ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

ISTOKEN : THE DIGITAL REVOLUTION OF FRACTIONAL OWNERSHIP & REAL ESTATE TOKENIZATION MODEL IN TÜRKİYE

M.Sc. THESIS

Göksu SABUNCUOĞLU

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ISTOKEN : TÜRKİYE'DE PARÇALI MÜLKİYETİN DİJİTAL DEVRİMİ VE GAYRİMENKUL TOKENİZASYON MODELİ

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to all women chasing their dreams…

FOREWORD

I am deeply grateful to everyone who has supported me throughout this journey. I would like to thank my supervisor Assoc. Prof. Dr. Kerem Yavuz ARSLANLI for his support and excellent guidance. Special thanks to my parents, Nevin SABUNCUOĞLU and Murat SABUNCUOĞLU, for their support, love , and sacrifices.

This thesis is dedicated to all the women chasing their dreams, whose determination inspires me every day.

May 2024

Göksu Sabuncuoğlu
(Architect)

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ABBREVIATIONS

AI	: Artificial Intelligence
AvaLP	: Avalanche Consensus Protocol
BIST	: Istanbul Stock Exchange
BSC	: Binance Smart Chain
CAGR	: Compound Annual Growth Rate
CMB	: Capital Markets Board
CBRT	: Central Bank of the Republic of Türkiye
CMBT	: Capital Markets Board of Türkiye
CSDI	: Central Securities Depository Institution
DApps	: Decentralized Apps
DeFi	: Decentralized Finance
DEX	: Decentralized Exchanges
DLT	: Distributed Ledger Technology
ETH	: Ether
EVM	: Ethereum Virtual Machine
GYODER	: Real Estate Investment Trusts Association
HPI	: Housing Price Index
IBC	: Inter-Blockchain Communication
ICO	: Initial Coin Offerings
IT	: Information Technology
KYC	: Know Your Customer
MKK	: Central Registry Agency
NFT	: Non-Fungible Token
OT	: Operational Technology
PMC	: Portfolio Management Company
PoH	: Proof of History
PoS	: Proof of Stake
PoW	: Proof of Work
PT	: Property Tokenization
P2P	: Peer-to-Peer
RECF	: Real Estate Crowdfunding

REIF	: Real Estate Investment Fund
REIT	: Real Estate Investment Trusts
SPV	: Special Purpose Vehicles
SPK	: Capital Markets Board of Turkiye
STO	: Security Token Offerings
TAKASBANK	: Central Authorized Clearinghouse
TPS	: Transactions Per Second
US	: United States
USD	: United States Dollar

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ISTOKEN: THE DIGITAL REVOLUTION OF FRACTIONAL OWNERSHIP & REAL ESTATE TOKENIZATION MODEL IN TÜRKİYE

SUMMARY

Real estate access has become increasingly challenging due to high property costs and financial difficulties in Türkiye , especially in major cities like Istanbul.These limits have hindered the ability of individual and small-scale investors to engage in significant real estate developments. Nevertheless, innovative solutions like fractional ownership ideas and real estate investment funds have arisen to address these difficulties and make real estate investments accessible to a wider range of individuals. Fractional ownership is the division of big assets into smaller shares, allowing investors to get these properties at a reduced price. This strategy allows individuals and small-scale investors to acquire real estate assets with less cash. Real estate tokenization has emerged as another viable strategy that has gained significance in addition to these alternatives. This thesis analyzes the current fractional ownership practices in Türkiye and proposes methods for regulating tokenization by referring to several real estate investment fund applications. An innovative real estate tokenization concept, called "ISToken" (Istanbul Token), has been created. It provides technological, legal, and financial solutions to enhance accessibility and liquidity in the real estate industry. The selection of a blockchain platform is pivotal for the triumph of the ISToken real estate tokenization methodology. The selection of Ethereum as the platform is based on its well-established community, successful advertising strategies, and seamless integration with the wider blockchain ecosystem.

In order to assess the viability of ISToken real estate tokenization in Türkiye , we examined real estate investment funds backed by regulatory-supported instruments as a point of comparison. This concept emphasizes the transformation of current regulatory issues to support tokenization. Smart contracts are being recommended as an alternative to Takasbank, which currently handles the secure trading of financial products. Additionally, Distributed Ledger Technology (DLT) is being considered as a replacement for the Central Securities Depository (CSD), which has a multi-central structure that aims to enhance security. The CMB (Capital Markets Board) is the primary regulatory authority overseeing the supervision and regulation of these institutions. It exclusively interacts with portfolio management firms (PMC) under the ISToken model. Regulated PMCs are the only direct counterparts in dialogue with SPK in the ISToken model. However, the only entity that can be considered as a counterpart to the investor is the Special Purpose Vehicle (SPV), which has been specifically created for the purpose of real estate tokenization using ISToken. The rationale behind establishing a Special Purpose Vehicle (SPV) for the ISToken model is that SPVs are already in place for particular financial transactions or projects, namely specialized initiatives, and all aspects of SPVs are governed by the Capital Markets Board (CMB).

The ISToken tokenization approach entails the transformation of properties into digital assets, enabling investors to acquire ownership of properties through smaller,

fragmented shares. This enables anyone to participate in real estate projects with modest financial investments, and investors may maintain ownership of properties through digital tokens. Tokenization efficiently and dependably handles these transactions, ensuring a quicker and more economical investing procedure. In Türkiye , the democratization of real estate access is facilitated by a combination of financial instruments and digital innovations, which provide investors with a wider and more efficient selection of investment options. Consequently, the real estate business becomes more easily reachable and varied, resulting in more robust growth for individual investors and the overall sector.

ISTOKEN : TÜRKİYE'DE PARÇALI MÜLKİYETİN DİJİTAL DEVRİMİ VE GAYRİMENKUL TOKENİZASYON MODELİ

ÖZET

Gayrimenkul piyasası, ekonomilerin temel yapı taşlarından biridir ve genellikle bir ülkenin refah düzeyini yansıtan önemli bir göstergedir. Dünyanın her yerinde birbirinden farklı sosyo ekonomik duruma sahip milyonlarca yatırımcı farklı düzeylerde gayrimenkul yatırımı yapma eğilimindedirler. Bunun temel sebebi günün koşulları değişken olsa bile uzun vadede gayrimenkul yatırımlarının güvenli liman olarak algılanmasıdır. Gayrimenkul piyasası gücünü bu güven hissinden ve yatırımcı çeşitliliğinden alır. Fakat özellikle son yıllarda Türkiye'de bu çeşitliliğin azaldığı özellikle küçük yatırımcının piyasada tutunamadığı görülmüştür. Küçük yatırımcıların yatırım yapamadığı hatta yatırım yapmayı hayal bile edemediği bu noktada piyasa koşullarını tekrar onlara uygun hale getirmenin yolları aranmıştır. Gayrimenkul piyasası; ekonomi politikaları, enflasyon, doğal afetler, nüfus artışı-azalışı, savaşlar gibi hemen her durumdan doğrudan etkilenmektedir. Enflasyonun tırmanması küçük yatırımcıların piyasada kendi ölçeklerinde yatırım araçları bulamaması sonucunu doğurmuştur. Bu durum hem sektördeki homojenite dengesini bozmuş hem de sektör binlerde aktörünü kaybetmiştir. Kişiler ölçeğinde bakınca Türkiye'de bugün beyaz yakalı olarak çalışan bir kişinin kendine daire satın almak için maaşının tamamını on yıllarca biriktirmesi gerekmektedir. Bunun imkansızlığı sebebiyle kişiler kazandıkları paranın yatırım aracına dönüşme konusunda umutsuzluğa kapılmakta ve birikim motivasyonları kaybolmaktadır. Sektörün bir diğer önemli problemi de likidite eksikliğidir. Gayrimenkul sektörü büyük hacimlerde işlemler yapılmasına rağmen en az likit olan sektörlerden olduğu için potansiyel yatırımcılar daha likit sektörlere kanalize olmaktadır.

Yaşadığımız yüzyılda başta finans sektörü olmak üzere tüm sektörler kendini revize etme, geliştirme ve teknolojik gelişmelerden beslenme eğilimindedirler. Dijitalleşme çağında teknolojinin getirdiği faydalardan yararlanması gereken gayrimenkul sektörü; likidite ve erişilebilirlik sorunlarını ancak bu şekilde çözebilir. Gayrimenkul sektörünün dijitalleşme sürecinde en önemli teknolojilerin başında blokzincir teknolojisi gelir. Finans sektörünün öncülüğü ile bir çok farklı sektöre entegre olmuş blokzincir teknolojisi likidite ve erişilebilirlik sorunlarına alternatif bir çözümdür . Veuger(2017), Lee ve Ng (2021) ın yaptıkları çalışmalarda blokzincir teknolojisini inovatif bir yaklaşım olarak nitelendirmiş ve merkeziyetsiz, değiştirilemez ve şeffaf yapısının işlemleri güvenli kıldığını vurgulamıştır. Blokzincirde yapılan hiçbir işlem değiştirilemez ,geri alınamaz ve manipüle edilemez dolayısıyla yüksek işlem güvenliği ve şeffaflığı ile blokzincirin gayrimenkul işlemlerinde kullanılması doğru bir yaklaşımdır.

Tezde ISToken gayrimenkul tokenizasyonu; blokzincir teknolojisinin kullanım alanlarından birisi olarak likidite ve erişilebilirlik sorunları için uygun bir çözüm olarak önerilmektedir. Gayrimenkul tokenizasyonu, fiziksel bir gayrimenkul varlığının

dijital tokenler aracılığıyla temsil edilmesini ifade eder. Bu tokenler, blokzincir üzerinde kayıtlı olup, sahiplik ve ticaret işlemlerinin dijital olarak gerçekleştirilmesini mümkün kılar. Her bir token, gayrimenkul varlığının belirli bir kısmını temsil eder ve bu sayede yatırımcılar, büyük gayrimenkul varlıklarına küçük miktarlarla yatırım yapabilir hale gelir. Gayrimenkul tokenizasyonunun gerçekleşmesi sadece teknolojik bir süreç değildir. Yüksek teknoloji çözümleri ön planda olmakla beraber hukuki ve finansal boyutları ile ele almak gerekmektedir. Tezde önerilen ISToken gayrimenkul tokenizasyon modelinde multidisipliner bir yaklaşımla literatür incelenmiş; model teknoloji, regülatif ve finansal yönlerden ele alınmıştır.

Blokzincir teknolojisinin en önemli iki enstrümanı olan DLT(Dağıtılmış Defter Teknolojisi) ve akıllı sözleşmeler, işlemlerin bloklara eklenmesini, korunmasını ve saklanmasını sağlarken kodlar üzerinde yürüten mekanizmayı oluştururlar. Blokzincir ekosisteminde Dağıtık defter teknolojisi (DLT), merkezi bir otoriteye gerek duymadan verilerin güvenli ve senkronize bir şekilde birden fazla konumda tutulmasını sağlar. Akıllı sözleşmeler ise, önceden belirlenmiş şartlar yerine getirildiğinde otomatik olarak yürürlüğe giren, blokzincir tabanlı dijital protokollerdir. Zheng ve arkadaşlarına göre (2019), blok zinciri tabanlı akıllı kontratlar çeşitli uygulamalarda verimliliği artırır ve maliyet tasarrufu sağlar. Blok zincirine entegre akıllı kontratlar, anlaşma şartlarını otomatik olarak uygular, idareyi basitleştirir ve genel verimliliği artırır. ISToken gayrimenkul tokenizasyonunda, blockchain platformunun seçimi modelin başarısında kritik öneme sahiptir. Diğer platformları değerlendirdikten sonra, Ethereum güçlü topluluğu, sağlam pazarlama stratejileri ve tüm blokzincir ekosistemi ile bağlantılı olması nedeniyle lider olarak ortaya çıkar. Bu durum, onu ISToken için ideal bir platform haline getirir.

ISToken gayrimenkul tokenizasyonu için en sınırlayıcı kısım tokenizasyon kavramının henüz Türkiyede regüle edilmiş olmamasıdır. Herhangi bir düzenlemeye tabi olmadan mülkiyet hakkı belirlemek, transfer etmek veya mülkiyeti parçalara ayırmak mümkün değildir. Doğrudan "tokenizasyon" özelinde bir regülasyon mevcut olmamasına rağmen "parçalı mülkiyet" kavramı Gayrimenkul Yatırım Fonlarıyla yıllardır kabul edilen , devlet kurumlarınca denetlenen ve düzenlenen bir gayrimenkul uygulamasıdır. Lowies ve arkadaşları (2018), küçük yatırım miktarlarına rağmen, kesirli sahiplik platformuna geniş bir yatırımcı yelpazesinin çekildiğini belirtmiştir. Buna zıt bir görüş olarak Bramley ve Dumlore (2007) İngiltere'deki paylaşım mülkiyetine dayalı modelleri incelemiş ve uzun vadede normal satın almaya göre daha az çekici olduğunu tespit etmiştir. Parçalı mülkiyet uygulamalarına ülkeden ülkeye farklılaşmalar mevcut olmasına rağmen geniş perspektiften bakıldığında ve ekonomik dalgalanmalar göz önüne alındığında parçalı mülkiyet uygulamalarının yaygınlaşması kaçınılmazdır. GYODER'in 2023 4. çeyrek Gösterge Raporu' na göre, Türkiye'de gayrimenkul yatırım fonlarının hacmi önceki döneme göre %56,5 artış kaydederek 75.8 milyar TL seviyesine yükselmiştir. Bu durum Türkiye'de gayrimenkul yatırım fonları parçalı mülkiyet kavramının oturduğunun göstergesidir.

ISToken gayrimenkul tokenizasyonun Türkiye'de uygulanabilirliği için, gayrimenkul yatırım fonlarının regülatif olarak desteklenen enstrümanları referans alınmıştır. Bu modelde, mevcut regülatif yönlerin tokenizasyonun lehine nasıl dönüştürülebileceğine odaklanılır. Finansal araçların takas işlemlerini güvenli bir şekilde yapıldığından sorumlu olan Takasbank yerine akıllı sözleşmeler; sermaye piyasalarındaki menkul

kıymetlerin kaydını tutan Merkezi Kayıt Kuruluşu (MKK) yerine çok merkezli yapısıyla güvenliği en üst seviyeye çeken DLT önerilir. Tüm bu kurumların denetlenmesinden ve düzenlenmesinden sorumlu olan ana regülatör SPK (Sermaye Piyasası Kurumu), ISToken modelinde sadece portföy yönetim şirketleri(PYŞ)'ni muhatap alır. Regülasyonu tamamlanmış PYŞ ler, ISToken modelinde doğrudan SPK ile diyalog halinde olan tek birimdir. Diğer bir taraftan yatırımcının tek muhatabı ise ISToken ile gayrimenkul tokenizasyonu amacıyla kurulan özel amaçlı şirket(SPV)'dir. ISToken modeli için SPV kurulmasının nedeni SPV lerin halihazırda belirli bir finansal işlem veya proje için yani özelleşmiş bir proje için kurulmasıdır ve SPV'ler tüm aşamaları ile SPK tarafından regüle edilmiştir. Gayrimenkulün tokenlara dönüştüğü; tokenların devletin regüle ettiği bir formata geldiği ve en sonunda hızlı bir şekilde alınıp satılabildiği sistem şu şekilde işler; portföy yatırım şirketi (PYŞ) ; ISToken SPV sine ait tokenları oluşturur aynı zamanda projeyi fonlamak için kitle fonlama platformunu oluşturur ve token satış sürecini yönetir. ISToken SPV'sinin tüm yönetimi ; SPK'dan aldığı lisansa dayalı kurulan portföy yatırım şirketi (PYŞ)'ye aittir. Mülkiyet haklarına ve gayrimenkule ilişkin tüm bilgiler ve süreçler akıllı sözleşmeler ile takip edilir ve tüm işlemler anlık olarak DLT'ye kaydedilir. Yatırımcılar, ISToken elde etmek amacıyla blokzincir tabanlı bir kitle fonlama platformunu kullanarak dijital cüzdanları aracılığıyla ödeme yaparlar. Ödenen miktar karşılığında yatırımcılara, aynı oranda token tahsis edilir ve bu tokenlar, yatırımcıların mülkiyet haklarının tapu siciline kaydedilmesiyle somutlaşır. Blokzincir teknolojisi, tüm işlemlerin bu dağıtık defter üzerinde gerçekleştirilmesini sağlar. Bu sayede, hiçbir işlem, veri veya bilgi kaybolmaz ya da silinmez. Blokzincir tabanlı sistem, işlemlerin izlenmesini şeffaf ve tarafsız bir şekilde güven ilkesi doğrultusunda mümkün kılar. İşlemlerin bu şekilde kaydedilmesi, tüm taraflar için denetlenebilirlik ve güvenilirlik sağlar ve bu da yatırımcıların haklarını ve menfaatlerini korur. Blokzincir teknolojisinin sunduğu bu güvenli ve izlenebilir yapı, yatırımcıların sürece olan güvenini artırır ve aynı zamanda yasal uyumluluğu destekler. ISToken gayrimenkul tokenizasyon projesi için bir blockchain platformunun uygunluğunu değerlendirmek, projenin başarısı açısından büyük önem taşımaktadır.

Platform seçimi, projenin teknik gereksinimlerine ve hedeflerine uygunluğunu belirlemek amacıyla ayrıntılı olarak analiz edilmiştir. Doğru platformun seçilmesi, projenin uzun vadeli başarısı ve sürdürülebilirliği üzerinde doğrudan bir etkiye sahip olabilir. Yanlış bir platform seçimi ise hem teknik hem de mali açıdan ciddi sorunlara yol açabilir. ISToken gayrimenkul tokenizasyon modeli, 7 güncel blockchain platformunu 15 önemli kriter doğrultusunda analiz ederek en uygun platformu belirlemeye çalışmıştır. Bu kapsamda, Binance Smart Chain, Ethereum, Solana, Avalanche, Polygon, Cosmos ve Polkadot blockchain platformları çeşitli parametreler üzerinden karşılaştırılmıştır. Bu karşılaştırmalar, her platformun belirgin özelliklerini ve performans metriklerini ortaya koymaktadır. Her bir platformun güçlü yönleri ve geliştirilmesi gereken alanları, kapsamlı bir değerlendirme ile belirlenmiştir. Bu değerlendirmeler, ISToken gayrimenkul tokenizasyon projesi gibi özel kullanım durumları için en uygun platformu belirlemek amacıyla yapılmıştır. Analizler sonucunda, Ethereum platformunun ISToken için en uygun seçenek olduğu ortaya çıkmıştır. Gayrimenkul tokenizasyon endüstrisi, karmaşık akıllı sözleşmeleri ve işlemleri etkili bir şekilde yönetebilecek güvenilir ve uyumlu bir blockchain platformuna ihtiyaç duymaktadır. Ethereum'un iyi kurulmuş altyapısı ve yenilikçi

yaklaşımı, bu tür zorlukların üstesinden gelmek için ideal bir platform olmasını sağlamaktadır. Ethereum'un sağlam ve esnek yapısı, akıllı sözleşmelerin etkin bir şekilde uygulanmasını ve yönetilmesini mümkün kılarak, projenin başarısı için gerekli olan teknik desteği ve güvenliği sağlamaktadır. Bu nedenle, Ethereum'un ISToken projesi için en iyi platform olduğu sonucuna varılmıştır.

Gayrimenkul tokenizasyonu, sadece Türkiye'de değil, küresel emlak piyasasında da büyük bir potansiyele sahiptir. Bu teknoloji, gayrimenkul sektörünü daha erişilebilir, şeffaf ve verimli hale getirme kapasitesine sahiptir. Bu nedenle, Türkiye'deki emlak piyasası aktörlerinin ve düzenleyici otoritelerin tokenizasyonun sunduğu fırsatları değerlendirmesi ve bu yenilikçi teknolojiyi benimsemesi, uzun vadede sektöre önemli faydalar sağlayacaktır. Tokenizasyonun başarılı bir şekilde uygulanması, Türkiye'nin emlak piyasasındaki rekabet gücünü artıracak ve uluslararası yatırımcıların ilgisini çekecektir. Bu süreçte, tüm paydaşların işbirliği içinde hareket etmesi, tokenizasyonun sunduğu potansiyelin tam anlamıyla gerçekleştirilmesine olanak tanıyacaktır. ISToken modeli, mevcut düzenlemelerle uyumlu bir şekilde çalışarak ve yeni düzenlemelere adapte olarak, tokenizasyonun geniş çapta benimsenmesi için gereken altyapıyı sağlamaktadır. Bu model, teknolojik gelişmelerin ve yasal düzenlemelerin birlikte ele alınmasını önermektedir. Bu bağlamda, hükümetin ve düzenleyici kurumların, tokenizasyonun yasal çerçevesini oluştururken diğer ülkelerdeki iyi uygulama örneklerini dikkate alarak Türkiye'ye özgü düzenlemeler geliştirmesi önemlidir. Tokenizasyonun sunduğu fırsatların en verimli şekilde değerlendirilmesi için, teknolojik yenilikler ve düzenleyici yaklaşımlar uyumlu bir şekilde ilerlemelidir. Bu sayede, Türkiye'nin emlak piyasasında öncü bir rol üstlenmesi ve küresel yatırımcılar için cazip bir pazar haline gelmesi mümkün olacaktır.

1. INTRODUCTION

The real estate market, like all other sectors, is in a state of constant change and development. In an evolving world becoming increasingly digitized, adaptation is necessary both on an individual and sectoral scale. The industry should become more liquid, and ways to embrace small investors again need to be explored. Digitization and integration with high technology are leading approaches for solving these challenges.There is a technology that simultaneously addresses liquidity and accessibility issues in the sector: Blockchain-Based Real Estate Tokenization. Tokenizing a Real estate stands among the sectors that have offered significant investment opportunities within the property market and has been one of the most trusted sectors by investors for centuries. According to Saull, A. et al, (2020) land investment is a significant aspect of the global economy, and real estate is the world's largest wealth reserve. Like in all countries around the world, people from all walks of life in Türkiye , both large and small investors, tend to make real estate investments to grow their savings and feel secure. The real estate market, despite being one of the largest markets in terms of volume, is often characterized as quite sluggish. Liquidity stands out as one of the most crucial factors for investors. One of the most significant problems of the real estate market is its low liquidity, to the extent that it can divert investors to more liquid sectors.

The real estate market is directly affected by all events worldwide. For example, events such as pandemics, economic crises, wars, and natural disasters create fluctuations in the real estate market with changing the accessibility of the sector. Real estate prices, when looked at globally and ignoring the specific condition of the property, tend to increase over centuries. Although there are occasional sharp declines and price breaks, considering the physical limitation of a certain land capacity and the continuous increase in the human population, it can be said that real estate accessibility will become more challenging in the coming centuries. Especially with the decrease in purchasing power parallel to economic crises, it has become increasingly impossible

for small investors to own an entire property. In recent years, there has been a striking decline in the ratio between the salary of an individual working for an average wage and the ability to buy real estate. According to the data from the Central Bank of the Republic of Türkiye , while the 124-month salary of an individual working for the minimum wage could cover the cost of an average house, by the end of 2022, it corresponds to a 190-month salary. This disparity is deepening, particularly in the three major cities of Istanbul, Ankara, and Izmir, highlighting how challenging it has become to enter the real estate market. This situation leads to small investors being excluded from the real estate market, resulting in negative consequences both at the individual level and in terms of market property, which means dividing it into dozens of digital units. An investor not willing to purchase the entire property can instantly acquire real estate tokens using their mobile phone. At the same time, they can also sell them instantly when needed.

Real estate tokenization requires a system that integrates with various industries and academic fields. This system's main outlines are primarily composed of technological, legal, and financial elements. When it comes to addressing the industry's accessibility and liquidity problems, an interdisciplinary real estate tokenization model stands out.

1.1 Background

Research and idea generation has been ongoing for years with regard to the integration of the real estate market with the digital sphere. As a result of the complexity of its multifaceted structure, real estate tokenization is one of the most specialized fields in this digital space. The use of blockchain technology is at the forefront of components in the real estate sector. Veuger (2017) has emphasized the need for innovative approaches in valuation, products and services, innovative business models, different market strategies, organization, and management issues in the real estate sector. Subsequently, he pointed to blockchain technology. Blockchain, a cutting-edge technology, is supported by trustworthy encryption and consensus mechanisms, according to Lee and Ng (2021), and it has a significant impact, particularly on property owners, financiers, and builders.

Blockchain and distributed ledgers, according to Lemieux (2017), are typically defined as "trusted and immutable transactions supported by open-source technology, publicly accessible, decentralized, and automated ledgers stored on a distributed network." However, there is no single definition that is universally accepted for these terms. Lemieux emphasizes the characteristics of blockchain, also known as distributed ledger technology (DLT), despite the fact that these terms have not yet been formally defined internationally. Antal and his colleagues (2021) have stated that distributed ledger technology, which is the foundational cornerstone of the Blockchain, has the potential to be a game-changer in various fields. They mentioned that recent developments are triggered not only by technological expectations but also by social expectations. The smart contracts are another instrument of the Blockchain. A smart contract performs the function of defining the conditions of a contract; however, unlike traditional contracts, it is executed in the form of code running on a blockchain. According to Uzair and his colleagues (2018), smart contracts are contracts that can be completed without any human interaction, and they conducted a study exploring the impact of smart contracts on the real estate sector in Pakistan by leveraging this feature of smart contracts to record similar data on blockchains. Through smart contracts and distributed ledger technology (DLT), blockchain can be used in the real estate industry. However, the accuracy and dependability of traditional land registry records is the primary factor that determines how successful this system is. Benbunan-Fich and Castellanos (2018) state that the lack of a comprehensive national land registry with accurate and comprehensive land records caused the project to be abandoned in Honduras, where they attempted blockchain-based land registry integration.In addition to a system where land records function accurately, digitization is highly beneficial. Yadav and Kushwaha (2021) propose a blockchain-based framework for digitizing property transactions, asserting that this technology reduces the risks of official document forgery and fraud.

The real estate market derives its strength from providing investors with property rights and the confidence that comes with these rights. Whether digital or not, it must be ensured that property rights remain intact when selling an entire property or just a fraction (1/100). To ensure the proper protection of property rights during the

digitization process, tokenization should be regulated by the government. Avcı and Erzurumlu (2023) emphasize that blockchain technology holds promise but lacks a robust legal infrastructure, and it may not be reliable enough for investors, especially if the country's land registry system does not support fractional ownership. According to Konashevych (2020), blockchain serves as a registry, displaying both property rights and transaction records. The role of the government, as stated by Konashevych, is to provide high-security standards and legal support. The increased presence of blockchain technology in the real estate sector is directly related to the feasibility of real estate tokenization and the concept of fractional ownership, particularly when recognized and regulated by the government. Tokens representing real estate assets in the digital realm must possess features that support the concept of ownership. Security tokens are considered financial instruments that represent ownership information of investment assets and are recorded on the blockchain network. Klayman (2017) claims that security tokens, like conventional securities, signify ownership of a business, an asset, or a portion of the project's cash flow. Real estate tokenization, as it is not yet regulated by the government, requires the establishment of an interim structure to create a tokenization model. Gupta et al. (2020) have discussed the use of Special Purpose Vehicles (SPVs) supported by security tokens and based on real-world assets. According to Avcı and Erzurumlu (2023), SPVs, due to their ownership of specific rights without a partner, can identify the property, announce tokenization to investors, issue tokens, acquire properties with the funds raised, and send tokens to investors' digital wallets. Roth et al. (2019) have proposed the tokenization of equity shares obtained through crowdfunding as a method that can be utilized to provide entrepreneurs with access to capital. According to Cohen (2016), if equity crowdfunding utilizes its technological capabilities, it has the potential not only to be a suitable option for individual investors but also to significantly impact the real estate finance market. To raise funds from investors for established SPVs, there is a need for a real estate crowdfunding platform. Greta and Tenca (2019) argue that creating a secondary market where assets become more liquid by being made divisible would be a significant advantage for the real estate crowdfunding sector.

In general, the tokenization of real estate assets is a tool that enables fractional ownership and risk-sharing. According to Swinkels (2022), fundamental questions about how ownership can be fragmented and how individuals can build portfolios are crucial to illuminate the significance and possibly disruptive nature of tokenized real estate markets. Avcı and Erzurumlu (2023), on the topic of ownership, have emphasized that ownership can be divisible to allow the creation of income and rights. Therefore, accurate determination of the information transmitted through the blockchain is essential to establish the obligations carried by a property and the rights of the titleholder. When it comes to the usability of blockchain technology, there are numerous theoretical studies on this subject. Saari et al. (2022), in addition to theoretical studies, has observed through examined empirical applications that blockchain can enhance efficiency, reduce transaction time, and provide verification, transparency, and automation. Swinkels (2022), who analyzed the results of blockchain-based real estate tokenization for the first time in the U.S., based on data compiled from 58 housing projects he worked on, concluded that many anticipated conceptual advantages of tokenized real estate investments can be realized in the real world. He even indicated that this could signify outstanding changes in the organization of financial markets in the future.

1.2 Problem Definition

The real estate sector has been one of the largest and most powerful industries from the past to the present. Growing and developing in conjunction with nearly two hundred and fifty related sub-sectors, it poses a fundamental problem when viewed from the perspective of investors: liquidity. When investors consider investing in any sector, they not only analyze the short and long-term profitability of that investment but also evaluate the liquidity of the investment as a parameter. While cash is the most liquid, the liquidity of assets such as cars and houses is low. The direct usability of the currency in the daily exchange of goods and services increases liquidity. The liquidity ranking among financial assets varies, with checks, government bonds, corporate bonds, stocks, durable consumer goods, and real estate. Since the real estate sector inherently consists of immovable properties, it is also the sector with the longest

investment turnaround time. Liquidity, which is one of the weakest points of the real estate sector, directs investors to more liquid markets. Innovative solutions need to be provided to address this issue, not only limiting the real estate market to be a safe haven for investors but also positioning it among sectors with high liquidity.

Another problem in the real estate sector is accessibility. Especially economic crises, pandemics, natural disasters, wars, and numerous other changes create fluctuations in the real estate sector worldwide. Although these fluctuations may sometimes go unnoticed, they can often affect the world. When evaluated from the perspective of small investors, the increase in real estate prices has made it impossible for millions of minimum-wage workers to participate in the real estate sector. This situation misleads investors into thinking that their savings are worthless and distances them from a secure haven to protect their savings, increasing their spending tendencies. The real estate market in Türkiye notably reflects price changes seen in many other countries, especially in recent years with sharp price increases during the pandemic and its aftermath.

