant puts into the equity fund. After the SPV acquires new rentable units, the rentable units are tokenized by the token platform and distributed towards the tenants, based on the proportion of investment into the equity fund. Next to the dividend distribution, smart contracts could also manage the token distribution of newly acquired rentable units.
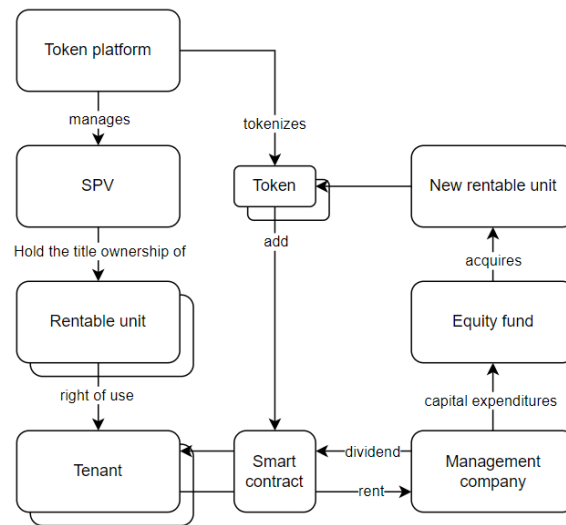
Source: Author

4.2 Setting up the token platform

In terms of cost, the establishment of a token platform, specifically the security token offering (STO), requires a budget of €100,000. This amount is divided into three categories: administrative costs accounting for 20%, software expenses covering 30%, and legal fees constituting 50% of the total budget (2140 Consulting, personal communication, 12 May 2023). It should be noted that both administrative costs and software expenses are recurrent, necessitating ongoing financial commitment. The cost could be part of the operational expenses toward the management company. This would favour the investor because the direct return is caped so higher operational expenses means less room to expand with the equity fund, therefore less capital gain for the home owner and tenant. Alternatively, an alternative solution could involve implementing a monthly fee for utilizing the token platform. This fee would be directly allocated to cover the expenses associated with running the token platform.

5 Results
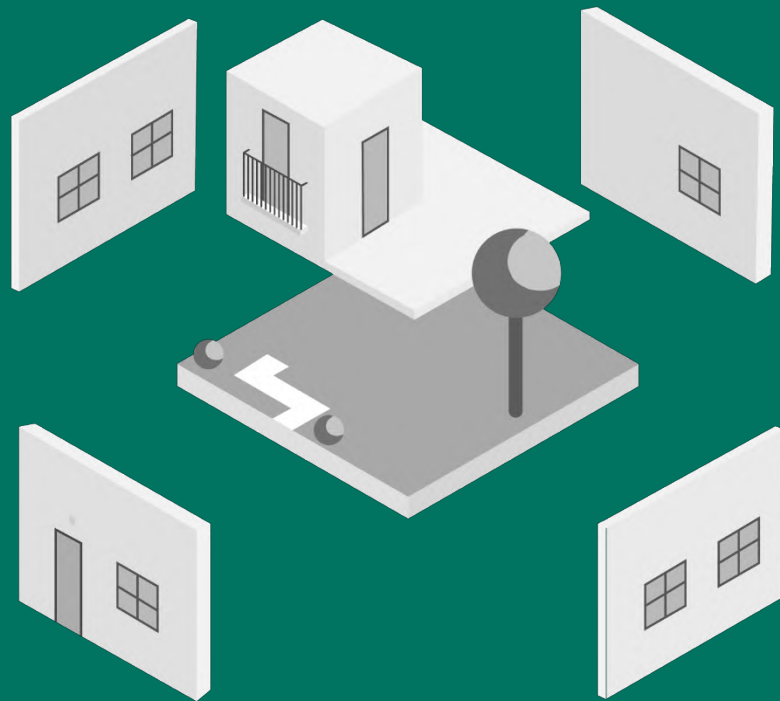
5   Results

5.1 Introduction

To further enhance the validity and reliability of the conceptual model, a financial feasibility study is conducted to analyse the performance against the home ownership and rental market and the model is reflected, based on the design principles.

5.2 Financial feasibility study

In order to assess the financial feasibility of the author's scheme, the initial conceptual model is transformed into a financial model. This model is designed to simulate a mortgage over a 30-year forecast period. To maintain simplicity and traceability, the financial model focuses on general behavior rather than precise accuracy. The assumptions in the financial model are based on European macroeconomic data, as the Special Purpose Vehicle (SPV) is not limited to a specific geographical area. To evaluate the scheme's potential, the financial performance is calculated from the perspectives of a direct real estate investor, a homeowner, and a tenant. The financial performance is then compared to the traditional market. To further examine the model's robustness, a Monte Carlo simulation is conducted. This simulation allows for testing the likelihood that the model will outperform the traditional market.

5.2.1 Calculations

The model assumes the following calculations:

The rent of a SPV is yearly indexed with the Consumer Price Index (CPI) but is also influenced by households moving houses within the SPV. When a household decides to move houses, an initial rent is determined. The model calculates an initial rent, based on the market value, multiplied with a Gross Initial Yield (GIY). The model assumes a fractional turnover, based on the average turnover rate. Furthermore, the SPV grows trough the equity fund which increase the overall rental income. The predicted rent per period can be calculated with the following formula:

$$GR_t = GR_{t-1} \times [1 + i_{t-1}] \times [1 - m] + CapEx_{t-1} \times y + NCV_{t-1} \times [1 + g_{t-1}] \times m, \qquad y > 0 \qquad (1)$$

Where GR equals the gross rent, i the consumer price index, m the turnover rate, CapEx the Capital Expenditures, y the Gross Initial Yield, NCV the Net Capital Value of the SPV and g the capital growth of the SPV.

By using the formula, the Capital Expenditures (CapEx) can be calculated that can be invested in acquiring new assets.

$$CapEx_t = \begin{cases} [NCV_{t-1} \times IR_{max}] - OpEx_t - GR_t, \text{if } CapEx_t > 0 \\ 0, \text{if } CapEx_t \leq 0 \end{cases} \qquad (2)$$

Where CapExt equals the Capital Expenditures in period t, NCVt-1 the net capital value at the start of period t, IRmax the maximum income return (dividend), OpExt the Operational Expenditures in period t and GRt the gross rental income in period t. The condition is that CapEx investment are only possible when the residue is larger than 0. If the Capital Expenditures would not be sufficient to acquire a new dwelling, the Capital Expenditures would be placed in an equity fund which could be used for a future acquisition. If the residue is smaller then 0, the income return is lowered.

The following formula shows the calculation of the income return:

$$IR_t = \frac{NCV_{t-1}}{[GR_t - OpEx_t - CapEx_t]} \qquad (3)$$

Where IRt equals the income return in period t, NCVt-1 the net capital value at the start of period t, GRt the gross rental income in period t, OpExt the Operational Expenditures in period t and CapExt the Capital Expenditures in period t.

Example

On average, the housing price in the Netherlands in 2022 was 428,591 (CBS, 2023c). If the fund contained 45 identical dwelling, the net capital value of the SPV sums up to 19,286,595. Based on a Gross Initial Yield of 5.42%, the annual gross rental income, after deducting 23% operational expenditures would be 804,369. In the case of YorSpace, the dividend rate for crowdfunding the starting capital of a Mutual Home Ownership equals 1.90%. The dividend is in absolute numbers 366,445. The capital investment volume for this year would amount to 437,924 which would allow the SPV to buy an additional asset. When there would only be 44 dwellings in the SPV, the capital investment volume (428,192) would not be sufficient to acquire a new asset and therefore would be placed in the equity fund.