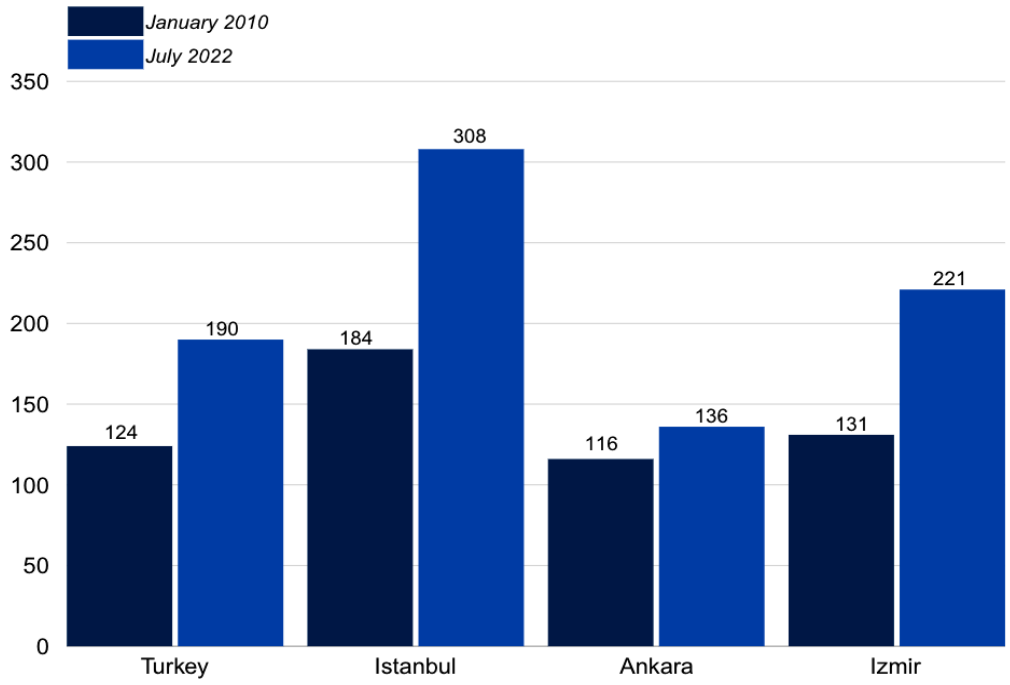


Figure 1.1 : The Relationship Between Housing Prices- Minimum Wage In Türkiye Over Past 13 Years (TCMB, 2022)

The housing price index, which the Central Bank of the Republic of Türkiye announces every month, provides essential data to assess the changes in real estate purchasing power. According to the analysis before 2022, in January 2010, 124 minimum wages were needed for a 75-square-meter apartment. However, in July 2022, for a dwelling of the same size, one needs to spend the entire salary every month for 308 months in Istanbul, 136 months in Ankara, and 221 months in Izmir. This means that a minimum wage earner has to spend his entire salary for 26 years just for the house. This situation is not promising for both small investors and the sector. One of the dynamics of the real estate market is its homogeneity. However, the replacement of millions of people outside the sector by giant companies leads to the formation of a completely heterogeneous market, negatively affecting the balance of the sector. For the positive and concrete development of the real estate sector, which directly affects the Turkish economy, sustainable and innovative solutions are needed. The sector needs to be approached with a visionary perspective, evaluating the benefits that the digital world can provide.

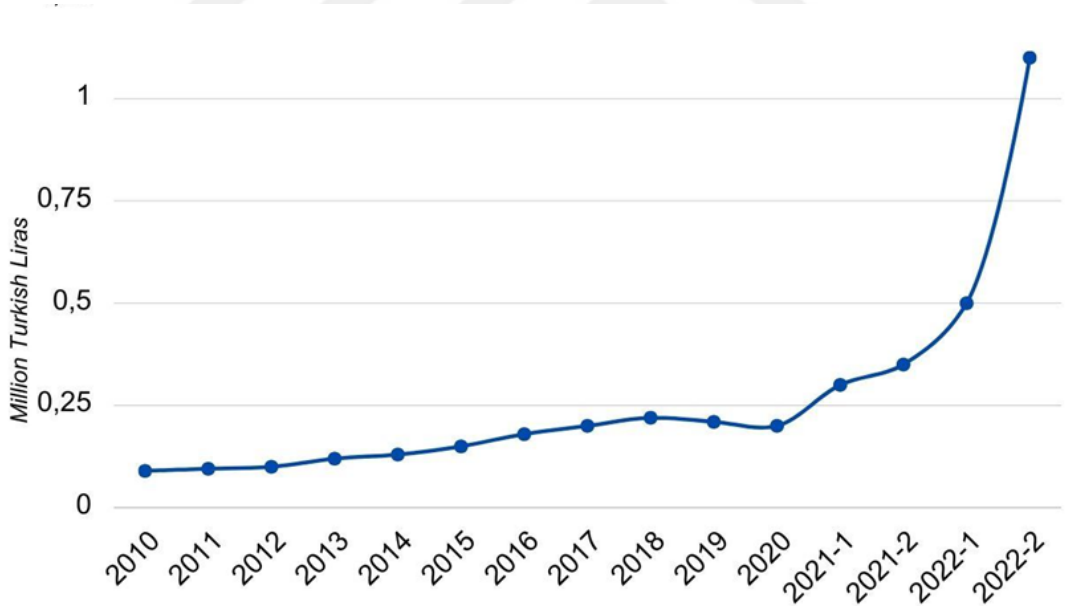


Figure 1.2 : 75 Square Meter Residential Property Price In Türkiye Over Past 13 Years (TCMB,2022)

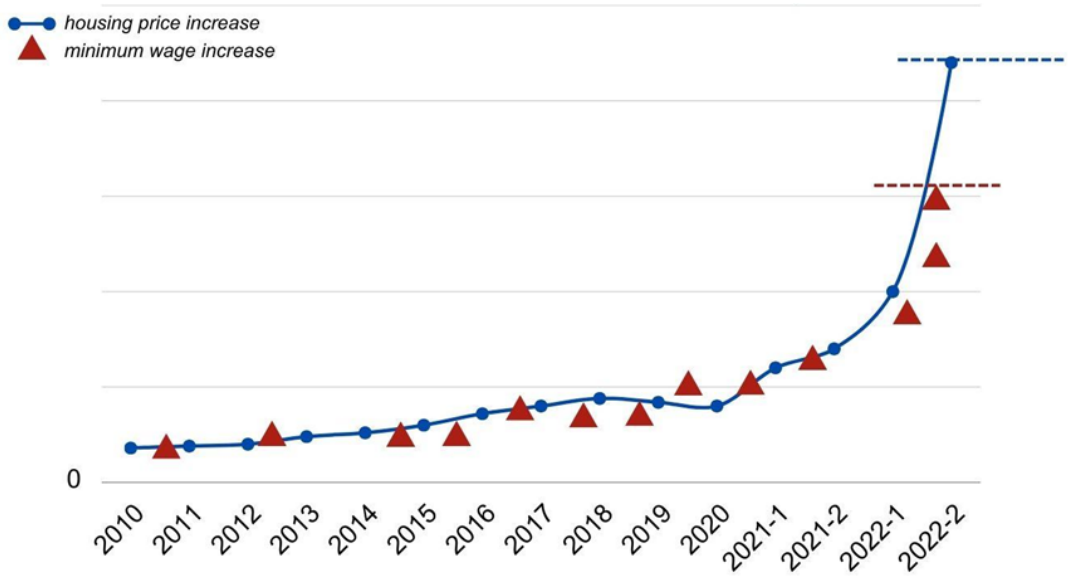


Figure 1.3 : The Relationship Between Housing Price Increase And Minimum Wage Increases

In the real estate industry, which relies on conventional approaches, there are challenges that extend beyond issues of liquidity and accessibility. According to Batubara et al. (2018) Public sector transactions are vulnerable to manipulation, resulting in a lack of transparency. Precisely, the precision and dependability of crucial data such as title documents, property history, and financial information are essential for carrying out transactions with utmost security and transparency. Nevertheless, under the existing systems, the potential for manipulation or inaccurate recording of this data amplifies the vulnerability to fraud and diminishes the dependability of transactions. Blockchain technology can resolve these concerns by guaranteeing the immutable storage of data in a decentralized way, therefore enhancing the security, transparency, and efficiency of real estate transactions. By adopting this approach, both purchasers and vendors may have enhanced confidence in the safety of their transactions.

Table 1.1 : Literature research outcomes about conventional real estate sector problems

Year	Author(s)	Problem	Definition
2018	Batubara et al.	Transperancy	Transactions in public services are susceptible to manipulation, which makes transparency remote.
2020	Konashevych	Centralization	Centralization is a source of many issues in governance: abuse of power, corruption, inefficient governance, and high costs, slowness and complexity of bureaucratic procedures.
2020	Konashevych	Third man	Data loss, corruption, power abuse, and decreased trust are all caused by third-party involvement and centralization.
2021	Teruel and Moreno	Indivisibility	Property indivisibility, high market value, and inherent rigidity make asset investment difficult in both cases of investment and disinvestment.
2022	Avci and Erzurumlu	Funding	The aftermath of the 2008 crisis, marked by a notable downturn in real estate prices , not only undermined trust in the banking sector but also accelerated the rise of the sharing economy.
2022	Badgujar et al.	Liquidity	Real estate has consistently been a favored and reliable investment, providing a steady income stream through rent or lease. However, a notable drawback of real estate investments is the lack of liquidity.

Conventional real estate transactions encounter issues with centralization. Centralization poses several challenges in governance, including the potential for power abuse, corruption, ineffective administration, and the burden of high expenses, sluggishness, and intricate bureaucratic processes (Konashevych,2020). These transactions are usually carried out via central authorities or middlemen, resulting in sluggish and expensive procedures. The centralized structure heightens the vulnerability to data manipulation and inaccuracies, hence detrimentally impacting the accessibility and credibility of all parties concerned. Moreover, the likelihood of papers being misplaced or modified in centralized systems diminishes the dependability of transactions and increases the vulnerability to fraudulent activities. Blockchain technology can resolve these concerns by providing a decentralized framework that guarantees secure, transparent, and unchangeable storage of data. This, in turn, enhances the safety and efficiency of real estate transactions. As a result, both buyers and sellers can have more assurance in the security and precision of their transactions.

1.3 Research Aim & Solution

In the 21st century, we have witnessed the most significant technological advancements in the history of humanity. One by one, as nations, industries, and individuals, we have tended to adapt to these developments in some way. While some sectors quickly adapt to technology, others may lag behind. The real estate sector, by its nature, tends to approach changes and transformations more cautiously. The role of being the locomotive of dozens of sub-sectors, coupled with its large volume, causes it to adapt slowly to changes. One of the prominent topics of technological developments in recent years is blockchain technology, which is used in various fields, especially in the financial sector. The features of blockchain, such as reducing transaction costs, shortening transaction times, and relying on the transparency and reliability of data, show that it can be a method used in the technological transformation of the real estate sector. Blockchain-based real estate tokenization, on the other hand, is a technological innovation developed to deal with the sector's problems, such as low liquidity and a lengthy and costly transaction process. This

method is based on fractionalizing real estate, reducing the capital needed by investors. Roth et al. (2019) emphasized the benefits of real estate tokenization, including fractional ownership, reduced entry barriers for investors, increased liquidity, and shorter transaction times. However, Morena et al. (2020) underscored critical challenges such as the difficulty of transitioning from a traditional structure to a decentralized one and the delay in regulatory compliance with technological innovations, despite these positive aspects. The feasibility of real estate tokenization largely depends on the correct construction of its legal infrastructure and the provision of legal solutions to address issues. The aim of this thesis is to evaluate real estate tokenization on a land scale, create a viable tokenization model, and objectively present the effects of tokenization on the real estate sector. The fundamental motivation for establishing a viable tokenization model is to serve as a significant resource for advancing the discussion and consideration of fractional ownership in a world where this concept is essential, taking it one step further towards becoming a reality.

1.4 Research Questions

• How can Blockchain technology be utilized to enhance traditional real estate transactions?

• Is it possible to establish connections between existing fractional ownership applications and traditional government institutions with Blockchain?

• Can a market with legal compliance be designed to ensure the feasibility of a Blockchain-based real estate tokenization model?

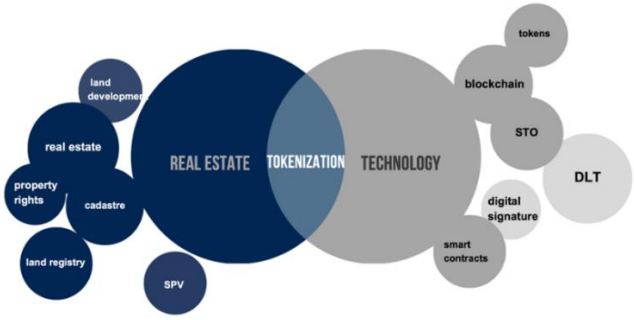


Figure 1.4 : Keywords From Tokenization

2. LITERATURE REVIEW

Blockchain-based real estate tokenization is a multidisciplinary field of study, involving various subfields such as technology, law, and finance, playing a role in shaping the concept of tokenization. In this thesis, which explores the practicality of real estate tokenization in Türkiye , a thorough literature review is conducted initially. Theoretical and experimental studies are categorized, and a tokenization model is developed in the thesis. Subsequently, the traditional real estate buying and selling practices, as well as fractional ownership in Türkiye , evolved with the proposed tokenization model, taking a step forward in the digitization process.

2.1 Technology

Blockchain is a distributed and unchangeable record that simplifies the process of documenting transactions and monitoring assets in a corporate network (https://www.ibm.com/topics/blockchain). Blockchain, together with its technological components, Distributed Ledger Technology (DLT) and smart contracts, have a crucial impact on contemporary digital ecosystems. Blockchain guarantees the storage of data in a manner that is not controlled by a single entity, cannot be changed, and is highly secure. This enables transactions to be conducted in a way that is open and can be easily tracked. Distributed Ledger Technology (DLT) serves as the fundamental basis of this structure by enabling all participants in a network to concurrently access a shared database and verify modifications through a consensus method. Smart contracts are computerized agreements that autonomously execute upon the fulfillment of predetermined circumstances, ensuring safe and dependable transaction procedures without requiring human involvement. The integration of blockchain, distributed ledger technology (DLT), and smart contracts introduces groundbreaking advancements and enhancements to several industries, such as banking, healthcare,

and supply chain management. Utilizing the core concepts of blockchain is crucial for resolving issues in the real estate industry.

2.1.1 Blockchain

Blockchain technology, conceptualized by an individual known as Satoshi Nakamoto in 2008, with roots dating back to the 1990s, is important to understand fully before exploring its applicability. In essence, what we call a blockchain is a database. The fundamental difference between a database and a blockchain comes from how the data is structured. A blockchain stores data in cells called blocks; each has a specific storage capacity and, when filled, is chained to the preceding filled block. This results in the creation of a chain of interconnected blocks. While a blockchain links data blocks, databases organize their data in tables. This allows some databases to be blockchains, but not all blockchains are databases. This system, being decentralized, establishes an irreversible timeline. Once a block is filled, it becomes a fixed point and part of an immutable timeline. Each block on the chain has a date and a precise timestamp. This storage capacity ensures increased security as a real-time ledger is continuously updated in the blockchain. Tasatanattakool and Techapanupreeda (2018) also claim that Blockchain is a decentralized and secure method of data storage, and they agree that this poses significant challenges for fraudulent activities.

Thanks to the mentioned features of blockchain, it has come to the attention of many industries. Blockchain technology and distributed ledgers, primarily attracting significant interest in the financial sector, are being used in various projects (Di Pierro, 2017). After its use in the financial sector, blockchain has integrated into diverse fields such as health, food safety, logistics, voting, public administration, and the music industry.The decentralization, data storage security, transaction speed, and many other features brought by blockchain technology have sparked considerations for its applicability in the real estate sector. The partnership between the real estate industry and blockchain, a subject widely discussed and researched, involves evaluating the advantages and disadvantages.

Table 2.1 : Literature Research Outcomes About Conventional Real Estate Sector Problems

Subtitle	Year	Author(s)	Outcomes
Blockchain	2017	Nofer et al.	Disrupting industries, particularly finance, by eliminating intermediaries, improving accuracy in identifying asset owners, and enabling precise tracking of physical goods.
Blockchain	2017	Veuger	Blockchain's impact on real estate reveals the need for further exploration of its practical application, emphasizing transparency and completeness as crucial for building trust.
Blockchain	2018	Bambara , Allen	Robustness, decentralization, enhanced security, elimination of vulnerabilities, and potential to reshape business models.
Blockchain	2019	Nijland	Blockchain implementation is most suitable during the pre-marketing and due diligence phases of real estate transactions, offering added value as a secure data sharing program.
Blockchain	2019	Chen , Kou	Five prominent research themes: economic benefit, blockchain technology, initial coin offerings, fintech revolution, and sharing economy.
Blockchain	2019	Paschen , Boon	Need for managers to assess the potential of blockchain and its strategic relevance to stay competitive in the industry.
Blockchain	2019	Belotti et al.	Emphasizes the need for guidance in effectively utilizing blockchain, providing a vademecum to help designers make informed decisions on when and how to adopt.
Blockchain	2020	Pankratov	With its potential to optimize transactions, expected to revolutionize the real estate sector within 6-7 years, providing a significant financial impact.
Blockchain	2021	Perwej, Haq	It enhances transaction speed, efficiency, secure data sharing. Regulatory frameworks, reliable digital data, and public-private partnerships are essential for implementation in real.

According to Pankratov et al. (2020), blockchain technology has garnered significant attention in various sectors in recent years. One of the most potential areas for this technology is the real estate sector. Blockchain technology provides benefits in the real estate sector such as preventing counterfeit documents, securely tracking transactions, and increasing transparency. It anticipates that blockchain will reshape the business model in industries and could influence how people live and work. The need for guidance in understanding and effectively using blockchain technology is addressed (Batubara et al., 2018). It emphasizes the strong need for understanding the advantages of blockchain compared to traditional solutions, or at least when to adopt blockchain, which type of blockchain aligns better with use case requirements, and how to utilize it (Belotti et al., 2019).

1-Immutable and Trustworthy Data

2-Transection Efficiency(Speed)

3-Improve Liquidity

4-Reduce Processing Cost

5-Data Transparency

6-Real Estate Diversification2.1.1 Stress in the Construction Industry

Table 2.2 : Literature Research Outcomes About Advantages of Blockchain

Year	Advantages	Author(s)	Definition
2017	Transection Efficiancy(Speed)	Volodin and Malenko	Compared to the current state, blockchain technology facilitates faster real estate transactions by streamlining transactions in the market and reducing human error.
2018	Reduce Processing Cost	Nasarre-Aznar	Transaction costs for housing access have decreased due to direct transactions being made possible by blockchain technology, which removes the need for middlemen in real estate transactions.
2019	Immutable and Trustworthy Data	Smith et al.	Blockchain recordkeeping is transparent and safe, increasing the data's underlying transparency.
2019	Real Estate Diversification	Garcia-Teruel	It is difficult for small investors to buy real estate outside of their state . Blockchain can contribute to cross-border transactions by producing records that cannot be changed, copied, erased, or falsified.
2020	Data Transperancy	Pankratov et al.	All data (documents for an apartment, money transfers, etc.) is recorded and verified in a distributed registry system, as opposed to IT platforms that are managed from a single location.
2022	Improve Liquidity	Mistrangelo	The idea of a "fractionable" asset can ease some of the constraints and difficulties faced by owners, increasing liquidity and making room for participants from various social or economic backgrounds.

By definition, a blockchain is a collection of linked data blocks that records transactions with certain attributes. With Blockchain technology, every transaction is time-stamped, registered, and publicly shared one after the other using a distinct

symbol. As a result, in order to forge a block, earlier blocks must also be forged. As a result, attempts to alter a transaction are prevented from happening within the mechanism (Karamitsos, 2018).

Everything on the blockchain will be unchangeable because of the distributed ledger's nature. Compliance with regulations is typically recorded by independent organizations that don't communicate with one another. Since the property's chain history can be used as a measure of accountability, providing a tamper-proof history ensures that all parties will be held responsible. Listing a property on the real estate market is usually the first step in the traditional land transfer process. A state-run land titles registration authority handles the sale's registration at the end, following contract exchanges during price negotiations. The issue with land transfers using the traditional method is that, in certain cases at least, it depends too much on land registration authorities manually recording the transfers, making it vulnerable to corruption and fraud. However, blockchain technology, also known as distributed ledgers, is generally understood to be open-source software that facilitates the storage of reliable, unchangeable transaction records in widely available, decentralized, distributed, and automated ledgers. Lemieux (2017) asserts that the main draw of this cutting-edge technology is its ability to create reliable, unchangeable records without the assistance of a reliable third party. In almost all real estate transfer transactions, the involvement of third parties increases both the time and cost of the process. Blockchain technology provides a solution to increase the transaction speed in real estate transfers by eliminating the need for intermediaries and relying on mathematical algorithms instead of trust in individuals (Nofer et al., 2017). Distributed applications can facilitate direct peer-to-peer (P2P) transactions by doing away with middlemen through the use of blockchain-based smart contract innovations. P2P transactions that are trustless are made possible by the blockchain, which acts as an unchangeable ledger that records events. Investors can cut expenses and speed up transaction processing times by using the blockchain system, which eliminates the need for middlemen (Norta et al., 2018). In real estate transfer transactions conducted on the blockchain, the involvement of different institutions and third parties will be eliminated, reducing the transaction time to a few minutes. Parameters such as the working hours of institutions, personal

situations of officials who will sign, or document transfers completely disappear, allowing transactions to take place on the blockchain every day of the year, at any time.

Liquidity is expected to rise in the blockchain use case because transactions can be completed much faster and users will be trading smaller quantities of real estate. Larger real estate investments frequently need to be held for a number of years, but a blockchain application can make it possible to sell an asset's share right away. What is being tokenized is another benefit of liquidity. According to Badgujar et al. (2022) the illiquidity problems can actually be resolved by blockchain technology, and more significantly, it makes this market accessible to regular investors. The creation of Security Tokens, which are secured by actual assets, can increase the liquidity of real estate.A trader or investor may trade these security tokens, which indicate a portion of the real estate, and they may be listed on reputable secondary exchanges. Mistrangelo et al. (2022) present an innovative approach known as "Property Tokenization" (PT), which aims to introduce a revolutionary financial instrument that is digital and legally effective. It permits the partial transfer of a real estate asset while retaining ownership and exclusive use, and it can generate liquidity with a less definitive solution than selling the entire asset. Swinkels (2022) has conducted an empirical investigation into the financial implications of tokenizing real estate markets, studying 58 properties in the United States. The findings of this study suggest that a significant number of the conceptual benefits of tokenized real estate investments can be achieved in practice. This suggests that future financial market organizations will see substantial innovations.

Blockchain makes it possible to reliably record transactions without the use of middlemen or centralized trust management. This innovation will have global repercussions, such as fewer middlemen in transactions, lower transaction costs for market activity such as the real estate sector (Moghayar, 2018). A similar idea, expressed by Kalyuzhnova I (2018), claims that the "blockchaining" of the registration system by reducing the number of intermediaries in the land registry-cadastre system will reduce transaction costs. A "blockchain passport" detailing the technical

specifications for each property could be created. This would make real estate valuation simpler, faster, and more cost-effective.

A number of documents, including a title deed, maintenance history, cap rates, occupancy rates, insurance records, building compliance records, fire code, elevator inspection, ownership history, tenant history, and comparable rents in the neighborhood, are required for a real estate investor to perform an initial review for a possible purchase transaction.A number of data providers are charging exorbitant fees for this information. It is required of government organizations, notaries, banks, and investors to depend on these data providers for the accuracy of the information. Blockchain technology has the potential to resolve several data transparency concerns in the real estate industry, giving investors the knowledge they need to make more confident and timely real estate investments.

Smith et. al. (2019) has mentioned a start-up called Property DNA as a solution to this issue. Blockchain based Property DNA involves various parties in commercial real estate investment, including tenants, owners, investors, and banks, making it crucial for information between parties to be clear and consistent. Contract terms are safeguarded and made clear for all parties in the real estate industry, particularly with the use of smart contracts, which are an essential component of blockchain applications. Pankratov et al. (2020) claim that smart contracts contain guidelines and directives that guarantee total transparency of the exchange process. This allows payments to be made in a way that conforms with all established regulations, fostering confidence between the parties to the real estate transaction.

Real estate diversification is the practice of distributing investments in real estate across a number of different markets or properties. Investing in a variety of properties, locations, and investment strategies can help diversify an investment portfolio and lower the risk of loss while also potentially increasing returns.Diversification may help to minimize risk and possibly increase returns: Investors can lessen the impact of any decline in a single property or market by distributing their investments among several properties or markets. Diversifying your real estate portfolio can be achieved through the following methods:

- Making various real estate investments.
- Investing money in different regions.
- Utilizing various investment techniques.

Having a diverse range of property types helps shield you from downturns in the market and the economy. Diverse property kinds can provide a range of investment returns and income streams. By distributing risk across several markets, geographic diversification makes it possible to profit from a range of economic situations. Access to various tenant categories and rental markets is another benefit of this strategy. Adding real estate investment trusts (REITs), fractional home investments, direct ownership, and crowdfunding to your portfolio can help diversify it even more. It is more difficult to encourage real estate investors to attain sectoral diversification and diversify their portfolios than it is to encourage investors in other industries. Investing in places you have never been to or are unfamiliar with can be unsettling, especially for inexperienced investors. To lower risk, investors usually choose to make investments in industries they are knowledgeable about. All real estate, however, does not help lower risk when it is concentrated in one location. Investing internationally presents a number of difficulties for many investors.Blockchain, according to Garcia-Teruel (2019), can create records that are immutable, uncopyable, undeletable, or immutable, which can lead to a transparent approach to cross-border transactions. Investors can access any property from anywhere in the world with the help of smart contracts, which can operate on a decentralized secondary market integrated with blockchain technology and customized to the specific regulations of each location.

Table 2.3 : Literature Research Outcomes About Disadvantages of Blockchain

Year	Disadvantages	Author(s)	Definition
2018	Energy Consuption	De Vries	In 2018, the estimated total energy consumption of the Bitcoin network was 2.55 gigawatts. This is similar to Ireland's 3.1 gigawatts of electricity consumption.
2019	Lack of Education	Perwej et al.	Numerous Blockchain startups competing for the same pool of lacking talent, but organizations have to deal with a talent pool that is contracting faster than the rate of growth in demand.
2020	Scalability	Ameyaw and De Vries	Four categories of limitations are mentioned: confirmation time, number of nodes, number of users, and transaction limit.
2023	Regulation & Governance	Avci and Erzurumlu	Despite the potential of blockchain technology, attempts to create a solid legal framework that would support the blockchain ecosystem have not been entirely successful.

One of the major problems in the blockchain ecosystem is the magnitude of energy consumption and resulting carbon emissions in cryptocurrency mining. In the 21st century, where projects aiming to reduce energy consumption and minimize environmental impact are developed in almost every sector, the annual carbon dioxide emissions from cryptocurrency mining are equivalent to the annual emissions from the U.S. railroads.

Blockchain uses a lot of energy because of its structure and data processing method. This energy demand is influenced by the capacity to carry out decentralized transactions, quick financial transactions, and mathematical computations. De Vries

(2018) estimates that the Bitcoin network uses at least 2.55 gigawatts of electricity at the moment, and it may eventually reach 7.67 gigawatts, which puts it on par with nations like Austria (8.2 gigawatts) and Ireland (3.1 gigawatts).

For the development of blockchain technology, adequate education should be provided to both university students and employees at the corporate level. However, it cannot be said that this level of professionalism has been reached yet. As Perwej et al. (2019) pointed out, only 52% of the world's top universities offer a blockchain course. As is the case with all new technologies, organizations and academia should collaborate to introduce the right curriculum. The educational aspect of blockchain technology is not limited to developers and academia. The lack of knowledge among users about blockchain and cryptocurrencies jeopardizes the widespread access to the technology. Especially in the real estate sector, it is challenging for individuals without any familiarity with the field to adopt blockchain technology. Therefore, user training sessions should be provided for the new technology to be used by end-users, addressing any questions or concerns they may have.

According to Saari et al. (2022), having various blockchain initiatives in a region, general experience, or familiarity with blockchains and cryptocurrencies positively influences the adoption of blockchain in real estate. Kshetri (2021) also stated that, in addition to familiarity, experimental assessments could be a practice to educate the public about blockchain advantages. In the implementation in the Andhra Pradesh state of India, officials conducted visits to villages to address concerns, educate landowners, and explain the benefits of blockchain. However, the lack of local blockchain expertise was identified as a challenge. Blockchain networks carry the feature of storing all transactions and data. The concentration of users and the consequent increase in the load of transactions and mathematical calculations cause blockchain networks to slow down. According to Ameyaw and De Vries (2020), as the size of the system grows, it imposes different types of limitations on the scalability of a specific application. These limitations are categorized into four main types: limitation by the number of transactions, limitation by the number of users, limitation by the number of nodes, and confirmation time limitation. Bitcoin has a limitation in the number of transactions it can process in every block because of the hardcoded limit to the block size in bytes.

Consequently, the limitation on the number of transactions also directly restricts the number of users. In addition, Bitcoin and Ethereum encounter capacity limitations in nodes depending on the algorithms they are based on.

The real estate sector and each transaction within that are regulated by national institutions according to the rules of each country. The role of each institution in any real estate transfer transaction is complementary to the others, and dozens of different actors come into play. The fundamental proposition of blockchain is to minimize or even eliminate the number of these actors, thereby speeding up transactions.

Though technology is exciting, there hasn't been much progress in creating a solid legal framework to support the blockchain ecosystem. The development of exchange markets, which are similar to crowdfunding markets, is hampered by the absence of a legal framework and consistent regulatory approaches. At the moment, smart contracts like Tokenestate are the only thing supporting investors' legal rights on a lot of platforms. But unless the nation embraces blockchain technology or there is a situation with fragmented ownership, this leaves investors with legal uncertainty (Avci and Erzurumlu, 2023). Creating any entity that is not recognized and regulated by the government is almost impossible to realize. However, the adoption of a regulated system can be ensured by society. The widespread adoption of blockchain is related to the extent to which society embraces decentralized governance models that it can regulate. Since blockchain is fundamentally political, aiming to regulate the behavior of groups through social and financial incentives, its widespread adoption depends on the extent to which society embraces such models (Graglia and Mellon, 2018). While blockchain technology continues to progress rapidly, legal regulation is not advancing at the same pace. According to Deloitte (2019), the necessary legal framework for the use of blockchain technology in the real estate sector has not yet been established.

2.1.2 Distributed ledger technology (DLT)

Ledgers have persisted throughout history with different materials. Although the material in which they are recorded has changed depending on the era, the logic of accounting record-keeping has remained. This record-keeping process has evolved and become digital in parallel with the advancement of technology today.On the other

hand, a distributed ledger aims to transform the traditional centralized record-keeping mechanism into a decentralized one. In clearer terms, a distributed ledger is a database that is independently maintained and updated by each participant in a large network. Records on this database are created and maintained independently at different nodes, accessible to each participant, rather than being centralized by a single authority.