5.2.2 Assumptions

The model makes the following assumptions:

i) The housing price is based on the average housing price in the Netherlands in the year 2022 e.g., € 428,591. The SPV contains 100 rentable units. The housing price and the size of the SPV need to be sufficient to keep the equity fund at a minimum. This because the equity fund does not generate an income. Therefore, when starting a SPV with a single rentable unit, it takes around 39 years in order for the equity fund to buy an additional rentable unit.

ii) The initial gross rent is based on an average gross initial yield of 5.42%, the inflation of the rent and operational expenses are based on the average Consumper Price Index YoY (CBS, 2023a), the capital growth of the housing price is based on the average annualized unfrozen weighted MSCI Europe Annual Property Index for the segment residential (MSCI, 2023a), the turnover is based on the average moving mobility in the Netherlands per 1,000 inhabitans (CBS, 2023b) and the gross initial yield is based on the average gross reversionary yield of standing residential investments in the Netherlands (MSCI, 2023b). Graph 8 shows the historical CPI, capital growth and turnover rate.

Graph 8: Historical time series
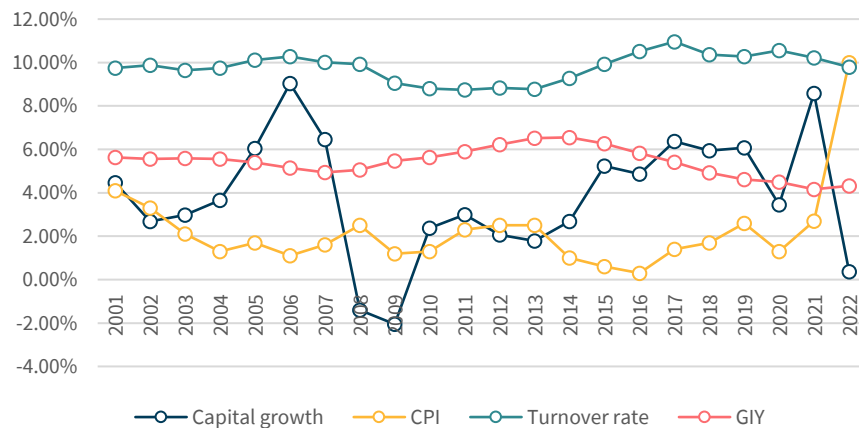
Source: CBS (2023a), MSCI (2023a), CBS (2023b), MSCI (2023b)

iii) The proposed scheme lacks a precedent for its tax framework. In the Netherlands, cryptocurrencies are subject to taxation if the taxable base value exceeds 50,650. The net worth tax is levied on the deemed yield of held assets, which is a fixed percentage return assumed by the government. In 2022, this deemed yield was set at 5.53%. However, considering a capped direct return of 1.90%, the deemed yield appears to be higher than the actual yield, which seems unrealistic according to the author's perspective.

The scheme aims to lower rent and increase equity for tenants by reducing the yield for investors, positioning them as socially responsible investors. Consequently, new regulations would be necessary to ensure appropriate taxation of the proposed scheme. On the other hand, under the proposed scheme, tenants who become homeowners would no longer be subject to real estate transfer taxes when moving houses. Silfhout (2021) disagrees with this notion and suggests that the acquisition of economic ownership by tokens should be taxed if it exceeds the qualifying interest threshold, as already

applicable to the acquisition of shares in real estate entities and participation rights in qualifying investment funds.

Table 4 presents a comparison of the annual taxes under the author's model versus traditional home ownership. To simulate home transfers during the forecast period, a fractional approach based on the average turnover rate is considered.

Table 4: Tax scheme authors model vs traditional home ownership

Net worth tax (authors model)		Real Estate Transfer Tax (traditional)	
Equity owned through tokens	428.591	Equity owned through tokens	428.591
Threshold	50.650	Avg turnover rate	9,79%
Deemed yield	5,53%	Taxable amount	41.965
Taxable amount	20.900	Real Estate Transfer Tax rate	2%
Tax rate	31%		
Tax*	6.479	Tax	839

The dividend payment would be 1.90% of 428,591 (8,143), which would mean that the tax rate equals to 80% of the dividend.

Because the tax scheme is not deemed realistic by the author, the net worth tax is not taken into account. For comparison to the traditional home ownership market, the real estate transfer tax is also not part of the financial feasibility study.

iv) Based on confidential acquired data, the operational expenses in relation to the gross rent are set at 23%.

v) Finally, the capped rent is determined by finding the optimal direct return so that the highest Internal Rate of Return (IRR) is achieved. The IRR grows until a capped direct return of 1.90% after which it will decline. If the capped direct return equals 3.50% or higher, the free cashflow is not sufficient to fill the equity fund after a certain point in time. If the capped direct return equals 4.20% or higher, the free cashflow would never be sufficient to fill the equity fund, which stables out the IRR to 2,47%. Therefore, the optimal capped direct return equals 1.90%.

Graph 9: IRR per capped direct return
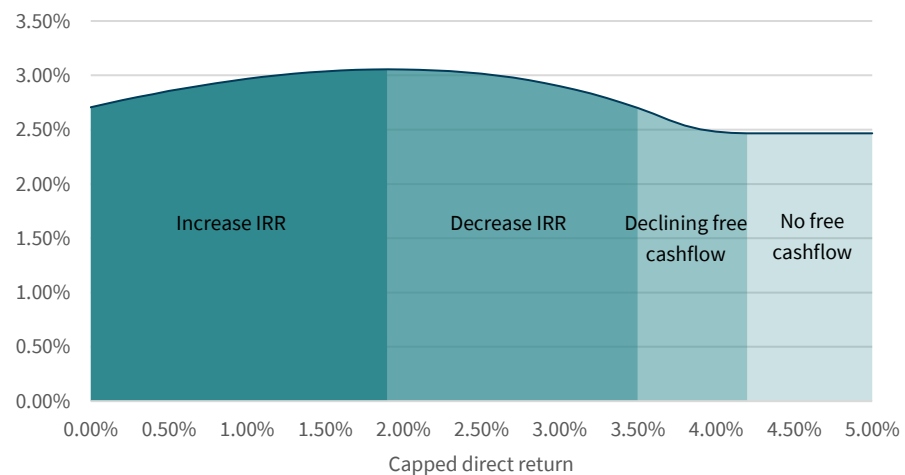
Source: Author

5.2.3 Comparison against investor market
Non-resident investors in the SPV are not entitled to receive new tokens generated from the acquisition of new rentable units through the equity fund. As a result, their capital growth is tied to the value of the tokens, while the capped direct return remains unchanged. To ensure attractiveness for retail investors, the capped direct return should be aligned with the direct return offered by direct real estate funds. Graph 10 illustrates the historical weighted annualized direct returns of the MSCI Europe Annual Property Index. In 2022, the income return stood at 2.80%. However, the proposed model carries fewer risks compared to a direct real estate fund, primarily due to lower rent losses. Tenants only receive tokens when they fulfill their rental obligations according to the rental contract.

Research conducted in 2021 revealed that 7% of private renters were in arrears due to COVID-19 (Clay, 2021). In a 2009 study conducted in Sweden, the figures showed that in normal market circumstances 1% of private renters and 5% of social renters experienced arrears (Stenberg et al., 2011). Rent losses not only impact operational activities but could also lead to temporary vacancies or even eviction. By implementing this scheme, tenants are incentivized to pay their rent due to the financial rewards offered through token ownership. This, in turn, is expected to reduce rent losses, making the capped direct return more secure and potentially even higher with a lower Operating Expense Ratio.