Table 2.4 : Literature Research Outcomes About DLT

Year	Features of DLT	Author(s)	Definition
2017	Trusted Recordkeeping	Lemieux	Distributed ledger technology assures secure and unchangeable records across diverse applications, particularly in recordkeeping areas such as real estate.
2017	Transforming Government	Ølnesa et al.	Governments should experiment with DLT applications to better understand their complexity and potentially redefine their roles in a changing institutional environment.
2017	Securing Property Rights	Bal	One of India's most significant problems is the lack of a standardized property rights regime, and blockchain technology should be utilized to establish a legal framework capable of guaranteeing property rights.
2020	Securing Property Rights	Konashevych	To succeed in DLT application, a well-designed technology architecture is crucial for managing data, addressing privacy concerns, ensuring legal compliance, enforcing smart contracts, tackling ledger scalability.
2021	Development Guidelines	Antal et al.	It discusses challenges, solutions, and suggest a three-tier architecture for DLT applications ; The Protocol and Network Tier , Scalability and Interoperability Tier, The Interoperability Tier.

Lemieux (2017) states that a novel framework has been put forth to evaluate the dependability of blockchain-based systems in guaranteeing reliable recordkeeping, especially in industries like real estate. The framework is based on archival science and concentrates on the long-term preservation of genuine records. Potential flaws in blockchain recordkeeping systems' precision, dependability, and long-term authenticity can be found by using an archival theoretic evaluation. Closing these gaps will be essential to the successful implementation of these technologies, and continued research and development in recordkeeping design options will lead to better social and technical outcomes. A blockchain is essentially a registry. It shows both transactional records and records of property rights. Blockchain is therefore compatible with both of the legal customs of property registries, namely the maintenance of chains of deeds and title records. For a variety of reasons, including technological, political, organizational, and legal, it is evident that the entire cadastral system cannot be moved to the blockchain in a single night. Rather, the conventional public registry and blockchain systems can function simultaneously, granting citizens the autonomy to decide where they wish to administer their property rights. Technology neutrality and competition will be guaranteed by this strategy. Because the land registry is a monolithic, centralized system and there is typically no such choice for citizens, the government's role in this situation is to ensure high security standards and legislative support (Konashevych ,2020). Keeping reliable records is crucial for the regular functioning and continuity of land registration systems. This directly forms the foundation for the protection of property rights. According to Bal (2017), India's land title system continues to have flaws in spite of reform initiatives. India needs standardized property rights to achieve its economic objectives. Blockchain technology has emerged as a potential solution to the call for decentralized, transparent record-keeping to improve the current system, backed by a legal framework guaranteeing property rights. A strong rights framework is essential for long-term economic growth in the real estate market because it provides efficiency and credit availability. The lack of transparency in India's centralized land records control causes fraud and delays. For India to succeed economically, blockchain technology and a standardized rights framework are imperative. Ølnes et al. (2017) outline two government perspectives on blockchain: governance by blockchain (using DLT for

internal processes and transaction governance) and blockchain governance (defining blockchain structures and ensuring alignment with public values). Both require a deep understanding of evolving blockchain technology. Small-scale e-government experiments are crucial for exploring applications and avoiding failures. Design decisions are pivotal, and flexibility is essential for large-scale implementation, despite inherent challenges in DLT characteristics, necessitating strong governance. There are some studies delves into challenges, solutions, and the application of DLT in decentralized infrastructure development. Antal et al. (2021) examines Distributed Ledger Technology (DLT) as the foundation for decentralized applications, with a specific emphasis on blockchain technology. A three-tier architecture is introduced to systematically classify technology solutions from over 100 papers and startup initiatives. The Protocol and Network Tier covers digital asset registration, transactions, data structure, and privacy, while the Scalability and Interoperability Tier addresses issues related to blockchain technology. The Interoperability Tier, positioned above the previous two tiers, deals with the integration and interoperability of multiple DLT applications and system deployments.

2.1.3 Smart contract

Smart contracts are contracts where the terms are encoded and recorded on the blockchain. Smart contracts and traditional contracts are essentially the same thing. What distinguishes them, making contracts "smart," is that the contracts are executed on the blockchain, not with the assistance of a notary or lawyer. As a direct consequence of the increasing popularity of digitization and blockchain usage today, smart contracts have become a part of our lives..According to Glaser and Bezzenberger (2015), every bank is presently working on creating a plan for how this technology will benefit their operations. To prove the growing interest in smart contracts, the fact that five international banks are currently developing proof-of-concept systems for a supply chain and trade finance platform that integrates smart contracts. This highlights how the financial industry is beginning to recognize and use smart contract technology more and more. (Deloitte,2016)

Table 2.5 : Literature Research Outcomes About Smart Contracts

Year	Features of Smart Contract	Author(s)	Definition
2018	P2P Transactions	Norta et al.	Recommended the blockchain-based smart contract application Evareium, which ensures transparency and transaction speed by eliminating third parties in commercial real estate.
2018	Trustworthy Recordkeeping	Uzair et al.	Smart contracts are proposed to prevent the inaccurate valuation of properties recorded by government organizations in Pakistan.
2019	Challenges and Advantages	Zheng et al.	Despite enforcing contracts without a third party, smart contracts may have bugs, requiring substantial efforts in software engineering and data analytics for detection.
2020	Smart Real Estate Sector	Ullah and Al Turjman	Using smart contracts can assist in upending conventional real estate and converting it into smart real estate that complies with industry 4.0 standards.

Recent developments in blockchain-based smart contract technology allow for the use of distributed applications to eliminate middlemen and facilitate peer-to-peer (P2P) transactions. The blockchain is an unchangeable, event-recording ledger that makes peer-to-peer (P2P) transactions trustless. Norta et al. (2018) state that the Evareium system is a distributed application that facilitates blockchain-based trades of commercial real estate, eliminating the need for middlemen and providing investors with lower costs, quicker transaction times, increased transparency, and less regulatory burdens. The Evareium system allows investors and other stakeholders to have an unrestricted direct interface with the production and distribution of the best financial returns on their investments. According to Uzair et al. (2018), government organizations in charge of monitoring land transactions in Pakistan record erroneous property values, which contribute to widespread corruption. Blockchain technology provides an open, decentralized ledger that can be accessed by anybody. Blockchain transactions necessitate network user verification, which lowers the risk of theft

compared to traditional markets. Automated and human-free, smart contracts improve transaction efficiency by doing away with middlemen. outlined the possible benefits of utilizing blockchain technology, especially with smart contracts, to store real estate data in Karachi. It is feasible to incorporate the use of smart contracts into the real estate business not just for individual transactions but for the whole sector. Smart contracts are a technology that has the potential to improve the entire system because they can be used in a variety of contexts, from real estate company management to city administration and throughout legal processes. Ullah and Al Turjman (2021) state that real estate brokers and agencies can incorporate smart contracts into their workflows to take the place of conventional contracts and enable them to make better decisions by utilizing more transparent contracts.Proptech companies have the option to explore and invest in additional technologies, like artificial intelligence and machine learning, and then incorporate them into the systems to execute blockchain smart contracts. In the industry 4.0 era, this can help bring the dreams of smart cities to life by upending traditional real estate and turning it into smart real estate. All levels of city management and governance are covered by this framework overall. According to Deloitte (2016) and Zheng et al (2019) Blockchain-based smart contracts bring enhanced efficiency and cost savings to various applications. By automating tasks, they accelerate processes, ensure accuracy, and reduce the risk of errors. Their decentralized execution minimizes the chances of manipulation or nonperformance, while also decreasing reliance on intermediaries. This results in lower costs and enables new business models. Embedded in blockchains, smart contracts automatically enforce agreement terms, streamlining administration and improving overall efficiency. On the other hand smart contracts, rapidly developing on blockchains, face challenges including programming languages, security, and privacy issues. The widespread use of blockchain and smart contract applications adds complexity. Bugs in smart contracts require extensive efforts in software engineering and data analytics. Bridging the gap between operational technology (OT) and information technology (IT) is crucial for development. Integrating software technology, natural language processing, and artificial intelligence holds potential solutions in the future (Zheng et al, 2019).

Table 2.6 : Highlighted Outcomes in Blockchain, DLT, and Smart Contracts

Subtitle	Year	Author(s)	Outcomes
Blockchain	2017	Nofer et al.	Disrupting industries, particularly finance, by eliminating intermediaries, improving accuracy in identifying asset owners, and enabling precise tracking of physical goods.
Blockchain	2018	Bambara , Allen	Robustness, decentralization, enhanced security, elimination of vulnerabilities, and potential to reshape business models.
Blockchain	2019	Belotti et al.	Emphasizes the need for guidance in effectively utilizing blockchain, providing a vademecum to help designers make informed decisions on when and how to adopt.
Blockchain	2020	Pankratov	With its potential to optimize transactions, expected to revolutionize the real estate sector within 6-7 years, providing a significant financial impact.
Blockchain	2021	Perwej, Haq	It enhances transaction speed, efficiency, secure data sharing. Regulatory frameworks, reliable digital data, and public-private partnerships are essential for implementation in real.
DLT	2017	Lemieux	Distributed ledger technology assures secure and unchangeable records across diverse applications, particularly in recordkeeping areas such as real estate.
DLT	2017	Ølnesa et al.	Governments should experiment with DLT applications to better understand their complexity and potentially redefine their roles in a changing institutional environment.
DLT	2017	Bal	One of India's most significant problems is the lack of a standardized property rights regime, and blockchain technology should be utilized to establish a legal framework capable of guaranteeing property rights.
DLT	2020	Konashevych	To succeed in DLT application, a well-designed technology architecture is crucial for managing data, addressing privacy concerns, ensuring legal compliance, enforcing smart contracts, tackling ledger scalability.
DLT	2021	Antal et al.	It discusses challenges, solutions, and suggest a three-tier architecture for DLT applications ; The Protocol and Network Tier , Scalability and Interoperability Tier, The Interoperability Tier.
Smart Contract	2018	Norta et al.	Recommended the blockchain-based smart contract application Evareium, which ensures sparency and transaction speed by eliminating third parties in commercial real estate.
Smart Contract	2018	Uzair et al.	Smart contracts are proposed to prevent the inaccurate valuation of properties recorded by government organizations in Pakistan.
Smart Contract	2019	Zheng et al.	Despite enforcing contracts without a third party, smart contracts may have bugs, requiring substantial efforts in software engineering and data analytics for detection.
Smart Contract	2020	Ullah, AlTurjman	Using smart contracts can assist in upending conventional real estate and converting it into smart real estate that complies with industry 4.0 standards.

2.2. Legality

There are a number of legal issues with using blockchain technology in the real estate industry. This makes it especially important for the current legal system to change to accommodate this new technology. It becomes unclear how to protect property rights, validate contracts legally, verify parties' identities, and determine the legal standing of blockchain-based records.

Table 2.7 : Literature Research Outcomes About Legality

Year	Legality	Author(s)	Definition
2017	Property Rights	Bal	Blokchain technology can contribute to India's economic development through standardized property rights implementation.
2019	ID Securiy	Teruel	Emphasizes the need for a linked official digital ID to prevent unauthorized access.
2020	Privacy	Konashevych	To apply blockchain effectively, a strong architecture is crucial for handling data, addressing privacy concerns, ensuring compliance, enabling smart contracts,improving scalability.
2023	SPV's	Avci, Erzurumlu	Proposes a blockchain-based tokenized security design using certificates issued by a Special Purpose Vehicle (SPV) to solutions to legal challenges by tokenization, finance, law.

The general acceptance of blockchain as a dependable, lawful, and secure alternative in real estate transactions is further complicated by general problems with blockchain protocols, such as transaction costs and network scalability. The legal framework must be updated to reflect modern technology in order to overcome these obstacles, and steps must be taken to protect the parties' rights. The application of blockchain

technology creates participant and blockchain network operator legal and regulatory uncertainty. This is mostly because many governments and regulators are still trying to understand blockchain technology and decide whether or not to change current laws to properly account for decentralization. While some governments are at the forefront of the blockchain adoption process , The United States, China, Switzerland, Singapore, and the United Kingdom can be listed as the top five countries (Blockchain-council.org, 2023), a number of national and local regulators are taking a more measured approach, choosing to watch and understand the effects of blockchain technology before enacting new laws and regulations. The lack of regulatory lucidity and the ever-changing legal and regulatory terrain present obstacles for market players, requiring a constant assessment of their participation in blockchain networks (World Economic Forum, 2023).

2.2.1 Fractional ownership

The term "fractional ownership" describes a type of property ownership in which a person owns less than 100% of a real estate asset. According to this model, investors or individuals share ownership of a property, with each owning a particular fractional interest or share. These shares are proportionately determined based on the value of the property and typically represent rights related to ownership. Investors can diversify their investment portfolios, split ownership costs, and use a smaller budget to enter the real estate market with the fractional ownership model. Decisions are made collectively in this model, though stakeholders frequently do not have total control over the property. One financial innovation that stands out for encouraging small-scale participation in real estate investment is fractional ownership.

Lowies et al. (2018) state that a wide variety of investors are drawn to the fractional ownership platform, even with relatively small investment amounts. They predict that fractional investment will probably become a permanent feature alongside conventional routes, influencing future investment strategies, in order to better understand motivations and perceptions. Bramley and Dumlore (2007) examined models based on shared ownership in the UK and found them to be less attractive in

the long run compared to normal purchases. According to them, the spread and adoption of the shared ownership concept depend directly on government support.

2.2.2 Property rights & land registry

The immutable ledger nature of Distributed Ledger Technology (DLT) implementation in blockchain technology indicates that it can be used for land registry records as well. It allows for recording ownership information of properties with specific timestamps for all records without the need for third parties such as notaries and land registry officials present in traditional land registry systems.Unique identifiers, such as parcel and identification numbers, can be safely stored in blockchain technology. Validity checks are made possible by implementable transaction rules, which replicate current Land Registry system procedures.Blockchain has the potential to automate the processing of deeds, particularly in the Netherlands, where stylesheet-based deeds exhibit characteristics akin to those of blockchain transactions.The advantages of blockchain, including automation and security, make it a good choice for updating land registries (Vos,2016).

Table 2.8 : Literature Research Outcomes About Land Titling

Year	Land Titling	Author(s)	Definition
2016	Blockchain Based Solution	Vos	Highlights the importance of legal expertise and checks and balances in implementing blockchain-based solutions in Land Registry cases.
2016	Accurate Records	Rahman,Talukder	Emphasizes the importance of accurate land records in Bangladesh and the role of digitization in resolving land-related conflicts, ensuring secure land ownership and transactions.
2017	Security	Manyilizu et al.	Proposed a model integrates ILMIS(Land Management Information System) with Factom and Bitcoin blockchains for secure land title storage, verification, and cost reduction.
2018	Record Modernization	Benbunan-Fich,Castellanos	Blockchain adoption for land record modernization varies between Honduras-Georgia due to socio-political, technical factors, with Georgia demonstrating successful implementation.
2018	Blockchain Based Solution	Themistocleous	Blockchain is not an illusion but a real solution, and advocates for the adoption of a blockchain-based land registry system in Cyprus.
2019	Transperancy	Thakur,Khadanga	Proposes using Blockchain Technology to address transparency, accountability, and data inconsistencies in India's land records management.
2020	Transperancy	Thao and Phap	Proposes blockchain technology to enhance transparency, efficiency, and trust in Vietnam's land records system, empowering citizens and ensuring the integrity of records.
2022	Security	Shang ,Price	Georgia's blokchain project improving government efficiency-trust with securely stored 1.5 m land titles, highlighting the importance of education,data quality, partner involvement.

With an emphasis on title rights and property registration in public databases, Konashevych (2020) gave a comprehensive overview of the application of blockchain and other DLTs in real estate. It can be utilized to make payments using cryptocurrencies or to store data and applications, such as titles and property rights that can be controlled by smart contracts and tokens. Another distinct perspective on this matter is that, notaries, lawyers, and land registries play crucial roles in traditional real estate transactions by making sure that all legal requirements are met and by providing detailed information about any potential liens.On the other hand, blockchain does not have the intrinsic capacity to inform itself or carry out initial compliance checks with legal requirements. Glaeser et al. (2022) explore the concrete power of land ownership rights by analyzing the rights of possession and transfer in 190 nations, revealing differences and difficulties. Even though transfer barriers and inadequate rights protection exist in many countries, there is a positive trend toward institutional improvement, especially in developing nations. This is consistent with the expectation that technology will reduce the expense of promoting property rights, leading to more effective results worldwide. Garcia-Teruel (2019) states that some suggested remedies include using permissioned distributed ledgers with attorneys or notaries, using oracles to verify events in the real world, and exploring the use of artificial intelligence (AI) to determine the legality of contracts. The use of blockchain technology in real estate transactions opens up new avenues for contract oversight, including the use of artificial intelligence to spot void clauses. There are difficulties in integrating co-ownership and other rights in rem with smart contracts, which calls for the use of "sidechains." One of the main objectives here is to alleviate the burden on the main chain, which becomes increasingly overloaded with rising usage rates. Sidechains can be used to address the most significant challenges faced by blockchains, namely scalability and interoperability.

2.2.3 Security token offerins (STO)

A digital asset that transfers value from an asset to a token and represents ownership or other rights is called a security token. In other words, security tokens are conventional investments like stocks, bonds, or other securitized assets in digital form.

As a similar view, through automation and "smart contracts" in a blockchain environment, STOs serve as digital representatives of asset or right ownership and support regulatory goals of transparency, equity, and market integrity. They also foster innovation and efficiency (Deloitte, 2020). There are several benefits over traditional securities:

1- Tokens are instantly transferable and can be traded on secondary markets around-the-clock;

2- Clearing and settlement take only a few minutes;

3- Tokens can be held personally; brokers and custody accounts are no longer necessary; and

4- The underlying blockchain guarantees transaction transparency (Ante and Fiedler,2020).

ICO vs STO

ICO and STO are two of the blockchain ecosystem's most frequently misunderstood concepts.The distinction between initial coin offerings (ICOs) and security token offerings (STOs) is crucial for the study of entrepreneurial finance, according to Lambert et al. (2021). In an effort to improve upon the drawbacks of initial coin offerings, token offerings have expanded to include security tokens. Participants in an initial coin offering (ICO) are legally recognized donors with restricted rights, whereas STO participants are investors with rights (Lennart,2020). ICOs, or initial coin offerings, are a new type of fundraising for blockchain-based businesses where investors receive digital coins, or "tokens," in exchange for money to support the business. Although there are many other uses for the tokens, utility tokens and equity tokens, which are shares of the company's future profits, are the two most popular uses. Utility tokens are used for the company's products and services once they become available (Gan et al. ,2020). In contrast, a security token offering (STO) is a type of crowdfunding in which tokens are issued and backed by securities or financial assets like bonds or stocks. Compared to initial coin offerings (ICOs), securities laws apply to STOs and offer greater protection to investors.

2.2.4 Special purpose vehicle (SPV)

One of the most significant challenges encountered in the integration of blockchain technology into the real estate sector is its lack of regulation. The inherent legal rights of Special Purpose Vehicles (SPVs) by their nature demonstrate the appropriateness of using SPVs in the development process of this unregulated technology. SPVs are vital components of the real estate industry; they are autonomous entities created for particular functions in real estate transactions. In order to reduce the financial and legal risks involved in real estate ventures, banks, developers, and investors frequently use these specialized companies. SPVs offer a structured and risk-reduced approach to property-based investments by facilitating the smooth transfer and conferment of ownership of real estate assets. The legal framework proposed by Avcı and Erzurumlu (2023) addresses legal challenges in crowdfunding and uses blockchain to address market structure issues. It includes a security token offering and exchange mechanism for real estate tokenization. Prospectuses comply with audit requirements to ensure compliance, and a Special Purpose Vehicle (SPV) pays for the associated costs. Finding real estate, tokenizing it, issuing tokens, buying it, and distributing tokens via the SPV are all steps in the process. Smaller investors can now participate in real estate without the need for an SPV partnership thanks to blockchain tokenized certificates from the SPV that represent the rights to an investment property. The advantages of blockchain technology are maintained in this model, which lowers organizational expenses while improving operational efficiency and transparency.

2.3 Finance

Tokenization of real estate, similar to equity crowdfunding in the finance sector, has become a disruptive force in the real estate market. By using a novel strategy, investors can obtain a portion of real estate assets by issuing tokens based on blockchain technology. It democratizes access to real estate investments, much like equity crowdfunding, allowing a wider range of investors to partake in profitable real estate ventures that were previously only available to larger, institutional players. Tokenization is the process of transforming ownership rights into digital tokens that can be exchanged on blockchain networks. This change brings a more transparent and

effective real estate transaction mechanism in addition to improving liquidity. Moreover, the advent of secondary markets based on tokenization enables investors to exchange these digital assets, resulting in heightened market activity and prospects for diversification. The landscape of real estate tokenization is still developing, but it has the potential to change conventional financing methods and make real estate investing opportunities more accessible to all. According to Baum (2020) creating smaller units out of the asset can increase effective demand. By using crowdfunding technology, one can increase the number of potential investors, create a larger secondary market, increase effective demand in the primary market, and raise the asset's perceived quality.

2.3.1 Blockchain based crowdfunding

Crowdfunding is a type of fundraising that is facilitated by online platforms and utilizes the combined financial contributions of many individuals. The idea behind the concept is that a project or business venture can be funded collectively by a large number of people, each contributing a relatively small amount.

Table 2.9 : Literature Research Outcomes About Crowdfunding

Year	Crowdfunding	Author(s)	Definition
2014	CF Experience	Vogel,Moll	Crowdfunding platforms address transparency and fraud, but concerns about inexperienced investors remain, despite global traction and notable investments in Silicon Valley&Bogota.
2015	Inovation	Maarbani	RECF is booming and poses a threat to traditional real estate models while offering innovative opportunities for participants- investors in the evolving landscape of real estate finance.
2018	Liquidity	Muneeza et al.	Discusses benefits of blockchain in CF, particularly in Shariah-compliant CF in Malaysia, highlighting enhanced security, efficiency, affordability.
2019	Transparency	Creta,Tenca	Highlights the benefits of using blockchain in real estate crowdfunding, such as transparency &efficiency.Digital tokens can enhance liquidity, but regulatory clarity is essential.
2019	Reducing Costs	Roth et al.	RET provides secure ownership, increased share divisibility,functioning secondary market, while reducing costs&intermediary control by separating asset ownership from CF platforms.

By democratizing capital access, this strategy enables a wide spectrum of investors to contribute to projects, inventions, or ideas that suit their interests. A particular kind of crowdfunding called "real estate crowdfunding" adapts this concept to the real estate sector. In this situation, a wide range of investors can provide funds to people and companies looking to buy real estate. Real estate crowdfunding platforms facilitate the connection between prospective investors and property developers or projects, providing a diverse and inclusive means of financing real estate projects, encompassing both residential and large-scale commercial endeavors. In addition to

giving investors the chance to diversify their holdings, this approach makes it easier for real estate developers to raise capital and attract new investors. Vantage Market Research (2023) forecasts that the global real estate crowdfunding market will reach a valuation of USD 161.8 billion by 2030 and will grow at a compound annual growth rate (CAGR) of 45.9% between 2023 and 2030. By 2022, the global real estate crowdfunding market was valued at USD 11.5 billion. Blockchain technology has the potential to change investors' experiences with equity-based crowdfunding. The shortcomings of traditional real estate crowdfunding, such as transparency and liquidity, highlight the use of blockchain and the advantages it can provide.Transparency is a major issue in traditional real estate crowdfunding since investors have little access to project financial health and property details, which makes it difficult to conduct an accurate risk assessment. Furthermore, many investors are now second-guessing their crowdfunding investment choices due to the illiquidity of traditional crowdfunding platforms, which makes it difficult for investors to withdraw their money before the project matures. Investors from anywhere can participate in real estate crowdfunding projects without being restricted by geography or having to rely on middlemen to make connections when blockchain technology is combined with traditional real estate crowdfunding. It also gives users the option to purchase and sell real estate tokens on a secondary market, which removes liquidity concerns by enabling users to withdraw their investments whenever they choose. With some similarities and differences to traditional crowdfunding, blockchain-based crowdfunding, which includes initial coin offerings (ICOs) and security token offerings (STOs), is a noteworthy financing technique. Venslavienė et al. (2023) have identified 21 success factors that can be divided into two categories: those that are specific to blockchain-based crowdfunding and those that apply to both models. Using the VASMA-L weighting methodology, the list was whittled down to 18 factors for a survey. The findings showed that the most important variables for investors in blockchain-based crowdfunding are industry, early investments, and the percentage of retained equity or token. Certain requirements, such as pre-registration and KYC/pre-registration, were deemed less significant. According to Maarbani (2015) the integration of technology into Real Estate Crowdfunding (RECF) platforms has enhanced the online investment experience, enabling investors to make faster and more

informed decisions. The global accessibility of these platforms facilitates connections among investors. The success of crowdfunding platforms in Australia is particularly associated with an innovative approach that combines investment and entertainment, especially through the integration of social media tools. The use of blockchain technology and crowdfunding in the Italian real estate industry is examined by Creta and Tenca (2019), with a particular emphasis on 12 crowdfunding platforms. According to interviewees, blockchain technology works best in the less creative and more stagnant real estate market with high entry barriers, according to their qualitative analysis. They discover that blockchain boosts information process efficiency, transaction immutability, transparency, and lowers expenses and time. One of the major challenges encountered in crowdfunding campaigns is fraud. Saadat et al (2019) applying Ethereum smart contracts to the crowdfunding site to that the contracts are fully automatically executed, thus preventing frauds and ensuring that the projects can be delivered within duration given. Guggenberger et al. (2023) designed an equity token prototype for compare equity crowdfunding and blockchain based version so they show that blockchain-based equity tokens can improve efficiency, transparency, and interoperability while adhering to regulatory requirements and facilitating secondary market trading.

2.3.2 Blockchain-Based secondary market

In the larger ecosystem, the secondary market—where tokenized assets are purchased and sold after the initial issuance—is essential. Token holders can sell or trade their assets without having to wait for the customary sale of the entire asset because it gives them liquidity. This liquidity feature is especially beneficial for investors who want to diversify or sell their holdings. According to the data gathered by Creta and Tenca (2021) from the interviews, having a more liquid secondary market would be extremely beneficial to the real estate crowdfunding industry as a whole. Using tokens to divisible assets could help achieve this goal. The secondary market's settlement and compliance procedures are among the many that blockchain's smart contract technology automates. This simplifies the entire trading process and lessens the need for middlemen. Tokens secured by infrastructure assets can be directly transferred between the wallets of infrastructure investors, provided that there are no legal or

contractual restrictions on the transfers (Tian et al. 2020). All participants can view and record every transaction on the blockchain, making the history of asset ownership and transactions transparent and auditable. Participants in the market gain trust as a result of this transparency. Since blockchain relies on a decentralized network, trading is possible around-the-clock. In contrast, traditional markets offer flexibility to investors worldwide and have set operating hours. Asset tokenization makes fractional ownership possible, allowing investors to hold a stake in valuable assets. As a result, investors have a lower barrier to entry and market inclusivity is improved. Roth et al. (2019) examined how tokenization affected crowdfunding participants: The people who stand to gain the most from tokenization are investors, who stand to gain more features, efficient secondary markets, and safe token ownership. Due to the Blockchain's ability to automate third-party services like banks and clearing houses, costs associated with these services can be greatly reduced (Roth et al.,2019).

Table 2.10 : Highlighted Outcomes in Legality, Land Titling, and Crowdfunding

Subtitle	Year	Author(s)	Outcomes
Legality	2017	Bal	Blokchain technology can contribute to India's economic development through standardized property rights implementation.
Legality	2019	Teruel	Emphasizes the need for a linked official digital ID to prevent unauthorized access.
Legality	2020	Konashevych	To apply blockchain effectively, a strong architecture is crucial for handling data, addressing privacy concerns, ensuring compliance, enabling smart contracts,improving scalability.
Legality	2023	Avci, Erzurumlu	Proposes a blockchain-based tokenized security design using certificates issued by a Special Purpose Vehicle (SPV) to solutions to legal challenges by tokenization, finance, law.
Land Titling	2016	Vos	Highlights the importance of legal expertise and checks and balances in implementing blockchain-based solutions in Land Registry cases.
Land Titling	2016	Rahman,Talukder	Emphasizes the importance of accurate land records in Bangladesh and the role of digitization in resolving land-related conflicts, ensuring secure land ownership and transactions.
Land Titling	2017	Manyilizu et al.	Proposed a model integrates ILMIS(Land Management Information System) with Factom and Bitcoin blockchains for secure land title storage, verification, and cost reduction.
Land Titling	2018	Benbunan-Fich	Blockchain adoption for land record modernization varies between Honduras-Georgia due to socio-political, technical factors, with Georgia demonstrating successful implementation.
Land Titling	2018	Themistocleous	Blockchain is not an illusion but a real solution, and advocates for the adoption of a blockchain-based land registry system in Cyprus.

2.4 Current Real Estate Market in Türkiye

Real estate markets possess dynamics that continuously change under the influence of economic cycles, global events, and local factors. Real estate markets worldwide are influenced by various factors, leading to different trends in different regions. Particularly after the global pandemic, inflation has been experienced worldwide, and its effects on the real estate sector continue to persist. Natural disasters and wars occurring in various regions of the world primarily disrupt daily conditions in their respective areas and subsequently ripple across the globe. The increase in inflation is directly related to the construction and real estate sector. Even under optimal conditions, real estate prices tend to increase in the long term, despite periodic declines, due to population growth and limited capacity for real estate development. Throughout history, real estate prices have constantly changed due to factors such as wars, natural disasters, countries' political stances, inflation, and pandemics. This change generally progresses in the opposite direction of purchasing power, making it increasingly challenging for the middle and lower-income groups to participate in the real estate sector over the years. When evaluated on a Turkish scale, the real estate sector, which faced challenges in 2022 due to the pandemic, high inflation, increased monetary costs, and imbalance between supply and demand, has experienced additional difficulties in the aftermath of Türkiye’s largest earthquake disaster at the beginning of 2023. Migration from earthquake-prone areas to other cities occurred, initiating the reconstruction process of the destroyed cities, accompanied by an observed increase in construction costs. Understanding the current state of real estate markets and being prepared for future trends requires consideration of factors such as the global economic situation, financing conditions, technological innovations, pandemics, natural disasters, and wars from a sectoral perspective. According to the Housing Price Index (HPI) data released by the Central Bank of the Republic of Türkiye (CBRT), which shows that prices for housing in Türkiye rose by 103.64% in May 2023 compared to the same month the previous year. Istanbul saw the highest growth rate during this time, at 95.18%. The Turkish lira depreciated 31.7% in value relative to the US dollar during this time, while inflation was 39.6%. Due to supply shortages, persistent inflation, and high interest rates, the real estate market is still

generally weak. The negative effects of the current supply constraints are being amplified by the increased demand for housing, especially following the February earthquake. Due to supply constraints, it is expected that the rate of increase in housing prices will slow down despite rising interest rates. Ongoing construction projects are still being impacted by the unfavorable market conditions. Construction projects are getting delayed as a result of cost increases and credit availability issues brought on by rising interest and exchange rates. This suggests that the inadequate supply of resources may cause demand to exceed supply in the near future. In contrast to the same period last year, residential sales, which stalled in 2022, continued to decline from January to May of 2023, indicating that the rapid rise in housing costs is likely to continue (Colliers Research Report,2023).

The total number of residential property transactions Between 2021 and 2024, Türkiye has had notable advancements in its economic condition, specifically in relation to inflation and the buying power of housing. The significant inflation rates and devaluation of the Turkish Lira have had a tremendous effect on the purchasing power of individuals, particularly in the real estate sector. Based on statistics from the Turkish Statistical Institute (TUIK), the inflation rate in Türkiye rose consistently during the last months, reaching 69.8% in April 2024, after standing at 47.8% in June 2023. Examining the inflation figures over the last five years indicates that between 2019 and the first half of 2021, inflation remained pretty constant at about 15%. Nevertheless, in the year 2022, it saw a significant increase, surpassing the 80% mark. After experiencing a decline to less than 40% in the latter part of 2023, the percentage increased once again to reach 69.8% in the initial half of 2024. The 10-year graph demonstrates significant increases in inflation beginning in 2021, indicating that despite intermittent decreases, inflation has consistently maintained at a high level.The elevated inflation rate has significantly reduced the country's economy, buying power, and living standards for all individuals. Inflation has had a widespread impact on several sectors, including food, transportation, and housing purchasing power. Notably, it has led to significant cost increases in the building industry. As a result, the increasing cost of housing has encountered difficulty in attracting purchasers.

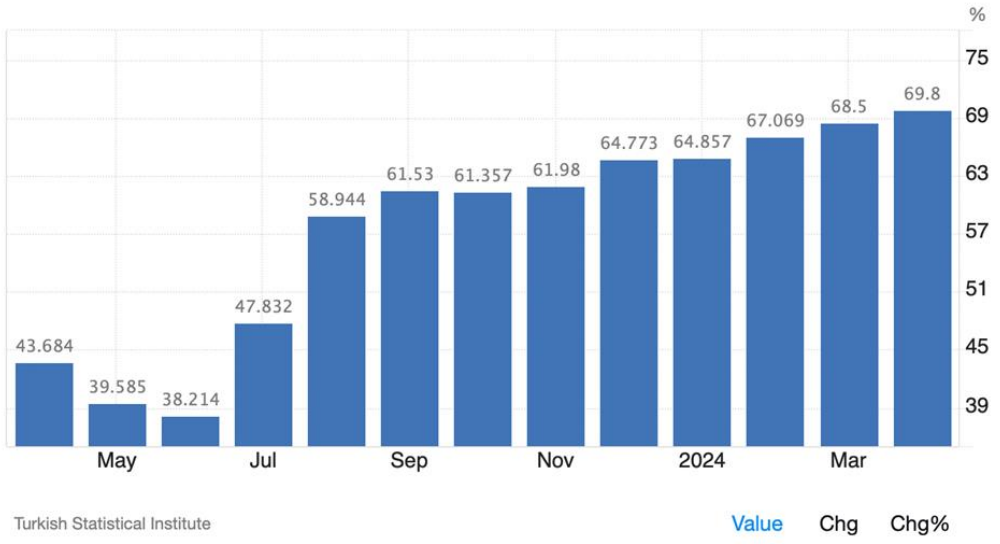


Figure 2.1 : The Inflation Rate in Türkiye Over The Past Year (TUIK, 2024)

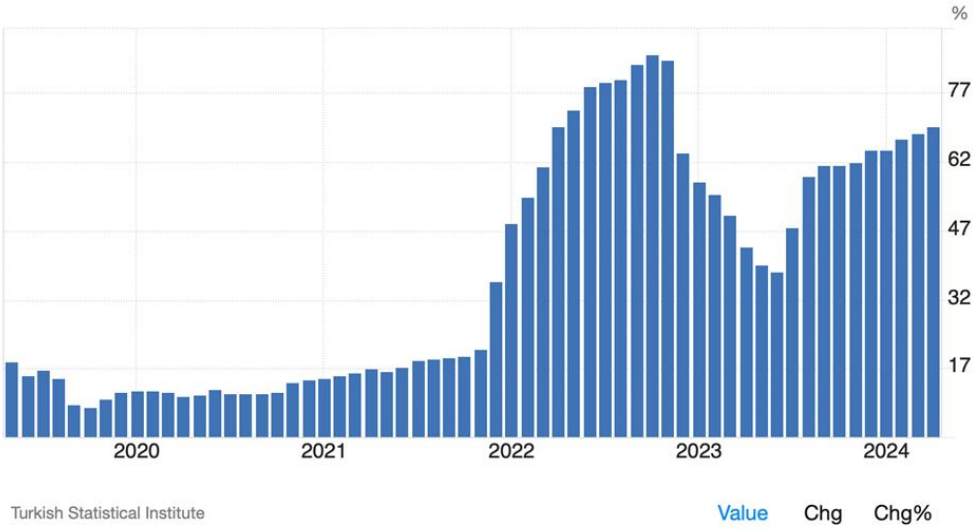


Figure 2.2 : The Inflation Rate in Türkiye Over The Past 5 Years (TUIK, 2024)

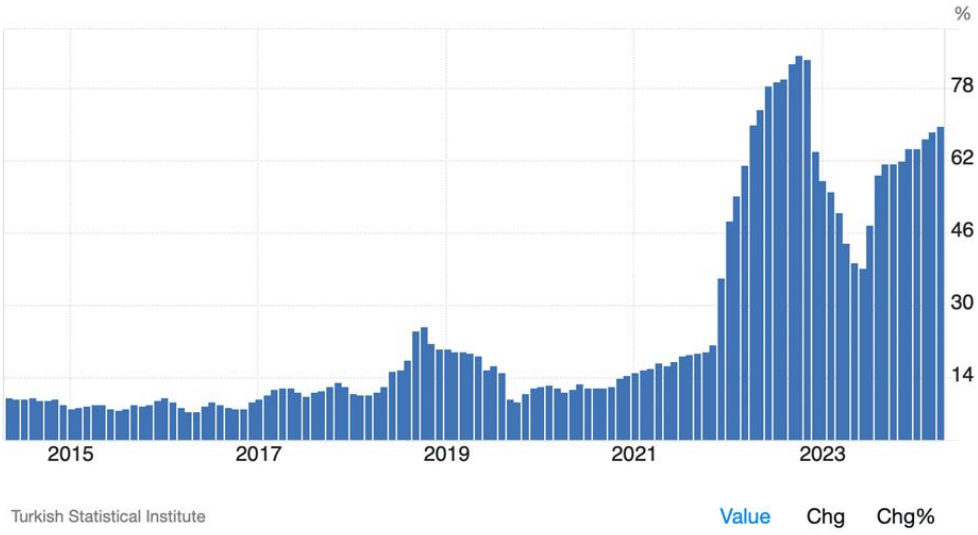


Figure 2.3 : The Inflation Rate in Türkiye Over The Past 10 Years (TUIK,2024)

The housing industry in Türkiye plays a crucial role in the economy and has experienced diverse changes over the past five years. From 2019 to 2024, house sales have experienced substantial transformations as a result of several circumstances. Upon analyzing the most recent 5-year period, a conspicuous decline is shown in the year 2020. The housing market in 2020 saw significant concerns, much like many other industries, as a result of the worldwide COVID-19 epidemic. At first, there was a significant decrease in the demand for housing as a result of the constraints and economic uncertainty brought about by the epidemic. Despite an initial surge in the housing market following the pandemic, sales figures between 2023 and 2024 consistently fluctuated between the range of 97,000 to 137,000 due to significant inflationary pressures.

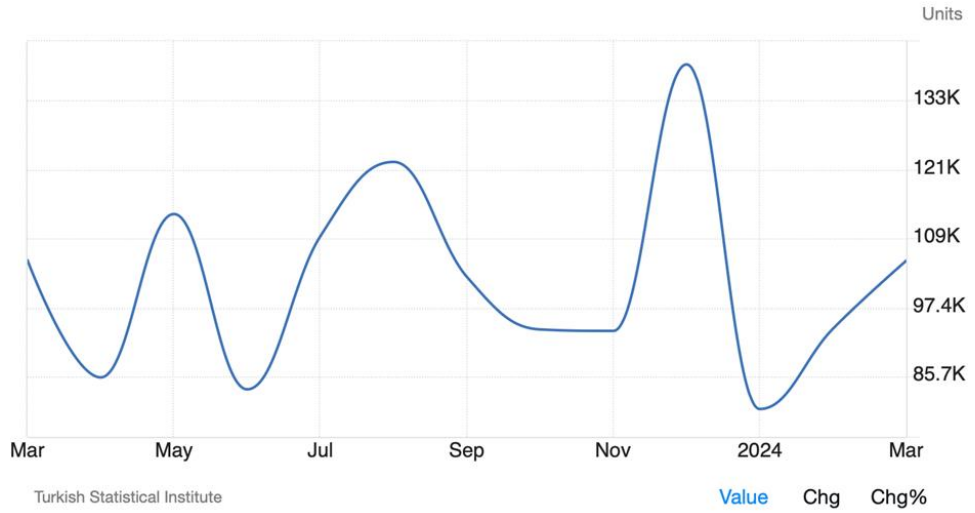


Figure 2.4 : The Number of Houses Sold in Türkiye in the Last Year (TUIK,2024)

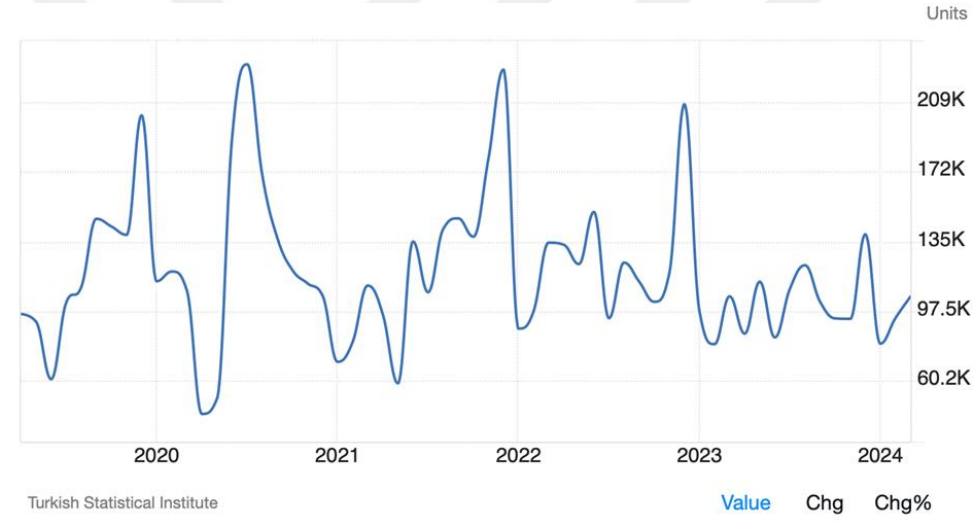


Figure 2.5 : The Number of Houses Sold in Türkiye in the Last 5 Years (TUIK,2024)

The housing industry in Türkiye has historically played a crucial role in shaping the economy. Nevertheless, Türkiye has experienced a notable decrease in homeownership rates in recent years. The decrease can be attributed to a multifaceted interplay of economic, social, and cultural forces. The data from TUIK unequivocally illustrates the decrease in homeownership rates over the last 5, 10, and 25 years. Since 2015, there has been a significant trend in Türkiye where people are facing growing difficulties in achieving homeownership. There are other crucial aspects that contribute to this predicament.First and foremost, the global economic crises and the

regional instability experienced by Türkiye have had a negative impact on the housing sector. Amidst the epidemic, the prevailing economic uncertainty and increasing rates of unemployment have compelled some families to forgo their intentions of purchasing homes.Another contributing reason is the economic instability resulting from elevated inflation rates and variations in currency exchange rates. The devaluation of the Turkish Lira has led to a rise in housing costs and a decrease in the ability to buy, making it challenging for numerous individuals to afford a home.The observed drop can be attributed to income disparity. Income inequalities hinder certain demographic groups from attaining homeownership, hence adversely affecting the overall rates of homeownership.Currently, the rates of homeownership in Türkiye are at their lowest point. Given the present state of the economy, it is anticipated that these rates will continue to decrease. Nevertheless, economic forces alone are insufficient to fully account for this predicament. It is important to consider the social and cultural aspects as well.

The fractional ownership concept is being considered as an innovative solution to the homeownership issue in Türkiye . Fractional ownership enables the division of property ownership among different persons or organizations. This approach offers an appealing option, particularly for young families and low-income individuals who are grappling with exorbitant housing costs and challenges related to accessibility.There are several benefits to fractional ownership. First and foremost, it allows individuals to obtain more economical accommodation by dividing the expenses of housing. In addition, the division of expenses, such as maintenance and repairs, decreases the financial burden on individual owners, so enhancing the probability of homeownership and guaranteeing economic stability.This solution model enables a varied approach to tackling the problem of homeownership in Türkiye . By offering more choices, particularly for young families and persons with modest incomes, it can facilitate the achievement of their goal of owning a home. Nevertheless, the successful execution of the fractional ownership model necessitates the creation of legal norms and suitable infrastructure.Real estate tokenization, the latest advancement in fractional ownership, is an innovative method to address the problem of homeownership in Türkiye . This concept has the potential to enhance the development of a more equitable and

environmentally-friendly housing policy, while successfully tackling the existing obstacles in homeownership in Türkiye .

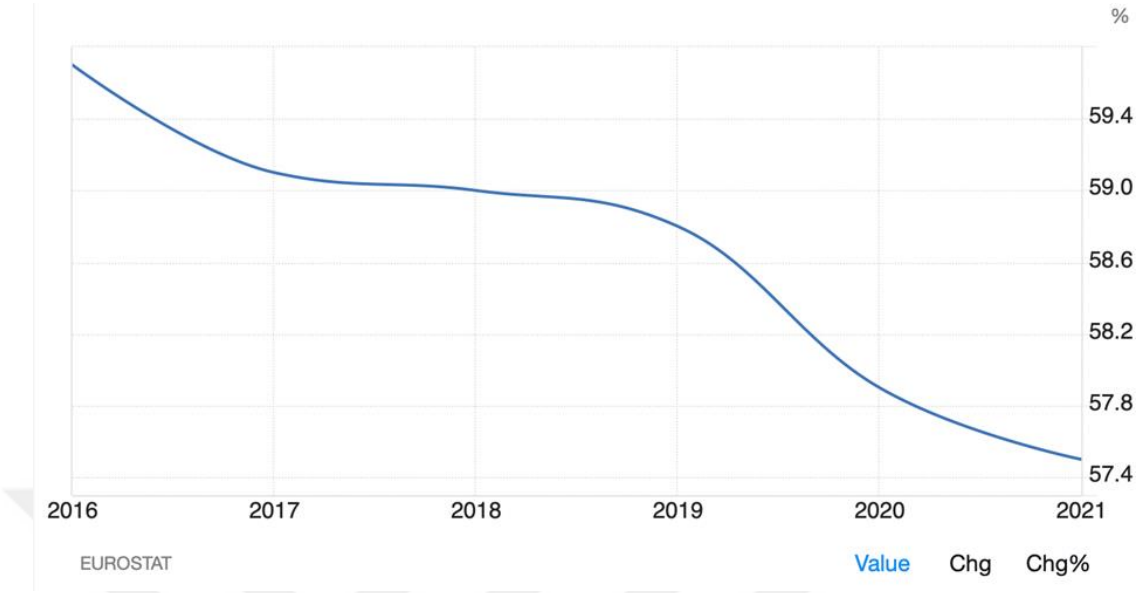


Figure 2.6 : The Homeownership Rate in Türkiye Over the Last 5 Years (EUROSTAT, 2021)

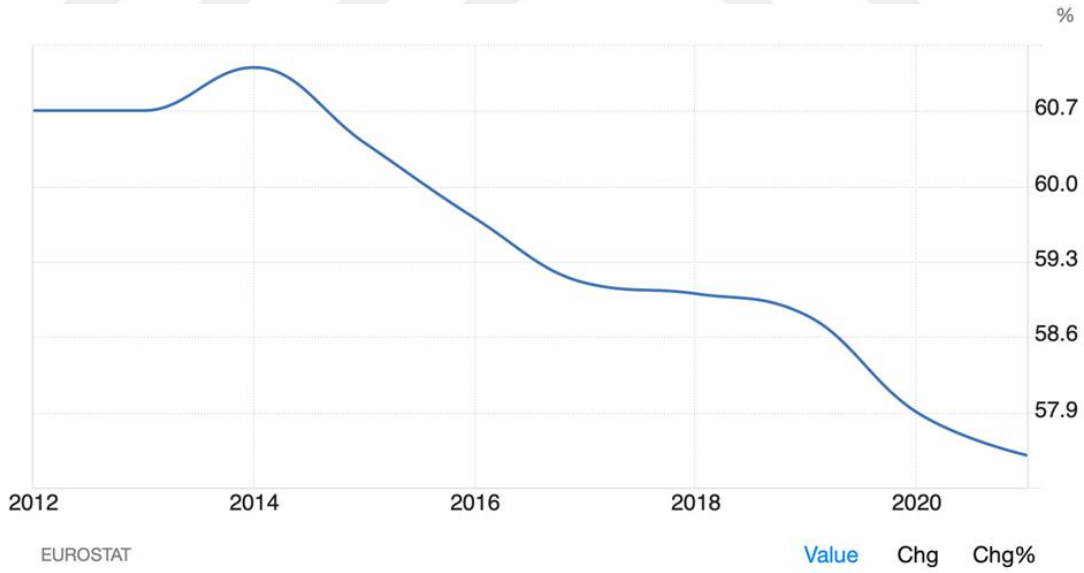


Figure 2.7 : The Homeownership Rate in Türkiye Over the Last 10 Years (EUROSTAT, 2021)

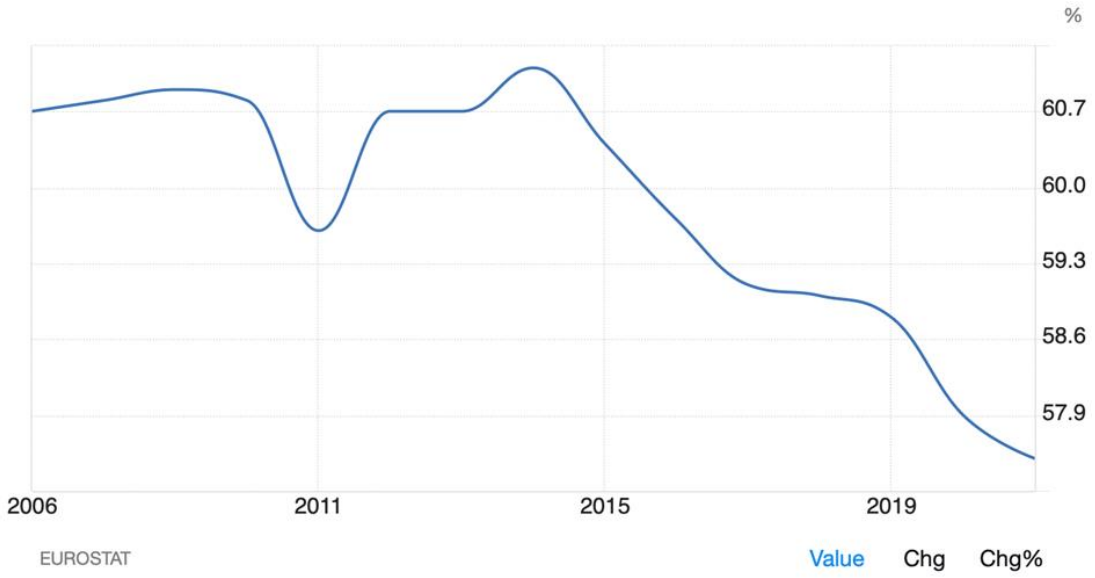


Figure 2.8 : The Homeownership Rate in Türkiye Over the Last 15 Years (EUROSTAT, 2021)

2.4.1 Conventional real estate practices

A traditional real estate purchasing process typically involves several key steps. Firstly, the buyer conducts extensive research to identify a property that aligns with their needs and financial constraints, utilizing resources such as real estate listings, agents, online platforms, and personal connections. Following this, the buyer reviews property listings, assesses photos and descriptions, and initiates contact with real estate agents or sellers to gather additional details or schedule property viewings. Upon finding a property of interest, the buyer conducts an in-person inspection to thoroughly evaluate its physical condition, environmental surroundings, and neighborhood features. Subsequently, armed with this information, the buyer determines the market value of the property and enters into negotiations with the seller. These negotiations continue until both parties reach an agreement on pricing, payment terms, and other relevant details.Once an agreement is reached, the buyer and seller typically sign a pre-contract or preliminary agreement. At this stage, the buyer often engages a real estate attorney to review the property's legal status. Simultaneously, the buyer applies for a housing loan to secure the necessary financing for the purchase, and upon loan approval, the sales process progresses.The final stage involves closing preparations,

during which official documents are prepared, and the attorney reviews title deeds, overseeing the transfer of property ownership between the seller and the buyer.

2.4.2 Real estate investment fund(REIF)

Real Estate Investment Fund (REIF) is a non-corporate entity established for a limited or unlimited duration by portfolio management companies, real estate portfolio management companies, and real estate and venture capital portfolio management companies with the aim of managing a portfolio consisting of assets and transactions determined by the Capital Markets Board of Turkiye (SPK) in accordance with the principles of fiduciary ownership for the account of shareholders, using the funds collected from qualified investors in exchange for their participation shares. REIF does not have legal personality and represents a pool of assets (URL 17).

Real Estate Investment Funds (REIFs) provide investors with a number of benefits. First off, because a REIF invests in a variety of real estate projects rather than just one, it offers investors greater diversification than individual real estate investments. By spreading out the investor's risk, this diversification raises possible returns. Second, investors can sell their shares at any time thanks to the liquidity that REIFs offer. Furthermore, because investors can invest in cheaper REIF shares rather than directly in pricey individual real estate projects, REIFs provide a lower barrier to entry into the real estate market. Because of all these advantages, REIFs are a desirable choice for investors who are thinking about making real estate investments. Real Estate Investment Funds (REIFs) invest in real estate projects with the funds collected from investors and distribute the income generated from these projects to the investors. Fund managers select, manage, and evaluate the projects in the portfolio (Re-Pie). Real Estate Investment Funds (REIFs) invest in real estate projects with the funds collected from investors and distribute the returns from these projects to the investors. Fund managers select, manage, and evaluate the projects in the portfolio (Re-Pie). REIFs can sell the shares they issue to qualified investors as defined in the Capital Markets Board's regulations on Real Estate Investment Funds (III-52.3) published by the Capital Markets Board (SPK).According to the Capital Markets Board's regulations pertaining to investment institutions, a qualified investor is any individual or legal

entity, as well as any professionals who are in high demand. Qualified investors are people and legal entities holding at least one million Turkish Liras in Turkish Liras as well as other currencies and capital market instruments (CMBT).

2.4.3 Growth of REIF's in Türkiye

In Türkiye , the amount of real estate investment funds has grown dramatically in the last several years. This rise is linked to the increasing interest in Turkish real estate projects from both local and international investors. Investing in large-scale real estate projects not only boosts cash but also strengthens trust in the business. The significance of real estate investment funds is closely tied to their role in fostering the advancement of the real estate industry and promoting economic progress in Türkiye . Real estate investment funds in Türkiye are regulated and implemented as a way to enable fractional ownership. These funds enable investors to easily invest in real estate projects and help them to develop and expand these initiatives by giving financial resources to the sector. Moreover, real estate investment funds provide investors with the chance to establish diverse investment portfolios and allocate risks.

Table 2.11 : REITs in Türkiye ,(GYODER,2023)

Reif Founder	Total	Reif
Re-Pie Portföy	28	Anadolu Stratejik, Asya Stratejik, Atar, Atış Invest Downtown AVM,Avrasya Stratejik,Avrupa Stratejik, Downtown Ofis, Fırat, İzmir Tarihi Kemeraltı, Levent, Meriç , Efor, Milenyum, Nef, Neva, Novada, Urfa, Sampaş Holding Özel, Trakya, Turesif, Yıldız, Dicle, Fırsat, Downtown Otel,Emlak Katılım, İzmir Kemeraltı, Ayaz ,Seyhan
Albaraka Pyş	19	Albatros, Anadolu, Anka, Arsa Kapısı, Batışehir, Bereket, Belinci Karma, Dükkan, Eksim, Goldeo, İkinci Karma, Karma, Metropol, One Tower, Rana Tm, Üçüncü Karma, Altıncı Karma, Onuncu Karma
24 Gyspyş	15	A1, Akasya, Altın Başak, Alzamil, Ayçiçeği, Erguvan, Fulya, Kardelen, Lotus, Menekşe, Nilüfer, Portakal Çiçeği,Primo, Lale
Neo Pyş	15	Altıncı, Avantaj, Beşinci, Birinci, Birinci Nef Arsa, Birinci Tekçe Arsa, Cornerstone, Dördüncü, Fırsat,İkinci, Sekizinci, Turkuaz, Üçüncü, Vartur, Yedinci
Nurol Pyş	14	Aks, Birinci, Charm, D Vizyon, Egç Konut, Fortis, M Charm, Nurol Tower, Oc Hedef, Z Rezidans, Altıncı, Beşinci, İkinci, Üçüncü
İş Pyş	7	Beşinci, Birinci, Dördüncü, İkinci, Quasar İstanbul Konut Katılım, Quasar İstanbul Ticari, Üçüncü
Arz Pyş	6	Altıncı, Beşinci, Birinci, Dördüncü, İkinci, Üçüncü
Atlas Pyş	4	A&Ak, Esta, Güney, Sağlam
Ak Pyş	3	Birinci, Dördüncü, İkinci
Aura Pyş	3	Konut Alfa Katılım, Kuzey Ege, Odak Konut
Hedef Pyş	4	Birinci,Form, İkinci, Üçüncü
Maqasıd Pyş	3	İttihad, Meydan, İmar
Omurga Pyş	3	Çatı Katılım, İkinci, Ufuk Karma
Ziraat Pyş	4	Başak Katılım Gayrimenkul, Tzhemsan Özel, Üsküdar Bgf
Aktif Pyş	2	Birinci, İkinci
Kızılay Pyş	3	Birinci, İkinci, Üçüncü
Rota Pyş	2	Birinci, İkinci
Ünlü Pyş	2	Birinci, İkinci
Qınvest Pyş	2	İkinci Re-Pie, Re-Pie
Foneria Pyş	2	Birinci, İkinci
Ft Pyş	2	Birinci, İkinci
Wam Gypyş	2	Birinci, İkinci
Akfen Pyş	1	Birinci
Allbatross Pyş	1	Birinci
Inveo Pyş	1	Nefes Ege
Oragon Pyş	1	Birinci
Oyak Pyş	1	Birinci
Tera Pyş	1	3b

According to the Real Estate Investment Trusts Association's (GYODER) second-quarter report , there are 144 real estate investment funds in total, including those that are in the issuance period and those that have received investments for the first time. GYODER supports the real estate sector's development in Türkiye and adds value to the economy of the nation. Real Estate Investment Funds (REIFs) now total 43.1 billion TL, a 15.6% increase over the previous quarter. Since the fourth quarter of 2018, the entire size of the REIF market has been observed to grow positively every quarter, up until the first quarter of 2023. According to the second-quarter figures for this year, the REIF market size increased by 179% from 19.8 billion TL to 43.1 billion TL in comparison with the same quarter in 2022.

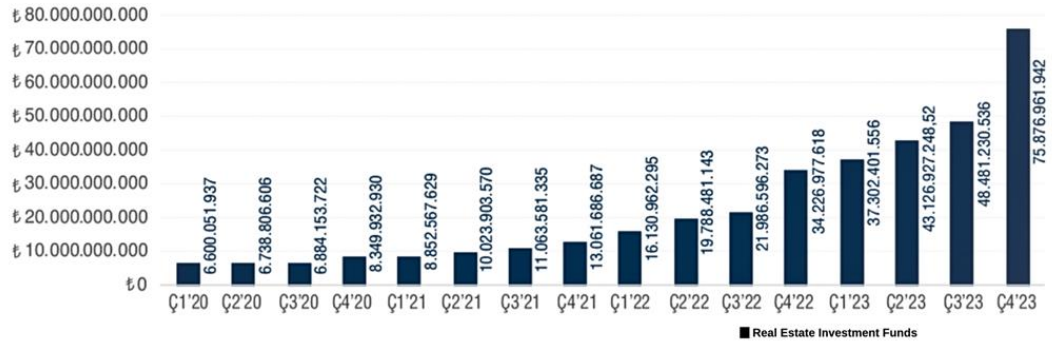


Figure 2.9 : REIFs Total Amount in Türkiye ,(GYODER,2023)

The Borsa Istanbul Qualified Investor Transaction Market offers trading for seven different real estate investment funds. The REIFs listed on the NYIP are: Albaraka Portfolio Management Batışehir REIF (ALBTS), Albaraka Portfolio Management Shop REIF (ALDUK), Albaraka Portfolio Management One Tower REIF (ALONE), Fiba Portfolio Management Inc. Re-Pie REIF (FPREP), Qinvest Portfolio Management Re-Pie REIF (QPERP), and Mükafat Portfolio Management Ataşehir Metropol REIF (MPATA). In Türkiye , Real Estate Investment Funds (REIFs) are generally available for investment through intermediary institutions like banks, brokerage houses, online trading platforms, and portfolio management firms. The first step is to open an account with a bank or brokerage company. Typically, these establishments provide their customers with a range of REIF options, enabling them

to invest in these funds via online trading platforms.Moreover, portfolio management firms that oversee REIFs are direct sources of application. You can get comprehensive information about the funds that are right for you, their track records, and risk factors by getting in touch with these companies. When investing in REIFs, financial advisors can also offer guidance. A person looking to invest in a Real Estate Investment Fund (REIF) has two options. The first option is to invest directly, meaning through contact offices. In this option, the investor must first provide a signed statement to the fund company declaring that they are a "qualified investor." Subsequently, the investor needs to open a custody account at a bank. To open the account, the investor must submit a set of documents, approximately one hundred pages long, with wet signatures. After the account opening process, the investor is required to transfer the investment amount to the relevant custody account. The entire process is completed when the fund company transfers the corresponding shares to the investor's account, following the completion of the fund transfer. Real Estate Investment Fund purchase transactions typically take around 1-2 business days. The second option is for the investor to purchase Real Estate Investment Funds through their investment account with a bank or brokerage firm. Investors who do not already have an investment account need to complete the suitability and appropriateness test according to the regulations of CMBT Law No. 6362 through the relevant bank or brokerage firm platforms. This process is usually completed within approximately 1 business day. As of 2023, out of a total of 144 real estate investment funds, only 7 are traded on the Borsa Istanbul (GYODER, 2023). As seen from the relevant metrics, investors using this channel have fewer options compared to the other method. Together with helping you create your investment strategy, they can help you identify the funds that suit your preferences. Lastly, the majority of Turkish banks and other financial institutions advise their customers about investment products. You can learn more about the characteristics and benefits of REIFs by getting in touch with these institutions.