Graph 10: Unfrozen weighted annualized MSCI Europe Annual Property Index (Income return)
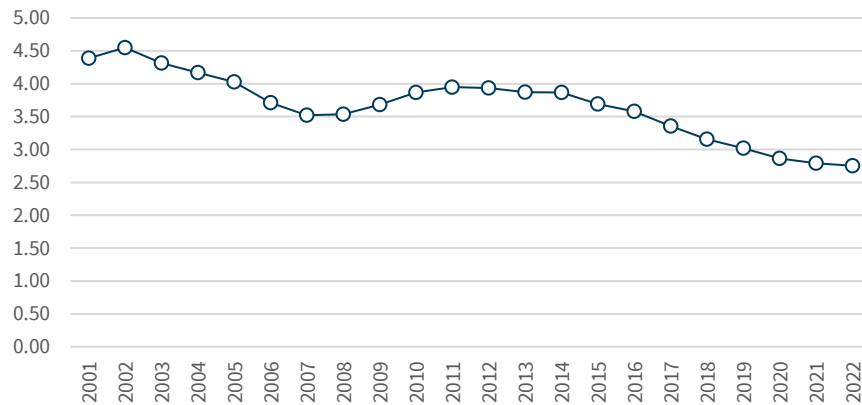
Source: MSCI (2023a)

Retail investors have the opportunity to participate by investing as little as €1. To further incentivize their involvement, a loyalty program can be established that rewards retail investors with higher positions on waiting lists for future rentals. As mentioned earlier, this approach is expected to attract a significant number of tenants due to the financial advantages it offers them.

5.2.4 Comparison against home ownership market

To validate the accuracy of the model, the capped direct return is set at 4.20%, resulting in insufficient free cash flow to fill the equity fund. Consequently, the SPV does not experience growth, and the member's equity aligns with the capital growth of the housing market. The dividend only fluctuates based on rent increases due to indexation or household movements within the SPV. As the member pays rent, the rent discount (dividend as a percentage of the gross rent) is calculated as 1 minus the operational expenses. Appendix B presents the results of a 30-year forecast period, where the equity consistently represents 100% of the housing price, and the rent discount is determined as 1 minus the operational expenses, therefore providing evidence for a correct model.

To compare the author's model with traditional home ownership, it is assumed that a homeowner transfers ownership to the SPV and continues to reside in the rentable unit. The capped direct return is set at 1.90% to facilitate SPV growth through the equity fund. For home ownership, it is assumed that the homeowner has no mortgage and remains in the home for 30 years. The annual living costs, including maintenance, taxes, insurance, and replacement cost reserves, are based on the average annual living costs (CBS, 2023). Appendix C-1 displays the free cash flow of the author's model, while Appendix C-2 presents the comparison against home ownership.

As the homeowner receives tokens equivalent to the appraised value upon transferring ownership to the SPV, the member starts with initial equity. Instead of receiving 100% of the free cash flow (rent after deducting operating expenses), a capped direct return is applied, and the remainder is invested in the equity fund. The equity fund acquires new rentable units, leading to an increase in the member's equity. These new units generate additional cash flows, resulting in an increasing dividend over time. After 30 years, the living costs decrease by 61%, while the member obtains 54% more equity compared to a homeowner.

If the member were to sell the tokens after the 30-year forecast period, the IRR would be 3.06%. For a homeowner selling the house after the same forecast period, the IRR would be 3.13%. The difference between the proposed model and home ownership is partly attributed to the higher operational

expenses in the model. The annual costs for the homeowner amount to €2,508, while the costs for the proposed scheme are 2.1 times higher. This can be explained by factors such as temporary vacancy, rent loss, broker fees, and more. If the operational expenses of the scheme were reduced to 21.5% of the gross rent, the IRR of the scheme would match that of home ownership.

To estimate the probability that the proposed scheme is underperforming compared to home ownership, a Monte Carlo simulation is run. A Monte Carlo simulation is a computational technique used to model and analyse uncertainty in various systems or processes. It involves running a large number of simulated trials or iterations to estimate the probability distribution of possible outcomes. For the Monte Carlo simulation, the following assumptions are simulated:

Table 5: assumptions for Monte Carlo simulation

Assumption	Mean	Std. Dev
Inflation	2,23%	1,91%
Capital growth	3,85%	2,77%
Turnover rate	9,79%	0,62%
Gross initial yield	5,42%	0,65%
Operation expenses as % gross rent	23,00%	1,00%

The simulation is run 10,000 times. Graph 11 shows the outcome of the simulations and table 6 shows the statistics.

Graph 11: 10,000 simulations of IRR proposed model vs traditional home ownership
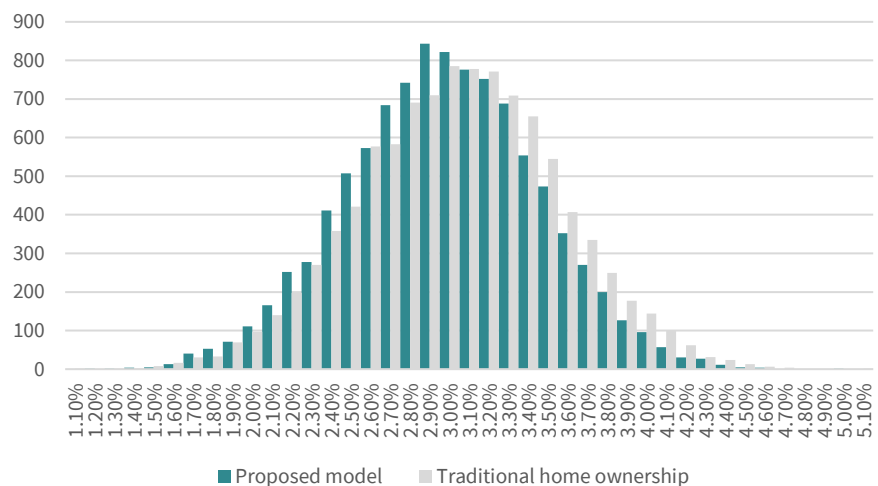
Source: Author

Table 6: Statistical parameters Monte Carlo simulation

Statistic	Proposed model	Traditional home ownership
Trails	10.000	10.000
Base case	3,06%	3,13%
Mean	3,03%	3,10%
Median	3,03%	3,10%
Standard deviation	0,49%	0,51%
Variance	0,00%	0,00%
Minimum	1,27%	1,20%
Maximum	5,06%	5,15%
Probability of underperforming	73,36%	26,64%

The proposed model and traditional home ownership both exhibit a normally distributed IRR. There is a 73% chance that the proposed model may underperform compared to the traditional home ownership scheme. It is worth noting that the author takes a conservative approach when estimating operational expenses. Additionally, the assumption is made that the token value index is equal to the housing price index, disregarding the potential impact of a liquidity premium. Introducing a liquidity premium would

increase the token value, subsequently raising the IRR of the proposed model. It is also worth discussing whether the lower IRR could be interpreted as the cost associated with having flexible living circumstances. Unlike traditional home ownership, where homeowners are tied to their properties to avoid real estate transfer taxes and market fluctuations, a member in the Special Purpose Vehicle (SPV) can enjoy the flexibility of moving houses like a tenant, while still benefiting from gaining or selling equity.

5.2.5 Comparison against rental market

The proposed model offers the greatest benefits to tenants when compared to investors or homeowners. By adhering to the rental agreement, tenants can accumulate equity over time without incurring any costs. According to the model's estimates, a tenant could potentially gain € 687,619 over a 30-year period, generating dividends equivalent to 21% of the gross rent (see also Appendix D). Essentially, after 30 years, the tenant would enjoy a rent discount of 21%. This financial advantage theoretically makes renting a house based on the proposed model more appealing for tenants. Additionally, tenants have voting rights and can influence decisions related to new acquisitions and improvements within the Special Purpose Vehicle (SPV).