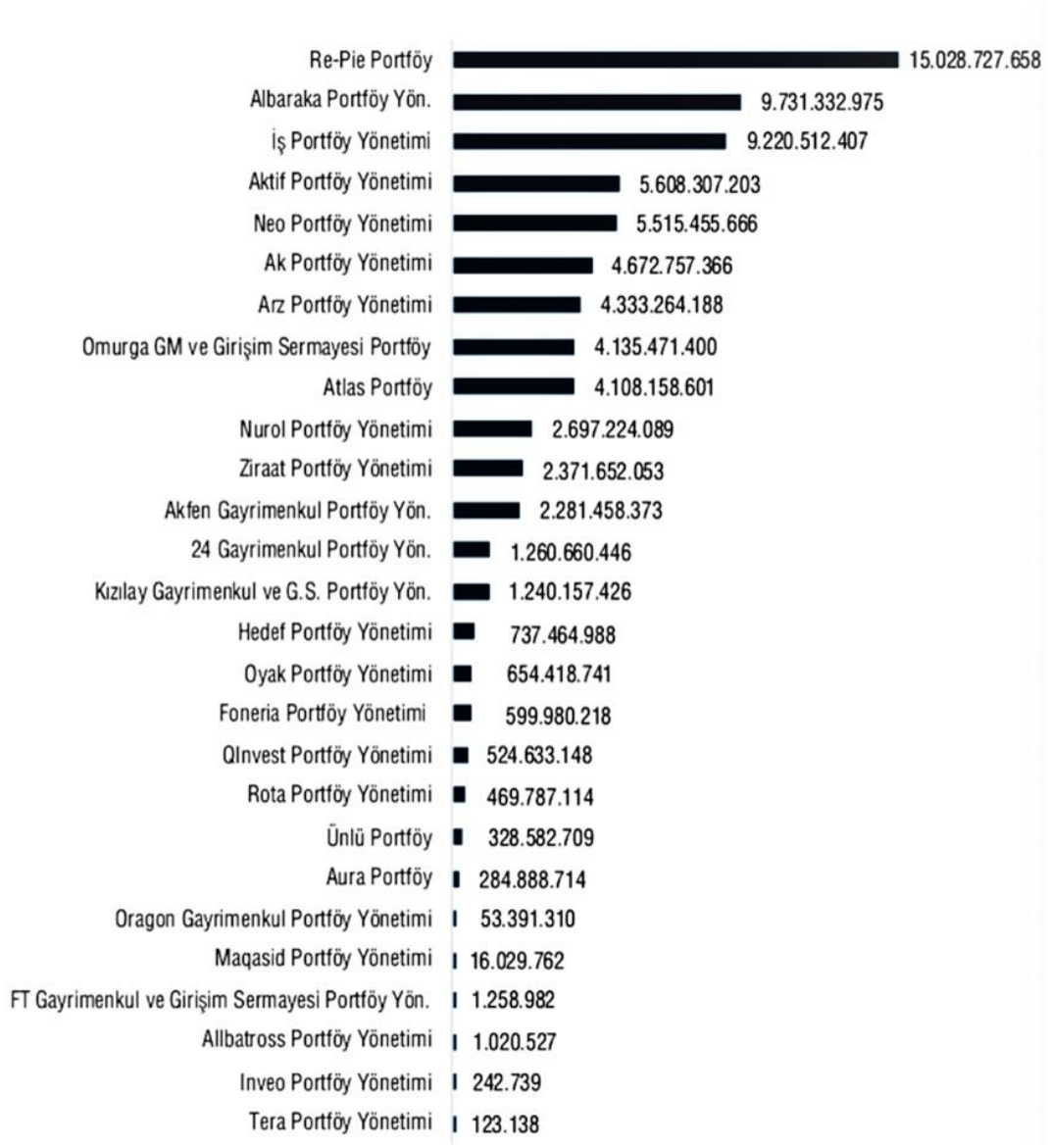


Figure 2.10 : Ranking of REIFs in Türkiye by Volume,(GYODER,2023)

3. METHODOLOGY

3.1 Real Estate Tokenization

Blockchain is widely used, among other things, to track who owns electronically transferred property, such as fractionalized securities like stocks, bonds, and real estate. The process of digitally representing a fractionalized security on a blockchain is known as tokenization.The fractionalized security would then be represented during that process by a token (henceforth referred to as a "tokenized fractionalized security"), which could be sold to potential investors for trading or financing via various platforms. Instead of using paper, the token itself functioned as ownership proof. (OECD, The tokenization of Assets and Potential Implications for Financial Markets, 2020). A digital revolution known as tokenization makes it possible to invest in and own real assets in fractions. Investors can profit from the security, liquidity, and immutability of cryptocurrencies by expressing these assets as digital tokens on the blockchain. The innovative idea of tokenization acts as a link between physical assets and the digital realm. It entails utilizing blockchain technology to convert legal or tangible rights into digital tokens. This process redefines ownership, investment, and transferability with a number of important features. Tokenization makes it possible to "fractionalize ownership" of real assets, allowing people with small initial investments—such as $5,000—to fractionally buy real estate. Buying small pieces of an asset is difficult in the traditional market. Assets like a $200,000 apartment can be tokenized to create digital tokens that each represent a portion of the asset's value. This makes trading on blockchains with smart contracts simple (Sazandrishvili 2020).

Table 3.1 : Literature Research Outcomes About Tokenization

Year	Tokenization	Author(s)	Definition
2019	Benefits& Challenges	Morena et al.	Offers benefits of auditability, reduced bureaucracy, improved settlement processes, transparency, accuracy, security, but challenges of decentralization, regulation, standardization.
2020	Liquidity	Tian et al.	Analyzed ZiyenCoin, an SEC-compliant energy asset security token, identified the benefits of tokenization for infrastructure assets, including improved liquidity, efficiency,transparency.
2020	Cross-Blockchain	Konashevych	Proposes a cross-blockchain protocol for asset transferability, enforceability, and resolution of legal disputes.
2020	Benefits	Baum	RET has potential but requires time for development&acceptance, with immediate opportunities in funds, debt, utility tokens; adoption commercial asset tokenization may take longer.
2022	Fractional Ownership	Mistrangelo et al.	Property tokenization facilitates fractional ownership through NFTs, integrating assets digitally to address real estate market barriers and promote sustainability and social inclusion.
2022	Challenges	Lu	RET in China face obstacles such as profitability, policy, financing, risk, which impede their widespread adoption despite offering higher returns but also higher risks.
2022	Benefits	Saari et al.	26 empirical evidence for transactions&tokenization show potential to rise efficiency, transparency, security i, observed that necessitate institutional changes&complementary tech.

3.1.1 Understanding “tokenization” : benefits and challenges

To understand tokenization, it's essential to discuss its significant benefits first. Blockchain technology itself is a compelling argument due to its inherent principles. This is followed by smart contracts and the digital representation they provide, reducing the need for intermediaries, offering worldwide accessibility, and consequently increasing liquidity. Blockchain is a distributed and decentralized ledger technology that is used in tokenization. This guarantees the safe storage and easy verifiability of token-related data, including ownership and transaction history. An integral part of tokenization are smart contracts, which are self-executing agreements with the terms of the agreement encoded directly into the code. They streamline and expedite transactions by automating and enforcing the token's rules. Tokenization revolves around the creation of digital tokens that stand in for rights or assets in the real world. Konashevych (2020), the token as defined as a unit of account and a container for user information. Since blockchain technology is often used to create these tokens, immutability, security, and transparency are guaranteed. Tokenization eliminates the need for middlemen like banks and brokers by leveraging blockchain technology and smart contracts. This reduces expenses and simplifies procedures. The process of tokenization makes investments accessible worldwide. Investors from all over the world can participate in the ownership of assets without the usual barriers thanks to tokens traded on blockchain platforms. Conventional assets, such as artwork or real estate, are frequently illiquid. On the other hand, tokenization enables fractional ownership of these assets, enabling a wider range of investors to take part and trade in smaller amounts. An integral part of tokenization are smart contracts, which are self-executing agreements with the terms of the agreement encoded directly into the code. They streamline and expedite transactions by automating and enforcing the token's rules.

Real estate tokenization is an innovative approach that not only provides various opportunities for investors but also supports the growth of the sector. However, it comes with some notable controversial elements that cannot be ignored. Like any innovative application, tokenization faces challenges, and what is crucial here is the discussion of how to generate solutions to these challenges. The idea of tokenizing real

estate is still relatively new, and widespread adoption is not yet realized, despite the potential advantages. Tokenization platforms must raise awareness among institutional investors, real estate developers, and the general public. The lack of standardized and clearly defined regulations is a significant obstacle to real estate tokenization. The legal framework surrounding the tokenization of real estate assets is often uncertain, and opinions on blockchain technology and cryptocurrencies vary across different jurisdictions. Due to concerns about potential legal consequences, real estate developers and investors may be hindered from adopting tokenization platforms due to this regulatory uncertainty. The traditional law does not provide provisions for fully digitized asset ownership, including smart contract validation, so additional regulations are required for asset ownership transfers and tokenizing financial assets like shares and currencies (Heines et al 2021). Lack of established tokenization protocols can lead to problems with interoperability and make it more difficult for tokens to be transferred between platforms easily. To guarantee compatibility and enable a more robust ecosystem, common standards for real estate tokens must be established. The potential for real estate tokenization to completely transform how we engage with and invest in real estate assets is enormous. But industry participants, including investors, developers, and regulatory agencies, must work together to overcome the obstacles mentioned above. To fully reap the benefits of real estate tokenization, these issues must be resolved as the industry develops and legislative frameworks change. The lack of well-established valuation models makes it difficult to determine the fair value of tokenized real estate assets. There may be uncertainty in pricing if conventional real estate valuation techniques do not transfer well into the tokenized environment. It might be challenging for investors to determine the actual value of their tokenized holdings.Tokenization attempts to improve liquidity by facilitating easier asset transferability and fractional ownership. Tokenization does not, however, automatically result in true liquidity in real estate markets. Challenges include the requirement for a thriving secondary market and the illiquid nature of some real estate assets. If there isn't enough demand or the market isn't developed enough, investors might have trouble selling their tokens. Real estate and other tangible assets are not immediately affected by tokenization in terms of liquidity. As trading volume and participant count rise, liquidity also rises (Morena et al.,2020). Tokenizing real

estate significantly depends on smart contracts to automate and carry out a number of tasks, including voting, ownership transfers, and dividend distribution. However, there are risks associated with smart contracts due to their inherent complexity and the possibility of coding errors or vulnerabilities.

This situation can explain this situation as follows :Modifications to smart contracts are almost impossible to make once they are deployed on blockchains. Thus, before smart contracts are formally deployed, it is crucial to assess their correctness. The complexity of modeling smart contracts makes it difficult to confirm that they are correct, though.

In addition to causing financial losses, security lapses or contract violations could undermine confidence in the tokenization ecosystem.

3.1.2 Successful tokenization cases

Real estate tokenization has emerged as a transformative and impactful phenomenon in the global real estate market, offering benefits such as increased liquidity, accessibility, and process efficiency. Although specifics such as ownership numbers and token costs might differ from case to case, tokenization's main objective is to lower barriers to entry and democratize real estate investing. Blockchain technology makes fractional ownership opportunities in high-value real estate accessible to investors, fostering a more diverse and inclusive investment environment. It is imperative that participants possess an understanding of the dynamic nature of these projects, though, as their success is contingent upon a number of variables, including market conditions, regulatory frameworks, and the capacity of platforms to forge trust among stakeholders and overcome obstacles.Real estate tokenization is redefining how people view real estate globally as the industry keeps moving in this direction, straddling the boundary between innovation and conventional asset classes. The noteworthy real estate tokenization initiatives that have been successful globally are listed below

Table 3.2 : Successful Tokenization Cases (Avcı and Erzurumlu, 2023)

Promoter	Domicile of Promoter	Label	Type	Size(€)
Aspen Digital	United States	Aspen Coin	Single Asset	16,330,200
Blockimmo	Switzerland	Hello World	Fund	2,705,600
Blocksquare	Slovenia	Techpark	Single Asset	15,001
Bolton	United Arab Emirates	Bolton Coin	Debt	61,537,800
Brickblock	Germany	Peakside Fund	Fund	2,200,000
BrickMark	Switzerland	BrickMark	Single Asset	110,000,000
Equitybase	Hong Kong	BASE	Fund	5,290,300
Evarei Management	Cayman Islands	Evareium	Fund	1,814,500
Fraxtor	Singapore	Fraxtor	Single Asset	small
iCap Equity	Washington, US	iCap Equity	Fund	1,130,000
Max Property Group	Netherlands	Max Propert Fund	Fund	6,090,000
Peakside	Germany	Peakside Fund IV	Fund	up to 200m
Property Token SA	Luxembourg	Belval	Single Asset	small
Quantum RE	United States	QuantumREIT	Fund	20,000,000
Resolute	United States	Resolute Fund	Fund	up to 100m
Shoijin	United Kingdom	Smartlands PBSA	Single Asset	1,000,000
SocialRemit	United Kingdom	CSR	Single Asset	2,078,700

source:Oxford

3.1.3 General steps of real estate tokenization

A Real estate tokenization requires a versatile technological strategy to ensure the safe and effective transformation of physical assets into digital tokens. Here, the steps involved in the real estate tokenization process are thoroughly examined in detail:

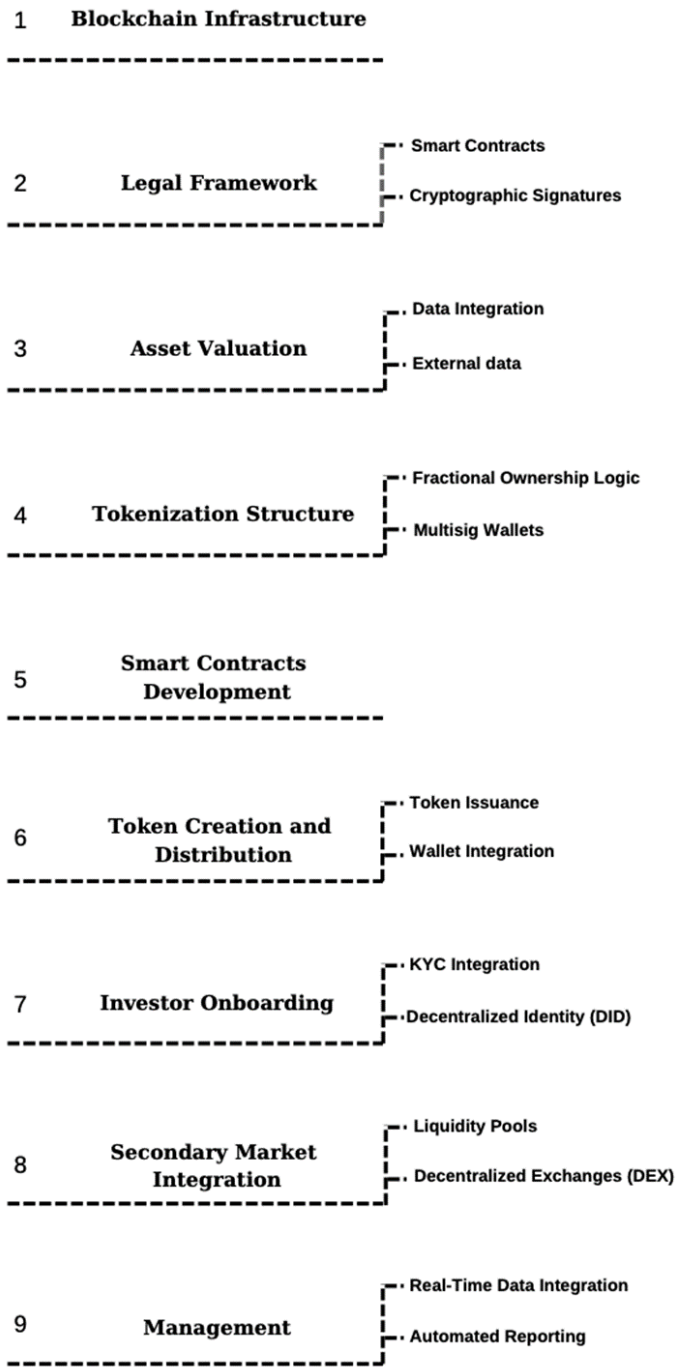


Figure 3.1 : General Steps of Real Estate Tokenization

The first step in the process is to choose and set up a strong blockchain infrastructure. The fundamental technology is blockchain, which offers a secure and decentralized ledger for recording and managing tokenized real estate assets. Because of their ability to support smart contracts, Ethereum and other blockchain platforms are frequently used for tokenizing real estate. Real estate tokenization requires the establishment of a clear legal framework. To make sure that tokenized assets abide by current laws, regulatory compliance and legal issues need to be carefully considered. The use of smart contracts and cryptographic signatures are fundamental elements in establishing a legal framework. Use smart contracts to incorporate contracts into the blockchain. Unwavering compliance is ensured by these contracts' automatic execution and enforcement of predetermined legal conditions. Digital signatures using cryptography can be used to validate and authenticate legal documents, ensuring the security and integrity of blockchain agreements. The real estate asset is carefully valued before tokenization. In doing so, the market value of the property, its prospective revenue, and any related liabilities must all be evaluated. Tokenization structure and the value that each token represents must be determined with precision in valuation. To determine the fair market value of the real estate asset, incorporate up-to-date market data and use sophisticated property valuation algorithms.In addition, providing a safe way for external data, like property values and rental income, to be external data incorporated into smart contracts through an external data feed. This guarantees valuations that are precise, timely, and appropriate given the state of the market. Tokenization structure definition creates a framework allowing real assets to be divided into more manageable and exchangeable parts. This framework includes the quantity of tokens representing ownership and the fractional ownership model. Additionally, it should encompass factors such as voting rights, profit shares, and other benefits associated with token ownership. Develop the smart contract logic necessary for overseeing fractional ownership, detailing how tokens represent ownership shares and how profit shares and voting rights are allocated. Enhance security by requiring the use of multiple private keys to approve significant transactions, achieved through the utilization of multisignature wallets. A key component of tokenization in real estate is smart contracts. The terms of the tokenized asset are enforced and automated by these self-executing contracts. Processes like ownership transfers, profit sharing, and

other predetermined conditions decided upon in the tokenization structure are made easier by smart contracts. The process of creating tokens begins once the smart contracts and tokenization framework are in place. Each token represents a portion of the real estate asset. Investors are then provided with these tokens, allowing them to participate in the ownership and potential profits of the property. Smart contracts or scripts are created to issue tokens in accordance with the tokenization structure. The overall distribution and supply strategy are specified. Secure wallet integration is carried out to assist investors in safely storing their digital tokens.

A user-friendly onboarding platform should be developed to draw in investors. Through a quick and safe process, investors can register on this platform, complete the required KYC (Know Your Customer) procedures, and purchase tokens. By using decentralized identity solutions, users can keep control over their personal data while improving security during the onboarding process. Utilizing blockchain-based identity verification to integrate Know Your Customer (KYC) procedures guarantees regulatory compliance. The trading of real estate tokens may be facilitated by the integration of a secondary market or token exchange platform. By giving investors the flexibility and exit options to buy or sell their tokens, this marketplace improves liquidity. To enable the trading of real estate tokens, implement liquidity pools utilizing decentralized finance (DeFi) protocols.Combine with decentralized exchanges to offer a safe and open real estate token trading environment.

Post-tokenization, continuous management of the asset is essential. This includes periodic updates on the property's performance, profit distribution, and adherence to regulatory changes. Smart contracts can automate many of these management functions.:Continuously integrate external data feeds to update property performance information on the blockchain, enabling smart contracts to adapt to current conditions. Implement mechanisms for automated reporting to deliver regular updates to token holders regarding property performance and financial status.

3.1.4 Similarities & differences: fractional ownership vs. tokenization

According to Baum (2020), tokenization has two meanings in the context of real estate technology today: it can refer to the fractionalization of property rights or the digital representation of asset ownership. A notion that existed before tokenization is fractional ownership, which is the division of a physical asset's ownership into smaller, exchangeable portions. Although its goals are similar to those of tokenization, there are clear variations in how they are carried out. By enabling people to participate with smaller sums of money, tokenization and fractional ownership seek to democratize investing. Similarities are facilitating the trading of smaller ownership units, both ideas help to increase liquidity in markets that have traditionally been illiquid. There are as many similarities as there are fundamental differences between Fractional Ownership and Tokenization. Legal agreements and centralized databases can be used to manage fractional ownership without necessarily utilizing blockchain technology. Conversely, tokenization is intrinsically linked to blockchain technology. Tokenization uses blockchain transactions to quickly and transparently transfer ownership. Legal procedures that are more traditional and possibly time-consuming may be involved in fractional ownership. Tokenization frequently incorporates smart contracts, which automates a number of procedures. This degree of automation may not exist in fractional ownership, which depends more on conventional legal frameworks.Due to tokenization's blockchain foundation and intrinsic digital nature, it provides global investment opportunities. Fractional ownership is frequently restricted to particular markets and legal environments.

In conclusion, tokenization and fractional ownership have similar objectives, but they differ in the technologies and approaches they employ. By utilizing smart contracts and blockchain technology, tokenization pushes the limits of efficiency and accessibility in asset ownership and investment. Fractional ownership, on the other hand, is a more conventional strategy with some restrictions on automation and access to international markets.

3.1.5 Traditional institutions and roles in Türkiye

The concept and practices of regulated fractional ownership persist in Turkiye. There are several entities and institutions that have been granted different rights and authority by the government to carry out these actions. An essential initial stage in Real Estate Tokenization involves accurately analysing current fractional ownership patterns and placing emphasis on the responsibilities played by the institutions involved in these activities. Blockchain applications that align with the functions of these organisations can be discovered. Prioritising the analysis of the components of the current system is crucial. These components include the Capital Market Board of Türkiye (SPK), Istanbul Stock Exchange (Borsa Istanbul), Central Authorised Clearinghouse (Takasbank), Central Registry Agency (MKK), Portfolio Management Company, and Real Estate Investment Fund (REIF).

The Capital Markets Board (CMB) was established on July 26, 1981, with Law No. 2499 on Capital Markets to regulate and supervise the participation of savings in economic development by investing in securities, ensuring effective and widespread participation of the public. The main goals of the CMB are to ensure the proper functioning of capital markets and institutions in terms of trust, transparency, and stability, as well as to regulate and supervise the protection of the rights and interests of savers. The CMB is an autonomous public legal entity with administrative and financial autonomy, performing its assigned duties and exercising its powers independently. The Ministry responsible for the CMB is the Ministry of Treasury and Finance. The headquarters of the CMB is located in Istanbul. In line with the objectives of ensuring the trustworthy, transparent, and stable operation of the capital market and protecting the rights and interests of savers or investors, the main purposes of the CMB are:

- To determine the operating rules of capital markets and institutions,
- To ensure that companies benefiting from funds from the market benefit optimally in compliance with certain rules,
- To protect the rights and interests of savers investing in the capital market,
- To ensure the fair and efficient operation of markets.

The main objective of Borsa Istanbul is to facilitate the practical and effective buying and selling of various assets eligible for trading on the exchange, including capital market instruments, foreign exchange, precious stones and metals, contracts approved by the Capital Markets Board, and other documents within the framework of existing laws. This is aimed to be achieved within a stable and reliable environment where the principles of free competition are valid. Borsa Istanbul's fundamental activities include facilitating the convergence of buying and selling orders for these assets, establishing and developing various markets, platforms, and marketplaces to determine and announce the resulting prices, and managing and operating stock exchanges and stock markets. The institution is regulated by the Capital Markets Board in accordance with the principles of the Capital Markets Law.

The cash and securities settlement of transactions taking place on the stock exchange is carried out on the second business day following the trading day, at the Istanbul Settlement and Custody Bank Inc. (Takasbank). Takasbank is the central depository responsible for the settlement of commitments related to the delivery of securities and payment of the proceeds arising from the buying and selling transactions conducted on the stock exchange. It is also the central depository mandated for the physical custody of securities traded on the Borsa Istanbul (BIST).

The Central Securities Depository (MKK) is a central structure designated by law to carry out the registration of capital market instruments issued through public offerings, recording these instruments in accounts opened on an owner-by-owner basis, monitoring the rights associated with them, and legally finalizing the records. In other words, it is a centralized system where securities are issued, held in accounts on an owner-by-owner basis, transferred, and rights related to them are established. With this structure, MKK serves as Türkiye’s Central Securities Depository.

Portfolio management companies, as defined in Article 55 of Capital Markets Law No. 6362, are publicly traded companies with the main activity of establishing and managing investment funds. Portfolio management is defined as the delegation of managing portfolios consisting of capital market instruments and other assets and transactions approved by the Capital Markets Board, in accordance with the risk-return

preference determined by the investor or portfolio manager, within the framework of a portfolio management agreement to be concluded with clients.

A Real Estate Investment Fund (REIF) is an asset pool established for a specified or unspecified period by portfolio management companies, real estate portfolio management companies, and real estate and venture capital portfolio management companies. These funds operate with the aim of managing a portfolio consisting of assets and transactions determined by the Capital Markets Board (CMB) under the principles of fiduciary ownership, using the funds collected from qualified investors in exchange for participation shares. This entity does not have legal personality.

3.1.6 Existing system of fractional ownership & REIF in Türkiye

The Real estate investment funds in Türkiye act as a regulatory framework for the process of real estate tokenization. They are currently regulated and functioning inside a specific system. Real estate investment funds, such as those involved in real estate tokenization, are a component of the fractional ownership notion. Thus, considering the jurisdiction and duties imposed by governmental bodies in these procedures, the creation of real estate investment funds progresses through many stages, setting the foundation for real estate tokenization.

Creating a real estate investment fund (REIF) in Türkiye necessitates meticulous adherence to legislative requirements and technical procedures. This process includes many stages, starting from the founding and extending to the operation of the investment fund. It also covers investing techniques, as well as the provision of investor information and reporting. The Capital Markets Board (CMB) regulates the creation and operation of real estate investment funds in Türkiye . The primary legal foundation is the Capital Markets Law, specifically identified as Law 6362. The "Principles Regarding Real Estate Investment Funds Communique" (III-52.3) provides comprehensive guidelines on the creation, management, monitoring, and reporting requirements of funds within the scope of this law. The Communique provides thorough information on the methods for establishing finances, obtaining relevant permissions, and completing application processes. This Communique also regulates the processes of investor information, periodic reporting, and transparency

standards. A real estate investment fund (REIF) shares a similar structure and purpose with a Special Purpose Vehicle (SPV), therefore allowing a REIF to also operate as an SPV. An SPV, or Special Purpose Vehicle, can be created specifically to secure funding for a real estate project. Its purpose is to efficiently finance and oversee the project. This Special Purpose Vehicle (SPV) can be specifically designed to exclusively oversee and control the assets and operations of this project. An SPV, or special purpose vehicle, can let a REIF, or real estate investment fund, invest in a particular project and separate out risks that are specific to that project.

Typically, Portfolio Management Companies (PMC) are the ones that initiate the creation process of a real estate investment fund. Portfolio Management Companies are entities entrusted with the professional management of real estate investment funds. Portfolio Management Companies (PMC) assure the attainment of investment objectives by efficiently using investors' resources. These firms engage in crucial activities such as developing investing strategies, diversifying portfolios, and managing risks.

In order for Portfolio Management Companies (PMC) to carry out their operations, they are required to get a license from the Capital Markets Board (CMB). These licenses certify that the firms have the requisite credentials and are able to operate in accordance with legal requirements. In order to acquire a license, Portfolio Management Companies (PMC) must fulfill specific financial prerequisites, possess a management team with credentials defined by the Capital Markets Board (CMB), and have efficient internal control procedures.

Once PMCs have obtained a license, they are required to carry out their operations in line with the principles of openness and accountability. The CMB consistently oversees PMC activities and validates their adherence to compliance standards. Portfolio Management Companies (PMC) have distinct responsibilities to provide detailed reports in order to safeguard the interests of investors and maintain the security of the market. These reporting duties entail the frequent submission of fund performance updates to investors and the Capital Markets Board (CMB).

Furthermore, Portfolio Management Companies (PMC) are required to strictly follow professional and ethical guidelines while making investment choices. The use of analyses, market research, and risk assessments in the fund management operations aids investors in making well-informed decisions. The management of real estate investment funds is carried out with professionalism, reliability, and transparency

Ultimately, Portfolio Management Companies (PMC) are vital in ensuring the prosperity of real estate investment funds. These firms, which are licenced and monitored by the CMB, enhance investor trust and guarantee the long-term viability of investment funds by providing investors with the assurance to invest their cash with confidence.

The establishment procedure of a real estate investment fund (REIF) consists of many steps that follow the identification of the fund initiator. Prior to submitting an application to the Capital Markets Board (CMB), the Founder firm establishes the business plan and strategy for the fund. Comprehensive documentation is developed on the founding of the fund, investing strategies, risk management plans, investor profiles, and other essential information. These documents are essential for the acceptance and approval of the application. Afterwards, the Founder business submits a formal application to the CMB together with the prepared documentation. As part of the application process, it is required to provide the fund's articles of association, prospectus, promotional documents, and any other essential paperwork. The CMB will conduct a comprehensive evaluation of the application and may require the applicant to correct any shortcomings. It is imperative for the applicant to possess legal and financial stability during this procedure. The CMB reviews the application and requires any required modifications to be made. Once approved, it authorizes the fund's articles of association. The articles of association provide comprehensive information on the fund's administration, investing tactics, investor privileges, and other crucial elements. The approval procedure entails a meticulous evaluation in relation to adherence to the requirements established by the CMB and regulations. After receiving clearance from the CMB, the fund is officially registered with the Trade Registry and obtains legal personality. In addition, the fund is officially registered with the Central Securities Depository (CSD). The registration steps are

essential for the issue and distribution of fund shares. Registering fund shares with the CSDI is crucial to safeguard investor rights and provide transparency. After investors have finished their buying and selling operations, the Clearing House takes over. The Clearing House guarantees the safe and quick completion of transactions. At this step, there is a transfer of fund shares between the buyer and the seller. Upon the completion of the acquisition, the Clearing House oversees the corresponding payments. At this step, the Clearing House oversees the payment process between the buyer and the seller and transfers the funds to their respective accounts if required. The CSD and the Clearing House have the responsibility of updating the pertinent accounts following the transactions. The CSD and the Clearing House keep and update the latest data on the fund shares owned by investors in their accounts. These processes are the essential stages of transaction and settlement for real estate investment funds. The primary function of organizations such as the CSDI and the Clearing House is to guarantee the safe, transparent, and systematic completion of transactions while safeguarding the interests of investors. The objective is to provide assurance and steadfastness in the market.

There exist several connections between real estate investment funds (REIFs) and Borsa Istanbul. The interaction between REIFs and Borsa Istanbul has a significant impact on both the functioning and performance of REIFs, as well as the overall market dynamics of Borsa Istanbul. Certain real estate investment funds are eligible for trading on Borsa Istanbul. Investors can engage in the trading of Real Estate Investment Funds (REIFs) on the stock exchange. Investors may fulfill their desire for Real Estate Investment Funds (REIFs) by utilizing Borsa Istanbul. This scenario has the potential to enhance the liquidity of Real Estate Investment Funds (REIFs) and streamline the trading process for investors. Real Estate Investment Funds (REIFs) have the potential to be incorporated into the indexes of Borsa Istanbul. Specifically, real estate sector indexes are utilized to gauge the performance of Real Estate Investment Funds (REIFs). The success of Real Estate Investment Funds (REIFs) is intricately linked to the general market sentiment towards the real estate industry and the valuations of real estate assets. Consequently, the performance of Real Estate Investment Funds (REIFs) is likewise mirrored in the indexes of Borsa Istanbul. There

is a reciprocal relationship between the success of Real Estate Investment Funds (REIFs) in the market and the overall trajectory of Borsa Istanbul. Positive advancements in the real estate industry can lead to an increase in the value of Real Estate Investment Funds (REIFs), hence positively influencing the overall performance of Borsa Istanbul. Likewise, overall decreases or variations in Borsa Istanbul might have an adverse impact on the performance of Real Estate Investment Funds (REIFs). The trajectory of Borsa Istanbul has a significant impact on investors' perceptions of risk and their preferences. For instance, when there is a notable decline in the Borsa Istanbul, investors typically gravitate towards more secure options and may exhibit interest in alternative investment vehicles like real estate investment funds. This scenario has the potential to augment the demand for Real Estate Investment Funds (REIFs). As a result, there is a reciprocal interaction and connection between real estate investment funds and Borsa Istanbul. The functioning and effectiveness of REIFs are impacted by the overall market dynamics of Borsa Istanbul. Additionally, the performance of REIFs can be significantly influenced by the direction of Borsa Istanbul. Consequently, investors and market analysts formulate their investment plans by taking into account the correlation between Real Estate Investment Funds (REIFs) and Borsa Istanbul.

The procedure of creating a real estate investment fund (REIF) in Türkiye is intricate and involves many steps, resulting in a significant time commitment in the present practice. At the beginning, a period of around 2 months is set aside for comprehending the legislation and regulatory framework and guaranteeing adherence. Subsequently, the procedure of identifying the fund initiator and acquiring the requisite licenses typically spans a duration of around 2 months, but the preliminary preparation and application process may extend for a lengthier period, often ranging from 2 to 3 months. The application and evaluation process by the CMB often lasts for a duration of 2-3 months, whilst the approval of the fund's articles of organization generally takes around 1-2 months. The process of registering the fund with the Trade Registry and the Central Securities Depository (CSD) might take anywhere from 1 to 2 months. As the fund is managed and operated continuously, tax regulations and compliance audits

are also frequently supervised. Typically, the procedure for setting up a real estate investment fund in Türkiye takes anywhere from 9 to 14 months.

Investing in real estate investment funds (REIFs) begins with prospective investors engaging in thorough research and assessment. At this stage, investors evaluate and contrast the performances, management fees, historical performances, and portfolios of various real estate investment funds. The research process often requires investors to allocate time in order to assess and choose appropriate funds, taking into account aspects such as risk tolerance, investing objectives, and financial condition.

In Türkiye , the current number of real estate investment funds is at 144 as of 2023. There are seven funds that are listed and traded on the stock exchange. Investors must commence the procedure by contacting portfolio management organizations in order to obtain the remaining funds. Investors must possess the "qualified investor" status, as defined by the Capital Markets Board (CMB), in order to engage in trading these funds. Qualified investors are individuals or entities that meet the specific criteria outlined in the regulations of the CMB and are classified as professional clients. Qualified investors within this context include investment funds, pension funds, securities investment trusts, venture capital investment trusts, real estate investment trusts, brokerage firms, banks, insurance companies, private financial institutions, portfolio management companies, retirement and aid funds, foundations, Social Security Law funds, public benefit associations, and other investors determined by the CMB to possess comparable qualifications. In addition, individuals and legal entities who possess a minimum of 1 million Turkish Liras in Turkish and/or foreign currency and capital market instruments on the public offering date are classified as qualified investors (URL 18).

Once the investor has fulfilled the requirements of becoming a qualified investor, they are required to establish a custody account with a bank or brokerage business. This agreement pertains to the custody account,

The document consists of over 100 pages and requires a physical signature before being saved. This procedure is typically finished within a timeframe of roughly 1-2 business days. After the custodial account is established, the investor's account is

identified inside the CSD. In order to acquire the chosen fund, the investor is required to transfer the corresponding fund amount to the custody account. Subsequently, the portfolio investment business transmits an order to the Central Securities Depository (CSD) to determine the investor's portion of the real estate investment fund. The share exchange occurs on the Clearing House, and the specific share is determined in the investor's custody account by the CSD. The duration of this procedure, including both the clearing and settlement phases, typically ranges from 1 to 2 business days.

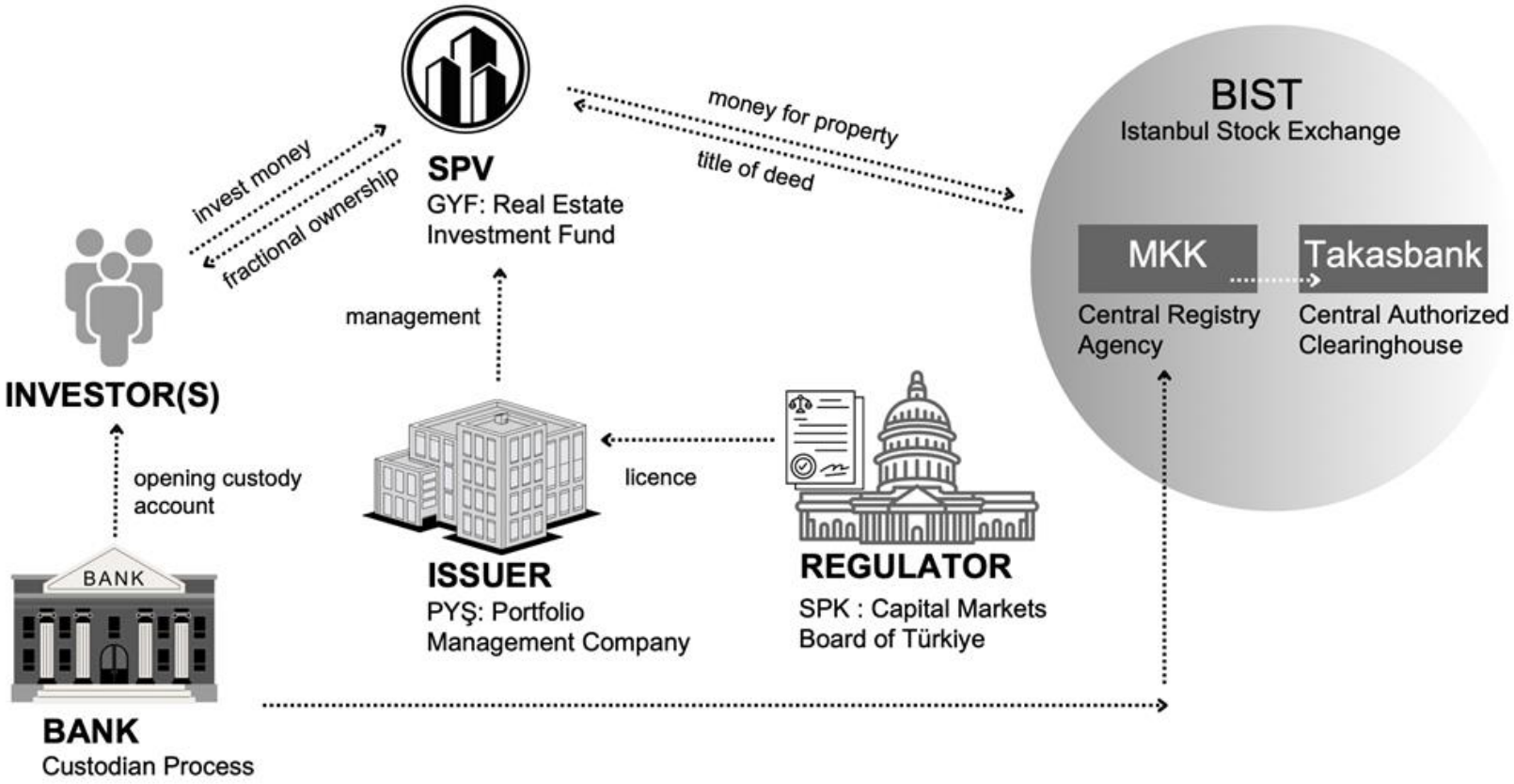


Figure 3.2 : Current Fractional System in Türkiye

4. PROPOSED MODEL : ISToken

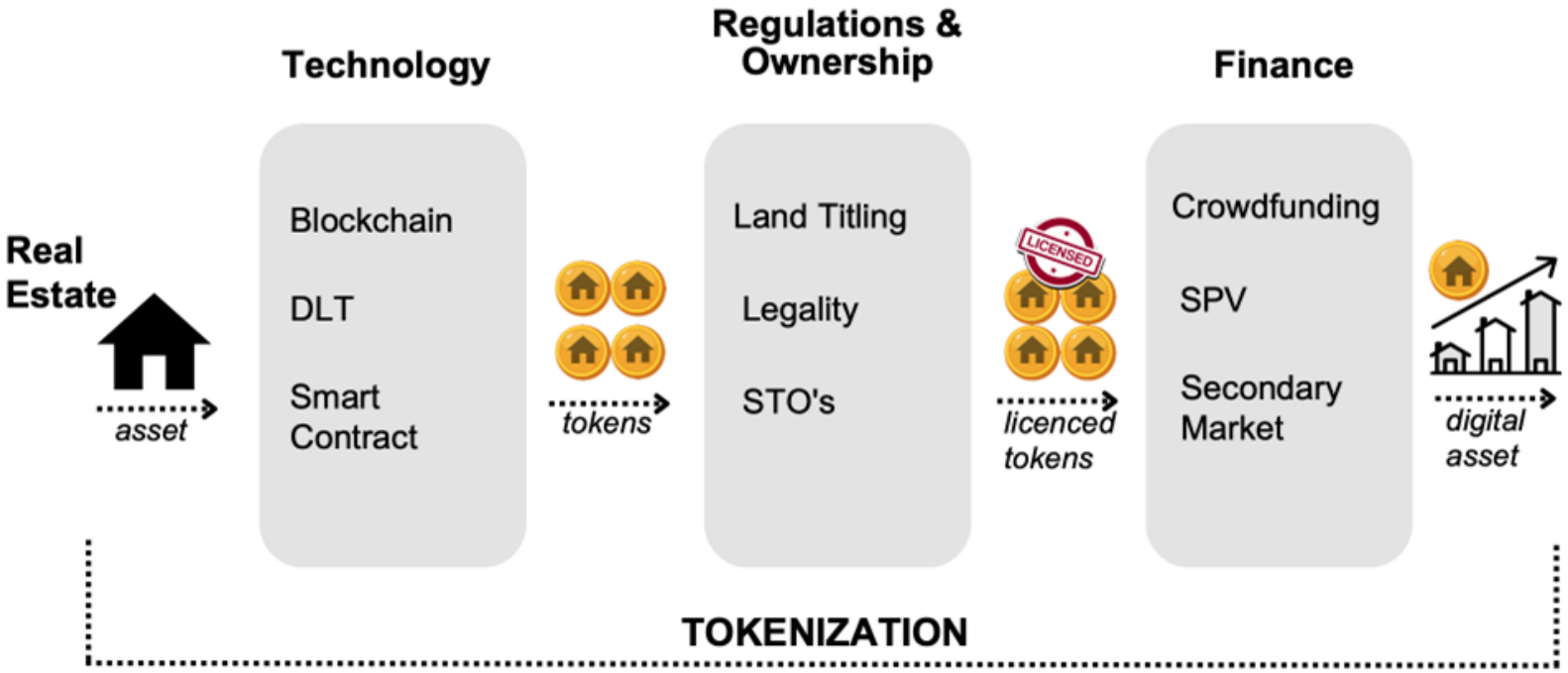


Figure 4.1 : Real Estate to Digital Asset

The proposed real estate tokenization for ISToken is a way of converting traditional real estate investments into digital assets and trading them through blockchain technology. This innovative financial instrument partitions real estate assets into smaller portions and presents them to potential investors, hence enhancing the accessibility of real estate investments. In order for real estate tokenization to achieve success, it is imperative to have a robust legislative framework and the necessary financial infrastructure in place. The real estate tokenization procedure of the project involves transforming a physically existing real asset into fragmented digital pieces that are represented on a three-legged table. The blockchain universe is the primary realm that must be taken into account when considering real estate tokenization. Within the realm of blockchain, the act of partitioning the ownership and investment of a real estate asset into smaller portions occurs. Blockchain facilitates the transparent, safe, and unchangeable storing of many types of data, such as real estate information, market data, legal documents, and more, using Distributed Ledger Technology (DLT). By eliminating the need for intermediaries in these transactions, a more transparent and dependable process is developed. This technology enables the commencement and implementation of a process known as tokenization in the real estate industry. DLT resolves all transactions pertaining to data privacy, security, and storage. The quantity and value of tokens, as well as the method, price, terms, and other determinations for their sale, are recorded in the blocks using smart contracts. Envision the consequences that occur in your surroundings when you engage in a real estate transaction. In the blockchain realm, the process, which involves notaries, middlemen, attorneys, signatures, and protocols, occurs within a few seconds. The decentralized and unchangeable nature of blockchain provides a distinct ecosystem, particularly significant for real estate transactions where confidence is paramount, in comparison to the real world. There are several tokens inside the blockchain ecosystem. ISToken employs Security Token Offerings (STOs) to tokenize real estate assets. The primary reason for this is the strong link of several tokens with fraudulent activities. Therefore, the most reliable token for the real estate industry, namely the asset-backed Security Token Offering (STO), has been chosen. Security Token Offerings (STOs) are subjected to a higher degree of regulation and compliance compared to other types of tokens. They are required to adhere to regulatory restrictions and are often categorized

as securities, offering investors more protection. Special Purpose Vehicles (SPVs) also have a substantial impact on resolving the regulatory element. These specialized firms are created to tokenize real estate and are available on the blockchain crowdfunding platform under direct regulation. Crowdfunding is a tool that can operate with the tokenization logic in the context of financial research. Blockchain crowdfunding merges the conventional crowdfunding paradigm with blockchain technology to offer a more transparent, safe, and easily accessible investment ecosystem. Traditional crowdfunding involves several people contributing modest sums of capital to finance a project, however blockchain crowdfunding utilizes blockchain technology and tokenization to facilitate the process. Smart contracts are utilized in blockchain crowdfunding. These intelligent agreements automate the process of gathering and distributing funds and are openly documented on the blockchain. This enhances transparency in the use and allocation of cash, hence fostering confidence among participants. Tokenization is a feature of blockchain crowdfunding that allows for investment options. Through the process of tokenization, investors have the opportunity to possess digital tokens that enable them to invest in a certain project or asset. Typically, these tokens symbolize a certain fraction of an asset or project and grant investors with matching entitlements and advantages. Upon completion of this procedure, an actual physical real estate asset undergoes a conversion into a digital asset within the blockchain ecosystem.

4.1 Integrated Model of ISToken

The ISToken real estate tokenization model focuses on how tokenization can be gradually integrated in Türkiye , where there is currently no regulation specifically related to tokenization. Changes never occur suddenly in any part of the globe, particularly in the realm of technical progress; both governments and individuals require time to acquire expertise and embrace new technology. The ISToken strategy prioritizes leveraging current regulatory components to facilitate tokenization, rather than focusing on uncontrolled aspects

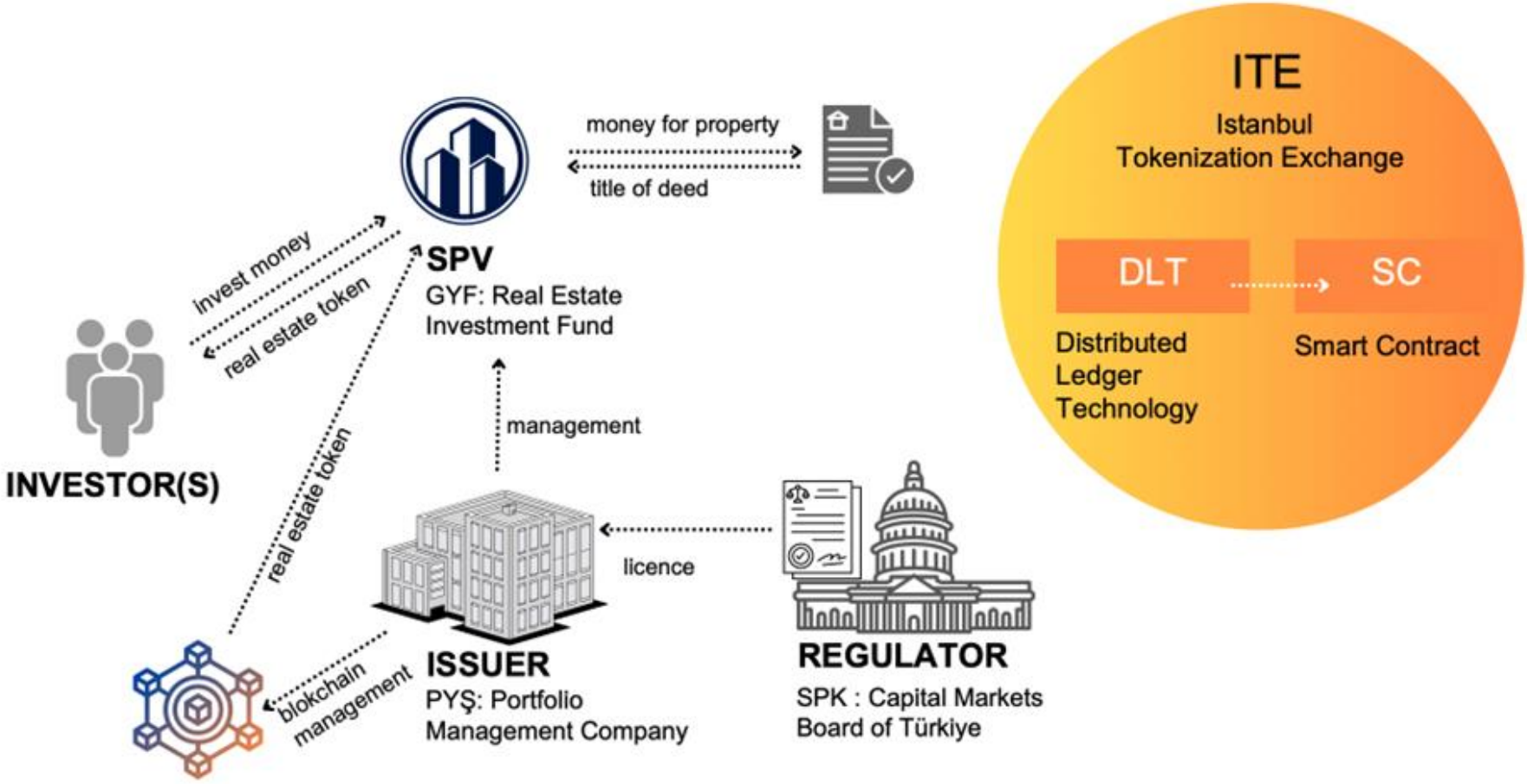


Figure 4.2 : ISToken Model

Fractional ownership is well-established in Türkiye , with a substantial number of real estate investment funds being regulated and accepted by the public. Takasbank plays a vital role in guaranteeing the secure and effective clearing and settlement of financial instruments when considering the primary actors involved in the purchase of fund shares. The Central Securities Depository Institution (MKK) is responsible for maintaining records of securities traded in capital markets. Its major objective is to ensure the secure and efficient maintenance of rights associated with these assets. Nevertheless, the execution of these processes may be significantly expedited by including the specified criteria from smart contracts into the blocks. The financial Markets Board (SPK) is the primary regulatory entity in Türkiye that regulates and supervises financial markets. The activities of both MKK and Takasbank are governed by the legislative framework and rules issued by the SPK, which determine the general functioning of the markets. The ISToken concept suggests the use of DLT (Distributed Ledger Technology) and smart contracts instead of MKK (Central Securities Depository) and Takasbank (Clearing and Settlement Institution). This implies that the SPK (Capital Markets Board) does not provide ongoing regulation and supervision over these institutions. Regulation and oversight are restricted to portfolio management firms (PMC) that function as issuers. In order to function, PMC is required to get a license from the SPK. This license demonstrates that PMC has met the particular standards related to its capital structure, corporate governance, and professional employment. The license applications are thoroughly assessed by SPK, and operating permits are granted to firms that satisfy the requisite criteria. This suggests that PMCs are well-suited for overseeing money for blockchain management and ISToken via the SPV that has been built. Within the context of blockchain integration, only SPK-regulated PMCs have the authority to directly communicate with the SPK in the ISToken model. However, investors only engage with the Special Purpose Vehicle (SPV) that has been created specifically for the purpose of tokenizing real estate, and they do so through the ISToken platform. An SPV, or Special Purpose Vehicle, is created specifically for specialized projects that often include buying, selling, leasing, or financing of a certain asset. The SPK, or Capital Markets Board, regulates all stages of these projects.

The PMC, in the role of as the issuer, generates ISToken SPV tokens, sets up crowdfunding channels for project financing, and oversees the token sale procedure. The complete administration of the ISToken SPV relies on the license acquired by the SPK. Ownership rights and all real estate-related information are monitored using smart contracts, and all transactions are promptly logged on the distributed ledger technology (DLT). Investors acquire ISToken by using their digital wallets on a blockchain-based crowdfunding platform. The quantity of tokens received is directly proportional to the amount spent, and the ownership rights are recorded in the property registry. Due to the nature of blockchain technology, every transaction, data, or information is securely stored and cannot be lost or erased. The process of tracking transactions is characterized by transparency and impartiality, operating on the fundamental premise of trust, and benefiting all parties involved

4.2 Blockchain Platform Selection: Comparative

Tokenization is the use of blockchain technology to create a digital representation of assets. It entails the division of assets, including as real estate, equities, artworks, and more, and their subsequent representation on the blockchain. The process of tokenization has the potential to revolutionize conventional asset management and trading, hence emphasizing the crucial role of selecting the appropriate blockchain platform. Platforms that can be used for real estate tokenization include Ethereum, Binance Smart Chain, Solana, Avalanche, Polygon, Cosmos, Elrond, and Polkadot. There are numerous parameters to consider in order to select the most suitable platform from these options. Consensus Mechanism, Smart Contract Execution, Transaction Fee, Interoperability, Security, Scalability, Finality Time, TPS, dApps, Cross Communication, and Incentives are among the evaluation criteria. After explaining these concepts and what they entail, the most suitable platform for ISToken has been chosen.

4.2.1 Blockchain platforms for tokenization

In real estate tokenization, the choice of blockchain platform is critical to the achievement of the undertaking. Platforms that fulfill specified requirements must

distinguish themselves from the numerous options accessible, especially as the main emphasis should be on the tokenization of real estate using tangible assets. Ensuring reliability and security is of utmost importance; a dependable platform fosters trust among investors and participants. It is crucial to select a platform that provides minimal transaction prices and quick processing times, since this might appeal to a diverse group of investors. Compatibility and scalability are crucial factors, since the platform must be capable of accommodating the division of huge assets into smaller portions. It is important to take into account legal and regulatory compliance, since it may be essential to adhere to the laws and regulations of the specific geographical locations where the project is being carried out. Finally, a user-friendly design and seamless integration add to the platform's growth and achievement. The convergence of these aspects necessitates the careful selection of an appropriate blockchain platform for the effective execution of a real estate tokenization initiative.

The proposed ISToken has compared Binance Smart Chain, Ethereum, Solana, Avalanche, Polygon, Cosmos, Polkadot, and Elrond blockchain platforms for real estate tokenization, highlighting their similarities and differences.

Binance Smart Chain (BSC) is a blockchain network launched in September 2020 by Binance, a prominent player in the cryptocurrency market. BSC is a platform that offers assistance for smart contracts and decentralized apps (DApps) in a manner comparable to Ethereum. An outstanding characteristic of Binance Smart Chain is its capacity to provide accelerated transaction speeds and diminished transaction expenses. The main objective of BSC is to deliver a high-performance blockchain infrastructure that gives a more efficient experience similar to that of Ethereum. In order to do this, Binance has used the Proof of Stake (PoS) consensus mechanism and included a dual-chain design that closely resembles the structure of Ethereum. The design of BSC guarantees compatibility with the Ethereum Virtual Machine (EVM) and enables quicker transaction speeds and lower transaction costs.

Binance Smart Chain's primary advantage is its high-speed transaction processing capability, which can handle up to 100 transactions per second (URL 8). This feature is especially crucial for applications that deal with substantial transaction volumes, such as decentralized finance (DeFi) systems. Binance Smart Chain exhibits cross-

chain interoperability, enabling it to engage with other blockchain networks like as Ethereum or Bitcoin. This facilitates the smooth movement of assets between several networks, allowing users to easily transfer their assets and take advantage of the benefits offered by different blockchain networks.

To summarise, Binance Smart Chain is essential in the cryptocurrency domain due to its capacity to offer fast transaction speeds, low transaction fees, and the ability to connect with various blockchain networks. It functions as a substitute for Ethereum, providing users with a robust platform for building decentralised apps and executing transactions with high efficiency.Cernera et al. (2023) state that DEX and DeFi dApp originated on the Ethereum blockchain, but DeFi services quickly emerged on all blockchains that can handle smart contracts. Despite Ethereum's dominant position in the DeFi industry, with more than $68 billion locked in its smart contracts, the BNB smart chain, also known as BSC (formerly Binance Smart Chain), presents itself as a swifter and more cost-effective alternative.

Ethereum is a blockchain platform that facilitates the creation of decentralised applications (DApps). Ethereum, which was launched in 2015, distinguishes itself from other blockchain systems due to its capacity to execute code blocks known as smart contracts. Smart contracts are software programmes that execute automatically when certain criteria are satisfied, offering versatility in a wide range of platform applications. Ethereum is a decentralised network consisting of globally distributed computers that adhere to a predefined set of rules known as the Ethereum protocol. The Ethereum network serves as the fundamental infrastructure for the creation and utilisation of communities, apps, organisations, and digital assets, accessible to everybody (https://ethereum.org/en/what-is-ethereum/). Ether (ETH), the digital currency that underpins the Ethereum network, serves as a medium for carrying out transactions and offers developers the necessary means to build decentralised applications (DApps). The functioning of Ethereum is dependent on miners resolving intricate mathematical problems to authenticate transactions and incorporate them into the blockchain. The technique, referred to as "Proof of Work" (PoW), is essential for guaranteeing the security of the network. Ethereum's versatility and capacity to scale allow developers to design diverse DApps and intelligent contracts for a wide range of

industries and applications. Ethereum's adaptable and inventive framework has had a substantial impact on the implementation and acceptance of blockchain technology in scholarly writing.

Nevertheless, Ethereum encounters obstacles in the form of scalability concerns and exorbitant transaction costs. Hence, many options are being investigated to ensure the ongoing advancement and enhancement of the platform.

Vujičić et al. (2018) stated that the Ethereum network has effectively processed more than one million distinct transactions in a 24-hour period, with an average rate of around 11 transactions per second, despite worries regarding scalability.

Solana is a blockchain platform established by Anatoly Yakovenko in 2017. The main objective is to develop a blockchain that is significantly quicker and more scalable than existing platforms. Solana utilizes a consensus technique known as Proof of History (PoH), which is one of its notable characteristics. This technique functions as a timestamp, calculating the time gap between blocks and expediting the verification of transactions.

PoH is utilised to encode the secure and verifiable progression of time into a ledger, which is a data structure that only allows for appending new information (Yakovenko,2017-White paper). A prominent characteristic of Solana is its exceptional transaction velocity. Solana reduces delays and congestion commonly seen in traditional blockchains by utilizing parallel processing and optimized data structures. The platform has the capability to handle a high volume of transactions, ranging from hundreds to tens of thousands per second.

Scalability is another benefit. The design of Solana enables the concurrent processing of several transactions, hence minimizing congestion and fee escalation on the blockchain. Additionally, it can accommodate a larger number of users and applications.

Solana's variable transaction fees and fast speed make it well-suited for DeFi (Decentralised Finance) applications and NFTs (Non-Fungible Tokens). The exceptional performance of this technology might encourage more widespread use of these applications and improve the overall user experience. Solana is a blockchain

platform that is known for its exceptional performance and scalability. It is expected to make substantial progress in the field of cryptocurrencies and blockchain technology. The novel technology and associated benefits are expected to continue attracting a larger user and developer base, thereby amplifying its influence and significance within the bitcoin ecosystem in the future. In addition to these advantages, Solana also has some weaknesses.Grayscale Building Blocks (2021) states that Solana carries certain hazards, particularly in terms of network security. These risks arise from the use of novel technological techniques, possible vulnerabilities in encryption, and the possibility of economic incentives not operating as planned. Consequently, these factors might result in insecurity or subpar performance.

Avalanche is a blockchain platform that prioritizes scalability, decentralization, and interoperability while also being adaptable and safe. The objective is to cater to a range of different scenarios, such as constructing blockchains tailored to certain purposes, initiating decentralized applications (Dapps), and generating customized digital assets with special regulations. The platform is specifically engineered to effectively manage a vast network of devices, guaranteeing minimal delays and a large number of transactions per second. Avalanche prioritizes security as a fundamental aspect, ensuring robust protection against assaults and promoting decentralization by allowing diverse client implementations without centralized management. Moreover, Avalanche is both governable and democratic, enabling token holders to actively engage in governance choices. The platform is capable of operating with different blockchains and assets, ensuring security and simplicity in the process of integration(Sekniqi et al.,2020-White Paper). According to Amores-Sesar and Cachin (2022) Avalanche is a blockchain consensus mechanism known for its exceptional performance in terms of low latency and large transaction volume. The AVAX coin has the 14th position in terms of market capitalization, signifying its importance as a cryptocurrency. Avalanche attains these remarkable characteristics by different consensus method rather than relying on proof of work. The Avalanche Consensus Protocol (AvaLP) is a unique consensus mechanism employed inside the Avalanche blockchain platform. This technique is specifically intended to oversee the process of confirming transactions and allows participants to achieve agreement through iterative

decision-making. AvaLP is renowned for enabling swift and effective transaction verifications, while also exhibiting resilience against assaults. The Avalanche blockchain platform is capable of achieving great performance and ensuring dependability due to its advanced features.

While Avalanche has several benefits, it may also have certain drawbacks, notably a potentially smaller developer base in comparison to other blockchain platforms. This might provide some obstacles for the advancement of the platform and the expansion of its ecosystem.

Polygon was born as a solution for solving the scalability challenges inside the Ethereum ecosystem. Polygon sets itself apart from other solutions by offering unique capabilities as a secondary layer solution integrated with Ethereum. Polygon employs multi-chain solutions to optimize transaction speeds and minimize costs, enabling users to execute transactions with greater speed and affordability. Polygon is a scaling solution known as a "layer two" or "sidechain" that operates in parallel with the Ethereum blockchain. It enables fast transactions and reduces costs. MATIC serves as the inherent digital currency of the network, fulfilling several purposes such as covering transaction fees, engaging in staking activities, and facilitating additional functionalities (https://www.coinbase.com/learn/crypto-basics/what-is-polygon). In addition, the implementation of the Proof of Stake (POS) consensus process by Polygon enhances energy efficiency, hence promoting a more ecologically sustainable network. The platform operates smoothly with Ethereum and enables the migration of projects based on Ethereum. Polygon guarantees user security and data integrity by following the notion of decentralization. Collectively, these capabilities establish Polygon as a prominent participant in the Ethereum ecosystem, acknowledged for its efficacy as a solution in the growing realm of cryptocurrency.