To validate these findings, a similar Monte Carlo simulation was conducted. Graph x displays the outcomes of 10,000 simulation runs, while table 7 presents the associated statistics. Accounting for standard deviation, the worst-case scenario would result in an equity gain of € 437,291, which is equivalent to € 140,884 today (adjusted for the housing price index).

Chart 12: 10,000 simulations of equity after 30 years forecast for tenant
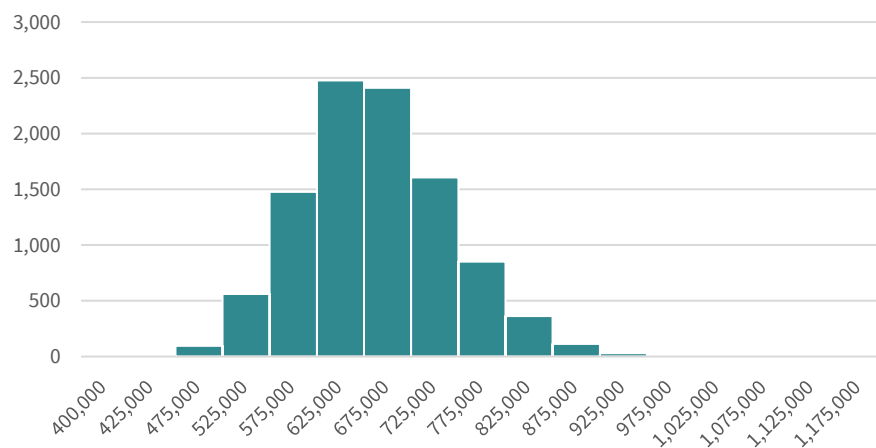
Source: Author

Table 7: Statistical parameters Monte Carlo simulation

Variable	Outcome
Trails	10.000
Base case	687.619
Mean	687.852
Median	681.798
Standard deviation	78.895
Variance	6.224.450.546
Minimum	437.291
Maximum	1.069.421

5.3 Validation against design principles

The previous paragraph explained the workings of the proposed model and its financial feasibility. In order to ensure the effectiveness and adherence of the conceptual model, the model is verified with the design principles, dictated in chapter 3.

1. Sufficient capital injections to provide low barriers for entry to the housing market for new residents.

The proposed model does not only relay on buying real estate in order to rent it but allows new member to trade their real estate for tokens. Furthermore, equity is obtained by the equity fund that is filled with the cashflow residue (arriving from rent after deducting the maintenance costs and dividend). Therefore, there is no need for a capital injection by investors. However, there are running costs to maintain the platform. Additionally, transferring ownership could be considered a taxable event, requiring the SPV to cover expenses such as Real Estate Transfer Tax, Notary costs, Agent costs, and Legal costs. If the SPV reaches a sufficient size, these costs could potentially be incorporated into the maintenance costs or implemented as a fee, eliminating the need for separate consideration. Moreover, research has indicated that token values correspond to the housing market index, creating a similar entry barrier as the traditional housing market. However, a notable advantage is that the real estate is fractionalized, thereby reducing the entry barrier for members. Lastly, since tenants acquire tokens, a Know Your Customer (KYC) and Anti-Money Laundering (AML) check must be conducted. Nevertheless, by utilizing smart contracts, the process of handling pre-issuance matters can be automated, streamlining the overall procedure.

2. Inclusivity to enable a broad range of participants to join and ensure accessibility.

The advantages of using a Special Purpose Vehicle (SPV) for real estate tokenization extend beyond geographical limitations. With the ability to encompass real estate assets from multiple countries, an SPV can establish a global real estate fund. This opens up opportunities for homeowners and investors worldwide to sell their real estate holdings to the SPV in exchange for tokens. By embracing fractionalization, the proposed model reduces barriers to entry, making it possible for individuals at various stages of the housing market, from first-time buyers to experienced real estate investors, to participate. The fractionalization of high-value properties also allows for lower investment minimums, broadening access to tokens and attracting a wider range of investors.

3. Lower the initial deposit required to allow residents to participate without having to possess a minimum of 10% starting capital.

In contrast to the traditional home ownership market, the proposed model eliminates the need for a substantial downpayment. Instead, tenants can gradually accumulate equity by fulfilling their rent obligations as outlined in the contract. Additionally, tenants have the opportunity to acquire additional equity by purchasing tokens on the secondary market. It is worth noting that the yield on additional tokens is lower as the equity gain is based on the proportion of investment in the equity fund, which is determined by the rent paid. By enabling tenants to enter the scheme without the requirement of a down payment, the proposed model offers an attractive option for individuals who are transitioning from their parents' house and do not have the means to accumulate equity. However, it is still necessary to conduct a credit check to assess the financial qualifications of prospective tenants.

4. Allow wealth creation to be amortized at any point in time by the resident to guarantee long-term commitment.

In addition to the familiar concept of gradually gaining equity over time (e.g., staircasing in the UK), the proposed model introduces the ability for members to sell their equity rather than solely acquiring it. This flexibility allows members to amortize the creation of equity by selling tokens on the secondary market whenever they choose. For instance, in the case of a tenant accumulating equity through rent payments, the equity can be retained, indirectly reducing the rent burden, or it can be sold if the member requires immediate funds. Importantly, selling tokens does not necessitate the member's departure from the network, as they can still remain a tenant.

5. Ensure that the scheme is simple to understand by a wide audience of members.

The proposed model is built on the blockchain network and is therefore digital. The obligations of paying rent, the creation of wealth by obtaining tokens and the distribution of dividend could all be displayed in a digital environment with modern user experience. Furthermore, secure and visible recordkeeping on blockchain can increase transparency to the underlying data compared to traditional schemes where information is mainly distributed by paperwork.

6. Automate cash flows to track, distribute, and secure money distribution between all stakeholders.

Cashflow distribution is efficiently handled through the implementation of smart contracts built on the blockchain network. These smart contracts automate rent collection and dividend distribution in a secure and reliable manner. By leveraging the capabilities of smart contracts, these processes operate autonomously, free from time constraints and administrative burdens. The use of blockchain technology enhances transparency and establishes a decentralized platform, reducing the likelihood of human errors. Smart contracts enable parties to establish clear and enforceable terms of agreements, including payment schedules, amounts, agreement durations, and penalties for non-compliance.

7. Encourage member involvement by distributing voting rights.

Unlike a REIT, where investors typically have limited voting rights, the proposed model incorporates voting outcomes as a fundamental aspect of investment decisions. Each member, whether an investor or tenant, is granted voting rights based on their ownership of tokens. However, as the SPV expands and the number of investment decisions increases, it may become challenging for all members to actively participate in voting. To address this issue, potential solutions could be implemented. One approach is to focus voting on predefined growth strategies, wherein the SPV acquires real estate in accordance with the approved strategies. Another option is to designate a representative or group of representatives who can vote on behalf of the members, effectively streamlining the decision-making process. Additionally, efforts can be made to present investment opportunities in a clear and understandable manner, facilitating broader member participation and reducing the threshold for voting.

8. Separate equity and housing need so that members can move houses without losing their invested equity.

The proposed model offers a unique advantage whereby members have the flexibility to transition between network-owned units, allowing them to adapt their living conditions to changing circumstances with the same convenience as the traditional rental market. A notable aspect is that equity accumulated by a member is not lost when moving houses, and no transfer tax is incurred. Moreover, a member even has the option to move outside the SPV, transitioning from a tenant to solely an investor while still retaining their accumulated equity. However, a key consideration is the need for future members to have faith in the shared ownership principles underlying the model.

Investments made by households within the SPV are subject to approval by the management company, which follows a voting system involving the members. Alternatively, households can choose to finance investments themselves, with the returns benefiting the community as a whole rather than solely the household. For instance, renovating a kitchen would typically increase the value of a home in a traditional market, benefiting the individual homeowner. In the proposed scheme, the appraised value of the rentable unit would increase, subsequently raising the overall net asset value of the SPV. The capital growth resulting from such renovations would be distributed among all token holders. This perspective raises the discussion that personalizing a home becomes less financially incentivized, emphasizing the notion that a home is primarily for living rather than solely a means of investment.

6   Conclusion
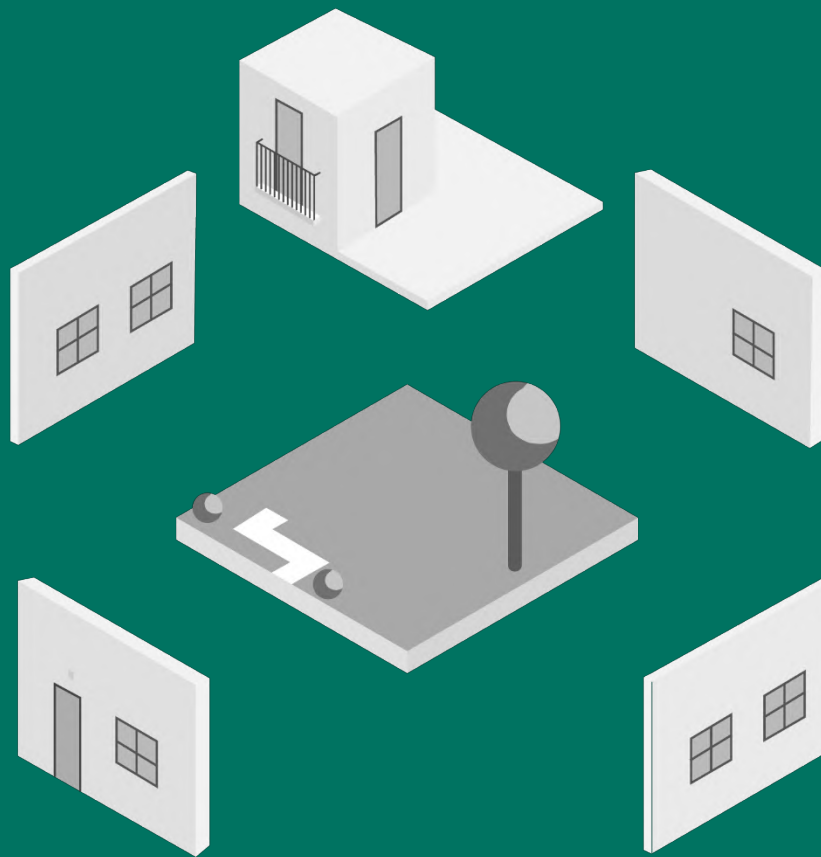
6   Conclusion

6.1 Summary and conclusion

This research sought to answer the question of whether an on-chain multi-asset fractional ownership scheme could potentially replace the home ownership and rental market. To accomplish this, the study delved into four key research questions. Firstly, it examined the advantages and disadvantages associated with the utilization of real estate tokens. Secondly, it evaluated the performance of existing fractionalized ownership models. Thirdly, a comprehensive case study was conducted to identify the advantages and limitations of off-chain multi-asset fractional ownership schemes, which formed the basis for developing design principles for an on-chain model. Finally, a conceptual model was devised and subjected to Monte Carlo analysis to assess its financial feasibility compared to the traditional home ownership and rental market. The model was subsequently refined based on the established design principles.

The first research question regarding the advantages and disadvantages of utilizing real estate tokens was answered using an extensive literature study. The study provides a concise explanation of how real estate tokens operate and examines their advantages and disadvantages in terms of liquidity, efficiency, costs, customizable diversification, accessibility, risk control, and transparency.

To address the second research question regarding the sufficiency of existing fractional ownership scheme's, the author provided an overview of previous attempts and highlighted the distinction between the shared ownership concept in the UK and housing cooperatives. The author discovered that cooperatives offer a range of social, economic, and psychological benefits for their members and have the potential to shape a new economy. However, limitations arise in terms of scalability and legal/financial restrictions. Combining shared ownership models with cooperatives can mitigate these limitations to a certain amount, although the investment process may become complex and illiquid. Tokenization emerges as a solution that enhances liquidity and accessibility in cooperative real estate investments, enabling members to transition between houses without needing to sell their tokens. Furthermore, smart contracts can take away the complexity of the scheme by automatization with secure and visible recordkeeping on the blockchain to enhance the transparency.

In light of the absence of on-chain multi-asset fractional ownership schemes, the author examined three off-chain schemes (Mutual home ownership, shared ownership co-op, and Musharakah Mutanagisah Partnership) to address the third research question concerning which design principles should be incorporated to establish an on-chain multi-asset fractional ownership scheme. Drawing on the insights gained from this case study, a sustainable home ownership model should integrate the following design principles: ensuring sufficient capital injections, promoting inclusivity, reducing the initial deposit required, allowing flexible wealth creation, ensuring scheme simplicity, automating cash flows, encouraging member involvement, and separating equity and housing need.

To address the final research question and establish a conceptual framework for an on-chain multi-asset fractional ownership scheme, the author presented a description of the proposed model. In this model, a token platform oversees multiple SPV's tailored to specific categories of rentable units. When a homeowner transfers legal ownership to an SPV, the economic ownership is tokenized through a security token offering. The SPV retains the legal ownership, while the tokens representing economic ownership are transferred to the homeowner. Homeowners have the option to become tenants and/or investors in the SPV, with the ability to exchange tokens on a secondary market. Tenants pay market rents for the use of rentable units, and a portion of the rent is allocated to cover operational expenses, managed by a management company. Additionally, a capped direct return is distributed to token holders based on predetermined smart contracts. The remaining free cash flow is channelled into an equity fund, which is utilized to acquire new rentable units for the SPV. These newly acquired units are tokenized by the SPV, and the tokens are distributed among tenants based on their contributions to the equity fund. This system facilitates wealth creation for tenants and leads to lower living costs through dividends received from owned tokens. Figure 7 visualizes the conceptual framework.