Jae Kwon created Cosmos in 2014. The introduction of this concept occurred in 2016, spearheaded by Ethan Buchman and Jae Kwon. Cosmos is a project designed and implemented to guarantee the compatibility of decentralized blockchains, advancing with both technical and community backing. The Cosmos network facilitates inter-blockchain communication. Cosmos's Inter-Blockchain Communication (IBC) protocol enables the interaction between various blockchains on the network. This

allows blockchains to go from a state of isolation to one of interoperability. Cosmos is built around the foundational framework of the Tendermint protocol. Tendermint is an algorithm employed to attain consensus in blockchain networks. Tendermint, an essential element of Cosmos, offers the required consensus mechanism to guarantee the safe communication across different blockchains.Cosmos presents a technique that allows numerous parallel blockchains to interact with one other while ensuring security, thereby circumventing the constraints of proof-of-work. Cosmos utilizes Tendermint Core's efficient Byzantine Fault Tolerant (BFT) consensus algorithm to establish connections across separate blockchains (referred to as zones) via the Cosmos Hub. The Cosmos Hub is a proof-of-stake cryptocurrency that supports multiple assets and possesses governance features. Zones interact via the inter-blockchain communication (IBC) protocol, enabling safe and quick transfers of tokens without the need for exchange liquidity (URL 21). Wu et al. (2022) present a queue theory model with limited space to enhance the efficiency of cross-chain transactions, using Cosmos as a case study. This study may be utilized as a comprehensive method for assessing the efficiency of cross-chain systems, such as Cosmos.

Polkadot is a network protocol that was introduced in 2020 with the goal of fully harnessing the capabilities of blockchain technologies. The innovative multi-chain protocol facilitates the movement of arbitrary data between different blockchains, enabling the development of many innovative applications. Polkadot is a flexible network protocol that enables the transport of many forms of data, including tokens, between multiple blockchains. The design of this system allows for the integration of cross-chain functionality, such as registries and calculations, across both public and private blockchains. This enables programmes to retrieve authorized data from private blockchains and utilize it in public blockchain settings. As an illustration, the academic records stored on a private blockchain of a school may be authenticated on a public blockchain using smart contracts (URL 20).

The Polka-dot architecture is founded on the ideas of sharding, a technique that offers a solution to the scalability and interoperability limitations that burden several current blockchain-based systems. According to Abbas et al. (2022) attracted by these notable attributes, investors promptly recognised the value of the Polkadot project, which

holds a strong position among the top 10 cryptocurrencies in terms of market capitalization (about 10 billion USD).

4.2.2 Parameters of comparison

Multiple criteria may be used to evaluate and compare blockchain systems for the purpose of real estate tokenization. The dimensions of a project may vary based on its specific requirements and objectives. However, the following variables are typically considered important: Consensus mechanism refers to the method by which a distributed network of computers agrees on the validity of transactions. Smart contract execution involves the automated execution of predefined agreements on a blockchain. Transaction fee is the cost associated with processing and validating a transaction on a blockchain. Interoperability refers to the ability of different blockchain networks to communicate and interact with each other. Security pertains to the protection of data and assets from unauthorized access or manipulation. Scalability refers to the ability of a blockchain network to handle a large number of transactions. Finality time is the duration it takes for a transaction to be considered irreversible. TPS, or transactions per second, is a measure of the speed at which a blockchain network can process transactions. dApps, or decentralised applications, are software applications that run on a blockchain network Furthermore, it is important to take into account additional variables influenced by the project's specific attributes and goals. It is important to assess whether a specific platform is appropriate for a given real estate tokenization project. Ultimately, the selection of the appropriate platform is crucial for the project's success and should thus be executed with meticulousness.

A consensus mechanism is a protocol or algorithm used for reaching agreement among different nodes of a blockchain network in case of disagreement. Because blockchain networks are decentralised, reaching consensus amongst many nodes—computers or servers—is crucial. The consensus process makes sure that any user on the network can dependable confirm and validate the transaction.Yadav and Kushwaha (2021) propose a consensus algorithm that provides secure communication for multiple broadcast nodes while also reducing communication costs by approximately 50% and message exchange costs by 54.86%. A consensus method allows the nodes in the

network to reach a mutual agreement over the authenticity of a particular transaction or block. This phenomenon takes place in the absence of any one governing body or centralised control inside the network. Consensus techniques guarantee that every member in the network works together to authenticate and uphold the precision and uniformity of transaction records. Different blockchain platforms may employ distinct consensus techniques. Some of the most often regarded options include: Proof of Work (PoW) is a system where miners verify transactions by completing intricate mathematical puzzles. The miner who successfully discovers the accurate answer appends a new block to the blockchain and is granted a reward. Several blockchains, including Bitcoin, employ this consensus technique. Proof of Stake (PoS) is a consensus mechanism where a node is selected at random to add a block to the network, depending on the amount of stake it has. Proof of Stake (PoS) has gained popularity because to its potential to decrease energy usage and enhance the scalability of blockchain networks. The demands of the network determine whether proof method is better: proof of stake (PoS) or proof of work (PoW). PoW is typically thought to be appropriate for boosting security, reducing fraud, and fostering trust. However, PoS is frequently used for scalability and network performance. PoS has the advantage of preserving network security through fast transaction rates and punishing validators, whereas PoW safeguards transaction history.(URL 10)

Smart contracts are independent, self-operating programmes that play a crucial role in blockchain technology. These systems are created to mechanize transactions and contracts, and may be employed on several blockchain platforms, but they are most frequently seen on Ethereum. Smart contracts are software applications that operate on blockchain technology and have the ability to autonomously perform actions whenever specific criteria are fulfilled. Smart Contract Execution refers to the implementation or performance of these smart contracts. This procedure takes place on a designated blockchain network and adheres to a defined protocol. Smart contracts are utilized to automate contractual agreements and bolster their security. A smart contract is executed exclusively on a designated blockchain network. For instance, in Ethereum, the implementation of a smart contract takes place on a virtual machine known as the Ethereum Virtual Machine (EVM). Essentially, the contract code is put

in a predetermined area on the blockchain. When a certain transaction occurs, this code is performed.

TPS (Transactions Per Second) refers to the number of transactions a blockchain network can process in a given period of time, typically per second. It is an essential indicator utilised to assess the efficiency, velocity, and capacity for growth of a blockchain network. The velocity of transactions in a blockchain network directly affects the user's satisfaction, the expenses associated with transactions, and the general level of acceptance of the network. The magnitude of this number is contingent upon several variables. Block size and block generation time are crucial characteristics that directly impact a network's capacity to process transactions per second. Blocks of larger sizes have the capacity to handle a greater number of transactions, however, the downside is that longer block creation times lead to longer transaction processing times. Moreover, the choice of consensus mechanism significantly influences the network's TPS value. Certain consensus techniques may exhibit greater speed and scalability, while others may demonstrate slower performance. The TPS value is influenced by the network infrastructure, with a quicker and more dependable infrastructure resulting in a higher TPS value. Ultimately, enhancements implemented to the blockchain protocol and software have the potential to augment the TPS value. In general, greater TPS numbers result in quicker transaction times and reduced transaction expenses, whereas lower TPS values might restrict the network's functionality and efficiency. As a result, blockchain projects frequently explore different technological approaches to enhance TPS numbers. However, well-known blockchains like as Bitcoin and Ethereum have traditionally achieved lower transaction per second rates, about 5 and 10 TPS respectively, as a result of their decentralized structure. This decentralized nature may cause slower transaction speeds, but it also boosts security. Optimal TPS is essential for ensuring the efficiency and competitiveness of blockchain networks, particularly for applications that need instantaneous transactions, such as financial transactions, gambling, and online marketplaces. Diverse tactics are utilized to enhance TPS, such as optimizing block sizes, formulating consensus methods, and applying off-chain solutions. However,

these approaches might occasionally undermine the decentralization and security of the blockchain (URL 11).

The finality time, a critical aspect of blockchain technology, represents the exact instant when a transaction is either validated or declared invalid. This indicates that the transaction has been permanently approved and considered reliable by all members of the network.Ethereum and other widely used blockchain systems utilize diverse consensus processes to complete transactions. Ethereum's present iteration employs a consensus process known as Proof of Work (POW). Typically, it takes several minutes or more for a new block to be definitively validated via this approach. Consequently, the completion of the transaction may require a significant amount of time, potentially lasting several minutes or longer. Minimizing the duration of blockchain finality is of utmost importance, particularly for time-sensitive applications like as financial transactions. For instance, expediting the completion of a payment transaction can bolster user confidence and improve transaction efficiency.The consensus process inside the blockchain network is the primary means of ensuring finality. Blockchain networks employ many consensus processes, each employing a distinct method to authenticate transactions and guarantee their ultimate confirmation.Although block finality is crucial in blockchain consensus algorithms, it does not necessarily occur instantaneously. Block finality and delay operate concurrently in blockchain networks. The finality rate of a blockchain is directly correlated to its latency level, which quantifies the amount of time required to validate a transaction. Reducing latency is crucial for creating an effective payment system (URL 12) .Nevertheless, using more efficient consensus processes to decrease the time it takes for blockchain transactions to be finalized may introduce some security vulnerabilities. Reduced finality periods heighten the susceptibility of the blockchain network. Hence, blockchain initiatives must implement many strategies to strike a compromise between minimizing the time it takes to achieve finality and guaranteeing security.To summarize, the time it takes for blockchain transactions to reach finality is a crucial determinant of the technology's dependability and transaction speed. Projects must exercise caution to avoid compromising security while striving to decrease this duration, since achieving a balance between dependability and velocity is crucial.

Blockchain transaction fees refer to the costs associated with each transaction conducted on a blockchain network, which are mandated by the network itself. These fees are associated with the costs involved in processing and authenticating transactions on the network.Transaction fees are essential for the maintenance of the seamless and efficient operation of blockchain networks. Each transaction on the network requires processing by miners or validators and then being added to a block on the blockchain. The supply of this service requires both time and resources, hence transaction fees serve as a means to encourage its provision.Blockchain transaction fees are often determined based on the size and intricacy of transactions. Generally, bigger transactions incur more expenses, whereas smaller transactions need lower fees. Furthermore, elevated network congestion typically leads to an escalation in transaction costs.Roughgarden (2021) states that there is an important difference between the demand and supply of blockchains like Bitcoin and Ethereum. This calls for a system that may choose a subset of transactions from the whole pool of pending transactions to be included "on-chain."Transaction fees in blockchain are crucial for guaranteeing the security and integrity of the network. Charges can operate as a deterrent to prevent spam or fraudulent transactions on the network. Furthermore, transaction fees serves as an incentive for miners or validators to fulfill their duties on the network. However, high transaction costs might have a negative impact on specific clients. Substantially increased transaction expenses can lead to consumer dissatisfaction, especially for small-scale transactions or transfers of minimal worth. Therefore, blockchain efforts often use various strategies to improve the effectiveness of transaction expenses. In essence, transaction fees in blockchain are vital for the operation of the network. An optimal equilibrium must be attained: the network's elevation should be enough for proper operation, without unnecessarily deterring consumers. The balance of this aspect is vital in promoting the widespread adoption and use of blockchain technology.

Decentralized applications (dApps) are applications that function on a decentralized network and store data, execute logical functions, or conduct transactions using distributed ledger technologies such as blockchain. These apps commonly operate on decentralized networks, making them independent of a central authority. Decentralized

applications, commonly referred to as "DApps" or "dee-apps," arise from the dependable data manipulation capabilities facilitated by smart contracts. Contrary to conventional apps, they function autonomously without being tied to a certain corporation or owner, and do not rely on a central server or entity. DApps consist of essential components such as user interface, data, and computation, which are executed through smart contracts on the blockchain (Metcalfe,2020). Wu et al. (2019) provide a detailed research of the growing popularity of decentralized apps (DApps) based on blockchain technology. The research conducted a comprehensive analysis of 995 decentralized applications (DApps) on the Ethereum platform. The analysis encompassed several elements like the popularity of DApps, development methodologies, and operational expenses. The results suggest that DApps provide helpful suggestions for different parties involved.

dApps utilize the security and transparency benefits provided by blockchain technology to provide secure and transparent interactions between users and developers. They frequently employ blockchain technology, like as smart contracts, to guarantee the integrity and security of data. Platforms such as Ethereum provide developers a range of tools to build decentralized applications (dApps). dApps can encompass decentralized exchanges that facilitate financial transactions using cryptocurrencies, programmes that offer digital identity management, voting systems, and other functionalities. dApps are software programmes that extract value from the blockchain by storing data, executing transactions, or carrying out logical operations. They function via smart contracts and do not need a central authority. dApps provide benefits such as uninterrupted operation, confidentiality, immunity to censorship, absolute data integrity, and computation without the need for trust, allowing users and developers to engage in secure and transparent interactions (URL 9).

DeFi, which stands for "Decentralized Finance," applies to the application of blockchain technology to deliver conventional financial services in a decentralized fashion. DeFi, short for decentralized finance, primarily focuses on carrying out diverse financial operations, including lending, borrowing, trading, insurance, and other similar activities, by utilizing smart contracts and other applications based on blockchain technology. DeFi enables users to carry out financial transactions without

the necessity of intermediaries or banks, thanks to its decentralized financial services. These benefits include reduced transaction costs, accelerated transactions, and increased financial accessibility. DeFi apps are commonly built on blockchain platforms like as Ethereum and function via smart contracts. Schär (2021) explores the decentralized finance (DeFi) ecosystem on Ethereum's blockchain, focusing on the utilization of smart contracts. The research delves into the potential benefits and hazards associated with DeFi. The paper presents a methodology for examining several elements, including architecture and token standards. It highlights that despite the associated dangers, DeFi enhances financial infrastructure by providing benefits like as efficiency, transparency, accessibility, and composability. DeFi establishes a completely digital alternative to Wall Street by building upon the fundamental concept of digital currency. Nevertheless, it possesses the capacity to generate financial markets that are more transparent, unrestricted, and equitable, devoid of any accompanying expenses. The advantages of DeFi encompass the absence of account opening requirements, the elimination of the need to disclose personal information, the ability to move assets in a flexible manner, prompt updates, and a high level of transparency (https://www.coinbase.com/learn/crypto-basics/what-is-defi).

Blockchain interoperability is the capacity for distinct blockchain networks to connect and engage with one other without difficulty. Put simply, it involves facilitating the exchange of data and assets between different blockchain systems. Hardjono et al. (2020) highlight the need of interoperability as a vital necessity for the durability and controllability of blockchain systems. The reason interoperability plays a vital role in the blockchain industry is because there is not a single blockchain. Various blockchains possess distinct protocols, consensus procedures, and characteristics, which presents a difficulty in establishing direct communication between them. Interoperability solutions seek to overcome this divide by establishing standards, protocols, or technologies that enable seamless communication and data interchange among diverse blockchain networks.Blockchain interoperability refers to the capacity to link several blockchain networks, effectively addressing scalability and connectivity challenges in blockchain systems (Qasse et al.,2019). Interoperability, in the context of blockchains, pertains to the ability of a blockchain to seamlessly exchange data with

other blockchains. On a specific blockchain, all held assets and transactions are meticulously logged. The proper interoperability solution enables the representation of any economic activity occurring on one blockchain onto another blockchain. This suggests that the economic activity of one chain can extend to another chain, which is a key characteristic of blockchain interoperability solutions (URL 15)

Cross communication in blockchain technology pertains to the exchange of information between distinct blockchains. A blockchain operates as a decentralized ledger, where the information contained inside the ledger is accessible and confirmable by all participants. Nevertheless, establishing communication across distinct blockchains may necessitate the amalgamation of diverse protocols and technology. Cross communication refers to the process of transferring information and data between distinct blockchains. Transferring tokens or other digital assets across multiple blockchains, such as Ethereum and Bitcoin, necessitates this form of cross-communication. To do this, it is necessary to create protocols, smart contracts, or other technologies that can function smoothly across many blockchains. This can facilitate the broader implementation and utilization of blockchain technology. Li et al. (2023) state that cross-chain technology enables the exchange of data and transfer of value between different blockchains. However, this technology encounters several obstacles. These tasks encompass guaranteeing the indivisibility of transactions, verifying transactions across different networks, safeguarding transaction confidentiality, securely handling assets, and assuring the accessibility of data across several chains. The technology must address the absence of interoperability design in the initial phases of blockchain development and adjust to different blockchain architectures.

The blockchain is an emerging technology with the capacity to enhance numerous information systems. Therefore, it is essential for the apps and their underlying platform to possess the capability to establish connections and exchange information. In order to actualize the multisystem blockchain concept, Pillai et al. (2020) suggest the implementation of a mechanism that enables cross-chain interoperability through transactions. This mechanism would establish connections and facilitate communication between multiple entities' blockchain systems in a decentralized

manner, without the need for any intermediary. Furthermore, it would ensure the preservation of trust and integrity established by individual blockchains.

Blockchain incentives cover a range of reward methods employed for improving the security, efficiency, and enduring prosperity of blockchain networks. These incentives are specifically crafted to stimulate engagement in mining operations, uphold the robustness of the blockchain network, and enhance network involvement. As an illustration, blockchain networks commonly compensate miners for their contributions by issuing fresh tokens or block rewards. Alternatively, blockchain systems can employ other techniques, such as smart contracts, voting rights, or additional incentives, to motivate players. The purpose of these incentives is to guarantee the network's security, enhance efficiency, and promote the long-term prosperity of the platform. The design of incentives is a crucial component of the comprehensive economic design of efficient blockchain networks. The item referred to here is the one that enhances the value proposition of a platform and establishes the framework for designing the platform's token. From an economic standpoint, it is the fundamental essence of the system. The implementation of efficient incentive structures is vital for ensuring the security, efficiency, and sustained prosperity of blockchain platforms. The development of novel incentive models and enhancement of current ones will facilitate wider adoption and use of blockchain technology. To ensure the creation of a sustainable and equitable blockchain ecosystem, it is crucial to maintain a mindset that is receptive to ongoing progress, while also protecting the interests of all players. Blockchain incentive schemes have several uses. One of them , Savinder (2023) employed a blockchain-driven incentive mechanism for crowdsensing apps to effectively amass data from smartphone users. Miners assessed high-quality data and rewarded contributors with bitcoin. Node authenticity checks were implemented to safeguard user privacy. Savinder (2023) performed studies and experiments to establish the validity and security of the system.

Blockchain technology provides a novel method for guaranteeing the security of digital assets and transactions. Nevertheless, platforms that employ this technology also have their own security obstacles. Security concerns are particularly prominent in several domains, including Smart Contract Security, Consensus Algorithm Security,

Scalability and Performance Issues, Identity Verification and Authorization, and Data Privacy and Security. There are existing solutions that have been implemented to address these security problems. The programmable feature of smart contracts on blockchain networks is highly captivating. Nevertheless, these smart contracts may have flaws or security vulnerabilities in their programming. These vulnerabilities have the potential to cause contracts to malfunction or enable attackers to seize payments. Thoroughly examining the code, implementing security standards, and following established guidelines are essential for improving the security of smart contracts. Consensus algorithms in blockchain networks provide unanimous agreement among all nodes about the legitimacy of a transaction or block. Nevertheless, certain consensus algorithms may be vulnerable to different types of assaults. For example, the Proof of Work (PoW) protocol is susceptible to 51% assaults. Hence, it is crucial to employ diverse consensus methods or bolster the security of current ones.

The scalability and performance challenges in blockchain networks sometimes arise from their capacity to handle large transaction volumes. Excessive transaction costs and delays can have a negative impact on user experience and restrict the adoption of the platform. In order to tackle these problems, a range of scaling solutions are being created and put into action, such as layered technologies, sidechains, and parallel chains.

Identity verification and permission management in blockchain systems are essential for regulating user access to the network. Nevertheless, problems like identity theft and fraud might arise, just like with conventional identity verification systems. In order to resolve these problems, it is necessary to implement robust identity authentication methods and employ cutting-edge solutions like biometric authentication. Although blockchain guarantees the visibility and capacity to track transactions, this characteristic can also give rise to concerns over the confidentiality of data. Several blockchain protocols with an emphasis on privacy have been created to safeguard sensitive data. These protocols employ cryptographic methods to guarantee the confidentiality of transactions and data.

Blockchain, with its decentralized architecture and robust data processing capabilities, finds applications in several areas. Nevertheless, scalability is a significant challenge

for this technique. Specifically, prominent blockchain systems like Bitcoin and Ethereum are facing challenges in managing the growing needs of users and transaction volumes. Presently, these platforms have a limited capacity to handle just a small number of transactions per second, and the time it takes to confirm a transaction can extend to several minutes. This scenario hampers the extensive use of blockchain technology and presents an obstacle to its implementation. The scalability problem is a substantial obstacle to the general use of blockchain technology. Specifically, prominent blockchain systems such as Bitcoin and Ethereum face challenges in managing growing user requirements and transaction volumes. Currently, these systems have limited capacity to execute just a small number of transactions per second, and it may take several minutes to confirm a transaction. This condition impedes the widespread use and adoption of blockchain technology. Nevertheless, other ways have been suggested to tackle this issue. Second-layer solutions allow off-chain transactions and sidechains, therefore enhancing transaction speeds. Protocol advancements may encompass novel consensus techniques like Proof of Stake (PoS) or scalability-improving attributes like as sharding. In addition, emerging platforms like Ethereum 2.0 or Polkadot aim to resolve this problem by providing a more efficient and expandable architecture. These solution pathways can mitigate the scalability issue of blockchain technology and expand its user base. Zhou et al. (2020) state that cross-chain solutions are now essential elements of Layer2 scaling solutions. Cosmos is a prominent illustration of a project that seeks to link autonomous blockchains in order to establish a unified network and improve scalability. Although these solutions provide some enhancements in scalability, they frequently undermine the core principle of decentralization in blockchain and present additional security risks. Essentially, these systems aim to achieve a harmonious equilibrium between decentralization, security, and scalability, despite their inherent benefits and constraints. According to Chauhan et al. (2018), the inclusion of the Inspector node model enhances the robustness and efficiency of the Sharding model, which was offered as a solution to the scalability difficulty of blockchain. The solution places utmost importance on the core aspects of Blockchain: Decentralization, Security, and scaling, with the goal of resolving scaling challenges in blockchain initiatives.

Multiple blockchain systems exist for the purpose of facilitating real estate tokenization. The following blockchain networks have been evaluated using criteria such as smart contract integration, consensus mechanism, transaction per second (TPS), finality time, transaction fees, compatibility with decentralized applications (dApps), and decentralized financial structures: Binance Smart Chain, Ethereum, Solana, Avalanche, Polygon, Cosmos, and Polkadot.

Scoring of platforms based on parameters

Seven well-known blockchain platforms were carefully examined in the quest for the best fit for the ISToken real estate tokenisation project: Binance Smart Chain, Ethereum, Solana, Avalanche, Polygon, Cosmos, and Polkadot. Every platform was ranked from 1 to 5 after being assessed according to a set of predetermined criteria. Even though the overall results were different, every platform showed its own distinct benefits and drawbacks, giving an extensive overview of their capacities.

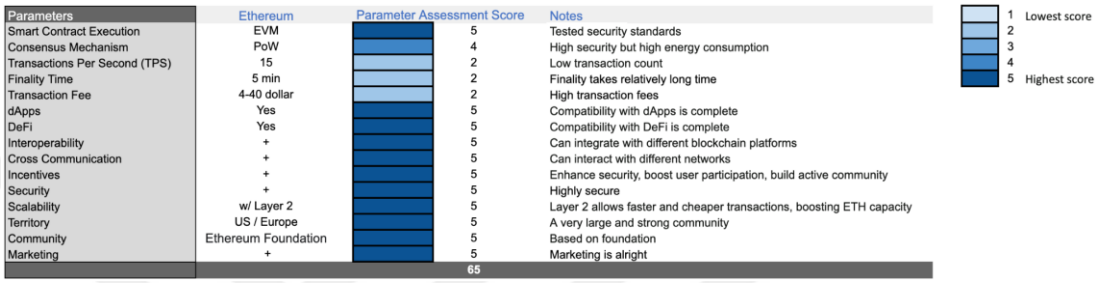
Parameters	Binance Smart Chain	Parameter Assessment Score	Notes
Smart Contract Execution	EVM	5	Tested security standards
Consensus Mechanism	PoSA	3	More centralized structure
Transactions Per Second (TPS)	200	3	Average transaction count
Finality Time	75 sec	4	Finality takes relatively short time
Transaction Fee	0,01	4	Low transaction fees
dApps	Yes	5	Compatibility with dApps is complete
DeFi	Yes	5	Compatibility with DeFi is complete
Interoperability	+	5	Can integrate with different blockchain platforms
Cross Communication	+	5	Can interact with different networks
Incentives	+	5	Continuously updates incentives for development network
Security	+	5	Highly secure
Scalability	+	5	Scalable with high speeds, low costs, and EVM compatibility
Territory	Asia / China	4	Too many whales
Community	Binance Company	2	A private company
Marketing	+	4	Marketing is good enough
		64	

1 Lowest score
2
3
4
5 Highest score

Figure 4.3 : Score of Binance Smart Chain

When evaluated according to the initially set parameters, Binance Smart Chain has strong points such as compatibility with DeFi and dApps, providing interoperability and cross-communication, and being a platform with high security. While its capacity to process 200 transactions per second places it at an average level among the evaluated platforms, its finality time parameter is seen to be reasonably good at 75 seconds. A significant criterion is its smart contract integration, which is achieved through EVM. The Ethereum Virtual Machine (EVM) offers developers a safe, platform-neutral environment in which to easily design smart contracts and decentralized apps (dApps). The EVM enables applications in the Ethereum ecosystem to run rapidly and effectively because of its capacity to handle large transaction volumes, optimize resource utilization through the gas system, and take advantage of

the support of a large developer community. The EVM is a recommended virtual machine in the realm of blockchain development because of these characteristics. PoSA as its consensus mechanism, which stands for "Proof of Staked Authority" and is a consensus mechanism particularly used in blockchain networks. The PoSA paradigm is notable for its integration of the "Proof of Stake" and "Proof of Authority" ideas. While PoSA provides benefits, its usage should be carefully considered due to drawbacks including the possibility of centralisation, high entrance hurdles, and potential security risks.



Parameters	Ethereum	Parameter Assessment Score	Notes
Smart Contract Execution	EVM	5	Tested security standards
Consensus Mechanism	PoW	4	High security but high energy consumption
Transactions Per Second (TPS)	15	2	Low transaction count
Finality Time	5 min	2	Finality takes relatively long time
Transaction Fee	4-40 dollar	2	High transaction fees
dApps	Yes	5	Compatibility with dApps is complete
DeFi	Yes	5	Compatibility with DeFi is complete
Interoperability	+	5	Can integrate with different blockchain platforms
Cross Communication	+	5	Can interact with different networks
Incentives	+	5	Enhance security, boost user participation, build active community
Security	+	5	Highly secure
Scalability	w/ Layer 2	5	Layer 2 allows faster and cheaper transactions, boosting ETH capacity
Territory	US / Europe	5	A very large and strong community
Community	Ethereum Foundation	5	Based on foundation
Marketing	+	5	Marketing is alright
		65	

Figure 4.4 : Score of Ethereum

Ethereum is the most advanced, tested, and widely adopted platform among those examined, making it a locomotive to which other platforms are in some way integrated. However, due to its size and the high number of transactions, its transaction speed and volume are lower compared to other platforms. Another disadvantage is the high transaction costs, which range from $4 to $40. The consensus mechanism it uses, Proof of Work, provides a strong security mechanism and securely validates the transactions on the blockchain network. However, it also has drawbacks, such as high energy consumption and slower transaction speeds. The Ethereum Virtual Machine (EVM) it uses for smart contract integration is a virtual machine that executes smart contracts on the blockchain network. EVM provides a decentralized operating environment for running smart contracts and supporting dApps (decentralized applications) on the Ethereum network. EVM is one of the cornerstones of the Ethereum network and plays a central role in the operation of the Ethereum ecosystem. Regarding DeFi and dApps, unlike traditional applications, dApps are supported by nodes on the Ethereum network rather than a central server. This enables dApps to benefit from advantages such as enhanced security, transparency, and resistance to censorship. Ethereum's capabilities

in smart contracts and dApps form the foundation of DeFi applications, allowing financial services to be delivered in a decentralized, transparent, and accessible manner. Although Ethereum faces challenges due to its size, it leads the way in finding various solutions thanks to its technological capabilities and the size of its developer community.

Parameters	Solana	Parameter Assessment Score	Notes
Smart Contract Execution	LLVM	3	General programming typically game development
Consensus Mechanism	PoS-PoH	4	Risk of centralization, but more environment friendly
Transactions Per Second (TPS)	200	3	Average transaction count
Finality Time	0.4 sec	5	Fastest finality time
Transaction Fee	0,00001	5	Very low transaction fees
dApps	Yes	5	Compatibility with dApps is complete
DeFi	Yes	5	Compatibility with DeFi is complete
Interoperability	-	1	Can not integrate with different blockchain platforms
Cross Communication	+	5	Can interact with different networks
Incentives	+	5	Encourages user participation, contributes community-building efforts
Security	-	1	An area where scams potentially occur or are frequently seen
Scalability	+	5	Can process transactions in parallel to ensure scalability
Territory	Europe	4	Concentrated more in Europe
Community	Solana Labs & S. Foundation	3	Positive as a foundation, but quite weak compared to ETH
Marketing	-	1	Marketing is broken
		55	

1 Lowest score
2
3
4
5 Highest score

Figure 4.5 : Score of Solana

When examining the Solana blockchain platform specifically in terms of smart contract integration, the LLVM it uses generally provides high-performance compilation and language support. While LLVM offers a general compiler infrastructure, it is not specifically designed for blockchain technologies. This means it does not directly support blockchain features and requirements. Additionally, the consensus mechanism used, Proof of History (PoH), relies on a single node to establish the chronological order of transactions, which can raise centralization concerns. If this node is compromised, it has the potential to disrupt the entire network. Another issue is its compatibility with blockchain platforms, which poses a negative characteristic. The platform has also been associated with numerous fraud incidents and has not been marketed effectively. Although it has advantages such as compatibility with DeFi and dApps and very short finality times, due to its critical disadvantages in key parameters, the Solana blockchain platform is not suitable for the ISToken tokenization model.