Figure 7: Proposed scheme author
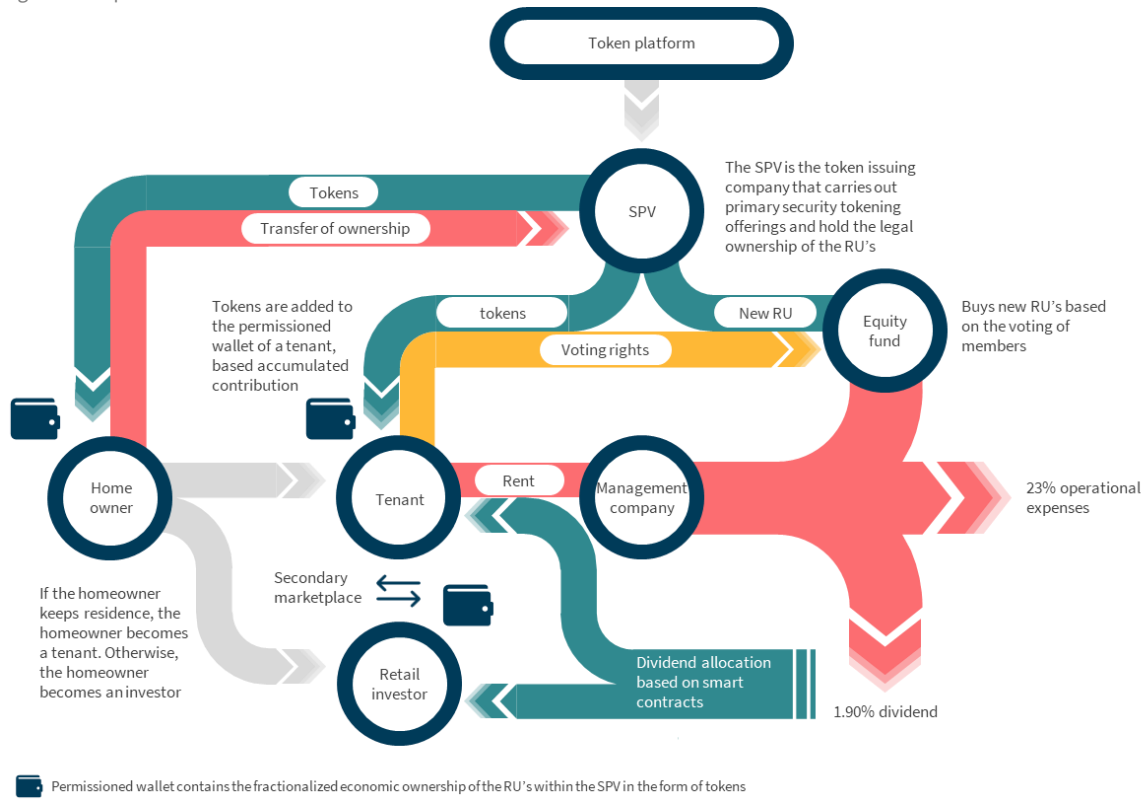
Source: Author

To evaluate the proposed scheme, a financial feasibility study is carried out, comparing the performance against the investor, home ownership and rental market. The results shows that the model underperformance against the unfrozen weighted annualized MSCI Europe annual property index (-0.90%). However, the model carries fewer risks compared to a direct real estate fund, primarily due to lower rent losses, which would allow for a higher capped direct return in the model. When compared against the home ownership market, the proposed scheme slightly underperformance by -0.07%. Based on the results of the Monte Carlo simulation, there is a 73,36% change that the proposed scheme will underperform again the home ownership market. However, the model takes a conservative approach for operational expenses and did not correct for a possible liquidity premium which would increase the token value, subsequently raising the IRR. The lower IRR could also be interpreted as the cost associated with having flexible living circumstances. In comparison to the rental market, the scheme exhibits significantly better results. After 30 years, a tenant would see an equity gain of €687,619. The Monte Carlo simulation places the minimum and maximum equity gains at €437,291 and €1,069,421 respectively.

Additionally, this research shows that the proposed model aligns with all design principles. The proposed model does not rely on capital injections, provides a more inclusive scheme to enable a broad range of participants to join and ensure accessibility, eliminates initial deposits from participants, allows wealth creation to be amortized at any point in time, and is understandable by participants due to blockchain by which recordkeeping is secure and visible. The complexity is limited because smart contracts enable parties to establish clear and enforceable terms and automate rent collection and dividend distribution in a secure and reliable manner. Moreover, the model promotes active member participation by distributing voting rights. Finally, it separates equity from housing need so that members can move houses without losing their invested equity.

The primary objective of this research was to propose an alternative scheme that can coexist alongside the traditional home ownership and rental market. By leveraging the power of blockchain technology, households have the opportunity to seamlessly transition between network-owned rentable units, all the while accumulating equity that progressively reduces their living costs over time. By fostering an ecosystem where blockchain technology and fractional ownership intersect, this scheme opens up new

possibilities for individuals to actively participate in the housing market and gain a stake in their living arrangements. It promotes a more inclusive approach to housing, allowing individuals with limited financial resources to access and benefit from the advantages traditionally associated with home ownership.

In summary, this research presents a proposed scheme that, based on blockchain technology, enables households to seamlessly transition between network-owned rentable units while gradually accumulating equity. By providing a viable alternative to traditional home ownership and rental market, this scheme paves the way for a more dynamic and inclusive housing market of the future.

6.2 Research limitations

This research sought to illuminate the potential of a multi-asset scheme. Several constraints, however, impacted the depth and breadth of this study:

Stakeholder participation

The original intention was to employ the Delphi method to gather insights from tokenization firms and other pertinent stakeholders. Despite diligent attempts spanning four months, the author faced challenges in securing participation from these stakeholders. This limitation led to a reliance on secondary sources for data and insights.

Ownership models insight

For the ownership models of Mutual home ownership, shared ownership co-op, and Musharakah Mutanaqisah Partnership, direct outreach was made to developments that implemented these schemes. Although responses were received, the entities were reticent to provide in-depth details, recommending reliance on available online documentation instead. Consequently, the examination of the advantages and limitations of these schemes is anchored in literature and market reports (see Appendix A) rather than direct experiences of members within these schemes.

Feasibility evaluation

In assessing the financial feasibility of the proposed scheme against traditional real estate markets and against the design principles, there was an absence of a comprehensive review from stakeholders. Although informal discussions occurred with stakeholders over the past year, no structured, in-depth interview was conducted, limiting the validation of findings against real-world stakeholder perspectives and experiences.

6.3 Further research

The research briefly touched upon the potential high operating costs associated with the proposed model, but it did not disclose the earnings for the token platform. As previously mentioned, participants could pay a monthly fee, or the earnings could be included in the operational expenses. Another possibility is that only a portion of the tokens from newly acquired rentable units would be allocated to tenants, while the remaining tokens would serve as payment directly to the token platform. However, all these options require the SPV to reach a sufficient size. Further research could explore how the startup phase of the model could be financed.

Determining the legal feasibility of the proposed model is beyond the scope of this research. However, the tokenization of residential real estate is already an existing practice, where legal ownership is obtained by the SPV and economic ownership is distributed among token holders. Further research is necessary to explore the legal aspects of the proposed model and evaluate its feasibility within the existing legal framework or the need for new regulations.

As discussed in Chapter 4, the capital wealth tax and real estate transfer tax render the proposed scheme financially unfeasible. Nevertheless, the author believes that the existing tax scheme in the Netherlands is inadequate for determining a fair and reasonable tax assessment. Since an SPV is not limited to a single country, tax handling may vary across jurisdictions. This research did not examine the tax situation in each country and excluded tax considerations from the financial feasibility study. Further research can be undertaken to develop a tax scheme tailored to the proposed model.

Lastly, there is still a prevailing belief among people that they should own their own homes. The shared economy principles have revolutionized various industries such as music (Spotify), movies (Netflix), and gradually the transportation sector with shared mobility. However, the real estate market remains largely traditional. In the proposed model, households would not directly own the house they live in but rather own shares in a larger SPV, of which their house is a part. Fractional ownership schemes like housing co-ops or Mutual Home Ownership demonstrate that there is a market for such models. However, further research is needed to ascertain if the market demand is sufficient to create a large enough SPV, allowing households to move between properties and distribute running costs effectively.

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Appendix A

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Appendix B

Verifying correctness of model

Housing price per rentable unit (RU)	428,591	Inflation	2.23%
Rent price per RU	23,214	Capital growth	3.85%
Initial no. of RU's	1	Turnover rate	9.79%
		Gross Initial Yield	5.42%
		Operational expenses as % initial rent	23%

Direct return is capped at 4.20%

t	No. of RU's	Rent	OpEx	Equity	Dividend	Free cashflow	Housing price	Direct return	Equity as % housing price	Rent discount
1	1	-23,214	-2,508	428,591	17,875	-5,339	428,591	4.17%	100.00%	77.00%
2	1	-23,769	-2,564	445,082	18,302	-5,467	445,082	4.11%	100.00%	77.00%
3	1	-24,371	-2,621	462,207	18,766	-5,605	462,207	4.06%	100.00%	77.00%
4	1	-25,021	-2,680	479,992	19,266	-5,755	479,992	4.01%	100.00%	77.00%
5	1	-25,719	-2,740	498,461	19,803	-5,915	498,461	3.97%	100.00%	77.00%
6	1	-26,464	-2,801	517,640	20,377	-6,087	517,640	3.94%	100.00%	77.00%
7	1	-27,256	-2,863	537,557	20,987	-6,269	537,557	3.90%	100.00%	77.00%
8	1	-28,097	-2,927	558,241	21,634	-6,462	558,241	3.88%	100.00%	77.00%
9	1	-28,986	-2,992	579,720	22,319	-6,667	579,720	3.85%	100.00%	77.00%
10	1	-29,924	-3,059	602,026	23,041	-6,883	602,026	3.83%	100.00%	77.00%
11	1	-30,912	-3,127	625,190	23,802	-7,110	625,190	3.81%	100.00%	77.00%
12	1	-31,951	-3,197	649,246	24,602	-7,349	649,246	3.79%	100.00%	77.00%
13	1	-33,041	-3,269	674,227	25,442	-7,600	674,227	3.77%	100.00%	77.00%
14	1	-34,185	-3,342	700,169	26,322	-7,862	700,169	3.76%	100.00%	77.00%
15	1	-35,382	-3,416	727,110	27,244	-8,138	727,110	3.75%	100.00%	77.00%
16	1	-36,634	-3,492	755,087	28,208	-8,426	755,087	3.74%	100.00%	77.00%
17	1	-37,944	-3,570	784,141	29,217	-8,727	784,141	3.73%	100.00%	77.00%
18	1	-39,311	-3,650	814,312	30,269	-9,042	814,312	3.72%	100.00%	77.00%
19	1	-40,738	-3,731	845,644	31,368	-9,370	845,644	3.71%	100.00%	77.00%
20	1	-42,227	-3,815	878,182	32,515	-9,712	878,182	3.70%	100.00%	77.00%
21	1	-43,779	-3,900	911,972	33,710	-10,069	911,972	3.70%	100.00%	77.00%
22	1	-45,396	-3,987	947,062	34,955	-10,441	947,062	3.69%	100.00%	77.00%
23	1	-47,081	-4,076	983,503	36,253	-10,829	983,503	3.69%	100.00%	77.00%
24	1	-48,836	-4,167	1,021,345	37,604	-11,232	1,021,345	3.68%	100.00%	77.00%
25	1	-50,662	-4,260	1,060,643	39,010	-11,652	1,060,643	3.68%	100.00%	77.00%
26	1	-52,563	-4,355	1,101,454	40,474	-12,090	1,101,454	3.67%	100.00%	77.00%
27	1	-54,541	-4,452	1,143,835	41,997	-12,544	1,143,835	3.67%	100.00%	77.00%
28	1	-56,598	-4,551	1,187,846	43,581	-13,018	1,187,846	3.67%	100.00%	77.00%
29	1	-58,738	-4,653	1,233,551	45,228	-13,510	1,233,551	3.67%	100.00%	77.00%
30	1	-60,963	-4,757	1,281,014	46,942	-14,022	1,281,014	3.66%	100.00%	77.00%

Appendix C-1

Financial feasability home owner

Housing price per rentable unit (RU)	428,591		Inflation		2.23%
Rent price per RU	23,214		Capital growth		3.85%
Initial no. of RU's	100		Turnover rate		9.79%
			Gross Initial Yield		5.42%
			Operational expenses as % initial rent		23%

Direct return is capped at 1.90%

t	No. of RU's	Rent	OpEx	Direct return	Dividend	Opening balance	Platform expansion	Closing balance	Equity as % housing price	Rent discount
1	100	2,321,411	-533,925	1.90%	814,323	42,859,100	-973,164	45,481,358	100.00%	35.08%
2	102	2,429,604	-558,809	1.90%	864,146	45,481,358	-1,006,649	48,237,998	102.19%	36.36%
3	104	2,545,637	-585,496	1.90%	916,522	48,237,998	-1,043,618	51,137,676	104.32%	37.59%
4	107	2,669,829	-614,061	1.90%	971,616	51,137,676	-1,084,153	54,189,459	106.40%	38.78%
5	109	2,802,527	-644,581	1.90%	1,029,600	54,189,459	-1,128,346	57,402,859	108.44%	39.93%
6	111	2,944,105	-677,144	1.90%	1,090,654	57,402,859	-1,176,307	60,787,862	110.44%	41.04%
7	113	3,094,966	-711,842	1.90%	1,154,969	60,787,862	-1,228,155	64,354,958	112.40%	42.12%
8	115	3,255,544	-748,775	1.90%	1,222,744	64,354,958	-1,284,025	68,115,175	114.34%	43.16%
9	117	3,426,304	-788,050	1.90%	1,294,188	68,115,175	-1,344,066	72,080,116	116.25%	44.18%
10	120	3,607,743	-829,781	1.90%	1,369,522	72,080,116	-1,408,440	76,261,991	118.14%	45.16%
11	122	3,800,393	-874,090	1.90%	1,448,978	76,261,991	-1,477,325	80,673,657	120.01%	46.12%
12	124	4,004,821	-921,109	1.90%	1,532,799	80,673,657	-1,550,913	85,328,660	121.86%	47.05%
13	127	4,221,632	-970,975	1.90%	1,621,245	85,328,660	-1,629,412	90,241,272	123.70%	47.96%
14	129	4,451,467	-1,023,838	1.90%	1,714,584	90,241,272	-1,713,046	95,426,542	125.52%	48.85%
15	131	4,695,012	-1,079,853	1.90%	1,813,104	95,426,542	-1,802,055	100,900,335	127.33%	49.72%
16	134	4,952,992	-1,139,188	1.90%	1,917,106	100,900,335	-1,896,698	106,679,386	129.13%	50.57%
17	136	5,226,179	-1,202,021	1.90%	2,026,908	106,679,386	-1,997,250	112,781,351	130.92%	51.40%
18	138	5,515,392	-1,268,540	1.90%	2,142,846	112,781,351	-2,104,006	119,224,858	132.70%	52.23%
19	141	5,821,498	-1,338,944	1.90%	2,265,272	119,224,858	-2,217,281	126,029,567	134.47%	53.04%
20	144	6,145,417	-1,413,446	1.90%	2,394,562	126,029,567	-2,337,409	133,216,231	136.24%	53.83%
21	146	6,488,125	-1,492,269	1.90%	2,531,108	133,216,231	-2,464,748	140,806,754	138.00%	54.62%
22	149	6,850,654	-1,575,650	1.90%	2,675,328	140,806,754	-2,599,675	148,824,267	139.75%	55.40%
23	151	7,234,097	-1,663,842	1.90%	2,827,661	148,824,267	-2,742,594	157,293,189	141.50%	56.16%
24	154	7,639,613	-1,757,111	1.90%	2,988,571	157,293,189	-2,893,932	166,239,309	143.25%	56.92%
25	157	8,068,427	-1,855,738	1.90%	3,158,547	166,239,309	-3,054,142	175,689,860	145.00%	57.68%
26	160	8,521,836	-1,960,022	1.90%	3,338,107	175,689,860	-3,223,706	185,673,604	146.74%	58.42%
27	162	9,001,210	-2,070,278	1.90%	3,527,798	185,673,604	-3,403,133	196,220,922	148.48%	59.16%
28	165	9,508,001	-2,186,840	1.90%	3,728,198	196,220,922	-3,592,964	207,363,900	150.21%	59.90%
29	168	10,043,745	-2,310,061	1.90%	3,939,914	207,363,900	-3,793,769	219,136,434	151.95%	60.63%
30	171	10,610,063	-2,440,315	1.90%	4,163,592	219,136,434	-4,006,157	231,574,328	153.68%	61.36%