Parameters	Avalanche	Parameter Assessment Score	Notes
Smart Contract Execution	AVM	4	Speed and low cost advantage
Consensus Mechanism	PoS-AvaLP	4	Risk of centralization, but more environment friendly
Transactions Per Second (TPS)	180	3	Average transaction count
Finality Time	1-5 sec	5	Finality takes short time
Transaction Fee	0,03	3	Average transaction fees
dApps	Yes	5	Compatibility with dApps is complete
DeFi	Yes	5	Compatibility with DeFi is complete
Interoperability	+	5	Can integrate with different blockchain platforms
Cross Communication	+	5	Can interact with different networks
Incentives	+	5	Staking, liquidity provision, developer incentives, community events to growth
Security	+	5	Highly secure
Scalability	w/ Subnets	4	Break the network into manageable units and improve scalability
Territory	US / Turkey	2	Community is not global
Community	Ava Labs	2	A private company
Marketing	-	2	Marketing is weak
		57	

1 Lowest score
2
3
4
5 Highest score

Figure 4.6 : Score of Avalanche

Avalanche is a platform with standout features among modern blockchain projects. It offers high speed and low-cost advantages through its smart contract execution capability (AVM), allowing users to perform more efficient and economical transactions. It uses Proof of Stake - AvaLP as its consensus mechanism; while environmentally friendly, this mechanism carries a risk of centralization. The platform has a capacity of 180 transactions per second (TPS), providing an average transaction count. The finality time ranges from 1-5 seconds, which is quite short and allows for rapid transaction completion. Transaction fees average around $0.03. Avalanche is fully compatible with decentralized applications (dApps) and decentralized finance (DeFi). Additionally, it has interoperability and cross-communication features with different blockchain platforms, enabling integration and interaction with other networks.The platform supports growth through various incentives such as staking, liquidity provision, developer incentives, and community events. It has a robust security structure. Scalability is achieved through subnets, which break the network into manageable units to improve performance. However, the community is generally limited to the US and Türkiye , lacking a global reach. Furthermore, the community is managed by a private company named Ava Labs, and marketing activities are weak.

In conclusion, Avalanche is a technically strong and innovative platform, particularly noted for its dApp and DeFi compatibility, fast finality time, and high security features. However, it requires improvement in marketing and community expansion. For these reasons, it has been deemed unsuitable for ISToken.

Parameters	Polygon	Parameter Assessment Score	Notes
Smart Contract Execution	EVM	5	Tested security standards
Consensus Mechanism	PoS	4	Risk of centralization, but more environment friendly
Transactions Per Second (TPS)	600	4	Relatively high transaction count
Finality Time	5 sec	4	Finality takes relatively short time
Transaction Fee	0,002	4	Low transaction fees
dApps	Yes	5	Compatibility with dApps is complete
DeFi	Yes	5	Compatibility with DeFi is complete
Interoperability	+	5	Can integrate with different blockchain platforms
Cross Communication	+	5	Can interact with different networks
Incentives	+	5	Staking, DeFi projects, developer support to strength Polygon ecosystem
Security	+	5	Highly secure
Scalability	w/ Sidechains	3	Has its own security mechanisms, and its security can vary
Territory	Asia Pacific	4	Community is large, almost no whales
Community	Polygon Labs	2	A private company
Marketing	+	4	Marketing is good
		64	

1 Lowest score
2
3
4
5 Highest score

Figure 4.7 : Score of Polygon

Polygon is a well-rounded blockchain platform featuring a range of capabilities that make it a strong contender in the blockchain space. It received a flawless grade in this category because its EVM-based smart contract execution is supported by tried-and-true security standards. The platform employs a Proof of Stake (PoS) consensus

process, which raises the possibility of centralisation even though it is ecologically benign. Through a variety of incentives, including staking, DeFi initiatives, and developer assistance, the platform fosters growth and adds to a strong and safe environment. Polygon can handle a comparatively large amount of transactions with a 600 TPS transaction capability, reaching finality in 5 seconds. Because of the exceptionally low transaction fees—roughly 0.002 USD—users can benefit financially. Polygon supports a broad range of use cases and is completely compatible with decentralised finance (DeFi) and applications (dApp) protocols. Its adaptability is increased by the smooth integration and interaction with different blockchain networks made possible by its cross-communication and interoperability characteristics.

Sidechains allow for scalability, yet the security of a given technique may differ. The Asia Pacific area is home to Polygon's community, which is distinguished by its size and dearth of prominent whales. Strong marketing efforts are made for the platform by Polygon Labs, a private firm that oversees the community.

In summary, Polygon is a technically sound and cutting-edge platform since it excels in a number of important areas. Its centralisation danger and the fact that a private corporation oversees it, however, are possible areas for development.

Parameters	Cosmos	Parameter Assessment Score	Notes
Smart Contract Execution	Cosmos SDK	3	Low security, future uncertainty
Consensus Mechanism	PoS-Tendermint	4	Risk of centralization, but more environment friendly
Transactions Per Second (TPS)	1400	5	High transaction count
Finality Time	1-3 sec	5	Finality takes short time
Transaction Fee	0,03	3	Average transaction fees
dApps	Yes	5	Compatibility with dApps is complete
DeFi	Yes	5	Compatibility with DeFi is complete
Interoperability	+	5	Can integrate with different blockchain platforms
Cross Communication	+	5	Can interact with different networks
Incentives	+	5	Staking, validator rewards, developer support, and community participation
Security	+	5	Highly secure
Scalability	w/ Interchains	3	Transferring data between different chains can lead to data loss
Territory	Switzerland	1	Target specific countries only
Community	The Interchain Foundation	3	Positive as a foundation, but quite weak compared to ETH
Marketing	+	3	Marketing is stable
		60	

1 Lowest score
2
3
4
5 Highest score

Figure 4.8 : Score of Cosmos

Cosmos is a platform that stands out among blockchain projects with many notable features. It executes smart contracts using the Cosmos SDK, which has the drawbacks of low security and future unpredictability. The platform employs the Proof of Stake (PoS) - Tendermint consensus process, which is environmentally friendly yet prone to centralization. Tendermint is a high-performance and low-latency blockchain engine that provides secure and fast transaction confirmations. However, it carries the risk of

centralization and has some uncertainties regarding long-term reliability. With its capacity of 1400 transactions per second (TPS), Cosmos stands out from its competitors. Transactions can be completed quickly because the finality time is only 1 to 3 seconds. The average transaction fee is $0.03 USD.

Cosmos is fully compatible with decentralized finance (DeFi) and decentralized applications (dApps). Additionally, it allows for integration and communication with other networks due to its cross-communication and interoperability features with various blockchain platforms. The platform promotes growth through a variety of incentives like staking, validator rewards, developer support, and community involvement while ensuring high security. Scalability is provided through interchains, although data loss can occur when transferring data between chains. The platform targets specific countries only and focuses on Switzerland. The Interchain Foundation, which oversees the community, is a good foundation overall but not as strong as ETH. The marketing campaign is consistent.

In conclusion, Cosmos is a robust platform in terms of technology, particularly recognized for its quick finality time and large transaction capacity. However, it does have certain drawbacks, including a risk of centralization and inadequate security.

Parameters	Cosmos	Parameter Assessment Score	Notes
Smart Contract Execution	Cosmos SDK	3	Low security, future uncertainty
Consensus Mechanism	PoS-Tendermint	4	Risk of centralization, but more environment friendly
Transactions Per Second (TPS)	1400	5	High transaction count
Finality Time	1-3 sec	5	Finality takes short time
Transaction Fee	0,03	3	Average transaction fees
dApps	Yes	5	Compatibility with dApps is complete
DeFi	Yes	5	Compatibility with DeFi is complete
Interoperability	+	5	Can integrate with different blockchain platforms
Cross Communication	+	5	Can interact with different networks
Incentives	+	5	Staking, validator rewards, developer support, and community participation
Security	+	5	Highly secure
Scalability	w/ Interchains	3	Transferring data between different chains can lead to data loss
Territory	Switzerland	1	Target specific countries only
Community	The Interchain Foundation	3	Positive as a foundation, but quite weak compared to ETH
Marketing	+	3	Marketing is stable
		60	

1 Lowest score
2
3
4
5 Highest score

Figure 4.9 : Score of Polkadot

Polkadot first shows how to integrate smart contracts using WebAssembly (WASM) when assessed based on the factors listed in the table. Compared to other technologies, WASM is less tested yet offers greater flexibility. Despite the possibility of centralisation, Polkadot employs a Proof of Stake (PoS) consensus process that is environmentally benign. Polkadot performs averagely or below averagely in various areas, with a transaction capacity of 180 TPS and a finality time of 10 minutes. At $0.1, transaction fees are reasonable. Polkadot can work with decentralized apps

(dApps) and decentralized finance (DeFi), but because it cannot connect or communicate with other blockchain platforms, it has a lot of difficulties with cross-platform communication and interoperability. Strong incentives are offered, and staking rewards help to maintain network security. However, it scores poorly in security and scalability. Geographically, Polkadot focuses on Switzerland, which limits its target area. The community managed by the Web3 Foundation is relatively weak compared to Ethereum, and its marketing efforts are limited. Based on these evaluations, it is clear that the platform needs further development.

All examined platforms have their unique advantages and each holds a significant place in the development of the blockchain ecosystem. When the parameters are generally reassessed, it is observed that some platforms have outperformed othe

Table 4.1 : Platforms with Parameters

Parameters	Binance Smart Chain	Ethereum	Solana	Avalanche	Polygon	Cosmos	Polkadot
Smart Contract Execution	EVM	EVM	LLVM	AVM	EVM	Cosmos SDK	WASM
Consensus Mechanism	PoSA	PoW	PoS-PoH	PoS-AvaLP	PoS	PoS-Tendermint	PoS
Transactions Per Second	200	15	200	180	600	1400	180
Finality Time	75 sec	5 min	0.4 sec	1-5 sec	5 sec	1-3 sec	10 min
Transaction Fee	0,01	4-40 dollar	0,00001	0,03	0,002	0,03	0,1
dApps	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DeFi	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interoperability	+	+	-	+	+	+	-
Cross Communication	+	+	+	+	+	+	-
Incentives	+	+	+	+	+	+	+
Security	+	+	-	+	+	+	-
Scalability	+	w/ Layer 2	+	w/ Subnets	w/ Sidechains	w/ Interchains	-
Territory	Asia / China	US / Europe	Europe	US / Turkey	Asia Pacific	Switzerland	Switzerland
Community	Binance Company	Ethereum Foundation	Solana Labs & S. Foundation	Ava Labs	Polygon Labs	The Interchain Foundation	Web3 Foundation
Marketing	+	+	-	-	+	+	-

Upon examining the integration of smart contracts, it is evident that Binance Smart Chain, Ethereum, and Polygon all utilize the Ethereum Virtual Machine (EVM). The Ethereum Virtual Machine (EVM) is a software platform that is designed to run smart contracts and distributed applications (dApps) on the Ethereum blockchain. Solana utilizes LLVM (Low-Level Virtual Machine), which provides a distinct function compared to EVM (Ethereum Virtual Machine). The EVM is specifically engineered to execute smart contracts on the Ethereum blockchain, whereas LLVM serves as a versatile compiler infrastructure that optimizes and compiles code across different programming languages. Avalanche utilizes its proprietary virtual machine known as the Avalanche Virtual Machine (AVM), which is designed to be compatible with the Ethereum Virtual Machine (EVM). Cosmos utilizes its proprietary virtual machine known as Cosmos SDK, whereas Polkadot leverages WebAssembly (WASM) specifically developed for smart contracts, web apps, and other applications. While every virtual machine has its own distinct functions, the Ethereum Virtual Machine (EVM) is particularly crucial for ISToken's platform selection due to its specific architecture for smart contracts on the Ethereum network. Ethereum primarily employs the Proof of Work (PoW) consensus method for its operations, whilst other platforms often explore other approaches but generally lean towards utilizing Proof of Stake (PoS). Platforms created after Ethereum commonly utilize PoS due to the substantial energy consumption associated with the Proof of Work process. Every consensus process possesses its own merits and drawbacks, and the selection is contingent upon the specific requirements and objectives of the project. Transaction per second (TPS) is a critical metric for blockchain platforms, as one of the primary advantages of blockchain technology is its ability to enhance the pace of operations in many industries. Cosmos and Polygon have superior speed, however Ethereum has the lowest average of 15 transactions per second. Comparatively, Solana has a finality time limitation of 0.4 seconds, whereas Polkadot and Ethereum have finality times of 10 minutes and 5 minutes, respectively. The ratios will play a vital role in determining the appropriate platform for financial transactions. However, currently, there is minimal distinction between the time it takes for traditional procedures, which may span several days, and blockchain operations, which can be completed in as little as 5 minutes or even 0.0001 minutes for a real estate transaction. Indeed, given consumer

behavior, transactions that are somewhat sluggish may be first seen in a good light. When considering transaction fees, Ethereum is the platform with the highest costs, whereas Solana is the platform with the lowest costs. Solana and Polkadot lack interoperability with other platforms, whilst the remaining systems exhibit interconnectivity among themselves. The matter of security remains unresolved for Solana and Polkadot. To enhance scalability, Polkadot manages the primary network burden by leveraging Ethereum layer 2, Polygon sidechain, and Cosmos interchain.

Cosmos and Polkadot are prevalent in Switzerland, while Avalanche is generally utilised in the United States and Türkiye . In the Asia Pacific area, Polygon and Binance Smart Chain are commonly utilized, whilst Solana is prominent in Europe. Ethereum, on the other hand, is widely adopted in both America and Europe. When evaluating marketing, it can be said that Ethereum is quite strong in this area, while Binance Smart Chain has sufficiently adequate marketing strategies. Polygon and Cosmos also have stable and commendable marketing. Platforms with weak marketing strategies include Solana, Avalanche, and Polkadot, which markets itself primarily through bloggers. Marketing is perhaps one of the professional fields that should be emphasized the most in today's world. Especially for a potentially groundbreaking formation in high technology, effective and reliable marketing strategies should be adopted

Parameters	Binance Smart Chain	Ethereum	Solana	Avalanche	Polygon	Cosmos	Polkadot
Smart Contract Execution							
Consensus Mechanism							
Transactions Per Second (TPS)							
Finality Time							
Transaction Fee							
dApps							
DeFi							
Interoperability							
Cross Communication							
Incentives							
Security							
Scalability							
Territory							
Community							
Marketing							
Parameter Assessment Score	**64**	**65**	**55**	**57**	**64**	**60**	**40**

Figure 4.10 : Platforms Scoring Based on Parameter

Following a careful analysis of several blockchain platforms, Ethereum emerges as the apparent front-runner in the field. With one of the biggest developer ecosystems in the blockchain space, Ethereum's community is one of its biggest benefits. It is lively and engaged. Through lively conversations this community consistently promotes innovation and advancements and acts as a critical source of technical assistance while promoting widespread adoption. The community's culture of cooperation makes it easier for decentralized apps (dApps) and financial products to grow quickly, keeping Ethereum at the forefront of blockchain technology and boosting investor and consumer confidence. Another crucial aspect that sets Ethereum apart is its extensive connectivity with other blockchain platforms and networks. As a central point for a multitude of sidechains, second-layer solutions, and interoperability protocols, Ethereum facilitates easy interaction and communication with a wide range of other platforms. Because of this interconnectivity, projects operating within the Ethereum ecosystem can take advantage of other blockchain technologies' advantages while still being compatible with Ethereum's infrastructure. Developers now have additional alternatives to design and scale their applications, improving user experience and encouraging creativity.

Furthermore, Ethereum's established ecosystem consists of a wide array of decentralized applications (dApps) and decentralized finance (DeFi) projects that address diverse use cases, from financial services to gaming and social interactions. Ethereum is more appealing because of its wide range of options, which makes it a one-stop shop for both developers and users. Because there are so many dApps developed on Ethereum, platform engagement rises, which boosts transaction volumes and liquidity

Parameters	Binance Smart Chain	Ethereum	Solana	Avalanche	Polygon	Cosmos	Polkadot
Smart Contract Execution	EVM	EVM	LLVM	AVM	EVM	Cosmos SDK	WASM
Consensus Mechanism	PoSA	PoW	PoS-PoH	PoS-AvaLP	PoS	PoS-Tendermint	PoS
Transactions Per Second (TPS)	200	15	200	180	600	1400	180
Finality Time	75 sec	5 min	0.4 sec	1-5 sec	5 sec	1-3 sec	10 min
Transaction Fee	0,01	4-40 dollar	0,00001	0,03	0,002	0,03	0,1
dApps	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DeFi	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interoperability	+	+	-	+	+	+	-
Cross Communication	+	+	+	+	+	+	-
Incentives	+	+	+	+	+	+	+
Security	+	+	-	+	+	+	-
Scalability	+	w/ Layer 2	+	w/ Subnets	w/ Sidechains	w/ Interchains	-
Territory	Asia / China	US / Europe	Europe	US / Turkey	Asia Pacific	Switzerland	Switzerland
Community	Binance Company	Ethereum Foundation	Solana Labs & S. Foundation	Ava Labs	Polygon Labs	The Interchain Foundation	Web3 Foundation
Marketing	+	+	-	-	+	+	-
	2	1	Not for ISToken	Not for ISToken	3	Conceivable	Not for ISToken

Figure 4.11 : Compatibility Rating for ISToken Model

With these things taken into account, Ethereum is the best platform for ISToken. A dependable and adaptable blockchain that can handle intricate smart contracts and transactions effectively is needed to meet the problems posed by tokenisation in the real estate industry. Ethereum is well-positioned to fulfil the demands of ISToken thanks to its well-established infrastructure and inventive attitude.

In conclusion, Ethereum's all-encompassing benefits—strong marketing tactics, wide-ranging connection, and community involvement—maintain its standing as a front-runner in the blockchain industry. It is the best option for ISToken because of these features, which also position it well for expansion and success in the rapidly changing digital market.

5. CONCLUSION

The current situation of Türkiye real estate market demonstrates a notable decline in the feasibility for small-scale investors as a result of elevated property prices, scarcity of available funds, and reduced ability to make purchases. Macroeconomic variables, such as economic volatility, elevated interest rates, and inflation, exert an adverse influence on the real estate market, dissuading potential investors. Small investors are finding it more difficult to acquire real estate investments because of the rising prices and lack of liquidity. This scenario leads to a decrease in transaction volumes within the industry and has a negative impact on overall economic activity. The real estate industry is widely recognised as a fundamental pillar of the economy. However, the sector has challenges in terms of liquidity and high prices, which impede widespread involvement in real estate investments. The limited market access for small investors not only risks their personal financial stability but also undermines the overall stability of the market. The technological transformation of current processes and structures is crucial in order to enhance the efficiency and accessibility of the real estate market for a wider range of investors. Given the significance of digitalisation in the present day, it is imperative to implement measures in the real estate industry to align with this trend. For optimal results, the process of digitalisation should commence by targeting crucial government institutions, thereby enhancing efficiency within the sector and promoting transparency and accessibility in the market.

Advanced digitalisation technologies, such as real estate tokenisation, are notable for their effectiveness in addressing liquidity and accessibility challenges within the sector. According to literature assessments, tokenisation is a recently introduced concept in Türkiye , with only a few global applications. Tokenisation technology is widely acknowledged as a major innovation in the real estate business and is anticipated to have extensive future applications. The ISToken model provides a comprehensive solution for implementing real estate tokenisation in Türkiye and showcases its compatibility with current regulatory frameworks. This thesis promotes the adoption of real estate tokenisation, an advanced method of digitisation. According

to literature reviews, tokenisation is a recently introduced concept in Türkiye , with limited global implementations. Tokenisation is a nascent technology that has the capability to be incorporated into the real estate market. The literature review focusses on the potential of tokenisation technology and underscores the significance of numerous associated ideas and components that bolster this technology.

Based on regulatory and financial analysis, literature evaluations suggest that the primary barrier to tokenisation is the absence of adequate legislation. While other nations have established and enforced regulatory frameworks for the tokenisation of real estate, the Turkish government has not yet formally acknowledged or controlled this domain. This engenders ambiguity for both investors and the real estate sector, impeding possible implementations. The absence of legislative regulations is the primary impediment to the widespread use of tokenisation in Türkiye . Considering the newness of the notion, it is impractical to anticipate that both the government and the people will readily embrace all the intricacies of this idea. Hence, it is evident that the implementation of a legal framework and the introduction of this technology will require a significant amount of time.

The literature places significant emphasis on the technological side of real estate tokenisation. Blockchain technology, Distributed Ledger Technology (DLT), and smart contracts are essential instruments in this context. Blockchain is a decentralised system that guarantees transparent and immutable recording of all transactions and data. DLT, short for Distributed Ledger Technology, embodies the fundamental concept of blockchain by offering a decentralised database that allows all participants to have visibility into every transaction occurring on the network. This technology obviates the necessity of a central authority, so enabling transactions to be executed with enhanced security and transparency. Smart contracts are programmable agreements that autonomously execute upon the fulfilment of specific circumstances. These contracts function on the blockchain, obviating the necessity for intermediaries and enabling transactions to be executed with greater speed and enhanced security. Smart contracts have the ability to automate the transfer of ownership, rental payments, and other transactions in the digitalisation of real estate ownership. Not only does this accelerate processes and decrease expenses, but it also improves openness and fortifies confidence between the involved parties. The Central Securities Depository (MKK) and Takasbank are crucial in their regulatory and supervisory functions within

Türkiye's financial markets. MKK is responsible for managing the documentation of capital market instruments and facilitating the transfer of ownership for these instruments. In addition, MKK safeguards the interests of investors and guarantees the transparency of market transactions. Takasbank is responsible for the clearing and settlement of securities and other financial instruments. It provides the required infrastructure to ensure secure and quick transaction completion. Takasbank also coordinates the payment and delivery processes amongst parties involved. DLT and smart contracts can fulfil analogous functions to MKK and Takasbank. These technologies facilitate expedited, cost-efficient, and transparent ownership transfers and clearing processes. For instance, a smart contract executed on the blockchain has the capability to autonomously manage the transfer of real estate ownership and document the transaction. This serves the purpose of transferring ownership from MKK while guaranteeing that transactions are securely and unchangeably documented. DLT-based systems can also perform the clearing and settlement functions of Takasbank, resulting in faster and more secure transactions. These technologies have the capacity to revolutionize the existing centralized structure into a decentralized and highly efficient market infrastructure.

The ISToken real estate tokenisation strategy aims to systematically include tokenization in Türkiye , where there is presently no explicit rule governing it. Both governments and individuals require a significant amount of time to comprehend and embrace technological advancements. The ISToken method utilizes established regulatory components to enable tokenization, rather than depending on unregulated elements. Fractional ownership is a well recognised practice in Türkiye , where there are several real estate investment funds that are regulated and widely accepted by the public. Takasbank and the Central Securities Depository Institution (MKK) serve crucial roles in ensuring the safe clearing, settlement, and record-keeping of financial instruments and securities in capital markets. The Capital Markets Board (SPK) exercises regulatory and supervisory authority over these entities.

The ISToken approach suggests utilising Distributed Ledger Technology (DLT) and smart contracts to accelerate these procedures. The SPK does not engage in continuous regulation and supervision of these emerging technologies, but rather concentrates on overseeing portfolio management firms (PMCs) as the entities responsible for issuing them. Portfolio Management Companies (PMCs) are required to acquire a licence from

the SPK, which serves as proof that they adhere to regulations concerning their financial structure, corporate management, and employment practices. Portfolio Management Companies (PMCs) supervise the management of blockchain and ISToken through a Special Purpose Vehicle (SPV). Exclusive communication with the SPK in the ISToken paradigm is limited to PMCs that are regulated by the SPK. Investors interact with the Special Purpose Vehicle (SPV) via the ISToken platform, specifically designed for specialised real estate transactions. The SPK oversees and controls every phase of these initiatives. The PMC, acting as the issuer, creates ISToken SPV tokens, establishes crowdfunding channels, and supervises the token sale process. The complete management of the ISToken SPV is dependent on the SPK license. Smart contracts are utilized to manage ownership rights and real estate-related data, while all transactions are recorded on the distributed ledger technology (DLT). Investors utilize their digital wallets on a crowdfunding site that operates on blockchain technology to obtain ISToken, with the ownership rights being documented in the property registry. Blockchain technology guarantees the secure and unchangeable storage of all transactions, fostering transparency, trust, and benefiting all parties involved. The ISToken real estate tokenisation approach has evaluated seven existing blockchain platforms based on 15 crucial criteria in order to determine the most appropriate platform. When evaluating the seven blockchain platforms—Binance Smart Chain, Ethereum, Solana, Avalanche, Polygon, Cosmos, and Polkadot—based on different criteria, specific attributes and performance indicators become apparent. Binance Smart Chain, Ethereum, and Polygon all employ the Ethereum Virtual Machine (EVM) for executing smart contracts. The EVM is known for its robust security and extensive compatibility with many Ethereum tools and decentralised applications (dApps). Solana utilises the LLVM framework, which provides excellent performance but has not been widely used. On the other hand, Avalanche utilises the AVM, a specialised system built for fast execution and cost efficiency. Cosmos utilises the Cosmos SDK, which offers flexibility but has lesser security and unknown prospects. On the other hand, Polkadot use WASM, providing flexibility but with less extensive testing compared to the EVM.

Binance Smart Chain employs the PoSA (Proof of Staked Authority) consensus process, which combines Proof of Stake (PoS) with Proof of Authority (PoA) to achieve faster block times. However, this approach carries the potential risk of

centralisation. Ethereum is presently employing the PoW (Proof of Work) consensus mechanism, but it is in the process of changing to PoS (Proof of Stake) with Ethereum 2.0. This shift is intended to decrease energy consumption, although it is currently associated with slower transaction speeds and higher costs. Solana utilises a distinctive amalgamation of PoS-PoH (Proof of Stake and Proof of History), enabling exceptional performance. Avalanche use the PoS-AvaLP consensus mechanism to mitigate the risks associated with decentralisation while simultaneously prioritising environmental sustainability. Similarly, Polygon utilises a PoS consensus mechanism to achieve a comparable equilibrium. Cosmos utilises the PoS-Tendermint consensus mechanism, while Polkadot employs PoS, each with their own unique advantages and potential concerns associated with centralisation.

Cosmos has the highest transaction per second (TPS) rate at 1400, followed by Polygon at 600, Solana and Binance Smart Chain at 200 each, Avalanche and Polkadot at 180 each, and Ethereum at 15. The finality duration differs considerably among different blockchain networks. Solana has the shortest finality time of 0.4 seconds, followed by Cosmos with a range of 1-3 seconds, Avalanche with a range of 1-5 seconds, Polygon with 5 seconds, Binance Smart Chain with 75 seconds, Ethereum with 5 minutes, and Polkadot with 10 minutes. The transaction fees for different blockchain networks are as follows: Solana has the lowest fee of $0.00001, followed by Polygon with a fee of $0.002, Binance Smart Chain with a fee of $0.01, Avalanche and Cosmos with prices of $0.03 apiece, Ethereum with fees ranging from $4 to $40, and Polkadot with a fee of $0.1. All platforms are compatible with dApps and DeFi, demonstrating full support in these domains. Binance Smart Chain, Ethereum, Avalanche, Polygon, and Cosmos exhibit robust interoperability, whilst Solana and Polkadot have weak interoperability. Interoperability is highly efficient in Binance Smart Chain, Ethereum, Solana, Avalanche, Polygon, and Cosmos, while it is lacking in Polkadot. Regarding incentives, all platforms provide a diverse range of benefits, including staking, validator rewards, developer support, and community engagement. The security measures of Binance Smart Chain, Ethereum, Avalanche, Polygon, and Cosmos are strong, while they are somewhat weaker in Solana and Polkadot. Scalability is attained through different approaches: Binance Smart Chain, Polygon, and Cosmos employ sidechains, Ethereum utilises Layer 2 solutions, Avalanche employs subnets, and Cosmos utilises interchains, whilst Polkadot lacks scalability.

The management of various blockchain platforms differs, with Binance Smart Chain overseen by Binance Company, Ethereum by the Ethereum Foundation, Solana by Solana Labs and the Solana Foundation, Avalanche by Ava Labs, Polygon by Polygon Labs, Cosmos by the Interchain Foundation, and Polkadot by the Web3 Foundation. Binance Smart Chain, Ethereum, Polygon, and Cosmos exhibit robust marketing strategies, whilst Solana, Avalanche, and Polkadot have comparatively weaker marketing endeavours. These evaluations provide an in-depth analysis of the strengths and weaknesses of each platform, giving a thorough overview to identify the best appropriate platform for certain use cases, such as the ISToken real estate tokenisation project. Considering all these aspects, Ethereum is the optimal platform for ISToken. The real estate tokenisation business necessitates a reliable and flexible blockchain that can efficiently manage complex smart contracts and transactions. Ethereum's robust architecture and pioneering methodology make it highly suitable for addressing these difficulties.

However, the implementation of real estate tokenisation is constrained by legal and regulatory ambiguities, which restrict its practical use. Ensuring the legal acknowledgement and control of tokenisation in Türkiye is crucial for the extensive implementation and approval of this technology. By analysing international instances, the United States Securities and Exchange Commission (SEC) oversees the regulation of digital asset offerings, such as real estate tokenisation. This is done through the implementation of particular legislation known as "Security Token Offerings" (STOs). In Australia, regulatory bodies such as the Australian Securities and Investments Commission (ASIC) are responsible for supervising digital asset offerings and implementing specific legislation. Member states within the European Union commonly establish unified legislation, such as the General Data Protection Regulation (GDPR) and financial regulations, which also encompass subjects like real estate tokenisation. Switzerland, recognised as a prominent nation in the realm of cryptocurrencies and tokenisation, has the Swiss Financial Market Supervisory Authority (FINMA) overseeing and monitoring these operations.

Currently, there is a lack of official legislation in Türkiye regarding this issue, which is causing confusion for both investors and the real estate market. The absence of legislative regulations is the primary impediment to the widespread use of tokenisation in Türkiye . Due of its novelty, it is impractical to anticipate that both the government

and the people will readily embrace all the intricacies of this notion. Hence, it is evident that the implementation of a legal framework and the introduction of this technology will require a significant amount of time. Participants and stakeholders in the real estate industry must adjust to and have confidence in this emerging technology. This process should be bolstered by educational and awareness initiatives, as well as strengthened through pilot projects and experimental implementations. The practical implementation of real estate tokenisation will be feasible through the resolution of legislative concerns, enhancement of technology infrastructure, and increased awareness among industry stakeholders. To adopt and implement tokenisation, it is necessary to build regulatory frameworks and improve technological infrastructure. It is imperative to analyse international case studies and establish and enforce comparable legislation in Türkiye within this framework.

The potential of real estate tokenisation extends beyond Türkiye and encompasses the entire global real estate industry. Tokenisation technology has the capacity to enhance accessibility, transparency, and efficiency in the real estate industry. Hence, it is imperative for participants in the Turkish real estate market and regulatory bodies to assess the potential of tokenisation and embrace this cutting-edge technology, as it will provide substantial advantages in the long run for the industry. Efficient implementation of tokenisation will bolster Türkiye's competitiveness in the real estate industry and entice foreign investors. The active participation of all stakeholders is crucial in order to fully exploit the potential of tokenisation. The ISToken paradigm facilitates the extensive implementation of tokenisation by seamlessly integrating with current legislation and accommodating future ones. This concept proposes that the integration of technical advancements and legal rules should be considered simultaneously. It is crucial for the government and regulatory agencies to create Türkiye -specific legislation when developing the legal framework for tokenisation, taking into account the best practices from other nations.

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