Appendix C-2

Comparison against home ownership

Housing price per rentable unit (RU)	428,591
Rent price per RU	23,214
Initial no. of RU's	100
Home ownership cost	937
Reservation replacement cost	1,571
Operational expenses home ownership	2,508

Inflation	2.23%
Capital growth	3.85%
Turnover rate	9.79%
Gross Initial Yield	5.42%
Operational expenses as % initial rent	23%

								Authors model				Home ownership		
							IRR	3.06%				3.13%		
t	No. of RU's	Rent	OpEx	Direct return	Dividend	Opening balance	Platform expansion	Rent	Equity	Dividend	Free cashflow	Equity	OpEx	Free cashflow
1	100	23,214	-5,339	1.90%	814,323	42,859,100	-973,164	-23,214	428,591	8,143	-15,071	428,591	-2,508	-2,508
2	102	23,776	-5,469	1.90%	864,146	45,481,358	-1,006,649	-23,769	454,814	8,641	-15,127	445,082	-2,564	-2,564
3	104	24,392	-5,610	1.90%	916,522	48,237,998	-1,043,618	-24,371	482,162	9,161	-15,210	462,207	-2,621	-2,621
4	107	25,060	-5,764	1.90%	971,616	51,137,676	-1,084,153	-25,021	510,705	9,703	-15,318	479,992	-2,680	-2,680
5	109	25,779	-5,929	1.90%	1,029,600	54,189,459	-1,128,346	-25,719	540,516	10,270	-15,449	498,461	-2,740	-2,740
6	111	26,549	-6,106	1.90%	1,090,654	57,402,859	-1,176,307	-26,464	571,669	10,862	-15,602	517,640	-2,801	-2,801
7	113	27,369	-6,295	1.90%	1,154,969	60,787,862	-1,228,155	-27,256	604,238	11,481	-15,776	537,557	-2,863	-2,863
8	115	28,240	-6,495	1.90%	1,222,744	64,354,958	-1,284,025	-28,097	638,303	12,128	-15,969	558,241	-2,927	-2,927
9	117	29,161	-6,707	1.90%	1,294,188	68,115,175	-1,344,066	-28,986	673,945	12,805	-16,181	579,720	-2,992	-2,992
10	120	30,133	-6,930	1.90%	1,369,522	72,080,116	-1,408,440	-29,924	711,247	13,514	-16,410	602,026	-3,059	-3,059
15	131	35,774	-8,228	1.90%	1,813,104	95,426,542	-1,802,055	-35,382	925,810	17,590	-17,792	727,110	-3,416	-3,416
20	144	42,822	-9,849	1.90%	2,394,562	126,029,567	-2,337,409	-42,227	1,196,400	22,732	-19,495	878,182	-3,815	-3,815
25	157	51,478	-11,840	1.90%	3,158,547	166,239,309	-3,054,142	-50,662	1,537,896	29,220	-21,442	1,060,643	-4,260	-4,260
30	171	62,024	-14,265	1.90%	4,163,592	219,136,434	-4,006,157	-60,963	1,968,634	37,404	-23,559	1,281,014	-4,757	-4,757
Exit strategy									1,968,634			1,281,014		

Appendix D

Financial feasability tenant

Housing price per rentable unit (RU)	428,591		Inflation	2.23%
Rent price per RU	23,214		Capital growth	3.85%
Initial no. of RU's	100		Turnover rate	9.79%
			Gross Initial Yield	5.42%
			Operational expenses as % initial rent	23%

Direct return is capped at 1.90%

t	No. of RU's	Rent	OpEx	Equity	Dividend	Taxes	FCF	Housing price	Equity as % housing price	Rent discount
1	100	-23,214	-533,925	-	-	-	-23,214	445,082	0.00%	0.00%
2	102	-23,769	-558,809	9,732	185	-	-23,584	462,207	2.11%	0.78%
3	104	-24,371	-585,496	19,954	379	-	-23,992	479,992	4.16%	1.56%
4	107	-25,021	-614,061	30,713	584	-	-24,438	498,461	6.16%	2.33%
5	109	-25,719	-644,581	42,056	799	-	-24,920	517,640	8.12%	3.11%
6	111	-26,464	-677,144	54,029	1,027	-	-25,437	537,557	10.05%	3.88%
7	113	-27,256	-711,842	66,681	1,267	-	-25,989	558,241	11.94%	4.65%
8	115	-28,097	-748,775	80,062	1,521	-	-26,575	579,720	13.81%	5.41%
9	117	-28,986	-788,050	94,225	1,790	-	-27,195	602,026	15.65%	6.18%
10	120	-29,924	-829,781	109,221	2,075	-	-27,849	625,190	17.47%	6.93%
11	122	-30,912	-874,090	125,105	2,377	-	-28,535	649,246	19.27%	7.69%
12	124	-31,951	-921,109	141,935	2,697	-	-29,254	674,227	21.05%	8.44%
13	127	-33,041	-970,975	159,770	3,036	-	-30,006	700,169	22.82%	9.19%
14	129	-34,185	-1,023,838	178,670	3,395	-	-30,790	727,110	24.57%	9.93%
15	131	-35,382	-1,079,853	198,700	3,775	-	-31,607	755,087	26.31%	10.67%
16	134	-36,634	-1,139,188	219,926	4,179	-	-32,456	784,141	28.05%	11.41%
17	136	-37,944	-1,202,021	242,417	4,606	-	-33,338	814,312	29.77%	12.14%
18	138	-39,311	-1,268,540	266,245	5,059	-	-34,252	845,644	31.48%	12.87%
19	141	-40,738	-1,338,944	291,486	5,538	-	-35,200	878,182	33.19%	13.59%
20	144	-42,227	-1,413,446	318,218	6,046	-	-36,181	911,972	34.89%	14.32%
21	146	-43,779	-1,492,269	346,523	6,584	-	-37,195	947,062	36.59%	15.04%
22	149	-45,396	-1,575,650	376,487	7,153	-	-38,243	983,503	38.28%	15.76%
23	151	-47,081	-1,663,842	408,200	7,756	-	-39,325	1,021,345	39.97%	16.47%
24	154	-48,836	-1,757,111	441,756	8,393	-	-40,442	1,060,643	41.65%	17.19%
25	157	-50,662	-1,855,738	477,252	9,068	-	-41,595	1,101,454	43.33%	17.90%
26	160	-52,563	-1,960,022	514,793	9,781	-	-42,782	1,143,835	45.01%	18.61%
27	162	-54,541	-2,070,278	554,485	10,535	-	-44,006	1,187,846	46.68%	19.32%
28	165	-56,598	-2,186,840	596,440	11,332	-	-45,266	1,233,551	48.35%	20.02%
29	168	-58,738	-2,310,061	640,777	12,175	-	-46,563	1,281,014	50.02%	20.73%
30	171	-60,963	-2,440,315	687,619	13,065	-	-47,898	1,330,304	51.69%	21.43%